

# Handbook on quarterly national accounts

2013 edition



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**2013 edition**

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## Foreword

This handbook is an update of the 1999 edition. Over the last fourteen years many developments had some impact on the compilation of quarterly national accounts (QNA). They include the update of the European System of National Accounts (ESA 2010) and associated transmission programme, the work of task forces to improve and harmonize particular aspects of QNA and the publication of the IMF's Quarterly National Accounts Manual in 2001. But perhaps the four factors that have necessitated and contributed most to the update of this handbook are the adoption by EU Member States of quarterly chain-linked volume estimates and quarterly institutional sector accounts, the improved timeliness of QNA, including the widespread adoption of flash estimates, and the amount of practical experience gained over the last fourteen years in compiling QNA.

A small project team was established to undertake the update and it was aided and guided by a QNA Task Force comprising representatives of EU Member States, Norway, Switzerland, Eurostat and the ECB.

At the first meeting of the QNA Task Force, in May 2011, there was agreement that the old handbook contained much material that can be found elsewhere and is too long. It was also agreed that the updated handbook should focus on addressing issues particular to QNA, or of more importance for QNA than annual national accounts (ANA), which are not dealt with elsewhere. These guiding principles led to the development of an outline for the updated handbook according to which some chapters in the 1999 handbook would be deleted, others shortened and a number of additions and improvements would be made. The outline and a road map, setting out a schedule for the update, were approved at a meeting of Directors of Macroeconomic Statistics (DMES) in June 2011.

QNA compilers, particularly newcomers, are the primary target audience for the updated handbook and major users of QNA are a secondary target. Accordingly, the overriding objectives have been to ensure that the updated handbook covers relevant topics and is clear and accessible, with examples where appropriate.

Some parts of the old handbook have been retained with relatively little change, while other parts were heavily edited, re-written or completely deleted. Much new material has been added. One of the chapters of the old handbook was deleted: concerns of the financial accounts. It was felt that a single chapter was inadequate and a separate handbook (which should be prepared by a separate task force comprising financial accounts experts) was needed.

## Acknowledgements

Eurostat would like to thank all those who contributed to the update of the handbook.

A QNA task force was established to guide the work. It was chaired by members of Eurostat: Jukka Jalava, Luis Biedma and Johannes Wouters. Other members of the task force were (in alphabetical order): Itziar Alberdi (INE, Spain), Stephanus Arz (initially ECB and later Deutsche Bundesbank, Germany), Dario Buono (Eurostat), Claudia Cicconi (ISTAT, Italy), Carla Grosa (INE, Portugal), Stefan Hauf (Destatis, Germany), Kornelie Korsnes (SSB, Norway), Peter Lee (ONS, UK), Eirik Linstad (SSB, Norway), Ronald Nelisse (CBS, the Netherlands), Bruno Parnisari (SECO, Switzerland), Aurelien Poissonnier (INSEE, France), Pilar Rey-Del-Castillo (Eurostat), José Pablo Valdés Martínez (INE, Spain).

A private company (Sogeti) was engaged to support the work, with a project team comprising Anders Nordin (project manager), Charles Aspden (editor) and Sandrine Cipponeri (preparation of the handbook for publication). Final editions were done by Christine Gerstberger and Magdalena Saigne from Eurostat.

The EU QNA Task Force met five times:

- 16-17 May 2011 Eurostat/Luxembourg
- 20-21 October 2011 ECB/Frankfurt
- 19-20 January 2012 FSO/Neuchatel
- 26-27 April 2012 ISTAT/Rome
- 20-21 September 2012 CBS/the Hague

In between meetings there was an extensive correspondence by email. An important tool was the use of questionnaires that allowed members of the Task Force to express their views on particular issues. This helped to resolve issues in between the formal meetings and allowed more rapid progress.

From late 2011, draft chapters of the updated handbook were posted on Eurostat's website for comment by Member States.

As noted in the Foreword, some parts of the old handbook have been retained with relatively little change, while other parts have been heavily edited, re-written or completely deleted, and much new material has been added. While Charles Aspden was responsible for much of this work, many task force members made substantial contributions. Several contributions warrant special mention, though:

- Aurelien Poissonier and Bruno Parnisari were largely responsible for drafting Chapter 5 (Statistical methods for temporal disaggregation and benchmarking)
- Aurelien Poissonier, Alexis Louvel and Bruno Parnisari were responsible for preparing Annex 5.B (Two-step optimal methods – French approach)
- Bruno Parnisari was responsible for preparing Annex 5.C (Temporal disaggregation of national accounts time series: an illustrated example using different methods and models)
- Dario Buono prepared Box 7.1 (Seasonal adjustment using Demetra+)
- Ronald Nelisse and Vincent Ohm prepared Annex 8.C (Benchmarking and balancing methods in the Dutch national accounts)

Comments on the Handbook are welcome and should be sent to Eurostat using the functional mailbox: [estat-gdp-query@ec.europa.eu](mailto:estat-gdp-query@ec.europa.eu).

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## List of abbreviations and acronyms

|                   |   |
|-------------------|---|
| <b>ANA</b>        | Annual National Accounts  |
| <b>AR(1)</b>      | AuroRegressive (model) of order 1   |
| <b>ARIMA</b>      | AutoRegressive Integrated Moving Average (model)                              |
| <b>ARMA</b>       | AutoRegressive Moving Average (model)   |
| <b>AVD</b>        | Additive Volume Data (method)   |
| <b>BFL</b>        | Boot, Feibes and Lisman (method)  |
| <b>BI (ratio)</b> | Benchmark to Indicator (ratio)  |
| <b>BPM6</b>       | Balance of Payment and International Investment Position, 2008, sixth edition |
| <b>BoP</b>        | Balance of Payments   |
| <b>CFC</b>        | Consumption of Fixed Capital  |
| <b>c.i.f.</b>     | cost, insurance and freight   |
| <b>CMFB</b>       | European Committee on Monetary, Financial and Balance of Payments Statistics  |
| <b>COFOG</b>      | Classification of the Functions of Government                                 |
| <b>COICOP</b>     | Classification Of Individual CONsumption by Purpose for households            |
| <b>CPI</b>        | Consumer Price Index  |
| <b>DMES</b>       | Directors of Macroeconomic Statistics   |
| <b>DRG</b>        | Diagnostic Related Group  |
| <b>EC</b>         | European Commission   |
| <b>ECB</b>        | European Central Bank   |
| <b>ECOTRIM</b>    | A program for temporal disaggregation of time series                          |
| <b>EEC</b>        | European Economic Community   |
| <b>ESA</b>        | European System of Accounts   |
| <b>ESS</b>        | European Statistical System   |
| <b>EU</b>         | European Union  |
| <b>FD</b>         | First Difference  |
| <b>FDI</b>        | Foreign Direct Investment   |
| <b>FIFO</b>       | First In First Out  |
| <b>FISIM</b>      | Financial Intermediation Services Indirectly Measured                         |

|               |  |
|---------------|--|
| <b>f.o.b.</b> | free on board  |
| <b>GDP</b>    | Gross Domestic Product   |
| <b>GDP(E)</b> | Gross Domestic Product derived using the expenditure approach                    |
| <b>GDP(I)</b> | Gross Domestic Product derived using the income approach                         |
| <b>GDP(P)</b> | Gross Domestic Product derived using the production approach                     |
| <b>GFCF</b>   | Gross Fixed Capital Formation  |
| <b>GFCE</b>   | Government Final Consumption Expenditure   |
| <b>GFS</b>    | Government Finance Statistics  |
| <b>GLS</b>    | Generalized Least Squares regression   |
| <b>GOS</b>    | Gross Operating Surplus  |
| <b>GMI</b>    | Gross Mixed Income   |
| <b>GREG</b>   | Generalised REGression estimation  |
| <b>HBS</b>    | Household Budget Survey  |
| <b>HFCE</b>   | Household Final Consumption Expenditure  |
| <b>IAS</b>    | International Accounting Standard  |
| <b>IIP</b>    | International Investment Position  |
| <b>ILO</b>    | International Labour Organisation  |
| <b>IMF</b>    | International Monetary Fund  |
| <b>INDS</b>   | Industries   |
| <b>INSEE</b>  | Institut National de la Statistique et des Etudes Economiques                    |
| <b>IPD</b>    | Implicit Price Deflator  |
| <b>IPI</b>    | Import Price Index   |
| <b>ISTAT</b>  | Istituto Nazionale di Statistica   |
| <b>IVI</b>    | Inventory valuation adjustment   |
| <b>KAU</b>    | Kind- of- Activity Unit  |
| <b>LFS</b>    | Labour Force Survey  |
| <b>MaxLog</b> | Maximum of the Log-likelihood function   |
| <b>MinSSR</b> | Minimum of the Sum of Squares of the Residuals                                   |
| <b>NACE</b>   | Nomenclature statistique des activités économiques dans la Communauté Européenne |
| <b>n.i.e.</b> | not included elsewhere   |

|                    |   |
|--------------------|---|
| <b>OECD</b>        | Organisation for Economic Cooperation and Development   |
| <b>OLS</b>         | Ordinary Least Squares regression   |
| <b>PCG</b>         | Partial Contributions to Growth (method)  |
| <b>PIM</b>         | Perpetual Inventory Method  |
| <b>PPI</b>         | Producer Price Index  |
| <b>PPY</b>         | average Prices of the Previous Year   |
| <b>PPY(-1)</b>     | average Prices of the Previous Year offset one quarter and lagged one quarter   |
| <b>NPISH</b>       | Non Profit Institutions Serving Households  |
| <b>NSI</b>         | National Statistical Institute  |
| <b>QNA</b>         | Quarterly National Accounts   |
| <b>RMSE</b>        | Root Mean Square Error  |
| <b>SDMX</b>        | Statistical Data and Meta data eXchange   |
| <b>SNA</b>         | System of National Accounts   |
| <b>SPV</b>         | Special Purpose Vehicle   |
| <b>STS</b>         | Short-Term business Statistics  |
| <b>SUT</b>         | Supply and Use Table  |
| <b>TRAMO/SEATS</b> | (TRAMO) Time series Regression with ARIMA noise, Missing values and Outliers; (SEATS) Signal Extraction in ARIMA Time Series (seasonal adjustment method) |
| <b>VAT</b>         | Value Added Tax   |
| <b>VBA</b>         | Visual Basic for Applications programming language  |
| <b>WGR</b>         | Weighted Growth Rate (method)   |
| <b>X-12-ARIMA</b>  | Version 12 of the US Bureau of the Census's seasonal adjustment method with an ARIMA extension  |

## 1. Introduction and overview

This chapter describes how the handbook complements and expands on the themes described in Chapter 12 of ESA 2010. It describes the purpose of the handbook and gives a summary description of the handbook's structure and the content of each chapter.

## Introduction

- 1.1. Quarterly national accounts (QNA) play a central role in assessing the performance of the economy in the recent past and provide the basis for forecasting the economy's future performance. The emphasis is on measuring quarterly changes, and so seasonally adjusted estimates and volume estimates, where applicable, take prominence.
- 1.2. While the growth rate of seasonally adjusted volume estimates of GDP for the latest quarter makes the headlines, QNA provide a comprehensive and consistent set of statistics that allows economists and other analysts to undertake detailed assessments of the recent performance of the economy in terms of production, final expenditures and income. Time series of QNA statistics support the development of forecasts using econometric models, business cycle analysis, and other economic analyses such as measuring the lags in the effects induced by economic shocks and studying the dynamics of various aspects of the economy.
- 1.3. Over time, the role of QNA has assumed greater importance and the demands put on them have increased in a number of different ways:
  - the demand for greater timeliness has led to the widespread introduction of flash estimates;
  - the demand for greater accuracy has led to the development of improved methods and data sources;
  - the demand for greater scope has led to the more widespread adoption of institutional sector and financial accounts;
  - the demand for greater consistency and comparability between the statistics of Member States has inspired a number of initiatives in fields such as seasonal adjustment, flash estimates, revision policy and analysis – all with the objectives of encouraging best practice and increasing the comparability of data.

These changing demands have also been reflected in the EU regulations concerning the data transmission programme.

- 1.4. For some countries, QNA represent the main national accounts activity. Great importance is attached to them and they are used to derive annual national accounts (ANA). In this case, ANA play a secondary role, at least in the compilation process. In other countries, QNA are considered, to varying degrees, as a supplement to ANA. But in the case of the latter group, there has been a change in emphasis from annual to quarterly compilation over time.
- 1.5. Chapter 12 of ESA 2010 describes and defines the major principles and characteristics of QNA. It notes that the coverage of QNA is the same as that of ANA: they encompass the entire sequence of accounts and the corresponding aggregates as well as the supply and use framework. However, the reduced availability of information and the quarterly frequency of compilation usually result in reduced coverage and scope for QNA.

- 1.6. QNA framework includes the following:
  - a. main aggregates (including employment and population);
  - b. financial and non-financial accounts by institutional sector;
  - c. breakdowns of key aggregates (gross value added, final consumption expenditure, gross fixed capital formation, imports and exports of goods and services, employment), but more limited in detail than ANA;
  - d. a simplified sequence of accounts.

It is argued strongly in the handbook that there are substantial benefits to be gained by compiling QNA in a supply and use framework.

- 1.7. The handbook discusses at length the data sources and methods used for compiling quarterly non-financial accounts for the total economy and each institutional sector up to and including the capital account. In most cases, sectoral decompositions are made using either source data specific to an institutional sector (e.g. government finance data) or more wide-ranging data that have a sectoral dimension (e.g. an economy-wide survey in which the units are coded to both industry of activity and sector). In some cases the data for one institutional sector may be used to impute those for other sectors, e.g. taxes and banking and insurance services. It is common practice to balance the estimates for the whole economy and then ensure that the institutional sectoral estimates are consistent.
- 1.8. The handbook does not address the compilation of financial accounts.
- 1.9. Chapter 12 of ESA 2010 also identifies issues that are of special significance in QNA and which are attributable to their high frequency. For most of these issues, the solutions proposed for compiling ANA apply directly to QNA, but in some specific cases the issues apply to QNA either exclusively, or to a far greater extent. The following issues are distinguished:
  - time of recording;
  - flash estimates;
  - balancing and benchmarking;
  - chain-linked volume estimates;
  - seasonal and calendar adjustments.

The handbook expands on what the ESA 2010 has to say on these issues.

- 1.10. The handbook is intended to be a reference for providing guidance on particular aspects of QNA compilation with the following attributes:
  - a. the guidance provided is consistent with agreed EU principles and ESS guidelines;
  - b. while the guidance is in accord with best practice, the handbook often also describes alternatives that may be adopted when it is not possible to adopt the recommended approach;
  - c. the guidance is a distillation of the knowledge and experience gained by national accountants and is intended to be practical.

## Structure of the handbook

- 1.11. The handbook has nine chapters following this one. They are:
2. Sources and methods used to compile initial estimates of QNA variables;
  3. Processes for acquiring basic data;
  4. The use of information in the compilation of QNA;
  5. Contribution of mathematical and statistical methods to temporal disaggregation;
  6. Chain-linked volume estimates;
  7. Seasonal and calendar adjustment;
  8. The balancing of QNA;
  9. The validation of QNA;
  10. Revision policy and analysis.
- 1.12. Chapter 2 identifies the basic data requirements for compiling QNA, provides lists of data sources commonly used by Member States and specifies an ideal data set. There are a number of instances where it is common for the available data to not meet national accounts requirements, such as not having an institutional sector dimension. These issues are discussed and advice is given on ways to deal with them. Data collected to meet EU regulations that can be used in the compilation of QNA are described in Annex 2.A.
- 1.13. Chapter 3 provides guidance on how to maximize the quality of the basic data by developing a good understanding of the characteristics of the data and a good working relationship with data suppliers.
- 1.14. Chapter 4 outlines different approaches to using the available data to derive estimates of QNA variables according to how well they meet national accounts specifications, their quality and the philosophy of the national statistical institute (NSI) with respect to modeling. Special attention is given to the derivation of flash estimates.
- 1.15. Chapter 5 describes some of the mathematical and statistical methods available for compiling estimates of QNA variables such that they are consistent with the corresponding annual data. These methods are divided into three categories:
- a. methods when no suitable quarterly data are available;
  - b. methods that benchmark preliminary quarterly estimates of a QNA variable, or a quarterly indicator, to the corresponding annual benchmarks;
  - c. methods that impute values for a QNA variable by modelling the relationship between (annualized) preliminary quarterly estimates of a QNA variable, or a quarterly indicator, and the corresponding annual benchmarks.

- 1.16. There are three annexes to Chapter 5:
- Annex 5.A provides a mathematical description of the most commonly used methods;
  - Annex 5.B describes and demonstrates the two-step optimal (category c) method used by the French NSI;
  - Annex 5.C demonstrates and compares the performance of a number of optimal (category c) and simpler (including category b) methods.
- 1.17. One of the major changes from the previous edition of the handbook is the inclusion of a chapter that is primarily focused on the aggregation of components to form chain-linked (or chain) volume estimates. Chapter 6 demonstrates why chain-linked volume estimates are needed and discusses the pros and cons of the most commonly-used formulae around the world. The chapter describes efficient ways of deriving chain-linked volume estimates using the annually-weighted chain Laspeyres formula, which has been adopted by EU Member States, and also describes how the contributions of components to the growth of major aggregates may be calculated. Extensive use is made of numerical examples to clarify the exposition. General principles for deriving initial volume estimates are also discussed. Ways of deriving seasonally adjusted chain-linked volume estimates are described in Chapter 7.
- 1.18. The treatment of seasonal and calendar effects is a key consideration for QNA. Chapter 7 introduces the underlying theory and describes the models and methods most commonly used for undertaking seasonal and calendar adjustment. Various methodological issues are addressed, such as the derivation of seasonally adjusted chain-linked volume estimates, their benchmarking to annual data and the question of whether to seasonally adjust major aggregates directly or indirectly. The issues of publishing trend-cycle estimates in addition to seasonally adjusted estimates and the publication of metadata are also discussed.
- 1.19. Chapter 8 recommends that there should be a single definitive measure of GDP, that full balancing should be undertaken to ensure that no statistical discrepancies are left in the data, and that all variables should be eligible for adjustment. It also recommends that current price and volume estimates, unadjusted and seasonally adjusted data should be balanced simultaneously. While focusing on the use of supply and use tables to balance GDP, the chapter also considers alternative ways of balancing GDP and describes the process for balancing the accounts associated with GDP (the production account, goods and services account and generation of income account) with the income distribution, capital and financial accounts and the institutional sector dimension. The chapter also describes multivariate mathematical and statistical techniques that can be used to ensure quarterly estimates are both balanced and temporally consistent with their annual counterparts after the major imbalances have been resolved manually. There are three annexes to Chapter 8:
- Annex 8.A describes a framework for quarterly balancing using a numerical example;
  - Annex 8.B provides a mathematical description of multivariate methods for benchmarking and balancing QNA;
  - Annex 8.C describes the statistical/mathematical methods used to benchmark and balance the Dutch national accounts.
- 1.20. Chapter 9 addresses the validation of QNA. It describes three distinct dimensions: statistical, accounting and economic. *Statistical validation* consists of ensuring the source data are as accurate possible, assessing whether methodological assumptions continue to be valid, ensuring methods are consistently and appropriately applied, and, most importantly, ensuring there are no compilation errors. *Accounting validation* consists of ensuring that accounting rules are obeyed. *Economic validation* consists of bringing to bear knowledge of what has been happening in the economy and looking at the national accounts estimates in conjunction with non-national accounts



data through the eyes of a trained economist. Annex 9.A discusses three commonly-made comparisons of national accounts variables with closely related indicators.

- 1.21. Chapter 10 discusses the causes of revisions to QNA and classifies them as routine, major and non-scheduled, according to their causes and timing. It discusses the nature of the revision process and the importance of both a well-founded revision policy and the quantitative analysis of revisions from both a user and a producer perspective. However, it stops short of prescribing a particular revision policy or particular types of revision analysis, as these are the subject of ESS guidelines under development.

## **2. Sources and methods used to compile initial estimates of QNA variables**

This chapter identifies the basic data requirements for compiling QNA, provides lists of data sources commonly used by Member States and specifies an ideal data set. It also identifies relevant data collected to meet EU regulations.

There are many instances when the available data do not meet national accounts requirements. These issues are addressed and advice is given on how to deal with them.

## Introduction

- 2.1. This chapter of the handbook discusses the basic data requirements for compiling QNA and also addresses some particular problems faced in deriving estimates with the available data. Following the introduction, it discusses some general conceptual and definitional issues of particular importance in QNA by clarifying and elaborating on what appears in ESA 2010 and 2008 SNA and then considers:
- a. the data requirements for estimating GDP using the production, expenditure and income approaches, subsequently referred to as GDP(P), GDP(E) and GDP(I), respectively, (i.e. the production account, goods and services account and the generation of income account);
  - b. the data requirements of the remaining items in the primary and secondary distribution of income accounts, the use of disposable income account and the capital account;
  - c. the data requirements for compiling all of the above by institutional sector;
  - d. how to overcome situations where the available data do not meet ESA 2010 and 2008 SNA specifications;
  - e. which basic data are commonly used for estimating QNA;
  - f. an ideal data set for compiling QNA.

Data available from collections undertaken to satisfy EU regulations are addressed in Annex 2.A.

- 2.2. The compilation of QNA requires a lot of statistical information. This information is usually referred to as *basic statistics* or *basic data*. The basic statistics collected by countries vary considerably. This is due to many factors, such as the availability of suitable administrative data, the resources available to collect statistics, institutional and philosophical differences, geographical differences and the composition and size of the economy.
- 2.3. One of the principal objectives of having international national accounting standards is to promote comparability between countries. But because no country is able to adhere to these standards perfectly and derive estimates with perfect accuracy, it is also necessary to standardize the basic statistics and compilation methods used to the extent possible in order to maximize comparability. Accordingly, in general, the more harmonized the systems of basic statistics in different countries, the more comparable are the corresponding national accounts statistics. These arguments apply primarily to ANA because international comparisons are generally made using annual data, but they are also relevant for QNA, albeit to a lesser extent.
- 2.4. For most, if not all, countries, ANA are considered to be of higher quality than QNA for the following reasons:
- a. less information is available on a quarterly basis than on an annual basis, and so there is more reliance on partial indicators to derive QNA;
  - b. the quarterly basic statistics available from respondents are commonly less well founded than annual basic statistics;
  - c. sample sizes are commonly smaller in quarterly surveys;
  - d. it is common practice to balance ANA in supply and use tables, but it is much less common (although it is recommended in this handbook — see Chapter 8) to balance QNA.

It is therefore common practice to use annual data to improve the quality of the corresponding quarterly data by modelling and benchmarking. (This matter is discussed in Chapters 4 and 5).

Thus if the data sources and methods used to compile ANA are harmonized between countries, the benefits for comparability should be conveyed to the quarterly data, too.

- 2.5. The three approaches to estimating GDP are not undertaken entirely independently of one another and some basic data sources are commonly used to estimate related components of value added, expenditure and income. An example is gross value added of the general government sector, government final consumption expenditure and compensation of government employees. Any measurement issues that are common to related variables are discussed when the first variable is addressed and a brief explanation and cross-reference is given when the related variables are addressed later in the chapter.
- 2.6. Although it is recommended that all QNA variables should be estimated directly, there may be instances where quarterly source data are unavailable. Smoothing and time series methods for imputing quarterly values for periods when there are annual benchmarks available are described in Chapter 5. There may also be instances, particularly when flash estimates are being derived, when the usual source data are unavailable for the latest period. Extrapolation methods for imputing quarterly values are described in Chapter 4. It is recommended that such methods should be used only to derive preliminary estimates that are subsequently subject to possible amendment in the balancing process (see Chapter 8).
- 2.7. In some cases when quarterly data are unavailable, the methods referred to in the previous paragraph do not produce satisfactory results - even for preliminary estimates that are then subject to amendment in the balancing process. In such cases, it is common practice to derive estimates as residuals by product flow balancing for components of GDP(P) and GDP(E) (e.g. changes in inventories), or value added balancing for components of GDP(P) and GDP(I) (e.g. gross operating surplus/gross mixed income).
- 2.8. Production and expenditure variables are compiled in both current prices and volume terms, and, generally, one is derived from the other. Sometimes basic statistics refer to volumes and current price figures are derived by inflating them, but more often a current price figure is deflated with a price index to obtain a volume estimate. An important exception can be the estimation of output for the non-market sector (see below). With this exception, no distinction is made between the sources for current price and volume statistics.
- 2.9. Methods are discussed below as to how the various building blocks of GDP can be derived. Since a recommendation in this handbook is to balance the components of GDP from the three different GDP approaches (see chapter 8), thought should be given to how each estimated building block should look like to make subsequent balancing possible. The balancing of the production and expenditure approaches is achieved by balancing the supply and use of product categories. This implies that the initial estimates of final expenditures, intermediate consumption, output, exports and imports should have a common product classification — see the *Eurostat Manual of Supply, Use and Input-output Tables*. Thought should also be given to the way the various estimates are valued, i.e. basic prices or market prices, since the output of any particular industry will usually be presented at basic prices whereas final expenditure will usually be presented in purchasers' prices.
- 2.10. There are six principal institutional sectors prescribed in the ESA 2010 and the 2008 SNA and, ideally, NSIs should compile a full set of QNA for each of them:
  - Non-financial corporations (S11)
  - Financial corporations (S12)
  - General government (S13)
  - Households (S14)

- Non-profit institutions serving households (NPISHs) (S15)
- Rest of the world (S2)

For the general government sector, the ESA 2010 transmission programme also requires breakdowns into subsectors. However, separate QNA for the households and NPISH sectors are not required and these are combined. Accounts for the rest of the world can be derived from the available balance of payments and international investment position statistics.

- 2.11. It is common practice to balance the estimates for the whole economy and then ensure that the institutional sectoral estimates are consistent (see §8.82-8.87). In some cases sectoral decompositions of a QNA variable may be made using many different sources of data (e.g. gross value added and gross fixed capital formation). In other cases more wide-ranging data that have a sectoral dimension (e.g. an economy-wide survey in which the units are coded to both industry of activity and sector) may be used. In many cases the data relating to one institutional sector may be used to impute those for other (counterpart) sectors, e.g. tax data from government finance statistics (GFS) and banking and insurance data from a prudential regulation authority.
- 2.12. There are some other aspects of the presentation of the chapter that should be mentioned at this point:
- a. For each of the items covered, references are made to paragraphs in the ESA 2010 and the 2008 SNA for definitions and a discussion of the item.
  - b. The text gives an indication as to whether the issue being raised is one of concept or measurement. In many cases both aspects are relevant. In respect of the former, while the concepts and definitions of the national accounts are the same for annual and quarterly data, there may be certain aspects of QNA which require clarification and elaboration of what appears in the annually-oriented ESA and SNA manuals. On the second issue, reflecting data availability and recording practices, the measurement of certain variables on a quarterly basis poses different problems from what might arise for the corresponding annual data.

### Some general conceptual and definitional issues

- 2.13. There are three general conceptual and definitional issues in the national accounts that are of particular relevance for quarterly data:
- time of recording;
  - consistency in recording and work-in-progress;
  - the meaningfulness of the quarterly data.
- 2.14. All three issues are inter-related, and all are likely to impact on most, if not all, of the variables appearing in the accounts to some extent. While the issues also affect the annual estimates, they are generally of greater significance for the quarterly figures.

## Time of recording

### Issues

- 2.15. The time of recording for the national accounts is defined and analysed in the ESA 2010, in particular in [§1.101-1.105](#), and in the 2008 SNA in §3.159-3.189. Three main systems of recording transactions may be used for any flows accounting, and they can potentially lead to different results, especially when the period of recording is less than a year. The point in time at which a transaction (a purchase or sale of a good or service) takes place may not be the same point in time at which the corresponding payment occurs. For instance, manufacturing production for a quarter reflects the amount of goods produced over that period, irrespective of the timing and the payment system used when the manufacturing goods are sold domestically or abroad. The purchase of a good may also induce a liability to pay (a commitment) sometime after the change of ownership. Also, taxes may be recorded the day the tax becomes due for payment <sup>(1)</sup>.
- 2.16. ESA 2010 and the 2008 SNA distinguish the following three systems for recording flows:
- **cash accounting system:** transactions are recorded when “cash” (the payment) is received or paid;
  - **full accrual accounting system:** transactions are recorded when the underlying economic events occur, regardless of the timing of the related payments;
  - **due for payment:** transactions are recorded when a commitment, a liability to make a payment occurs (pension liabilities for instance in the public sector, or tax payment).
- 2.17. A general and well accepted principle in national accounting is that transactions between institutional units, or production within a unit, should be recorded when the economic activity takes place, i.e. the accrual accounting view, rather than when money movements are recorded (the cash perspective) or when payment is due. The ESA 2010 and the 2008 SNA recommend recording on an accrual basis throughout. Flows should be recorded when economic value is created, transformed or extinguished, or when claims and obligations arise, are transformed or are cancelled.
- 2.18. In practice, and this is certainly more the case and a preoccupation within QNA than within ANA, the implementation of this recommendation may be difficult. Any deviation from a pure accrual principle in the basic data may lead to discrepancies in the recording of production, consumption and income measures of GDP and between aggregates on the same side of GDP.
- 2.19. The quarterly basic data used in the compilation of expenditures, production and income aggregates come from various statistical sources, such as administrative records, government finance statistics, household surveys, manufacturing or other enterprise surveys, trade statistics, etc. The accounting systems used to measure and generate such data may vary considerably. Concerning for instance Balance of Payments (BoP) current account data, the UN Manual on *Statistics of International Trade in Services* <sup>(2)</sup> as well as the IMF’s *Balance of Payments and International Investment Position Manual* <sup>(3)</sup> both specify that, in principle, every operation should be recorded on an accrual basis. However, in practice it can never be assumed that firms do not report some transactions on a cash basis. For countries that compile their BoP current account data by using bank payment statistics, the cash principle will in most cases be applied. Another example that can be cited is the case of some income components that are often influenced or

(1) §3.163 of the 2008 SNA makes a further distinction between recording flows on a due-for-payment basis and on a commitment basis. This distinction is not addressed in this chapter.

(2) [http://unstats.un.org/unsd/tradeserv/TFSITS/MSITS/m86\\_english.pdf](http://unstats.un.org/unsd/tradeserv/TFSITS/MSITS/m86_english.pdf)

(3) <http://www.imf.org/external/pubs/ft/bopman/bopman.pdf>

derived from social transfer statistics. Even when recorded on a quarterly or monthly basis, the time when social transfer data are recorded is often affected by administrative and/or organizational decisions and does not always reflect the true economic phenomenon.

- 2.20. The ESA 2010 recognises that in some circumstances at a quarterly level alternative accounting methods may be necessary, such as a *cash-adjusted basis*, to minimize distortion in the characteristics of time series.

#### *What to do*

- 2.21. In general, national accountants should work with source data providers to minimize divergences from accrual accounting. For example, some major enterprises may report their economic activities for periods other than calendar months and quarters in business surveys. In such cases, the survey statisticians should negotiate with each major enterprise to try to obtain data on a calendar period basis. In the case of government finance data not being on an accrual basis, national accountants should work with the government finance statisticians to approximate accrual recording.
- 2.22. While the technical difficulties of performing adjustments at the level of statistical sources to reduce inaccuracies arising from different times of recording should not be underestimated, national accountants and their data suppliers should do their best to ensure that the basic data are at least approximately on an accrual accounting basis. To the extent that they fail to do so, some discrepancies between the recorded flows will remain.
- 2.23. To the extent that deficiencies in the time of recording follow a seasonal pattern, seasonal adjustment will smooth out timing differences. In addition, the use of supply and use tables in the balancing process can also help to overcome some of the timing discrepancies. However, use of these procedures should not lessen the extent to which adjustments should be made to unadjusted figures or to the basic data prior to balancing.

### **Consistency in recording and work-in-progress**

#### *Issues*

- 2.24. It is recommended in the previous sub-section that statisticians should do their best to ensure that the basic data are recorded on an accruals basis. In this sub-section two common occurrences of breaches in accrual accounting and the means of ensuring a consistent recording are considered:
- a. the production of goods or services over lengthy periods;
  - b. the need to ensure that consistent data for the same variable are included in the accounts of different institutional sectors and within or between components of the three GDP approaches.
- 2.25. Failure to record the production of goods and services not completed within an accounting period as work-in-progress can lead to serious inconsistencies in the accounts. If they are not recorded in inventories of work-in-progress, their production can be recorded in a later accounting period and be inconsistent with the compensation of employees earned from production. Furthermore, if they are not recorded in inventories of work-in-progress and then re-classified to inventories of finished products on completion, then there is the possibility of an understatement of production if a withdrawal of inventories of finished products is recorded when the products are sold.

- 2.26. For the second problem, particular examples might be estimates of tax payments in the accounts of corporations and of tax receipts in the government accounts.

*What to do*

- 2.27. Incomplete production at the end of an accounting period should be recorded in inventories of work-in-progress to ensure consistency in QNA. This has been common practice by NSIs in their quarterly business surveys in respect of goods, but services have largely been ignored. While most services are consumed as they are produced, there is growing evidence of services being produced over lengthy periods by producers in the business and financial services industries. Hence, quarterly business surveys need to be designed to capture incomplete service production as inventories of work-in-progress at the end of each quarter, just like goods.
- 2.28. The second issue, the problem of consistency in both timing and across sectors, is resolved by defining the payments or receipts figure for one party as being the same as the receipts or payments figure as recorded by the other party. Thus in the example mentioned above, accrued tax receipts may be measured in the government accounts and the taxes paid in the corporate accounts brought into line with this measure, or vice-versa depending on the data available. In either case, an accruals adjustment will be necessary in the financial accounts.

### **Meaningfulness of quarterly data**

*Issues*

- 2.29. The need to establish meaningful quarterly data is a vital part of the whole exercise of compiling QNA. A particular issue is how to determine the quarterly profile for GDP using data from production, expenditure and, possibly, incomes in a meaningful way.
- 2.30. The matter considered here concerns the meaningfulness of the quarterly data, particularly for those variables where transactions occur infrequently and irregularly during the year. Problems of this type largely reflect the absence of accruals recording and commonly arise from administrative and other arrangements for making payments. For example, interest payments may occur half-yearly or annually, payments of taxes on operating surplus may be concentrated in one or two quarters of the year, and recurrent taxes on land and buildings, which may be seen as an annual tax, may be paid irregularly during the year. When problems of this nature occur, the pattern exhibited by the figures, particularly on an unadjusted basis, may not be seen as meaningful or having much economic significance.

*What to do*

- 2.31. With the exception of dividend payments and compensation of employees, all series in both unadjusted and seasonally adjusted form should, as far as possible, appear on an accrual basis. Nevertheless, given the primacy of seasonally adjusted figures in QNA, the primary objective is to try to derive meaningful seasonally adjusted figures. For series with a measurement deficiency that has a regular seasonal pattern, the seasonal adjustment process should provide quarterly figures that are deemed to be sensible.
- 2.32. Several possible solutions may be considered when the measurement deficiency is non-seasonal. In some cases it may be possible to relate the variable of interest to an 'explanatory' variable. One example is to determine the quarterly profile of unadjusted data for taxes on operating surplus by using an appropriate tax rate applied to the corresponding series of the operating surplus. When



such a method is not possible, the quarterly unadjusted series may be imputed from the corresponding annual estimates by using a smoothing or time series method (see Chapter 5). Alternatively, the annual figure may be distributed equally over all four quarters, which may lead to a ‘step’ change between the fourth quarter of one year and the first quarter of the next. The choice of approach will depend on the nature of the variables being considered. In particular, while the step change should generally be avoided, it may be appropriate when structural or fiscal changes have occurred. Again, the need for adjustments to the financial accounts should not be overlooked.

### GDP(P): the production approach

- 2.33. To compile GDP using the production approach, estimates are needed of value added at basic prices for all the industries in an economy. The methods used to derive estimates for market and non-market sector-dominated industries differ and so it is best to deal with them separately.

#### *Market sector-dominated industries*

- 2.34. In general terms, two different approaches can be used to derive quarterly volume <sup>(4)</sup> and current price estimates of gross value added for market sector-dominated industries:
- a. Ideally, independent estimates of output and intermediate consumption should be derived and then differenced.
  - b. More commonly, quarterly estimates of intermediate consumption are unavailable and estimates of gross value added are derived using only estimates of output, or a surrogate for output.
- 2.35. When there is a lack of adequate data for intermediate consumption, initial estimates of quarterly gross value added by kind of activity for market sector activities can be made by assuming that output and intermediate consumption grow at the same rate in volume terms, either from the previous quarter or from the same quarter of the previous year. Such an assumption is best made at the most detailed industry level practicable (see also §8.58-8.62). One way of proceeding for each industry is as follows:
- a. Derive volume estimates of output by using volume indicators related to output, such as deflated sales or turnover data, or product quantities, to extrapolate output in the base period.
  - b. Obtain volume estimates of intermediate consumption by multiplying (a) with ratios of output to intermediate consumption obtained from a recent period.
  - c. Inflate the volume estimates of output and intermediate consumption with output and intermediate consumption price indices, respectively, to obtain current price estimates of output and intermediate consumption.
  - d. Difference the estimates of output and intermediate consumption to obtain current and volume estimates of value added. Note that the volume estimates need to be expressed in the prices of the previous year prior to differencing. The resulting estimates of gross value added in the prices of the previous year can then be linked to form chain-linked volume estimates — see Chapter 6.
- 2.36. The use of a fixed ratio between output and intermediate consumption is a way to make maximum use of the available information and is often valid because the structure of output and intermediate

<sup>(4)</sup> For a description of what is meant by the term ‘volume estimates’ refer to Chapter 6.

consumption does not change quickly over time in terms of volume. However, it should be noted that the assumption suffers weaknesses:

- a. Market producers continuously strive to improve the efficiency of their production process. These improvements may not amount to much for each individual quarter. However, if the quarters are used to provide a first estimate of the annual numbers, the quarterly efficiency gains may cumulatively lead to a downward bias compared to independent annual estimates compiled later.
  - b. Output and intermediate consumption consist of various goods and services. The magnitude and momentum of changes in the volume of each good or service produced or consumed depends on the supply and demand for final products and the nature of their production functions. The most important distinction with regard to the latter is the difference between variable costs and fixed costs. For example, when a goods' producing industry expands output quickly, goods used as inputs will have a volume growth closely corresponding to the volume growth of the goods produced. Since an increase in output will first lead to a better use of productive capacity, rents and various other business services are likely to show considerably lower growth. Not taking sufficient account of differences in the nature of the various input components will lead to the underestimation of value added in times of growth and overestimation in times of decline.
  - c. For some industries, particularly agriculture, the ratio of intermediate consumption to output can fluctuate greatly in the short-term. In such cases, this approach should be avoided.
- 2.37. The conceptually correct approach of deriving estimates of gross value added as the difference between output and intermediate consumption can also be problematic if the estimates of output and intermediate input are subject to substantial error, particularly if they are of similar magnitude and gross value added is relatively small. For this reason, this approach is best adopted in conjunction with the use of supply and use tables in order to ensure plausible and consistent estimates. In the case of agriculture, the advantages of this approach are often so great that it should be used even without supply and use tables.

### ***Non-market sector-dominated industries***

- 2.38. For non-market production there is no net operating surplus and so for non-market sector-dominated industries current price estimates of gross value added are usually derived using indicators of the costs of labour input - either wages data or quantity measures, such as hours worked, multiplied by a wage cost index. Some countries try to measure gross value added more precisely by adding estimates of consumption of fixed capital (CFC) to estimates of compensation of employees.
- 2.39. Volume estimates of value added are usually derived by one of three approaches:
- a. adopting the same approach as the one used for current price estimates, but with the components expressed in volume terms;
  - b. double deflation (a volume measure of output less a volume measure of intermediate consumption, both expressed in the prices of the previous year, and the result is then chain-linked), where output is measured using output indicators, such as the number of pupils to measure the output of schools, or the number of treatments by diagnostic related group (DRG) weighted by their average cost in the base year for the output of hospitals;
  - c. output volume indicators are used as indicators of growth in value added.

Note that the use of output indicators for non-market activities is usually confined to the production of individual services.

### **Output**

- 2.40. Output is defined and analysed in the ESA 2010, [§3.14-3.87](#), and in the 2008 SNA, §6.85-6.212. The problem areas of the quarterly estimates considered here are:
- work-in-progress;
  - agricultural production of crops;
  - other agricultural production;
  - storage;
  - the use of employment as an indicator of output.

### **Work-in-progress**

- 2.41. Work-in-progress is analysed in the ESA 2010, [§3.46-3.47](#) and in the 2008 SNA, §6.110-6.113.

### *Issues*

- 2.42. There are various kinds of activity where the recording of work-in-progress might be a problem. These are the growing of crops within agriculture and storage (which are considered as separate issues in §2.54-2.68 and §2.72-2.73, respectively) and, for certain industries, the construction of major capital items such as heavy machinery, ships and buildings, and also certain service activities such as the development of computer software or the making of a film. In these and other cases where production is not completed within a quarter, it would distort economic reality to record the output as if it were all produced at the moment when the process of production happens to terminate, and so work in progress should be recorded.
- 2.43. The problem, as discussed here, has two parts. The first is the general application of the principles of measurement to QNA, embracing, in particular, limitations of data availability and lower accuracy of the quarterly information. The second concerns possible inconsistencies between the figures going into the output and expenditure parts of the accounts.
- 2.44. In considering the consistency between estimates for output and expenditure, it is useful to distinguish three cases:
- a. a contract of sale, extending over several accounting periods, is agreed in advance and payments are made at the completion of each stage;
  - b. 'speculative' production (i.e. production of major items, such as buildings, without a contract for sale);
  - c. activity which is for own account.
- 2.45. The problem of consistency is only likely to arise in case (a) when the information used to make estimates on the output and expenditure sides of the account comes from two different sources. In other words, the purchaser's estimate of what should be recorded as gross fixed capital formation (GFCF) may be different from what the producer evaluates as constituting output. For cases (b) and (c), a recording problem will exist only if output and expenditure are estimated from different sources and not from the same own-account producer, although, as noted earlier, the issue is still relevant when comparing such data with other variables such as wages.

*What to do*

- 2.46. If the staged payments in case (a) are considered to approximately reflect the progress of production, then they can be used to measure both GFCF at purchasers' prices and output at basic prices after subtracting any margins or product taxes from the payments (and adding any subsidies on products). If the staged payments are not considered to be an adequate indicator of output, then it is necessary to measure output using the 'cost-allocation' methodology described below.
- 2.47. The ESA 2010 states that additions to work-in-progress should be valued at the current basic price of the finished product (see the ESA 2010, §3.46). Furthermore, if the value of output treated as work-in-progress is to be estimated in advance, the value is based on the actual costs incurred plus a mark-up (except for non-market producers) for the estimated net operating surplus or mixed income. The provisional estimates are subsequently replaced by those obtained by distributing the actual value (once known) of the finished products, over the period of work-in-progress (see the ESA 2010, §3.47).
- 2.48. Three features of this process may be noted. First, the imputation for the return to capital is usually made by way of a mark-up on the other costs incurred. Second, the imputation for the labour income of unincorporated enterprises can be based on estimates of earnings and hours worked. Third, the estimates made for each period of time need to be valued at the expected sale price at that point of time, thereby matching the values of inputs and outputs.
- 2.49. The proposed methodology can be described as follows. Assuming that the basic price of the finished product remains unchanged over the periods during which it is produced and that the basic price is known, the value of the addition to work-in-progress in a given period should be proportional to the cost of inputs used in the production process. Then in each period the value of output is proportional to the cost incurred <sup>(5)</sup>. Where the basic price is unknown, the estimate needs to take account of operating surplus/mixed income as well as costs. Thus for the example where basic costs are known:

$$O_t = \frac{I_t}{I_T} O_T$$

where

- $O_T$  represents the value of total output;
- $O_t$  represents the value of output in the period (quarter);
- $I_T$  represents the total cost of inputs;
- $I_t$  represents the cost of inputs in the period (quarter).

<sup>(5)</sup> When the production of an asset takes place over a number of years it is preferable to take account of the discount factor. For example, suppose the basic value of the asset  $O_T$  when completed is 200 and it is built at a constant rate over four years. The value of output in the first year will increase in value over the remaining three years as the waiting time until the asset can be used in production reduces. Given a discount rate of 5% per annum and assuming no inflation, output valued at 43.2 at the end of year 1 will have a value of 50 at the end of year 4, when the asset is completed (i.e.  $43.2 \times 1.053$ ). See the 2008 SNA, §20.63 for a further information.

- 2.50. In the period in which the production activity ends the following movements in the accounts take place:
- the output of the period (quarter) is  $O_t = O_T - \sum_{i=1}^{t-1} O_i$
  - a withdrawal of  $\sum_{i=1}^{t-1} O_i$  from work-in-progress takes place.
  - the inventories of finished goods are augmented by the value  $O_T$ .
- 2.51. Without undertaking some detailed analysis of how estimates are made for individual projects, it is difficult to determine how important inconsistencies arising from these recording practices might be. Some discussions with producers on existing practices might throw light on the magnitude of the problem, and it may be possible to ensure that for some assets at least the purchaser and producer use the same method of recording.
- 2.52. As with other possible distortions to the figures, if the inconsistencies in recording practices of producers and purchasers are generally uniform throughout the year, they will tend to cancel out in any particular quarter. Furthermore, if the inconsistencies are of a seasonal nature then they will be smoothed out by seasonal adjustment. Finally, confronting estimates of supply and use for different products in the balancing process will help to iron out inconsistencies of this kind, although any adjustments considered necessary should be made in advance of balancing.
- 2.53. The problems of estimating work-in-progress, described above, also affect the measurement of changes in inventories - see §2.135-2.161.

#### *Agricultural production of crops*

- 2.54. The measurement of the output of agriculture is defined and analysed in the ESA 2010, [§3.54](#), and in the 2008 SNA, §6.136-6.138.

#### *Issues*

- 2.55. The various problems of measuring output (and other variables) for agriculture on an annual basis are exacerbated for quarterly statistics. To consider the problems and how they might be solved, it is useful to sub-divide the estimation process into two parts. The first part relates to measurement of activity, such as the production of milk or eggs, where output is essentially produced and sold in the same quarter. The other, more problematic area, concerns those parts of the production process that extend over a number of quarters - crop production is an example. This section focuses on the problems that arise with measuring this latter activity; although mention is made later of some issues relevant to the estimation of the regular production.
- 2.56. Where the production processes cross the year-end, the annual estimates are also affected. Thus some broad principles of recording are already included in the ESA 2010. The ESA states that growing crops, standing timber and stocks of fish or animals reared for the purposes of food should be treated as inventories of work-in-progress during the process and transformed into inventories of finished products when the process is completed (see ESA 2010, §3.54). This section endeavours to expand on these principles to provide a possible practical approach to quarterly measurement.
- 2.57. Before looking at the problem of measuring long-term production, it is useful to set out briefly the principles involved. In doing so it is helpful to distinguish between two types of production which might span a number of quarters. One concerns 'one-off' production, such as annual crops, trees

for timber and livestock for consumption; the second relates to ‘continuing’ production, covering, for example, fruit trees, vines, breeding and dairy cattle that provide the basis for annual output. For the former, all unfinished output, such as a growing crop, is classified as work-in-progress. For continuing production, unfinished output, such as growing fruit trees that have not yet reached maturity, is classified to work-in-progress (becoming GFCF when completed), except where it is on own account. In this latter case it is classified to GFCF from the outset.

*What to do*

- 2.58. The explanation of how quarterly measurement might be undertaken is discussed in terms of crops, but the principles apply equally to other long-term production within agriculture. Current price estimation is addressed first.
- 2.59. The ESA 2010 and the 2008 SNA recommend that output of crops and similar production is considered in the same way as for other industries where production spans a number of quarters. This involves distributing the total value of the output of the crop over the whole period of production in proportion to the costs incurred in each quarter. The production process runs from the initial work of preparing the land right through to final sale, and so costs need to be estimated for each quarter during this period. In the initial quarters this reflects preparation of the land and sowing of the seed; in subsequent quarters the estimates relate to harvesting, storage, distribution and final sale. In line with the measurement principles outlined above, the quarterly amounts estimated (total value multiplied by proportion of costs) are recorded as final expenditures (GFCF or work-in-progress in changes in inventories) and as output.
- 2.60. Costs include material inputs, compensation of employees, a return to the labour and capital of unincorporated enterprises (gross mixed income) and a return to capital of incorporated enterprises (gross operating surplus). Thus the income earned from production should be recorded consistently with production. This ensures that the production of the crop, the final expenditures on production, and the income earned from production are all recorded consistently.
- 2.61. Some assumptions about the likely movement in wages and prices over the whole period are needed to make the estimates. These prices are also relevant for deriving volume estimates. In addition, the value of the crop to be spread over the quarters is initially unknown and so an estimate has to be made. When the actual value of sales is known, the quarterly estimates are revised. At that stage it is also sensible to look again at the cost estimates used for the quarterly allocation. Since estimates of work-in-progress are made directly, rather than from book value data, there are no adjustments for holding gains.
- 2.62. The method proposed in the 2008 SNA for allocating crop output over all the quarters pertaining to its production raises two major problems. The first, as has been stated above, results from the need to estimate a value for the crop before the harvest is sold. In practice, this is at least two quarters in advance of sale. With farm output varying markedly with the weather such estimation is far from easy. The second problem, the imputation of a value for activity (or income) at least two quarters before it actually takes place (or is received), is at variance with economic reality and is often difficult to explain to the general public and users.

- 2.63. There are several possible ways of getting round these two problems. One approach (to be called for convenience the ‘alternative’ approach) is considered in the handbook. The principle underlying this approach is that in those quarters where preparatory work is being undertaken for the harvest and the crop is reaped, output is taken to be equal to the input costs (materials and employment and self-employment incomes, and a return to capital). In the quarter(s) in which the crop is sold, output is taken as the difference between receipts in the quarter(s) and the costs incurred in the previous quarters.
- 2.64. A theoretical assessment of the two approaches is made below. First, it is useful to explain and compare them in a worked example. For both approaches, activity for a given ‘annual’ harvest is assumed to span the four quarters of the calendar year. In Q1 and Q2 the land is prepared and the crop is sown and tended; the harvest occurs in Q3, and the crop is stored and sold in Q4. Two harvest years are covered in order to better compare the two approaches. For convenience, only final values (200 and 300) for the two crops are assumed. The figures in the example are direct estimates of changes in inventories, rather than book values. The calculation used for both methods can be adapted to take account of certain departures from the simple assumptions of the example: that the production process extends over more than four quarters, in particular.

*Recommended approach*

- 2.65. Column (1) gives the figures for costs associated with the activity. This is assumed to be the same for both years. The value of sales (200 and 300) is spread over the four quarters of each year in proportion to costs, and is shown in column (2). In both years the crop is reaped in Q3 and sold in Q4. Hence in Q3 the inventory is reclassified from work-in-progress (-140 in year 1 and -210 in year 2) to finished goods (140 in year 1 and 210 in year 2). Output of storage and distribution services occurs in Q4 and is recorded in inventories of work-in-progress (60 in year 1 and 90 in year 2). At the time the sales in Q4 are recorded (200 in year 1 and 300 in year 2) - column (6) - the work-in-progress is re-classified as inventories of finished goods and the inventories of finished goods are run down (-200 in year 1 and -300 in year 2) – column (5).

Table 2.1: Recommended approach

| Quarters/years | Costs<br>(1) | Work-in-progress |      | Finished goods |      | Sales<br>(6) | Output<br>(7) |
|----------------|--------------|------------------|------|----------------|------|--------------|---------------|
|                |              | (2)              | (3)  | (4)            | (5)  |              |               |
| Year 1: Q1     | 10           | 20               |      |                |      |              | 20            |
| Q2             | 20           | 40               |      |                |      |              | 40            |
| Q3             | 40           | 80               | -140 | 140            |      |              | 80            |
| Q4             | 30           | 60               | -60  | 60             | -200 | 200          | 60            |
| Year 2: Q1     | 10           | 30               |      |                |      |              | 30            |
| Q2             | 20           | 60               |      |                |      |              | 60            |
| Q3             | 40           | 120              | -210 | 210            |      |              | 120           |
| Q4             | 30           | 90               | -90  | 90             | -300 | 300          | 90            |

*Alternative approach*

- 2.66. In the alternative approach, the figures of costs are the same as in the recommended approach. Then, as described in §2.61, output and change in inventories of work-in-progress over the first three quarters of the year are simply equal to the costs. In Q4 the work-in-progress of the previous three quarters is unwound and the receipts from the sale of the harvest are recorded under sales. There is no recording of finished goods.

Table 2.2: Alternative approach

| Quarters/years | Costs | Work-in-progress |     | Finished goods |     | Sales | Output |
|----------------|-------|------------------|-----|----------------|-----|-------|--------|
|                | (1)   | (2)              | (3) | (4)            | (5) | (6)   | (7)    |
| Year 1: Q1     | 10    | 10               |     |                |     |       | 10     |
| Q2             | 20    | 20               |     |                |     |       | 20     |
| Q3             | 40    | 40               |     |                |     |       | 40     |
| Q4             | 30    | 0                | -70 |                |     | 200   | 130    |
| Year 2: Q1     | 10    | 10               |     |                |     |       | 10     |
| Q2             | 20    | 20               |     |                |     |       | 20     |
| Q3             | 40    | 40               |     |                |     |       | 40     |
| Q4             | 30    | 0                | -70 |                |     | 300   | 230    |

2.67. For both approaches, the quarterly information to be recorded in the accounts is shown below for the production, expenditure and income measures. The entries relate to unadjusted data and need to be seasonally adjusted.

- *Production measure*

Output: columns (2)+(3)+(4)+(5)+(6)  
Intermediate consumption: cost of materials component of column (1)

- *Expenditure measure*

Inventories of the producer  
(work-in-progress): the sum of columns (2) and (3)  
(finished goods): the sum of columns (4) and (5)  
Inventories of the purchaser (raw materials): column (6), if sales are for intermediate consumption  
Household or government consumption or exports: column (6), if sales are to a final buyer

- *Income measure*

Compensation of employees and mixed income: “income” cost component of column (1)  
Operating surplus: column (7) - column (1)

2.68. There are a number of obvious points which emerge from a consideration of the two approaches. First, the alternative method clearly avoids two problems: the need to impute annual output and the economic reality of the estimates, which have been raised as difficulties with the recommended approach. Second, there are no problems with the alternative approach if price changes occur over the quarters and revisions to the estimates are likely to be less. However, the alternative approach would seem to be at variance with commercial accounting practices, which follow more closely the principles of the recommended approach.

2.69. Caution is needed in interpreting the figures in the tables, which are purely for illustrative purposes. In particular, the profile of output is arbitrary as is the relationship between the level of costs and receipts. Thus only broad conclusions may be drawn from the data. However, it is evident that the alternative approach could result in an unduly high peak (or dip) in output in Q4 as a result of an abnormally good (or bad) harvest. This would also be evident in the seasonally adjusted data unless further ‘smoothing’ adjustments were undertaken.



### *Regular agricultural production*

- 2.70. Mention was made earlier of the measurement of output of regular activities such as production of milk and eggs. A good deal of quarterly information on values, volumes and prices is normally available for the agriculture industry. Many current price estimates can usually be derived directly or readily estimated, and it is generally adequate to use estimates of output of these variables as indicators to extrapolate base year value added.
- 2.71. Estimation of value added for agriculture in volume terms is normally undertaken using double deflation (i.e. a volume measure of output less a volume measure of intermediate consumption).
- 2.72. There is a further issue for agriculture that needs to be considered. This relates to how to treat in the deflation process prices of seemingly identical products that are sold at different times of the year and which exhibit seasonal variation. One example of this is potatoes, where old and new varieties are produced and sold in different months of the year. As a general rule, and within the accuracy of the available data, deflation should be undertaken in as much detail as possible. Thus the aim should be to treat these seemingly identical items as different products, and to derive volume estimates for them separately. Where volume estimates are obtained by valuing current year quantities at base year prices <sup>(6)</sup>, the valuation should be undertaken for short time periods, say on a monthly basis. Thus for each month of the current year, quantity is valued at the basic prices in that same month in the base year. A volume index for the current quarter is then obtained by summing these monthly data over the quarter and relating the sum to the (quarterly) average of a similarly estimated base year figure. A broadly similar approach is followed where deflated values are used. Thus for each month of the current year, the value is deflated by the price index for that particular month. The monthly volume estimates are then summed, as above. The treatment of agriculture production also has implications for the recording of information on changes in inventories in the expenditure account and for components of the distribution of income account.

### *Storage*

- 2.73. Storage is defined and analysed in ESA 2010 [§3.58-3.59](#) and in 2008 SNA §6.142-6.145. The Annex to Chapter 6 of the 2008 SNA describes how the output of storage should be recorded in theory, suggests practical methods for measuring output and provides examples to illustrate how these methods may be used. In particular, it discusses how to differentiate between output due to storage and holding gains and losses.
- 2.74. In most cases, changes in the value of products held in storage are recorded as nominal holding gains/losses. However, the ESA 2010 and the 2008 SNA identify three cases where changes in price can reflect in part the output of storage services:
- The quality of the good may improve with the passage of time, e.g. in the case of wine; only cases where maturing is part of the regular production process should be regarded as production.
  - Seasonal factors affecting the supply or demand for a specific good that lead to regular, predictable variations in price over the year, even though its physical qualities may not have changed.
  - The production process is sufficiently long that discounting factors should be applied to work put in place significantly long before delivery.

<sup>(6)</sup> To form volume estimates of national accounts aggregates, volumes estimate are valued at previous year prices at the elemental level. They are then aggregated and linked together to form annually- linked chain Laspeyres indices — see Chapter 6.

*Employment-type indicators**Issues*

2.75. Employment, or an associated variable, is commonly used as an indicator when deriving a volume measure of output for non-market production, particularly for general government, but is also sometimes used for market production in the absence of output data. Three problems potentially arise when employment is used as an indicator for measuring output:

- changes occur in the average hours worked;
- changes occur in the skills of the persons employed;
- changes occur in labour productivity.

Changes in the average hours worked

- 2.76. A number of factors can contribute to changes in the average hours worked in a quarter:
- a. seasonal and calendar-related effects can have both positive and negative effects on output: negative when employees are on holiday and positive when seasonal peaks occur in their workload;
  - b. changes in the average hours worked due to changes in part-time/full-time shares in the work force, changes in standard hours and changes in overtime.
- 2.77. All of the deficiencies associated with changes in average hours worked can be avoided if ‘hours actually worked’ rather than employment is used as the volume indicator of output.

Changes in the skills of the persons employed

- 2.78. Changes in the average skill level of the persons employed usually evolve quite slowly over time and they are only a serious concern if hours worked is used to derive the annual estimates as well as being a quarterly indicator. In other words, if the annual volume estimates of output are derived using true volume measures of output and hours worked is only used to distribute and extrapolate these annual benchmarks, then changes in the average skill level is unlikely to have a significantly deleterious effect on the quarterly estimates.
- 2.79. In the case of the volume of output of general government, particularly collective output, no satisfactory true indicator of annual output may be available and there may be no better alternative than to use measures of input. In such instances, changes in annual labour input can be measured by constructing volume indices that take account of changes in the skill level. These volume indices can be constructed either by weighting the numbers of employees in each occupation category, or pay point, by their average remuneration in the base period, or by deflating compensation of employees by a suitable wage cost index. Whichever way the volume index is derived, there is an underlying assumption that the relative skills of employees are directly proportional to their remuneration. If there is evidence that this assumption is invalid, then the weights should be adjusted accordingly.

Changes in labour productivity

- 2.80. Labour productivity is derived as the ratio of output, or value added, to a measure of labour input, preferably hours worked or hours worked adjusted for changes in skill level, and it is usually expressed as an index. Changes in the index reflect all the changes in output not attributable to changes in labour input. In the long run, changes in labour productivity largely reflect changes in

the amount of capital (e.g. equipment and buildings) available per unit of labour input (e.g. hour worked), which is called the capital/labour ratio, and multifactor productivity, which is defined to be the growth in output that cannot be explained by growth in the inputs. In the short term, changes in labour productivity can occur quite rapidly according to the business cycle as the rates of the utilisation of capital and labour vary (see Chapter 9).

- 2.81. The comments made above regarding changes in the skill levels of the persons employed apply to long-term changes in labour productivity. Thus if quarterly measures of labour input are only used to distribute and extrapolate annual estimates derived using true output indicators, then long-term changes in labour productivity are not of concern. However, if labour input measures are also used to derive the preliminary annual estimates (they are not recommended for deriving final annual estimates), then an adjustment should be made for both changes in the level of labour skills and long-term changes in labour productivity, either to just the annual data or to both the annual and quarterly data <sup>(7)</sup>.
- 2.82. Short-term changes in labour productivity due to the vagaries of the business cycle are unlikely to apply to non-market production and are usually only a concern when measuring market production.
- 2.83. Volume measures of general government output for individual consumption may also be measured by using output indicators, such as the number of students or student-hours stratified by primary, secondary and tertiary institutions weighted by average cost in base year for education services, or the number of treatments per diagnostic related group weighted by average cost in base year for hospitals. But such methods are usually only applied to derive annual estimates.

### *Intermediate consumption*

- 2.84. Intermediate consumption is defined and analysed in ESA 2010, [§3.88-3.92](#), and in 2008 SNA, §6.213-6.232.

#### *Issues*

- 2.85. The measurement of intermediate consumption requires that products should be recorded and valued at the time they enter the process of production. In practice, producers do not usually record the actual use of goods in production directly. They record the value of purchases of materials and supplies intended to be used as inputs and the stocks of such goods held in inventory at the beginning and end of each accounting period. Intermediate consumption has therefore to be estimated as a residual item, by subtracting from the value of purchases made the national accountant's estimate of the change in inventories of materials and supplies (see ESA 2010, §3.92; 2008 SNA, §6.216). The estimation of changes in inventories from opening and closing book values is discussed in §2.136-2.162.
- 2.86. In concept, quarterly estimates of intermediate consumption are required to derive:
- a. quarterly estimates of final consumption expenditures by non-market producers, which are derived (at least in current prices) by summing costs;
  - b. quarterly estimates of gross valued added by industry.

<sup>(7)</sup> See the OECD manual Measuring Capital, 2008 for advice on how to measure capital services, including those provided by the fixed assets owned by general government. See the OECD manual Measuring Productivity, 2001 for advice on how to combine an index of capital services with an index of labour input. See Chapter 20 of the 2008 SNA for a general discussion of capital services, capital stock, consumption of fixed capital and how they relate to each other.

- 2.87. Information on purchases is collected on an annual basis, preferably with a product breakdown. In any case, a product breakdown of intermediate consumption is available in annual supply and use tables. Quarterly information on purchases may be available for general government, but it is less common for information to be collected quarterly for other producers, and very rare for such data to have a product breakdown.
- 2.88. In §2.37 it is argued that, due to a lack of adequate quarterly output and intermediate consumption data, value added for most industries should not be estimated by subtracting intermediate consumption from output except within supply and use tables. How to make initial estimates of intermediate consumption for use in supply and use tables is discussed in §2.35-2.36 and §8.58-8.62.

### ***Taxes less subsidies on products***

- 2.89. The major issue with taxes less subsidies on products is obtaining estimates on an accruals basis. This is discussed in the broader context of estimating taxes *less* subsidies on production and imports with respect to estimating GDP(I).

### ***Deriving production account estimates for institutional sectors***

#### *Issues*

- 2.90. The derivation of quarterly estimates of the components of the production account (i.e. output, intermediate consumption and value added) for general government can be readily derived using government finance statistics. As for general government, NPISHs are primarily, if not exclusively, engaged in non-market production and so their output is equal to the sum of costs and their net operating surplus is zero. The estimation of NPISH production is included in the discussion of the estimation of their final consumption expenditure (see §2.107-2.108). Estimating the production of dwelling services by households is relatively straightforward, but it is much more difficult to distinguish between the productive activities of businesses in the financial and non-financial corporations and households sectors.

#### *What to do*

- 2.91. A business register is required in which producer units (preferably KAUs) are classified to industry of activity and, either directly or indirectly, to the institutional sector to which the parent (i.e. the institutional unit) of the producer unit belongs. This enables business survey data to be classified both by industry of activity and by institutional sector. To obtain sectoral estimates of satisfactory accuracy may require a complex survey design with a large sample. For example, a relatively large sample of small businesses may be needed because they can be either incorporated or unincorporated. In addition, administrative sources from government and information from prudential regulation authorities may often offer very useful information for the compilation of the production accounts for general government and financial corporations.
- 2.92. Given the difficulties of deriving quarterly estimates for financial and non-financial corporations and unincorporated enterprises (households sector), it may be necessary to employ temporal disaggregation methods (see Chapter 5) in which quarterly estimates for the total economy are used to distribute and extrapolate the annual estimates for each sector.

**Basic data commonly used to derive estimates of GDP(P)**

2.93. Table 2.3 lists data commonly used by Member States to derive estimates of gross value added by activity. With the exception of agriculture, they relate to the measurement of output.

Table 2.3: Production Approach – Sources/Indicators

| NACE A21 – industry branches | Components   | Sources/Indicators   |
|------------------------------|--|--|
| Agriculture and forestry     | <ul style="list-style-type: none"> <li>• Output               <ul style="list-style-type: none"> <li>– Wheat and barley</li> <li>– Other grains</li> <li>– Livestock slaughtering</li> <li>– Whole milk and eggs</li> <li>– Wool production</li> <li>– Animal production (GFCF)</li> <li>– Other crops</li> <li>– Fruits and vegetables</li> <li>– Other horticultural products</li> </ul> </li> <li>– Forestry</li> <li>• Intermediate consumption</li> </ul> | <ul style="list-style-type: none"> <li>• Indicators:               <ul style="list-style-type: none"> <li>– Marketing boards</li> <li>– Harvesting data</li> <li>– Quantity of meat produced and prices obtained from abattoirs</li> <li>– Numbers of animals slaughtered</li> <li>– Data on deliveries</li> <li>– Quantity data</li> <li>– Stock numbers from agricultural censuses</li> <li>– Allocation of annual estimates</li> <li>– Quantities and values delivered at auctions</li> <li>– Annual turnover from trade associations (allocated to the quarters)</li> <li>– State forestry sales</li> <li>– Labour force in forestry</li> <li>– Quantity of timber felled</li> <li>– Official government estimates</li> </ul> </li> <li>• Administrative data</li> <li>• Statistics on quantities</li> <li>• Indicators:               <ul style="list-style-type: none"> <li>– Costs of marketing, fodder, fuels.</li> <li>– Fodder and consumption of fertilizers</li> </ul> </li> </ul> |
| Fishing                      |  | <ul style="list-style-type: none"> <li>• Value and size of catches</li> <li>• Sales revenue and quantities</li> <li>• Amount of fish slaughtered on fish farms</li> </ul>  |

| NACE A21 – industry branches   | Components  | Sources/Indicators   |
|--|---|--|
| Mining and quarrying   |   | <ul style="list-style-type: none"> <li>• Index of industrial production</li> <li>• Quantity data</li> <li>• Expenditures on mineral exploration</li> <li>• Metres drilled</li> </ul>   |
| Manufacturing  |   | <ul style="list-style-type: none"> <li>• Index of industrial production</li> <li>• Turnover from VAT statistics or business surveys</li> <li>• Censuses</li> <li>• Production information</li> </ul>   |
| Electricity, gas, steam and air conditioning supply                  |   | <ul style="list-style-type: none"> <li>• Quantity data</li> <li>• Sales</li> <li>• Index of industrial production</li> <li>• Consumption of inputs</li> </ul>  |
| Water supply; sewerage, waste management and remediation activities  |   | <ul style="list-style-type: none"> <li>• Quantity data</li> <li>• Revenue</li> <li>• Index of industrial production</li> <li>• Turnover from VAT statistics or business surveys</li> <li>• Consumption of inputs</li> </ul>  |
| Construction   | <ul style="list-style-type: none"> <li>• Private sector <ul style="list-style-type: none"> <li>– Residential construction</li> <li>– Non- residential construction</li> </ul> </li> <li>• Public sector construction</li> </ul> | <ul style="list-style-type: none"> <li>• Turnover of general trade contractors in general building construction and engineering</li> <li>• Employment figures</li> <li>• Volume index</li> <li>• Gross fixed capital formation</li> <li>• Indicators: <ul style="list-style-type: none"> <li>– Estimates of work put in place by type of dwelling</li> <li>– Estimates of work put in place by type of structure</li> <li>– Building and engineering construction surveys</li> <li>– Estimates of work done</li> <li>– Employment indicators</li> <li>– Budget data</li> </ul> </li> </ul> |
| Wholesale and retail trade; repair of motor vehicles and motorcycles |   | <ul style="list-style-type: none"> <li>• Sales or turnover from VAT statistics or business surveys</li> <li>• Sales by public market authorities</li> <li>• Output volume indicators</li> <li>• Volume trade index</li> <li>• Sum of calculated trade margins</li> </ul>   |

| NACE A21 – industry branches              | Components   | Sources/Indicators  |
|---|--|---|
| Transport and storage                     | <ul style="list-style-type: none"> <li>• Transport               <ul style="list-style-type: none"> <li>– Air transport, rail freight, pipeline system, water transport, ferry operations,...</li> <li>– Transit operation</li> <li>– Road haulage</li> </ul> </li> <li>– Taxicab services</li> <li>• Postal and courier services</li> </ul> | <ul style="list-style-type: none"> <li>• Turnover from VAT statistics or business surveys</li> <li>• Index of industrial production</li> <li>• Indicators:               <ul style="list-style-type: none"> <li>– Passenger numbers</li> <li>– Weight/volume- kilometers</li> <li>– Revenues</li> <li>– Volume measures of output of industries relying on road haulage</li> <li>– Number of workers</li> </ul> </li> <li>• Indicators:               <ul style="list-style-type: none"> <li>– Data for letters and parcels</li> <li>– Gross revenue of the postal service</li> </ul> </li> </ul> |
| Accommodation and food service activities |  | <ul style="list-style-type: none"> <li>• Turnover from VAT statistics or business surveys</li> <li>• Indicators:               <ul style="list-style-type: none"> <li>– Balance of payments data</li> <li>– Statistics on nights spent by non-residents</li> <li>– Estimation according to total domestic consumption</li> <li>– Sales in restaurants</li> <li>– Nights spent in hotels</li> </ul> </li> </ul>  |
| Information and communication             | <ul style="list-style-type: none"> <li>• Publishing</li> <li>• Motion picture, video and television programme production, sound recording and music publishing activities</li> <li>• Programming and broadcasting activities</li> <li>• Telecommunications</li> <li>• Computer programming, consultancy and related activities</li> </ul>    | <ul style="list-style-type: none"> <li>• Index of industrial production</li> <li>• Indicators:               <ul style="list-style-type: none"> <li>– Employment indicators</li> <li>– Audience viewing hours</li> <li>– Sample surveys of radio advertising sales</li> <li>– Number of subscribers to cable services</li> </ul> </li> <li>• Turnover from VAT statistics or business surveys</li> </ul>  |

| NACE A21 – industry branches                                  | Components  | Sources/Indicators  |
|---|---|---|
| Financial and insurance services                              | <ul style="list-style-type: none"> <li>• FISIM</li> <li>• Other financial services</li> <li>• Insurance services</li> </ul>   | <ul style="list-style-type: none"> <li>• Stocks of financial assets and liabilities and interest payment flows of financial intermediaries from prudential regulation authorities or central banks</li> <li>• Indicators: <ul style="list-style-type: none"> <li>– Revenue</li> <li>– Stock market volume traded</li> <li>– Issues of stocks and bonds</li> <li>– Mutual fund sales</li> <li>– Hours worked or employment</li> <li>– Volume indices (e.g. number of cheque account transactions)</li> </ul> </li> <li>• Premiums paid obtained from prudential regulation authorities or directly from insurance companies</li> </ul> |
| Real estate activities  | <ul style="list-style-type: none"> <li>• Real estate activities with own or leased property</li> <li>• Real estate activities on a fee or contract basis</li> </ul> | <ul style="list-style-type: none"> <li>• Estimates of end period housing stock</li> <li>• Average rent per m<sup>2</sup></li> <li>• Final consumption expenditure of households on dwelling rent</li> <li>• Turnover from VAT statistics or business surveys</li> <li>• Information from property valuations</li> </ul>   |
| Professional, scientific and technical activities             | <ul style="list-style-type: none"> <li>• Market sector</li> <li>• Non-market sector</li> </ul>  | <ul style="list-style-type: none"> <li>• Turnover from VAT statistics or business surveys</li> <li>• Indicators: <ul style="list-style-type: none"> <li>– Employment</li> </ul> </li> </ul>   |
| Administrative and support services                           |   | <ul style="list-style-type: none"> <li>• Turnover from VAT statistics or business surveys</li> <li>• Indicators: <ul style="list-style-type: none"> <li>– Employment</li> </ul> </li> </ul>   |
| Public administration and defence; compulsory social security | <ul style="list-style-type: none"> <li>• Current price estimates</li> <li>• Volume estimates</li> </ul>   | <ul style="list-style-type: none"> <li>• Compensation of employees plus CFC</li> <li>• Employment multiplied by wage cost index</li> <li>• Deflated wages and salaries or compensation of employees</li> <li>• Employment or hours worked</li> </ul>  |



| NACE A21 – industry branches  | Method  | Sources/Indicators   |
|---|---|--|
| Education   | <ul style="list-style-type: none"> <li>• Current price estimates</li> <li>• Volume estimates</li> </ul>   | <ul style="list-style-type: none"> <li>• Compensation of employees plus CFC</li> <li>• Employment multiplied by wage cost index</li> <li>• Deflated wages and salaries or compensation of employees plus CFC</li> <li>• Employment or hours worked</li> <li>• Number of students or student-hours stratified by primary, secondary and tertiary institutions weighted by average cost in base year</li> </ul>  |
| Human health and social work activities   | <ul style="list-style-type: none"> <li>• Current price estimates</li> <li>• Volume estimates               <ul style="list-style-type: none"> <li>– Hospitals</li> <li>– General practitioners</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>• Compensation of employees plus CFC</li> <li>• Employment multiplied by wage cost index</li> <li>• Deflated wages and salaries or compensation of employees plus CFC</li> <li>• Employment or hours worked               <ul style="list-style-type: none"> <li>– Number of treatments per diagnostic related group weighted by average cost in base year</li> <li>– Number of treatments weighted by average cost in base year</li> </ul> </li> </ul> |
| Arts, entertainment and recreation  | <ul style="list-style-type: none"> <li>• Market sector               <ul style="list-style-type: none"> <li>– Gambling and betting activities</li> </ul> </li> <li>• Non-market sector</li> </ul>                     | <ul style="list-style-type: none"> <li>• Turnover from VAT statistics or business surveys               <ul style="list-style-type: none"> <li>– Gambling revenue from tax authorities</li> </ul> </li> <li>• Labour income</li> <li>• Employment or hours worked</li> </ul>   |
| Other service activities  |   | <ul style="list-style-type: none"> <li>• Business surveys</li> <li>• Labour income</li> <li>• Employment or hours worked</li> </ul>  |
| Activities of households as employers; undifferentiated goods-and services-producing activities of households for own use | <ul style="list-style-type: none"> <li>• Activities of households as employers of domestic personnel</li> <li>• Undifferentiated goods-and services-producing activities of private households for own use</li> </ul> | <ul style="list-style-type: none"> <li>• Labour force survey</li> <li>• Domestic service and other household services CPI</li> </ul>   |

## GDP(E): the expenditure approach

2.94. The components of final expenditures on GDP are estimated by using various sources according to the available data and the choices made by countries. The following section describes the data sources commonly used for each of the major components.

### *Final consumption expenditure of households*

2.95. Household final consumption expenditure is defined and analyzed in ESA 2010 [§3.95-3.96](#) and in 2008 SNA §9.56-9.80. There are no particular problems concerning the final consumption of households. Table 2.4 lists data commonly used by Member States.

2.96. The main sources used in compiling estimates of the final expenditure of households are sales or turnover statistics. Sales of goods through retail outlets are usually structured by “type of outlet” and must be converted to outlays on products through the use of a transformation matrix. In order to do this with the necessary detail, regular censuses or surveys of retail businesses must be carried out to collect product data by type of outlet.

2.97. There is an increasing tendency for households to purchase goods using the internet from:

- a. traditional domestic retailers (e.g. shops);
- b. domestic retailers that only sell goods via the internet;
- c. retailers in other countries.

2.98. This means that statisticians need to ensure that retail sales by both (a) and (b) are included in retail surveys. Sales by (c) to residents and sales by (a) and (b) to non-residents should be included in the balance of payments and used to adjust the reported retail sales to obtain estimates of household final consumption expenditure.

2.99. With increasing affluence, households tend to spend a smaller proportion of their disposable income on goods and an increasing proportion on services. Consequently, the importance of services data is increasing. As can be seen from Table 2.3, many industry-specific indicators are used to measure growth in the production of services. Turnover data from business surveys and VAT statistics are used for many industries.

2.100. The major issue in using service industry indicators for estimating household final consumption expenditure is discriminating between the final expenditures of households and NPISHs on the one hand and the intermediate consumption and gross fixed capital formation of government and enterprises (including unincorporated enterprises) on the other hand. The common practice is to use ratios from the annual supply and use tables to make these allocations from the quarterly data.

2.101. Another important source of data for the final consumption expenditure of households is the household budget survey (HBS). In these surveys, household respondents are asked to report their expenditures over a specified period of time. One of the principal uses of these surveys is to derive weights for the periodic rebasing of the CPI. Accordingly, some countries only conduct a HBS every five years or so. Other countries conduct HBSs much more frequently, and some have a continuous rolling survey. Obviously, HBSs conducted every five years are only of direct use as benchmarks for deriving annual estimates, but if they are conducted quarterly, then they may be used directly in compiling QNA.

2.102. HBSs have advantages and disadvantages with respect to the alternative sources of retail sales and service industry indicators. Their major advantages are that they:

- a. directly measure the expenditures of households. (Ideally, questionnaires should be carefully worded so that expenditures of unincorporated enterprises, such as major expenditures on the maintenance of owner-occupied dwellings, the costs of running a business from home, and the purchase of tools and motor vehicles for business purposes are either not recorded or can be easily excluded when deriving estimates of household consumption expenditure);
- b. they are not subject to the inadequacies of the business register.

2.103. Their major disadvantages are:

- a. the sample sizes are usually modest, particularly if they are conducted quarterly, and so the sampling errors of expenditures on costly, but infrequently purchased, items (motor vehicles, caravans, boats, aeroplanes, etc.) can be quite large;
- b. households may omit to record some expenditures for various reasons, such as:
  - they forget to record all their expenditures, or the respondent is unaware of all the expenditures made by other members of the household;
  - they are unaware of certain type of expenditures such as insurance costs and FISIM charged by banks;
  - they understate expenditures on products that society has a negative view of, such as gambling losses, tobacco, alcohol, prostitution and illegal drugs;
  - the respondent has been understating their income to the tax office and is concerned that the statistics office will pass their data to the tax authorities.

2.104. It is commonly found that estimates of household final consumption expenditure based on HBSs are much lower in total than those derived using other sources. Nevertheless, HBS data can be useful for estimating expenditures on some components and in particular for decomposing aggregates to producer finer level estimates. In any case, a good practice is to combine and cross-check data from the different sources, taking account of the strengths and weaknesses of each.

2.105. In some countries for certain specific products (i.e. food and beverages, alcohol, tobacco and, sometimes, fuel and power) the product (commodity) flow method is employed to derive the use of particular goods and services from their known supply.

2.106. If the expenditures can be considered stable over the short-term, then smoothing or time series methods can be used to distribute and extrapolate annual estimates (for example, rents) – see Chapter 5. This method is also useful for minor expenditures for which no other method is readily available (for example personal care expenditures).

Table 2.4: Household Consumption Expenditure – Sources/Indicators

| COICOP* one digit  | COICOP* two digits  | Sources/Indicators  |
|--|---|---|
| Food and non-alcoholic beverages                                   | <ul style="list-style-type: none"> <li>• Food</li> <li>• Non-alcoholic beverages</li> </ul>   | <ul style="list-style-type: none"> <li>• Sales or turnover statistics</li> <li>• Household surveys</li> </ul>   |
| Alcoholic beverages, tobacco and narcotics                         | <ul style="list-style-type: none"> <li>• Alcoholic beverages</li> <li>• Tobacco</li> <li>• Narcotics</li> </ul>   | <ul style="list-style-type: none"> <li>• Sales or turnover statistics</li> <li>• Product flow method</li> <li>• Excise data</li> </ul>  |
| Clothing and footwear  | <ul style="list-style-type: none"> <li>• Clothing</li> <li>• Footwear</li> </ul>  | <ul style="list-style-type: none"> <li>• Sales or turnover statistics</li> <li>• Product flow method</li> </ul>   |
| Housing, water, electricity, gas and other fuels                   | <ul style="list-style-type: none"> <li>• Actual rentals for housing</li> <li>• Imputed rentals for housing</li> <li>• Maintenance and repair of the dwelling</li> <li>• Water supply and miscellaneous services relating to the dwelling</li> <li>• Electricity, gas and other fuels</li> </ul>   | <ul style="list-style-type: none"> <li>• CPI (rentals)</li> <li>• Housing stock (rentals)</li> <li>• Household surveys</li> <li>• Sales or turnover statistics</li> <li>• Weather data, volumes of gas, electricity etc. generated</li> <li>• Revenue statistics from utilities</li> </ul>  |
| Furnishings, household equipment and routine household maintenance | <ul style="list-style-type: none"> <li>• Furniture and furnishings, carpets and other floor coverings</li> <li>• Household textiles</li> <li>• Household appliances</li> <li>• Glassware, tableware and household utensils</li> <li>• Tools and equipment for house and garden</li> <li>• Goods and services for routine household maintenance</li> </ul> | <ul style="list-style-type: none"> <li>• Sales or turnover statistics</li> <li>• Employment/earnings in the activity concerned</li> <li>• Product flow method</li> </ul>  |
| Health   | <ul style="list-style-type: none"> <li>• Medical products, appliances and equipment</li> <li>• Outpatient services</li> <li>• Hospital services</li> </ul>  | <ul style="list-style-type: none"> <li>• Employment/earnings in the activity concerned</li> <li>• Beds occupied by private patients in hospitals</li> <li>• Assume same growth as Health GVA</li> <li>• Medical and hospital insurance claims</li> </ul>  |
| Transport  | <ul style="list-style-type: none"> <li>• Purchase of vehicles</li> <li>• Operation of personal transport equipment</li> <li>• Transport services</li> </ul>   | <ul style="list-style-type: none"> <li>• Sales or revenue statistics</li> <li>• Household surveys</li> <li>• Passengers, passengers/km</li> <li>• Freight km</li> <li>• Traffic indicators</li> <li>• Stock of vehicles (personal transport)</li> <li>• New motor vehicle registrations</li> <li>• Fuel consumption (litres)</li> </ul> |

| COICOP* one digit                                   | COICOP* two digits   | Sources/Indicators   |
|---|--|--|
| Communication                                       | <ul style="list-style-type: none"> <li>Postal Services</li> <li>Telephone and telefax equipment</li> <li>Telephone and telefax services</li> </ul>   | <ul style="list-style-type: none"> <li>Sales or revenue statistics (household sector)</li> <li>Minutes spoken (household sector)</li> </ul>  |
| Recreation and culture                              | <ul style="list-style-type: none"> <li>Audio-visual, photographic and information processing equipment</li> <li>Other major durables for recreation and culture</li> <li>Other recreational items and equipment, gardens and pets</li> <li>Recreational and cultural services</li> <li>Newspapers, books and stationery</li> <li>Package holidays</li> </ul> | <ul style="list-style-type: none"> <li>Sales or turnover statistics</li> <li>Cinema: number of viewers</li> <li>Books: number of copies edited</li> <li>Household surveys on tourist services</li> <li>Radio and TV licences</li> </ul>  |
| Education   | <ul style="list-style-type: none"> <li>Pre-primary and primary education</li> <li>Secondary education</li> <li>Post-secondary non-tertiary education</li> <li>Tertiary education</li> <li>Education not definable by level</li> </ul>  | <ul style="list-style-type: none"> <li>Private education: employment/earnings in the activity concerned</li> </ul>   |
| Restaurants and hotels                              | <ul style="list-style-type: none"> <li>Catering services</li> <li>Accommodation services</li> </ul>  | <ul style="list-style-type: none"> <li>Sales or turnover statistics</li> <li>Number of overnight stays in hotels (hotel occupancy survey)</li> </ul>   |
| Miscellaneous goods and services                    | <ul style="list-style-type: none"> <li>Personal care</li> <li>Prostitution</li> <li>Personal effects n.e.c.</li> <li>Social protection</li> <li>Insurance</li> <li>Financial services n.e.c.</li> <li>Other services n.e.c.</li> </ul>   | <ul style="list-style-type: none"> <li>Sales or turnover statistics</li> <li>Employment/earnings in the activity concerned</li> <li>Population growth (personal services)</li> <li>Funeral services (death rate)</li> <li>Stock exchange transactions (brokerage charges)</li> <li>Output of the services providers (finance, banking and insurance services)</li> </ul> |
| Non-profit institutions serving households (NPISHs) | <ul style="list-style-type: none"> <li>Housing</li> <li>Health</li> <li>Recreation and culture</li> <li>Education</li> <li>Social protection</li> <li>Other services</li> </ul>  | <ul style="list-style-type: none"> <li>Combined with estimates for households</li> <li>Employment/earnings in the activity concerned</li> <li>Information from NGOs</li> </ul>   |

\* Classification of Individual Consumption by Purpose

### ***Final consumption expenditure of non-profit institutions serving households (NPISHs)***

- 2.107. The final consumption expenditure of NPISHs is defined and analysed in ESA 2010, [§3.97](#), and in 2008 SNA, §9.105-9.111.
- 2.108. As NPISHs are primarily, if not exclusively, engaged in non-market production, their output is derived as the sum of costs (i.e. compensation of employees plus intermediate consumption plus consumption of fixed capital plus other taxes minus subsidies on production). Subsequently, final consumption expenditure can be derived as output less own account capital formation less receipts from the sale of goods and services (this last component is offset in household consumption). Quarterly estimates should be derived in the same way as the annual estimates. Where this is not possible, quarterly estimates of the components of final consumption expenditure (including output) may be derived by using indicator series benchmarked to annual estimates using temporal disaggregation methods (see Chapter 5). Candidates for ‘indicator’ series are compensation of employees for current price estimates, and employment or hours worked for volume estimates. In both cases, the recent relationship between the indicator series and the annual figures should be assessed.

### ***Final consumption expenditure of government***

- 2.109. Government final consumption expenditure (GFCE) is defined and analyzed in ESA 2010, [§3.98](#), and in 2008 SNA, §9.84-9.102.

#### *Issues*

- 2.110. As mentioned earlier on the issue of the time of recording, source data for GFCE (both individual and collective) may be recorded on a cash, rather than an accrual, basis. One consequence of using data on a cash basis is that certain estimates of spending in the government account may not be consistent with the output and income recorded by market producers. The degree of potential inconsistency is likely to vary for different countries, and reflects government recording practices and the nature of the spending. Within GFCE the main problems are likely to be in the areas of spending on defence and health.

#### *What to do*

- 2.111. It is suggested that compilers should examine the basic data for GFCE to see whether they appear erratic or otherwise implausible (for example, where expenditure is much higher in the last quarter of the budget year), and are thus unlikely to be consistent with the associated figures of counterparties in the production and income accounts. Where inconsistencies are thought to exist, attempts should be made to put the figures onto more of an accrual basis.
- 2.112. Ideally, the derivation of estimates on an accrual basis should be achieved by ensuring that the government figures are compiled on the proper basis. Until this can be done, national accounts compilers and the providers of the information should consider how best the basic data should be modified. In the absence of any related information for doing so, one possibility is to simply distribute the estimated annual figure using indicators, such as employment or the wages of government workers. This should be done for both the unadjusted and seasonally adjusted data. The particular areas for concern might be earmarked for special attention in the balancing process, which may also highlight the extent of any inconsistencies and help to improve the series. It is important to note that when cash figures are modified in this way adjustments are also needed to the financial accounts to ensure consistency.

2.113. Adjustments to GFCE also have implications for the measurement of output and income for the government accounts.

2.114. Table 2.5 lists data commonly used by Member States to derive estimates of government final consumption expenditure.

Table 2.5: General Government Consumption Expenditure – Sources/Indicators

| COFOG*                           | Sources/Indicators  |
|----------------------------------|---|
| General public services          | <ul style="list-style-type: none"> <li>Expenditure statistics (comprehensive government finance data)</li> <li>Expenditure statistics (sample surveys)</li> <li>Wage and salaries statistics</li> </ul> |
| Defence                          |   |
| Public order and safety          |   |
| Economic affairs                 |   |
| Environmental protection         |   |
| Health                           |   |
| Recreation, culture and religion |   |
| Education                        |   |
| Social protection                |   |
| Housing and community amenities  |   |

\* Classification of Functions of Government

### **Gross fixed capital formation**

2.115. Gross fixed capital formation (GFCF) is defined and analysed in ESA 2010, [§3.122-3.138](#), and in 2008 SNA, §10.31-10.117. Table 2.6 lists data commonly used by Member States to derive estimates of gross fixed capital formation.

#### *Issues*

2.116. There are three issues considered here, of which the first two are inter-related. They are:

- the measurement of GFCF on an accrual basis;
- the consistency of measurement with other parts of the accounts;
- the derivation of estimates by institutional sector.

Table 2.6: Gross Fixed Capital Formation – Sources/Indicators

| Gross Fixed Capital Formation – AN_F6*  | Sources/Indicators  |
|---|---|
| Dwellings   | <ul style="list-style-type: none"> <li>• Building activity statistics (e.g. value/volume of work done by builders) relating to dwellings</li> <li>• Capital outlays by purchasers of capital goods (improvements to dwellings, public construction)</li> <li>• Number of units sold (brokers' commissions on sale of new dwellings)</li> <li>• Index of construction output or turnover</li> <li>• Number of building permits issued, with adjustments for delay/realization</li> <li>• Production or sale of building products, such as concrete</li> <li>• Labour inputs in physical terms and labour cost</li> </ul> |
| Other buildings and structures  | <ul style="list-style-type: none"> <li>• Building activity statistics (e.g. value/volume of work done by builders) relating to non-residential building</li> <li>• Civil and other engineering construction activity statistics</li> <li>• Capital outlays by purchasers of capital goods</li> <li>• Index of construction output or turnover, other than dwellings</li> <li>• Labour inputs in physical terms and labour cost</li> <li>• Investment intentions</li> <li>• Production or sale of building products, such as concrete</li> </ul>   |
| Transport equipment   | <ul style="list-style-type: none"> <li>• Capital outlays by purchasers of capital goods</li> <li>• Product (i.e. commodity) flow approach (using manufacturing output, export and import data by product)</li> <li>• Estimated commercial share of dealers' sales, new motor vehicle registrations</li> </ul>   |
| Other machinery and equipment, of which: <ul style="list-style-type: none"> <li>• Office machinery and hardware</li> <li>• Radio, TV and communication equipment</li> </ul> | <ul style="list-style-type: none"> <li>• Capital outlays by purchasers of capital goods (corporate sector)</li> <li>• Product flow approach</li> <li>• Average purchased by farms/unincorporated businesses multiplied by estimated number of farms/unincorporated businesses (machinery and equipment)</li> </ul>  |
| Weapons systems   | <ul style="list-style-type: none"> <li>• Government finance statistics</li> </ul>   |
| Cultivated assets   | <ul style="list-style-type: none"> <li>• Extension of annual models used to derive estimates of the production of cultivated assets</li> </ul>  |
| Intellectual property products, of which: <ul style="list-style-type: none"> <li>• Computer software</li> <li>• Research and development</li> </ul>                         | <ul style="list-style-type: none"> <li>• Value/volume of work done by capital goods producers</li> <li>• Product flow approach</li> <li>• Metres drilled (oil and gas exploration well drilling)</li> <li>• Labour inputs in physical terms and labour cost</li> <li>• Turnover from VAT statistics or business surveys (for computer software)</li> </ul>  |

\* Breakdown of fixed assets

2.117. (a) The first issue arises when the source data for GFCF is recorded on a cash, rather than an accrual, basis. This may be compounded when recorded spending is unduly high (or low) in the final quarter of the year as attempts are made to use up financial allocations or meet spending targets. The issue of accruals recording is discussed in §2.15-2.23.



- 2.118. (b) With respect to the consistency of the estimates of GFCF with other parts of the accounts, there are three possible areas of concern:
- imports of goods within the expenditure measure of GDP;
  - output in the production measure;
  - operating surplus (if independently estimated) in the income measure.
- 2.119. The problem of consistency is worsened by the recording of transactions on a cash basis. The first two areas of concern are discussed in general terms in the sections on the time of recording (§2.15-2.23) and consistency problems in recording (§2.24-2.28). Both areas of concern are reduced to the extent that supply-side data are used to derive estimates of GFCF – as discussed further below. The third area of concern reflects very much the way corporations record GFCF and operating surplus in their commercial accounts, the adjustments necessary to put these onto a national accounts basis when they are derived from the same source and the reconciliation necessary when they are from different sources.
- 2.120. (c) Estimates of GFCF are commonly derived by a mix of demand-side and supply-side data. For example, estimates of GFCF of equipment by corporations are commonly derived using data from capital expenditure surveys and estimates of GFCF of dwellings, other buildings and other structures are commonly derived from data obtained from producers in the construction industry. Capital expenditure surveys can be designed to provide estimates of GFCF by institutional sector (and industry of activity), but if the surveys only collect new capital expenditure there remains the problem of dealing with transactions involving used assets. Supply-side data sources cannot generally provide information about the institutional sector of the final purchaser.
- 2.121. Government finance statistics (GFS) usually provide an adequate source of data for GFCF by asset type for general government and possibly public enterprises as well. The only GFCF undertaken by households is of dwellings, and in some countries the great bulk of GFCF of dwellings is undertaken by households. So, the challenge is how to determine the GFCF of the other institutional sectors.

*What to do*

- 2.122. (a) and (b) Most of the problems concerned with the first two issues have been addressed in the relevant sections referred to above. One that has not concerns intellectual property products. There are significant differences between the recommendations made in business accounting standards and ESA 2010 concerning whether expenditures on purchases and expenditures incurred in the production on own account of intellectual property products should be recorded as fixed capital formation or expensed. Business accounting standards are much more conservative than ESA 2010 and recommend less of such expenditures be recorded as fixed capital formation. This issue is comprehensively addressed in the OECD *Handbook on Deriving Capital Measures of Intellectual Property Products*.
- 2.123. For other types of products, business and ESA 2010 accounting standards mostly align, and it is mainly a matter of ensuring that the time of recording of output, operating surplus and fixed capital formation are consistent. This can be resolved by examining with corporations the basis of their recording practices and making what adjustments are needed to put the figures onto a national accounts basis.
- 2.124. (c) One approach to deriving estimates of GFCF by institutional sector is to derive estimates of GFCF for the total economy and then allocate them to each institutional sector by asset category, with advantage being taken of any special characteristics of particular asset categories (e.g. heavy industrial equipment is predominantly acquired by non-financial corporations). A second approach

is to allocate the quarterly GFCF for the total economy to institutional sectors by using annual sector structures of non-financial and financial corporations and households. Government GFCF can usually be directly taken from GFS. A more sophisticated allocation to sectors is possible if quarterly GFCF by industry and an annual industry/sector matrix are available. Finally, in those cases where direct information of GFCF by institutional sector is available (e.g. capital expenditure survey with an institutional sector dimension), they can be aggregated to obtain estimates for the total economy. In practice, each approach (or combinations of them) may be used, and the ones adopted by each NSI will be determined by the information available.

2.125. GFCF is equal to acquisitions less disposals of fixed assets, which means that source data measuring only new capital expenditure need to be adjusted to take account of disposals. Disposals comprise sales, capital transfers in kind and barter of fixed assets to another institutional sector. Sales of fixed assets between different institutional sectors may or may not affect the estimates of GFCF for the total economy. When used motor vehicles are sold by units in one of the corporation sectors or general government to households, then the stock of fixed assets is reduced. But sales of used assets between domestic businesses or general government have no effect on the estimates of GFCF for the total economy. The following text outlines a possible strategy given a quarterly capital expenditure survey of employing businesses and quarterly building and engineering construction activity surveys. The capital expenditure survey may collect expenditures on only new fixed assets or it may also collect data on acquisitions and disposals of used assets. For the sake of simplicity the outline ignores disposals. Also, the outline does not take account of any limitations of the survey data.

2.126. *Dwellings:*

- a. estimates for general government are derived from GFS;
- b. estimates for corporations are derived from capital expenditure survey data;
- c. estimates for the household sector are derived as the difference between the estimates derived for the total economy for dwellings (derived from building activity survey estimates of value of work done and the estimates for general government).

2.127. *Other buildings and structures:*

- a. estimates for general government (and maybe public enterprises) are derived from GFS;
- b. estimates for the other institutional sectors are derived first by subtracting the estimates for general government (and maybe public enterprises) from a total economy estimate (based on data from the quarterly building and engineering construction activity surveys) and second by allocating this sub-total according to institutional sector estimates of expenditures on other buildings and structures from the capital expenditure survey. However, the data from the capital expenditure survey first need to be adjusted to take account of GFCF by non-employing businesses. This may be done using recent tax data. If the coverage of capital expenditure survey is less, say only employers with ten or more employees, then this adjustment is greater.

- 2.128. This approach may be refined if the quarterly building and/or engineering construction activity surveys provide additional information, such as the following four-way split:
- private enterprises doing work for private enterprises or NPISHs;
  - private enterprises doing work for public enterprises or general government;
  - public enterprises doing work for private enterprises or NPISHs;
  - public enterprises or general government doing work for public enterprises or general government.
- 2.129. *Machinery and equipment*:
- a. estimates for general government are derived from GFS;
  - b. estimates for corporations and NPISHs are derived from capital expenditure survey data plus any coverage adjustment required;
  - c. estimates for the household sector (unincorporated enterprises) may also be derived from capital expenditure survey data, but the coverage adjustment will be very large. By far the largest component is likely to be GFCF on transport equipment, and new motor vehicle registrations may provide a good indicator for this component.
- 2.130. *Computer software and databases*: as discussed earlier, estimates of this component of GFCF are commonly based on relatively weak source data and there may be no directly relevant data available from which to allocate the estimates for the total economy to institutional sectors. If this is the case, then it is suggested the institutional sector data for GFCF on computer equipment be used to make the allocation.
- 2.131. There is usually little difficulty in allocating the GFCF of other fixed assets to institutional sectors.

### **Consumption of fixed capital**

- 2.132. Consumption of fixed capital (CFC) is defined and analysed in ESA 2010, [§3.139-3.145](#), and in 2008 SNA, §6.240-6.257.
- 2.133. Estimates of CFC are usually derived by the method used to estimate capital stock, which is almost always the Perpetual Inventory Method (PIM). The PIM is usually applied to annual data at a detailed level for a range of different assets by industry/institutional sector, and uses information on the value and prices of GFCF. Certain assumptions have to be made as to how the fixed assets fall in value over the course of their service lives. Two common assumptions are either that they decline by a fixed proportion each year (i.e. geometric depreciation) or that they decline by an equal amount each year (i.e. straight line depreciation). If the latter model is used, then it is necessary to specify the mean service life of each asset category and the retirement distribution about the mean. Some countries combine the estimation of capital stock and CFC with estimation of the flow of capital services provided by the fixed assets <sup>(8)</sup>.
- 2.134. Quarterly estimates of CFC are needed to derive net measures of value added and operating surplus and to derive estimates of output when obtained by summing costs. The most important example of the latter is the output of general government (and hence government final consumption expenditure). In principle, it should be possible to adapt the structure and assumptions of the annual model as a basis for deriving quarterly information. However, the data for the GFCF required for the estimates are commonly unavailable in the detail needed.

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<sup>(8)</sup> The OECD Manual *Measuring Capital, 2008* provides a comprehensive description of the use of PIM to estimate all of these variables.

2.135. The GFCF for most asset categories does not vary very much from one year to another and most have mean service lives of over 8 years. Taken together, these characteristics imply that the great bulk of consumption of fixed capital in a quarter relates to fixed assets acquired in previous years. This in turn suggests that acceptable quarterly estimates of CFC can be made using simple models that interpolate and extrapolate the annual estimates.

### *Changes in inventories*

2.136. Changes in inventories are defined and analysed in ESA 2010, [§3.146-3.153](#), and in 2008 SNA, §10.118-10.148.

2.137. Some Member States derive their quarterly estimates of changes in inventories using data from enterprise (or business) surveys. Others use a variety of other approaches, including product flow balancing, models and qualitative surveys, or some combination of these. The recommended approach is to use enterprise survey data for at least the three principal inventory-holding industries: manufacturing (by stage of processing), retail trade and wholesale trade. But it is desirable, that survey data be obtained for all industries, including service industries. For some of these industries (see §2.27) there may substantial changes of inventories of work in progress of services (e.g. production of financial services) or intellectual property products (e.g. software).

2.138. Two issues are addressed here. The first concerns the process of using enterprise survey data to derive estimates of changes in inventories, and the second concerns the derivation of estimates of changes in inventories by institutional sector.

### *The process of using enterprise survey data*

#### *Issues*

2.139. The value of changes in inventories in a period is equal to:

the value of goods entering inventory

*less* the value of goods leaving inventory

*less* the value of any recurrent losses of goods held in inventory.

In the national accounts, goods entering and leaving inventory should be valued at the market prices prevailing at the time of entry or withdrawal, respectively. This ensures that sales, output and intermediate consumption are measured correctly.

2.140. Enterprise surveys do not collect changes in inventories, rather they collect either opening and closing book values of inventories or just closing book values of inventories. In the latter case, the closing book values of one quarter are assumed to be equal to the opening book values of the next quarter. Having only opening and closing book values means a model has to be used to estimate the national accounts concept of changes in inventories in which several assumptions have to be made. The standard approach for deriving estimates of changes in inventories from the book value data is described below; it should be conducted at the most detailed level practicable:

- a. deflators for the opening and closing book values are constructed based on assumptions as to how enterprises value their inventories;
- b. the opening and closing book values are expressed in constant prices using the deflators from (a);

- c. the values from (b) are differenced to obtain changes in inventories at constant prices;
- d. inflators centred on the middle of the period are constructed;
- e. the values from (c) are inflated to obtain changes in inventories at current prices and then aggregated to get the required totals;
- f. the inventory valuation adjustment (IVA) is obtained as the difference between the changes in inventories calculated using book values and those calculated at current prices;
- g. changes in inventories at constant prices are expressed in the prices of the previous year so that they can be aggregated with other volume estimates to form chain Laspeyres-type volume estimates of higher level aggregates (see Chapter 7);
- h. separately, chain-linked volume estimates are also derived from the opening and closing stock values and then differenced to obtain pseudo chain-linked volume estimates of changes in inventories.

2.141. The assumptions underlying this approach fall into two categories:

- a. assumptions about how enterprises value their inventories;
- b. an assumption that the weighted average price of flows into and out of inventories is equal to the average of the opening and closing prices of the period. This assumption is valid if the inflows and outflows occur at a steady rate and prices change at a steady rate over the period. In other circumstances, the assumption may or may not be valid; it just depends on the timing of volume and price changes over the period.

*Assumptions about how enterprises value their inventories*

2.142. The International Accounting Standard <sup>(9)</sup> (IAS 2) of 31 December 2010 states that businesses should value their inventories at the lower of cost or net realisable value. It prescribes a two-stage process for deriving the valuation of inventories at cost.

2.143. First, the cost of inventories should be measured by summing all the actual costs incurred in getting them to their current condition and location. The Standard allows the use of techniques for the measurement of the cost of inventories, such as the standard cost method <sup>(10)</sup>. The retail method may be used for convenience for the inventories of retailers if the results approximate cost.

2.144. Service providers should measure their inventories at the costs of their production. These costs consist primarily of the labour and other costs of personnel directly engaged in providing the service, including supervisory personnel, and attributable overheads. Labour and other costs relating to sales and general administrative personnel are not included but are recognised as expenses in the period in which they are incurred. The cost of inventories of a service provider does not include profit margins or non-attributable overheads that are often factored into prices charged by service providers.

<sup>(9)</sup> The Standard does not apply to:

- (a) The measurement of inventories of producers of agricultural and forest products, agricultural produce after harvest, and minerals and mineral products, to the extent that they are measured at net realizable value in accordance with well-established industry practices. When such inventories are measured at net realizable value, changes in that value are recognized in profit or loss in the period of the change.
- (b) Commodity broker-traders who measure their inventories at fair value less costs to sell. When such inventories are measured at fair value less costs to sell, changes in fair value less costs to sell are recognized in profit or loss in the period of the change.

<sup>(10)</sup> Standard costs take into account normal levels of materials and supplies, labour, efficiency and capacity utilization. They are regularly reviewed and, if necessary, revised in the light of current conditions. The retail method is often used in the retail industry for measuring inventories of large numbers of rapidly changing items with similar margins for which it is impracticable to use other costing methods. The cost of the inventory is determined by reducing the sales value of the inventory by the appropriate percentage gross margin. The percentage used takes into consideration inventory that has been marked down to below its original selling price. An average percentage for each retail department is often used.

2.145. Second, in situations where there are large numbers of interchangeable products, the Standard allows two ways of assigning the cost of inventories to the actual items in inventory. This amounts to determining the time point(s) at which costs are determined:

- first in first out (FIFO), which means that it is assumed that the items in inventory are those most recently purchased or produced;
- weighted average cost, which means that the items in inventory are valued at the weighted average cost of those in inventory at the beginning of the period and those produced or purchased during the period.

2.146. The Standard recommends that the cost of inventories of items that are not ordinarily interchangeable and goods or services produced and segregated for specific projects should be assigned by using specific identification of their individual costs.

2.147. Whether enterprises actually work out how long goods have been in inventory as per FIFO in order to determine the pricing point for determining costs is an open question. Whatever they do, there is likely to be a considerable variation between industries and items within manufacturing and wholesale and retail trade in the length of time items are held in inventory.

*Assumption that the weighted average of the prices of flows into and out of inventories is equal to the average of the opening and closing prices of the period*

2.148. This assumption only affects the current price estimates of changes in inventories. How justified this assumption is can have a major bearing on the estimates. For example, suppose prices are rising over the period and the volumes of inventories at the beginning and end of the period are exactly the same, then:

- a. the value of inventories at the end of the period would be valued higher than those at the beginning of the period because costs had risen, and so the changes in inventories (in terms of book values) from an enterprise survey would show an increase;
- b. the national accounts estimate of changes in inventories, using the model described above, would be zero;
- c. the true national accounts measure of changes in inventories could be either negative or positive depending on the sequence of additions and withdrawals. If there were a preponderance of additions early in the period followed by a preponderance of withdrawals later in the period then the changes in inventories over the period would be negative because the goods entering inventory would be valued at a price lower than those that left inventory, overall. If the sequence of additions and withdrawals were reversed, then there would be a positive change over the period.

2.149. If prices are falling over the period, IAS 2 says that inventories should be valued at net realisable value. If volumes are the same at the beginning and end of the period, then:

- enterprise surveys would record a negative change in inventories;
- the national accounts estimate, using the model described above, would be zero;
- the true national accounts measure of changes in inventories could be either positive or negative, depending on the sequence of additions and withdrawals.

- 2.150. There are three problems to be addressed concerning the estimates of changes in inventories on a quarterly basis:
- determining how enterprises actually value their inventories so that deflators can be developed that match these valuations (i.e. the first assumption);
  - overcoming the problems of uneven flows into and out of inventory and variable rates of price changes over the period (i.e. the second assumption);
  - dealing with inaccurate data arising from non-sampling errors in the book value data and sampling error arising from the survey design and sample size.

*What to do*

- 2.151. To address the first problem, NSIs need to undertake an investigation to determine how enterprises are valuing their inventories. Such an investigation could contact major inventory-holding enterprises to get details of what they actually do and contact accounting bodies, such as institutes of chartered accountants or major accounting firm(s), for advice on what most other enterprises do in particular industries. It is most important that accurate information be obtained for those inventories that are high in value and subject to large price changes, such as petroleum and mineral products.
- 2.152. If FIFO is being used, then the time lag between the time point for valuing costs and the valuation date can be estimated by calculating the inventory-to-sales ratio.
- 2.153. The second problem, which does not affect the volume estimates, can only be minimized by shortening the period over which inventory data are collected, such as by collecting the data monthly, weekly or daily.
- 2.154. Ways to minimize non-sampling error are discussed in Chapter 3.
- 2.155. Estimates of changes in inventories obtained from enterprise surveys are commonly subject to large standard errors of movement from one quarter to the next, and therefore often display large erratic movements that can have a major impact on GDP growth. However, while the standard errors of the movement of changes in inventories from one quarter to the next may be large relative to GDP growth, the relative standard errors of the levels of inventories in any quarter are usually quite small. These phenomena suggest a strategy, described below, for adjusting the initial quarterly estimates of changes in inventories whilst ensuring that they are consistent with the estimates of levels in the short to medium term.
- 2.156. At current prices, changes in inventories over a period are generally not equal to the difference between the opening and closing levels of inventories of the period, but they are in volume terms. Thus in volume terms, but not current price terms, there is a direct link between changes in inventories and inventory levels. This implies that in volume terms it is justifiable to make substantial adjustments to the changes in inventories in a particular quarter, but it is unjustifiable to make a sequence of adjustments over a number of quarters that causes the implicitly adjusted level of inventories to deviate substantially from the survey estimates. In other words, when making adjustments to the volume estimates of changes in inventories the national accountant has to take account of the accumulated effect of previous adjustments.

2.157. If the adjustments made to quarterly current price changes in inventories in the balancing process relate to the volume component and not to prices, then corresponding adjustments can be made to the volume estimates of levels from the quarterly survey. In this way, the adjusted inventory levels and the actual inventory levels from the survey – all in volume terms - can be monitored, and not allowed to diverge too much. If the adjustments are made to the price component of changes in inventories, then it is not possible to determine what the corresponding adjustment should be to the inventory levels, and so the link to the level estimates from the survey is broken. This link to the inventory level estimates is very useful and one would only be willing to give it up if there was strong evidence that the second assumption was seriously compromised.

Table 2.7: Changes in Inventories – Sources/Indicators

| Aggregates – A*10 breakdown according to NACE Rev.2   | Sources/Indicators   |
|---|--|
| Agriculture, forestry and fishing   | <ul style="list-style-type: none"> <li>• Business surveys (wool and fruit stocks)</li> <li>• Information from holders of farm stocks</li> <li>• Product flow (agricultural stocks, forestry stocks)</li> <li>• Models (growing crops and maturing livestock)</li> </ul>  |
| Mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply; water supply; sewerage, waste management and remediation activities | <ul style="list-style-type: none"> <li>• Business surveys (mining, manufacturing, energy)</li> <li>• Information from holders of stocks (oil refineries, bulk petroleum stations, electricity utilities and at car and truck dealerships)</li> <li>• Figures assumed to move in line with unincorporated manufacturing and trade inventories (unincorporated enterprises)</li> </ul> |
| <i>of which: manufacturing</i>  | <ul style="list-style-type: none"> <li>• Business surveys</li> </ul>   |
| Construction  | <ul style="list-style-type: none"> <li>• Business surveys (new housing stocks)</li> <li>• Assumed to move in line with usage of construction materials</li> </ul>  |
| Wholesale and retail trade; repair of motor vehicles and motorcycles; transportation and storage; accommodation and food service activities                   | <ul style="list-style-type: none"> <li>• Business surveys</li> </ul>   |
| Information and communication   | <ul style="list-style-type: none"> <li>• Business surveys</li> <li>• Employment</li> </ul>   |
| Financial and insurance activities  | <ul style="list-style-type: none"> <li>• Business surveys</li> <li>• Employment</li> </ul>   |
| Real estate activities  | <ul style="list-style-type: none"> <li>• Business surveys</li> <li>• Financial records</li> </ul>  |
| Professional, scientific and technical activities; administrative and support service activities  | <ul style="list-style-type: none"> <li>• Business surveys</li> <li>• Employment</li> </ul>   |
| Public administration and defence; compulsory social security; education; human health and social work activities   | <ul style="list-style-type: none"> <li>• Government finance statistics</li> </ul>  |
| Arts, entertainment and recreation, repair of household goods and other services  | <ul style="list-style-type: none"> <li>• Business surveys</li> <li>• Employment</li> </ul>   |



- 2.158. It is evident that the second assumption (the weighted average of prices of flows into and out of inventories is equal to the average of the opening and closing prices of the period) is less likely to be valid for changes in inventories calculated directly over a year than a quarter. Therefore, there is a strong argument for using the data from QNA to provide initial annual estimates for balancing in supply and use tables. Furthermore, if inventory data from annual sources are used, then the practice of restricting adjustments to the volume component of changes in inventories becomes much less attractive.

### ***Deriving estimates of changes in inventories by institutional sector***

#### *Issues*

- 2.159. Estimates of changes in inventories for general government (and maybe public enterprises) are usually available from GFS. But enterprise surveys of inventories for the rest of the economy commonly have limited scope and/or coverage. Given that most inventories are held by manufacturers, wholesalers and retailers, the survey may be designed such that most of the sample is concentrated on units in those industries. As a result, financial institutions may be poorly represented in the sample, and if so, estimates for them could be subject to very large sampling errors. In addition, small employers and non-employers may be excluded from the survey, and so estimates for unincorporated enterprises may be poor. Agriculture, forestry and fishing are also commonly excluded from inventory surveys. These problems can be split into two components:
- deriving estimates by institutional sector for the economy other than general government and agriculture;
  - allocating estimates of changes inventories for the agriculture industry to non-financial corporations and unincorporated enterprises.

#### *What to do*

- 2.160. (a) One option is to allocate the quarterly figures (for the total economy less general government and agriculture) using models with indicators to allocate annual sector data to the quarters or, more crudely, by applying the sector structure of the current or latest available year to the quarterly totals. If there are no annual data, another, less satisfactory, option is to assume that the changes in inventories of financial corporations and unincorporated enterprises (households sector) other than those engaged in agricultural, fishing and forestry production are zero, and all other changes in inventories (other than those of general government and units engaged in agriculture, fishing and forestry) are allocated to the non-financial corporations sector.
- 2.161. Estimates of changes in inventories for enterprises engaged in agriculture, forestry and fishing are usually derived using various models (see §2.54-2.69 for a discussion of the models that can be used for crops). Allocating the model totals to the non-financial corporations and households sectors (unincorporated enterprises) can be quite arbitrary. In the absence of better indicators, estimates of output or value added by institutional sector in these industries can be used to make the allocations.

### ***Acquisitions less disposals of valuables***

- 2.162. Valuables are defined and analysed in ESA 2010, [§3.154-3.157](#), and in 2008 SNA, §10.151-10.154.

*Issues*

- 2.163. Estimating the value and volume of transactions in valuables on a quarterly basis may not be easy due to the lack of quarterly basic data.

*What to do*

- 2.164. In such a situation, alternative solutions need to be considered. The easiest strategy is to use smoothing methods (see Chapter 5) to distribute and extrapolate the annual data. Any market information may be used to improve the estimation and to trace the path for specific items (e.g. price lists for precious stones and metals and data on the values at which works of art, antiques, jewellery, etc. are insured).
- 2.165. Usually there is no alternative other than to rely on statistical techniques or annual sector structures to derive quarterly estimates by institutional sector.

**Exports and imports of goods and services**

- 2.166. Exports and imports of goods and services are defined and analysed in ESA 2010, [§3.158-3.179](#), and in 2008 SNA, §26.49-26.57.

*Issues*

- 2.167. The problem identified is that of inconsistent recording of flows between institutional units, discussed in §2.24-2.28.

*What to do*

- 2.168. A solution for this problem has been suggested in the relevant section referred to above. More discussion of this can be found in the IMF Balance of Payments and International Investment Position Manual (6th Edition).

**GDP(I): the income approach**

- 2.169. Among the three approaches to the compilation of GDP, there is less experience among Member States in the estimation of quarterly figures on the income side than either of the other two.
- 2.170. The considerations relating to the measurement of value added by institutional sector, described earlier in §2.90-2.92, apply to the estimation of compensation of employees, gross operating surplus and gross mixed income. Taxes and subsidies on products are not derived by sector. This only leaves the derivation of quarterly estimates of other taxes and subsidies on production by institutional sector to be addressed – see below.

**Compensation of employees**

- 2.171. Compensation of employees is defined and analysed in ESA 2010, [§4.02-13](#), and in 2008 SNA, §7.28-7.70. Table 2.8 lists data commonly used by Member States to derive estimates.

*Issues*

- 2.172. There are two main components of compensation of employees: wages and salaries and employers' social contributions.
- 2.173. The way in which employers make certain payments of wages and salaries to employees raises a number of potential problems for recording on an accrual basis. Again, these are likely to be of greater significance for quarterly estimates than for the annual figures. There are two major types of recording problems:
- if employees are paid weekly or fortnightly, then there can be a calendar variation arising from the varying number of paydays in a quarter: 12, 13 or 14 weekly paydays and 6 or 7 fortnightly paydays;
  - wages and salaries paid in a quarter can include exceptional payments, such as advance or late payments, or bonus or '13th month' payments.
- 2.174. Employers' actual social contributions are usually directly linked to wages. They often take the form of a mark-up percentage of wages paid. In such cases the above mentioned problem in time of recording is also relevant. In the case of defined contribution schemes, the actual contribution can be expected to correspond to the liability the employer incurred over the period. In the case of defined benefit schemes, there is also an imputed contribution that is determined by the difference between the actual contribution and the change in the employee's pension entitlements over the period.

Table 2.8: Compensation of employees – Sources/Indicators

| Components  | Sources/Indicators   |
|---|--|
| Wages and salaries of government employees <ul style="list-style-type: none"> <li>– Local government employees</li> <li>– Military pay and allowances</li> </ul>      | <ul style="list-style-type: none"> <li>• Government finance statistics</li> <li>• Indices of employment and salaries</li> <li>• Employment/earnings surveys</li> <li>• Government finance statistics</li> <li>• Social insurance statistics</li> </ul>   |
| Wages and salaries in welfare institutions (NPISHs)   | <ul style="list-style-type: none"> <li>• Employment/earnings surveys</li> <li>• Output</li> </ul>  |
| Wages and salaries of market sector employees <ul style="list-style-type: none"> <li>– Agriculture, forestry and fishing</li> <li>– Financial institutions</li> </ul> | <ul style="list-style-type: none"> <li>• Employment/labour cost surveys</li> <li>• Supplementary labour income</li> <li>• Product of employment and average earnings or wage index (including some large public sector enterprises)</li> <li>• Agriculture surveys</li> <li>• Value of fish landed</li> <li>• Employment and banking industry pay scale</li> </ul> |
| Employers' contributions to social security   | <ul style="list-style-type: none"> <li>• Government finance statistics</li> <li>• Ratio of wages and salaries</li> </ul>   |
| Employers' other social contributions   | <ul style="list-style-type: none"> <li>• Accounts of scheme administrators</li> <li>• Employment/earnings surveys</li> </ul>   |
| Payments in kind  | <ul style="list-style-type: none"> <li>• Labour cost surveys</li> <li>• Ratio to wages and salaries</li> <li>• Difference between ordinary rents and rents actually paid</li> </ul>  |

*What to do*

- 2.175. Payday variation can be dealt with in one of two ways. First, if the information is available, adjustments can be made to the source data. This should be possible in the case of general government. If market sector wages are collected in a quarterly survey, then enterprises can be asked to report wages by mode of payment (i.e. monthly, fortnightly and weekly) and to indicate how many paydays there were for each mode in the current quarter. The second way of deriving payday adjustments is by making estimates of the payday effect using regression analysis – see Chapter 7.
- 2.176. If payday adjustments are made, then it is essential to ensure that the operating surplus is consistent with the payday-adjusted wages and salaries data. If the operating surplus is derived residually, then this happens automatically, but if operating surplus is derived independently, then an off-setting adjustment will most likely be needed. Ideally, wages and operating surplus should be obtained from the same sample survey. In which case, off-setting adjustments can be made at the unit record level.
- 2.177. With respect to exceptional payments, wages and salaries are recorded in the period during which the work is done. However, ad hoc bonuses or other exceptional payments, 13th month, etc. are recorded when they are due to be paid.
- 2.178. Once again it is necessary to ensure that the operating surplus is consistent. If the wages and salaries data are used elsewhere in the accounts; for example, to derive estimates of output or income tax, then the exceptional payments should be treated as an increase in price. Hence, they should be reflected in current price estimates but be excluded from volume estimates.
- 2.179. In almost all countries, quarterly and monthly employment and earnings surveys are used to estimate wages and salaries of non-government employees. The surveys usually provide detail on numbers employed and average earnings by industrial activity. The main sources for wages and salaries for the government sector are the government accounts.
- 2.180. Income taxes represent another relevant indirect source even if some problems can arise when using these kinds of basic statistics (delay in recording, problems of updating). In some activities, such as agriculture, services of domestic staff and forestry and fishing, compensation of employees may be estimated using a smoothing or time series method (see Chapter 5) due to the difficulty in obtaining regular employment data. Other methods, like indirect indicators, may be used for some specific categories.
- 2.181. If the imputed social contributions of employers to defined benefits schemes are available from employers, then they should be collected along with other labour compensation data. If they are unavailable from employers or pension funds, then national accountants have to make an estimate. This issue is discussed further in the section on net social contributions and social benefits other than social transfers in kind, below.

Table 2.9: Gross Operating Surplus/Mixed Income - Sources/Indicators

| Components                                 | Sources/Indicators   |
|--|--|
| Operating surplus of corporate enterprises | <ul style="list-style-type: none"> <li>• Surveys of company profits</li> <li>• Derived as a residual <ul style="list-style-type: none"> <li>– Records of government or other official agencies</li> <li>– Company reports to shareholders</li> </ul> </li> </ul>   |
| Mixed income of unincorporated enterprises | <ul style="list-style-type: none"> <li>• Sample surveys</li> <li>• Output, sales or revenue statistics <ul style="list-style-type: none"> <li>– Assumed to move in line with value added or output</li> <li>– Number of working proprietors</li> <li>– Residential investment outlays, value of work done</li> <li>– Number of dwellings multiplied by average floor space multiplied by average rental paid per metre. Gross rent less operating costs</li> </ul> </li> </ul> |

### *Operating surplus and mixed income*

2.182. The operating surplus is estimated from information available from surveys of corporate profits and often the records of government for the operating surplus of government enterprises. Statistics on output, sales or revenue are commonly used as indicators of mixed income of unincorporated enterprises. Other indicators for operating surplus/mixed income include taxes and company reports to owners.

2.183. Table 2.9 lists data commonly used by Member States to derive estimates of gross operating surplus and gross mixed income.

### *Taxes on production and imports*

2.184. Taxes on production and imports are defined and analysed in ESA 2010, [§4.14-4.29](#), and in 2008 SNA, §7.21-7.97. The taxes included under this heading are:

- a. taxes on products, such as VAT and excise duties, and taxes on imports;
- b. other taxes on production, such as recurrent taxes on land, buildings and other structures and payroll taxes.

2.185. Taxes and subsidies on production are not just important components in their own right but also important to tie the three GDP approaches together. Data used for the production approach lead to estimates of total gross value added in basic prices and the addition of taxes less subsidies on products is required to reach GDP. The expenditure approach provides a measure of GDP at market prices, whereas the income approach requires estimates of taxes less subsidies on production and imports to reach GDP.

*Issues*

- 2.186. All countries have monthly or quarterly records available for taxes less subsidies on production and imports, but they are usually on a cash basis rather than the desired accruals basis. Five problems have been identified:
- a. the need for information to be recorded on an accrual basis;
  - b. the consistency of recording in different parts of the accounts;
  - c. the meaningfulness of the figures;
  - d. estimating prices and volumes in the face of increasing administrative use of government data;
  - e. allocating other taxes less subsidies to institutional sectors.
- 2.187. (a) Information on receipts appearing in the government accounts, which is the primary source for the estimates appearing in the other accounts, are generally on a cash basis. One reason for this is the delay that exists between the tax being deducted by the producer and paid over to, and then recorded by, government. This problem may also arise when payments are made in advance of a possible increase in the tax rate. The accrual problem here is a particular example of the general issue discussed in §2.15-2.23.
- 2.188. (b) The second issue, which has some relationship with the first, is to ensure payments and receipts are recorded on a consistent basis in different parts of the account. This issue has been discussed in general terms in §2.24-2.28.
- 2.189. (c) One particular variable where the basic data may not be economically meaningful is payments of recurrent taxes on land, buildings or other structures. This tax, which may be regarded as an annual tax, may be paid in only one or two quarters of the year, and the resulting quarterly figures for both the seasonally adjusted series and, particularly, the unadjusted series will have little economic significance. This issue has been discussed in general terms in §2.29-2.32.
- 2.190. (d) The fourth issue arises from European rules on government deficits and debt levels, government payments and receipts - all of which are receiving ever closer scrutiny. This administrative use of government data can make adjustments to data on taxes and subsidies for reasons of accrual accounting controversial.
- 2.191. (e) Taxes and subsidies on products are not derived by institutional sector, but other taxes and subsidies are. It is common practice to use government finance statistics to derive estimates for the total economy, but data by institutional sector may be lacking.

*What to do*

- 2.192. In respect of all five problems, the extent of any distortion to the tax figures depends very much on the arrangements existing in individual countries for paying these taxes.
- 2.193. (a) Where taxes accrue and are paid on a fairly regular basis during the year, the distorting effect of using cash receipts may be only small. However, for household consumption the main determinant of taxes on products - the profile of quarterly spending - is far from even during the year, although the seasonal pattern will be fairly constant from one year to the next.

- 2.194. It is recommended that where taxes on products are recorded in the government accounts on a cash basis these figures should be adjusted so that they relate better to the consumption activity for the period. The exact nature of how this might be done will depend on the way in which the tax is collected and recorded. One possibility is to lag receipts by a number of weeks to allow for the delay between accrual and receipt. An alternative approach is to derive the accruals-based estimate of the tax by applying the relevant tax rates to the appropriate detailed components of spending in the quarter (allowing for zero-rated commodities). A third approach, where no 'explanatory' variable exists, involves the use of smoothing or time series methods (see Chapter 5) to allocate the annual figure over all four quarters. Checks should be made on the plausibility of the overall tax/spending ratios. Further guidance is provided in the Eurostat *Manual on Quarterly Non-financial Accounts for General Government*.
- 2.195. (b) Consistency can be achieved by using for the figures for payments in the accounts of producers the (estimated accrual) figures that appear as receipts in the government accounts.
- 2.196. (c) It is proposed that where figures are not economically meaningful, adjustments should be made along the lines suggested in §2.29-2.32.
- 2.197. (d) National accountants should always do their best to follow national accounting principles. In a situation such as the one described above, where basic data on a cash basis are being used for non-national accounting purposes, national accountants should carefully and comprehensively explain to users why and how the basic data are being adjusted to meet the needs of the national accounts, and make this information highly accessible.
- 2.198. (e) It is recommended that each type of other tax on production should be considered separately and a strategy should be developed for allocating them to institutional sectors according to their particular characteristics. For example, if payroll tax liabilities are determined according to the level of wages or compensation of employees, then estimates of compensation of employees (or wages) for each institutional sector could be used to allocate the economy-wide total. If this is not possible, annual sector structures can be used to allocate the quarterly tax receipts to the paying sectors.
- 2.199. Finally, as mentioned before, where cash figures are adjusted to an accrual basis, or in some other way, it is necessary to include compensating adjustments (the difference between adjusted and cash figures) in the financial accounts to ensure consistency of recording.

### **Subsidies**

- 2.200. Subsidies are defined and analysed in ESA 2010, [§4.30-4.40](#), and in 2008 SNA, §7.98-7.106.

#### *Issues*

- 2.201. Subsidies are equivalent to negative taxes on production in so far as their impact on the operating surplus is in the opposite direction to that on taxes on production. The payment of subsidies by government can give rise to problems similar to those encountered with taxes. The two specific problems discussed here are:
- that payments will not always reflect the way the subsidies should accrue. This problem commonly arises for those subsidies that may be regarded as essentially annual in nature, and for which the quarterly payments recorded are not meaningful;
  - the allocation of other subsidies by institutional sector.

*What to do*

- 2.202. (a) As with taxes, the aim should be to ensure that each subsidy is recorded on an accrual basis. This may be attempted in various ways. Where such payments are made to public corporations or to large private corporations, it may be possible to get some information from their QNA as to how the subsidies have accrued. If this is not possible, estimates should be obtained by relating the subsidy to the economic activity on which it is due. Failing that, smoothing or time series methods (see Chapter 5) should be employed. In all cases, quarterly figures need to be adjusted to revised annual data. Finally, as with taxes, any move away from the cash-based figures will require an associated adjustment for the financial accounts to maintain consistency.
- 2.203. (b) Each type of other subsidy on production should be considered separately and a strategy should be developed for allocating them to institutional sectors according to their particular characteristics. If other subsidies are provided to particular industries according to their level of output, for instance, then a cross-classification of output by institutional sector by industry of activity could be used to make the allocation.

**The allocation of primary income account – property income**

2.204. The allocation of primary income account comprises the following components:

- a. operating surplus
- b. mixed income
- c. compensation of employees
- d. taxes on production and imports
- e. subsidies
- f. property income
  - interest
  - dividends
  - withdrawals from quasi corporations
  - reinvested earnings on foreign direct investment
  - investment income attributable to insurance policy holders
  - investment income payable on pension entitlements
  - investment income attributable to collective investment funds shareholders
  - rent

2.205. All but property income have been dealt with, in under the heading GDP(I), in the preceding paragraphs. Property income is defined and analysed in ESA 2010, [§4.41-4.77](#), and in 2008 SNA, §7.107-7.160.



2.206. Except for interest and dividends, the major problem likely to be encountered is the derivation of estimates by institutional sector. Table 2.10 sets out the possible entries for each of the major components of property income. For those components of property income that involve transactions with the rest of the world, data are drawn from the balance of payments statistics. This applies to the whole of reinvested earnings on direct foreign investment and elements of all the other components

Table 2.10: Uses and resources of property income by institutional sector

|   | Uses |     |     |     |     |    | Resources |     |     |     |     |    |
|---|------|-----|-----|-----|-----|----|-----------|-----|-----|-----|-----|----|
|   | S11  | S12 | S13 | S14 | S15 | S2 | S11       | S12 | S13 | S14 | S15 | S2 |
| Interest                                      | X    | X   | X   | X   | X   | X  | X         | X   | X   | X   | X   | X  |
| Distributed income of corporations:           |      |     |     |     |     |    |           |     |     |     |     |    |
| Dividends                                     | X    | X   |     |     |     | X  | X         | X   | X   | X   | X   | X  |
| Withdrawals from income of quasi corporations | X    | X   |     |     |     | X  |           |     | X   | X   | X   | X  |
| Reinvested earnings on FDI                    | X    | X   |     |     |     | X  | X         | X   | X   | X   | X   | X  |
| Investment income disbursements:              |      |     |     |     |     |    |           |     |     |     |     |    |
| Attributable to insurance policy holders      |      | X   |     |     |     | X  | X         | X   | X   | X   | X   | X  |
| Payable on pension entitlements               |      | X   |     |     |     | X  |           |     | X   |     |     | X  |
| Attributable to collective investment funds   |      | X   |     |     |     | X  | X         | X   | X   | X   | X   | X  |
| shareholders                                  |      |     |     |     |     |    |           |     |     |     |     |    |
| Rent  | X    | X   | X   | X   | X   |    | X         | X   | X   | X   | X   |    |

### Interest

#### Issues

2.207. Interest is defined and analysed in ESA2010, [§4.42-4.52](#), and in 2008 SNA, §7.113-7.126. Two issues are addressed here:

- recording interest (excluding the service charge) on an accruals basis;
- estimating interest flows by institutional sector.

2.208. (a) Interest should be recorded in the accounts on an accrual basis; that is accruing continuously over time to the creditor on the amount of principal outstanding. The interest accruing in each accounting period is the amount receivable by the creditor and payable by the debtor. Such amounts must be recorded whether or not they are actually paid or added to the principal outstanding. The problem that arises here is essentially that of the need for accruals recording. Some payments of interest are made half-yearly or annually, and these need to be put on to the accrual basis. The extent of the problem clearly depends on the practices for making interest payments. Estimation is complicated by the fact that data sources on interest always include a

service component. This service charge should be eliminated from the interest and should be considered as part of the output.

- 2.209. (b) Units in all institutional sectors pay and receive interest. While financial institutions are the only ones to undertake financial intermediation and are a counterparty to most transactions involving the payment and receipt of interest, they are not a counterparty to all such transactions. Non-financial corporations and general government also sell financial instruments, such as bonds, on which interest is payable. Data concerning interest payments and receipts are available from domestic financial institutions either directly or indirectly via a prudential regulatory authority, by type of financial instrument. Data on interest flows are generally available from non-financial corporations via surveys and general government via government finance statistics. Also, special surveys are conducted to estimate financial flows between domestic units and the rest of the world to compile balance of payments statistics. So, data relating to at least one counterparty of all, or nearly all, transactions involving the payment and receipt of interest within an economy are usually available. However, difficulties can arise in allocating flows of interest between institutional sectors because the available data are either inconsistent or they do not adequately identify the counterparty to interest flow transactions. The latter can be particularly problematic for the households sector.

*What to do*

- 2.210. (a) It is recommended that where it is necessary to put payments of interest onto an accrual basis, it is achieved by relating appropriate 'average' rates of return to the outstanding levels. The average rate of return should exclude the service component (FISIM). This can be accomplished by using 'risk-free' interest rates for the respective instruments (loans and deposits), for example interbank interest rates. Adjustments should be made for both unadjusted and seasonally adjusted data. The quarterly estimates can then be aligned with the firmer based annual totals. Again, it should be emphasised that whatever is done the approach for the given instrument should be consistent between payments and receipts, and across the institutional sectors. How this may be achieved is discussed in the following paragraph. Adjustments made to cash figures require related adjustments in the financial accounts.
- 2.211. (b) The recommended approach is to compile whom-to-whom-matrices. Best results are obtained if separate matrices are compiled for different types of financial instrument, e.g. deposits, bills of exchange, one-name paper, bonds and loans. The matrices should be filled with all available information. The supervising financial authority is usually the most important source. It often provides breakdowns of loans and deposits by counterparty, which can be used to fill many of the cells of the whom-to-whom matrix. In addition, other sources can be used to estimate the totals for each sector (and subsectors if required). As mentioned before, the interest flows relating to loans and deposits should be adjusted to allow for FISIM. Interest flows from borrowers to financial intermediaries are reduced by FISIM, while interest flows from financial intermediaries to depositors are increased by FISIM. Finally, the matrices should be balanced, with higher 'weight' being given to the most reliable parts of the matrices. The resulting matrices represent a balanced system so that for each instrument total payments of interest equal total receipts.
- 2.212. If there are only sufficient data to employ this approach to derive annual estimates of inter-sectoral interest flows, then quarterly indicators can be used to temporally distribute the annual estimates. For example, to make quarterly estimates of interest payable and receivable by the households sector the following indicators may be used:
- a. Interest received by households:
    - bank interest paid on deposits to persons, unincorporated enterprises;
    - other depository corporations interest paid to households.

- b. Interest paid by households - dwellings:
  - bank interest received from housing;
  - other depository corporations interest received on housing;
  - securitizers<sup>(1)</sup> interest received on housing.
- c. Interest paid by households – consumer debt:
  - bank interest received from personal loans (consumer credit);
  - other depository corporations interest received from personal loans (consumer credit).
- d. Interest paid by unincorporated enterprises:
  - bank interest received from unincorporated enterprises;
  - other depository corporations interest received from unincorporated enterprises.

2.213. Having made quarterly imputations of interest flows for each sector, it is important to ensure that they balance and are consistent with the total economy flows.

### *Dividends*

2.214. Dividends are defined and analysed in ESA2010, [§4.53-4.57](#), and in 2008 SNA, §7.127-7.132.

#### *Issues*

- 2.215. Unlike interest, no attempt is made to record dividends on an accruals basis. The reason for this is that the period over which dividends accrue is indeterminate and so, with the exception of super dividends (discussed in 2008 SNA §7.131), no attempt is made to align dividend payments with earnings.
- 2.216. Dividends are payable by financial and non-financial corporations and corporations in the rest of the world, and receivable by units in all institutional sectors. The principal difficulties are in deriving estimates of dividends receivable by the households sector and resolving inconsistencies in the available data.

#### *What to do*

- 2.217. The recommended approach is the same as that for interest, i.e. to construct and balance a matrix of inter-sector flows of dividends and to use quarterly indicators if such matrices can only be derived for annual data.

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<sup>(1)</sup> The securitization process is a means of creating a liquid market for assets, such as mortgages and credit card loans, which are illiquid. In addition, the process can be used to improve the liquidity of assets such as bonds. The securitizers considered here are those legal entities, other than banks and other depository corporations, that issue short and/or long term debt securities, via a special purpose vehicle (SPV), by using specifically selected assets to back them and generate the payment streams necessary to fulfil interest and principal requirements of investors.

### *Withdrawals from income of quasi-corporations*

2.218. Withdrawals from income of quasi-corporations are defined and analysed in ESA2010, [§4.58-4.63](#), and in 2008 SNA, §7.133-7.135.

#### *Issues*

2.219. Withdrawals from income of quasi-corporations flow from the financial corporation, non-financial corporation and rest of the world sectors to the households, NPISH, general government and the rest of the world sectors. Given the availability of data for the rest of the world (from balance of payment statistics) and receipts by general government (from government finance data), then estimates for the income receivable by the aggregate of households and NPISH sectors can be imputed if data of withdrawals are available for the quasi-corporations classified to the financial and non-financial corporation sectors. The task is then to separately estimate the income receivable by the households and NPISH sectors. This is possible if the business register records the affiliations of quasi-corporations to NPISHs. Another possibility is to examine the annual reports of major NPISHs.

### *Reinvested earnings on foreign direct investment*

2.220. Reinvested earnings on foreign direct investment are defined and analysed in ESA2010, [§4.64-4.67](#), and in 2008 SNA, §7.136-7.139.

#### *Issues*

2.221. Although for some countries reinvested earnings on foreign direct investment might be of minor importance, for other countries, this variable can be sufficiently large to have an appreciable influence on major macroeconomic aggregates, such as national income.

2.222. Three problems may be encountered when estimating this variable:

- a. it can be difficult to determine which enterprises should be considered as 'foreign direct investment enterprises';
- b. data on reinvested earnings can be very volatile and their accuracy might sometimes be questioned;
- c. whereas in most cases the balance of payments are the main source, the allocation of the counterpart transactions, and more specifically the allocation between non-financial corporations and financial corporations, may be quite challenging, given that reinvested earnings can be either positive or negative.

#### *What to do*

2.223. (a) Estimates of reinvested earnings for foreign direct investment and non-resident investment funds are commonly obtained from a quarterly survey of international investment used to derive estimates for the balance of payments. Foreign direct investment enterprises are often members of large multi-national enterprise groups that have rather complicated enterprise structures. A register of direct investment enterprises that also contains detailed information about their company structure is very helpful. This register (which may be an integrated part of the general business register) needs to be kept up to date, which requires maintaining close and frequent contact with the responding enterprises.

- 2.224. (b) The best way of dealing with large, volatile transactions is to undertake a careful analysis of large transactions and outliers in close cooperation with the data supplier and/or the direct investment enterprise itself.
- 2.225. (c) The balance of payments survey can be designed to provide reinvested earnings data both payable to non-residents and receivable from non-residents by institutional sector to address the third problem. In the absence of such information, the compiler has to rely on second best methods. The use of distributions based on more detailed annual data for the sector allocation or on the distribution of a related variable like dividends are possibilities.

#### ***Investment income attributable to insurance policy holders***

- 2.226. Investment income attributable to insurance policyholders is defined and analysed in ESA 2010, [§4.68](#), and in 2008 SNA, §7.133-7.135.

##### *Issues*

- 2.227. In the case of life insurance, except for a small proportion going to and coming from the rest of the world, all investment income attributable to insurance policyholders flows to the households sector from the financial corporations sector. By contrast, there are policy holders of non-life insurance in all sectors.

##### *What to do*

- 2.228. Property income attributable to non-life insurance policy holders (i.e. premium supplements) can be allocated to institutional sectors in proportion to policy-holders' funds, using data from the prudential regulatory authority. If only annual data are available, then quarterly estimates of policy-holders' funds by institutional sector may be estimated by temporally disaggregating annual data using available quarterly indicators.

#### ***Investment income payable on pension entitlements***

- 2.229. Investment income payable on pension entitlements is defined and analysed in ESA 2010, [§4.69](#), and in 2008 SNA, §7.147-7.150 and in part 2 of Chapter 17.

##### *Issues*

- 2.230. The major problem is to adequately estimate the total flows; there are no particular problems in making an allocation by institutional sector. As for life insurance, except for a small proportion going to and coming from the rest of the world, all investment income payable on pension entitlements flows from pension funds to the households sector. However, some pension funds are administered by the employer, which may or may not be a financial institution and may be unobserved.

##### *What to do*

- 2.231. This issue is addressed in the discussion on net social contributions and social benefits other than social transfers in kind – see below.

### ***Investment income attributable to collective investment fund shareholders***

2.232. Investment income attributable to collective investment fund shareholders is defined and analysed in ESA 2010, [§4.70-4.71](#), and in 2008 SNA, §7.151-7.152.

#### *Issue*

2.233. The problem addressed here is the allocation of investment income attributable to collective investment fund shareholders by institutional sector.

#### *What to do*

2.234. The reinvested earnings arising from resident investments funds can be allocated to institutional sectors according to the proportions of the equity issued by the investment funds to the units in each sector.

2.235. The allocation of reinvested earnings of non-resident investment funds to domestic institutional sectors is best achieved by adding an institutional sector dimension to the balance of payments survey used to obtain the aggregate estimates (along with the collection of direct foreign investment data). Otherwise second-best methods must be used.

### ***Rent***

2.236. Rent is defined and analysed in ESA 2010, [§4.72-4.76](#), and in 2008 SNA, §7.153-7.160.

#### *Issues*

2.237. The major issue is measuring the flows between institutional sectors. There are units in all domestic sectors that pay and receive rent for the use of land and other natural resources.

#### *What to do*

2.238. The recommended approach is the same as the one for interest, i.e. construct and balance matrices of the rent payable and receivable for each type of natural asset using all the available data. However, taking into account the rather limited overall importance of these transactions and the scarcity of direct sources, second best solutions may be used to estimate the sector distribution, such as applying annual sector structures to the quarterly data.

### **The secondary distribution of income account**

2.239. The secondary distribution of income account concerns:

- a. current taxes on income and wealth
- b. net social contributions
- c. social benefits other than social transfers in kind
- d. social security benefits in cash
- e. other social insurance benefits
- f. social assistance benefits in cash

- g. other current transfers
  - net non-life insurance premiums
  - non-life insurance claims
  - current transfers within general government
  - current international cooperation
  - miscellaneous current transfers

2.240. For most of these components there are no particular difficulties in deriving quarterly estimates for the total economy. One exception is likely to concern certain elements of net social contributions. In particular, the employers' imputed social contribution to defined benefit schemes and households' social contribution supplements (included in the property income payable by pension funds to households in the allocation of primary income account). In these cases the challenge is to derive annual estimates that can serve as benchmarks for quarterly estimates. There are also some particular issues with respect to current taxes on income, wealth, etc. and other miscellaneous current transfers.

2.241. Regarding the matter of deriving estimates by institutional sector, in most cases the source data used to compile the aggregates for the total economy also provide the means to allocate these aggregates to institutional sectors. The major exceptions are net premiums and claims for non-life insurance and miscellaneous current transfers. The remaining components of other current transfers concern transactions with government units that can usually be estimated using government finance statistics with little difficulty.

#### ***Current taxes on income, wealth, etc.***

2.242. Current taxes on income, wealth, etc. are defined and analysed in ESA 2010, [§4.77-4.82](#), and in 2008 SNA, §8.52- 8.64.

2.243. The taxes included under this heading are:

- taxes on income, in particular on wages and salaries, mixed income and operating surplus;
- other current taxes, such as taxes on capital and wealth.

#### *Issues*

2.244. Four problems have been identified:

- a. the need for information to be recorded on an accruals basis;
- b. the consistency of recording in different parts of the accounts;
- c. the meaningfulness of the figures in an economic sense;
- d. for some taxes the final extent of tax liability is not known until sometime after the period of compilation.

2.245. (a), (b) The first two issues are broadly the same as those raised in respect of taxes on products (see §2.184-2.199).

- 2.246. (c) Two particular series where problems of this kind may arise are taxes on mixed income and on operating surplus. Payments may be made in only one or two quarters of the year and the resulting quarterly figures for both the seasonally adjusted and unadjusted data, but particularly the latter, will have little economic significance. This problem is broadly addressed in §2.29-2.32).
- 2.247. (d) This problem affects both annual and quarterly estimates. It relates particularly to taxes on operating surplus and, to a lesser extent, to taxes on mixed income. In extreme cases, the final liability may not be known until 10 years after the activity. The issue is how to treat these 'revisions' to data in the accounts.

*What to do*

- 2.248. For all of the four problems the extent of any distortion to the tax figures will depend very much on the arrangements existing in individual countries for paying these taxes. Any distortions should be removed from both the unadjusted and seasonally adjusted data.
- 2.249. (a) Where taxes accrue and are paid on a fairly regular basis during the year, the distorting effect of using cash receipts may be only small. Taxes on wages and salaries are normally collected under a 'pay-as-you-earn' system. If the levels of wages and salaries are broadly uniform during the quarters of the year, then this delay may not constitute much of a problem. However, as indicated in §2.171-2.181, wages and salaries can, at times, exhibit erratic quarterly movements.
- 2.250. It may be possible to put the quarterly figures for taxes on wages and salaries closer to the accrual basis by lagging the receipts data by the lag between payment and recording. If this cannot be done, then adjusted figures can be derived by applying an estimate of the ratio of tax to wages and salaries to the latter data for the quarter. This second solution may be more appropriate for dealing with the existence of 'lumpy' payments of wages and salaries. In adopting this approach, the impact of tax rebates on the calculation may need to be considered.
- 2.251. For taxes on mixed income and on operating surplus, or indeed other taxes which exhibit a profile that is not meaningful, adjustments should be made to the basic quarterly figures. This should be done by applying an appropriate tax rate to the corresponding level of economic activity and adjusting the new series to the annual level.
- 2.252. (b) Consistency may be achieved by using the (estimated accruals) figures that appear as receipts in the government accounts to derive payments in the accounts of the producers.
- 2.253. (c) It is proposed that where figures are not meaningful in an economic sense, then adjustments are made along the lines suggested in §2.29-2.32 in order to obtain a meaningful quarterly profile that is constrained to the annual estimates. As described in ESA 2010, §4.82, taxes recorded in the accounts may be derived from two sources: amounts evidenced by assessments and declarations or cash receipts. Whichever source is used, the available data should be adjusted to an accrual basis as described in the ESA.
- 2.254. (d) The raw data should be adjusted to approximate accrual recording as well as possible – see ESA 2010, §4.82. As elsewhere, when cash figures are adjusted to an accrual basis, or in some other way, it is necessary to include compensating adjustments in the financial accounts to ensure consistency of recording.



***Net social contributions and social benefits other than social transfers in kind***

2.255. Net social contributions are defined and analysed in ESA2010, §4.83-4.107, and in 2008 SNA, §8.80-8.86. Social benefits other than social transfers in kind are defined and analysed in ESA 2010, §4.102-4.107, and in 2008 SNA, §8.87-8.112. Social insurance schemes are discussed in more detail in Part 2 of Chapter 17 of the 2008 SNA.

*Issues*

2.256. Net social contributions and social benefits other than social transfers in kind concern pensions and other social benefits. The latter include payments arising from illness or unemployment and may be paid to the beneficiary or their dependants (see §8.68 of the 2008 SNA). In Member States, most non-pension benefits are funded out of the government's general revenue and are part of social assistance, and so, there are no social contributions by households in such cases. Deriving estimates of transactions relating to pensions generally poses the greatest difficulties.

2.257. The estimation of pension-related net social contributions and social benefits relies on much the same data sources and the use of integrated methods. The availability of information and choice of methods is largely dependent on the organisation of social insurance schemes in the Member State. In most countries the receipt of net social contributions for pensions and the payment of pensions by general government (as administrator of social security schemes) and by independent pension funds (as managers of employment-related social insurance schemes other than social security) are fairly well covered by direct quarterly data sources. Problems may be encountered with the estimation of the receipts of contributions and the payment of benefits by pension funds in the other sectors (i.e. where the employer manages the pension fund).

2.258. As discussed in respect of compensation of employees, there are two types of employment-related pension schemes other than social security: defined contribution schemes and defined benefits schemes. In the case of defined contribution schemes, there are no employers' imputed pension contributions (D6121) and households' pension contribution supplements (D6141) are directly related to past and current actual contributions to these schemes. In the case of defined benefits schemes, the employers' imputed pension contributions (D6121) are actuarially-determined and the households' pension contribution supplements (D6141) are partly dependent on them.

2.259. Net social contributions comprise the following:

- employers' actual pension contributions (D6111)
- employers' actual non-pension contributions (D6112)
- employers' imputed pension contributions (D6121)
- employers' imputed non-pension contributions (D6122)
- households' actual pension contributions (D6131)
- households' actual non-pension contributions (D6132)
- households' pension contribution supplements (D6141)
- households' non-pension contribution supplements (D6142)

The sum of the eight items less the pension and non-pension scheme service charges equals net social contributions. The first four items are part of compensation of employees, and the fifth and sixth items (i.e. D6131 and D6132) are generally obtained from the same data sources.

2.260. Social benefits other than social transfers in kind comprise the following:

- social security pension benefits (D6211)
- social security non-pension benefits in cash (D6212)
- other social insurance pension benefits (D6221)
- other social insurance non-pension benefits (D6222)
- social assistance benefits in cash (D623)

*What to do*

2.261. If some quarterly components of net social contributions are available, they may be used to impute the growth rates of other components that are unavailable. More specifically, if employers' actual and imputed social contributions (D6111 and D6121) are available, which are both part of compensation of employees, they may be able to be used as quarterly indicators of related variables, such as households' actual pension contributions (D6131).

2.262. In the absence of any actual data for the values of net contributions receivable and benefits payable by some pension funds, such as ones managed by employers, then one possible approach is to assume that these values are in the same proportion to compensation of employees as those cases for which there are complete data, such as the data obtained from a survey of private pension funds. If this is not possible, then quarterly estimates for the missing observations can be made by using more detailed annual data in combination with quarterly indicators that are (closely) related to net social contributions, such as compensation of employees.

2.263. If data are missing for social benefits directly paid by employer-managed pension funds, which seems to be the case for a number of countries, then one option is to assume that pension contributions have the same growth rate as pension benefits paid (i.e. for employer-managed pension funds D6221 grows at the same rate as D6111 + D6121 + D6131 + D6141). Alternatively, more general estimation methods may have to be applied, using more detailed annual data combined with a quarterly indicator.

***Net non-life insurance premiums and non-life insurance claims***

2.264. Net non-life insurance premiums and claims are defined and analysed in ESA 2010, [§4.112-4.117](#) and in 2008 SNA, §8.115-8.125 and Part 1 of Chapter 17.

*Issues*

2.265. Estimates of net non-life insurance premiums and claims are made in parallel with each other, relying on the same data sources and using integrated methods. For almost all countries information on these transactions can be derived from statistical surveys, from administrative authorities supervising the insurance market or from business organisations representing the industry. Cross border flows are generally covered by the balance of payments. However, gaps in the data are common:

- a. only annual data may be available;
- b. where quarterly data are available, there may be no counterpart information;
- c. data available from insured units may not separately identify insurance premiums and claims.

*What to do*

- 2.266. If quarterly information on net non-life insurance premiums and claims are available but without counterpart information, the amounts for the counterpart sectors may be estimated using the annual structures. Where quarterly information on non-life insurance transactions is completely absent, all the corresponding annual estimates may be temporarily disaggregated into quarters by using mathematical techniques (see Chapter 5). Finally, the equality between total resources and total uses for both premiums and claims can be used in the balancing procedure to derive a missing value for a sector as a residual.

**Current transfers within general government**

- 2.267. Current transfers within general government are defined and analysed in ESA 2010, [§4.118-4.120](#) and in 2008 SNA, §8.126-8.127.

*Issues*

- 2.268. There are no particular issues. Data are available from government finance statistics.

**Current international cooperation**

- 2.269. Current international cooperation is defined and analysed in ESA 2010, [§4.121-4.124](#) and in 2008 SNA, §8.128.

*Issues*

- 2.270. There are no particular issues. Data are available from government finance statistics.

**Miscellaneous current transfers**

- 2.271. Miscellaneous current transfers are defined and analysed in ESA 2010, [§4.125-4.140](#) and in 2008 SNA, §8.129-8.140.

*Issues*

- 2.272. Unsurprisingly, miscellaneous current transfers have a rather heterogeneous character. In those cases where general government is involved, estimates can usually be readily made using government finance statistics. However, in most cases there is hardly any quarterly data available on flows between households and NPISHs, and on flows within the household sector.

*What to do*

- 2.273. In the absence of quarterly data sources, there may be no alternative other than to derive quarterly estimates by distributing and extrapolating the available annual data (for example, information on voluntary contributions, membership subscriptions and charitable donations obtained from a household expenditure survey) by using quarterly indicators if available, and if not by smoothing (see Chapter 5).

## Use of disposable income account

2.274. The use of disposable income account contains only three main entries other than the balancing item, saving. Final consumption expenditure is disaggregated between individual and collective consumption expenditure. The third item is the adjustment for the change in pension entitlements.

### *Individual and collective consumption expenditure*

2.275. These two items are defined and analysed in ESA 2010, [§3.100-3.121](#) and various parts of Chapter 9 of the 2008 SNA. All household final consumption expenditure is individual and in the ESA 2010 all goods and services provided by NPISHs are treated as individual. The disaggregation of final consumption expenditure between individual and collective expenditure therefore effectively entails allocating final government consumption expenditure to its individual and collective components. §3.104 of the ESA 2010 defines which of the COFOG components should be recorded as expenditures on individual consumption and which should be recorded as expenditures on collective consumption. When the former is added to the final consumption expenditure of households and NPISHs, total individual consumption is obtained, and this is also equal to the actual final consumption of households. Conversely, actual government final consumption is equal to its expenditure on collective consumption.

2.276. If the COFOG classification referred to in the previous paragraph is only available for annual data, then it may be used to disaggregate the quarterly totals of government final consumption expenditure. One way of doing this that avoids the step problem (that can arise from assuming a fixed proportion for the quarters in each year) is to use total government consumption expenditure as the quarterly indicator for each of the annual COFOG categories in one of the temporal disaggregation methods described in Chapter 5.

### *Adjustment for the change in pension entitlements*

2.277. The adjustment for the change in pension entitlements is defined and analysed in ESA 2010, [§4.141-4.144](#), and in 2008 SNA, §9.20-9.25. As this item is defined as the difference between net social contributions receivable and pension benefits paid by private funded pension funds, the same problems and suggestions to solve them apply – see above.

## The capital account

2.278. Most of the components in the capital account have already been addressed under the heading of GDP(E). The only exceptions are capital transfers and acquisitions less disposals of non-produced non-financial assets.

### *Capital transfers*

2.279. Capital transfers are defined and analysed in ESA 2010, [§4.145-4.167](#), and in 2008 SNA, §10.200-10.212. There are no particular quarterly measurement issues for the components capital taxes and investment grants, as quarterly estimates can usually be derived from quarterly government sources or the balance of payments. Problems may, however, be encountered with the estimation of other capital transfers.

### **Other capital transfers**

2.280. Investment grants and other capital transfers are defined and analysed in ESA 2010, [§4.164-4.167](#) and in 2008 SNA, §10.210-10.212.

#### *Issues*

2.281. Other capital transfers include a wide range of rather heterogeneous transactions. The availability of direct quarterly information for this component depends to a great extent on the involvement of government or the rest of the world in transactions. If they are involved, there often will be some quarterly data, probably including counterpart information. However, it is common for there to be little quarterly data for other capital transfers between domestic private sectors.

#### *What to do*

2.282. The gap concerning the missing data on capital transfers between domestic private sectors can be filled by applying temporal disaggregation techniques to the more sound and complete annual estimates (see Chapter 5). In addition, the balancing process will enable missing items to be derived as residuals.

### **Acquisitions less disposals of non-produced non-financial assets**

2.283. Acquisitions less disposals of non-produced non-financial assets are defined and analysed in ESA 2010, [§3.184-3.194](#), and in 2008 SNA, §10.164-10.199. There are three distinct types of non-produced non-financial assets: natural resources; contracts, leases and licences; and goodwill and marketing assets.

2.284. In the case of natural resources, all transactions are between resident units and for the total economy they net to zero. The task of estimation is therefore to measure transactions between domestic institutional sectors. Administrative sources can often provide the required data.

2.285. Estimation of transactions concerning the other two types of non-produced non-financial assets is more problematic, and the same strategies used in deriving annual estimates should be employed.

### **Ideal data requirements for QNA**

2.286. This section specifies ideal and minimum sets of data needed for the derivation of estimates of QNA of good and acceptable quality, respectively.

2.287. The precise specification of desirable data sets depends to a certain extent on the economic structure in a country and the importance of the various components in the accounts. For example, if agriculture represents 1-2% of GDP in one country, the statistics can be based on less information for this industry than for a country where the proportion is, say, 10%.

2.288. The sets of data suggested here do not deal with the above considerations explicitly or with the accuracy of the information collected. With regard to the latter, suffice it to say that the accuracy of the basic data is a major determinant of the quality of the national accounts.

2.289. The data set, described below, is designed to meet nearly all of the basic data requirements for compiling quarterly estimates as per the OECD-Eurostat national accounts questionnaire. This includes:

- the production, expenditure and income approaches to measuring GDP at current prices and in volume terms for the first two;
- the primary and secondary distribution of income accounts and use of disposable income accounts;
- capital accounts;
- financial accounts.

2.290. All of these data are expected to be compiled with the required industry, institutional sector and asset-type detail. There may be some other, minor information required from government and non-government sources. Consideration also needs to be given to any additional data needed to meet country requirements, such as regional data, more detailed industry data and product breakdowns to meet the needs of supply and use tables and deflation.

### ***Suggested “ideal” data set for compiling quarterly estimates***

(Some items are marked with an “\*” - for an explanation see §2.301.)

#### ***Quarterly budget expenditure surveys\****

2.291. Expenditures on goods and services. Three key points are the need for the sample to be:

- representative;
- rotated reasonably slowly (e.g. one eighth rotation each quarter);
- sufficiently large to ensure reasonably accurate estimates.

#### ***Business surveys***

2.292. These should collect information by industry and institutional sector, as appropriate, on:

- sales/turnover;
- purchases\*;
- gross fixed capital formation by principal asset type;
- inventories;
- compensation of employees;
- gross operating surplus;
- employment;
- financial information\*.

Inventories should be collected for different stages of processing, where significant. For example, mining (intermediate inputs, outputs), manufacturing (intermediate inputs, work-in-progress, finished goods), wholesale and retail trade (goods for resale), service industries that produce products that may not be completed in a quarter (work-in-progress).

2.293. Specific business surveys are generally run to support the monthly index of production and the monthly (or quarterly) index of retail sales. Some product/commodity breakdown is desirable for production and expenditures to aid the construction of quarterly supply and use tables and deflation.

**Box 2.1. Ideal data requirements for quarterly national accounts**

- *Quarterly household budget surveys\**
- *Business surveys*
  - sales/turnover;
  - purchases\*;
  - gross fixed capital formation by principal asset type;
  - inventories;
  - compensation of employees;
  - gross operating surplus;
  - employment;
  - financial information\*;
  - sectoral and industry breakdown.
- *Government spending and receipts*
  - data to compile the accounts with respect to the general government sector;
  - data needed to split government final consumption expenditure into its collective and individual components;
  - current taxes on income and wealth;
  - taxes and subsidies on products, and production and imports;
  - property income receivable and payable;
  - social contributions to government social security schemes;
  - social benefits payable to households.
- *Balance of payments and international investment position*
- *Other primary and secondary income flows*
  - dividends paid and received by corporations;
  - interest flows between sectors;
  - non-life insurance premiums, property income attribute to policyholders, claims and changes in technical provisions;
  - life insurance and annuity premiums, property income attribute to policyholders, claims, and changes in entitlements;
  - non-government pension schemes: contributions, payments and changes in pension entitlements.
- *Price indices*
  - Consumer price indices;
  - Producer price indices for goods (including agriculture);
  - Producer price indices for services\*;
  - Export and import prices for goods.

***Government spending and receipts***

2.294. Sufficient information should be available on an accrual basis to compile all the required estimates relating to the general government sector, including:

- the data needed to split government final consumption expenditure into its collective and individual components;
- current taxes on income and wealth;
- taxes and subsidies on products, and production and imports;
- property income receivable and payable;
- government social security schemes (pension and non-pension): contributions and benefits.

***Other primary and secondary income flows***

2.295. The major items required are:

- dividends paid and received by corporations;
- (pure) interest flows between sectors;
- non-life insurance premiums, property income attributed to policyholders and claims; life insurance and annuity property income attributed to policyholders;
- non-pension social insurance benefits from other employment-related schemes: actual and imputed contributions, property income payable on non-pension entitlements and benefits;
- pensions payable under a defined contribution scheme: property income earned by pension fund, property income payable on pension entitlements, actual contributions, household pension contribution supplements, benefits;
- pensions payable under a defined benefit scheme: property income earned by pension fund, property income payable on pension entitlements, actual and imputed contributions, household pension contribution supplements, benefits.

2.296. Dividends paid and received by corporations may be available from the tax office, otherwise they can be included in the surveys run to obtain balance of payments income flows. The bulk of interest flows are available from either the central bank or a prudential regulatory authority responsible for supervising financial intermediaries. Likewise, data relating to insurance and non-government pension schemes are commonly available from prudential regulatory authorities. Ideally, it is also desirable to have estimates of the service charges for insurance and pensions from the corporations, but this may hard to obtain.

***Balance of payments and international investment position and international trade statistics***

2.297. Data are required from the goods and services account, primary and secondary income accounts, capital account and financial account of the balance of payments and international investment position. These accounts provide the following data:

- exports and imports of goods (f.o.b.) and services;
- primary income transactions with non-residents;
- secondary income transactions with non-residents;
- capital transfers with non-residents.



2.298. In addition, detailed international trade statistics are required to support the compilation of quarterly supply and use tables and the compilation of chain-linked volume estimates of exports and imports of goods and services.

### *Price indices*

2.299. These should cover:

- Consumer price indices;
- Producer price indices for goods (including agriculture);
- Producer price indices for services\*;
- Export and import prices for goods;
- Wage cost indices.

### *Tax authorities and government administrative sources*

2.300. Information on the following variables may be available from government administrative sources for use in the compilation of the income measure of GDP:

- Wages and salaries;
- Operating surplus;
- Mixed income;
- Dividends paid and received.

2.301. The above list should be regarded as an ideal, main data set. It includes certain items (marked \*) that should ideally be part of a national statistical system, but for reasons such as high cost or respondent burden are either absent quarterly or suffer from severe measurement problems. In such cases compromises may be made that still enable the compilation of estimates of adequate quality.

- a. The cost of running a *household expenditure survey* that meets the specified criteria and incurs the associated respondent burden make it somewhat of a luxury. For this reason, much less frequent surveys that relate to a year are more common.
- b. *Purchases* by businesses are useful for deriving estimates of gross value added, but given that output to intermediate consumption ratios can be expected to change relatively slowly in volume terms, adequate estimates can generally be made by making assumptions for most industries.
- c. *Financial* (and international investment) *information* are required for the financial accounts and the balance sheet. International investment information can be obtained from balance of payments and international investment position sources and is not addressed further here. Financial information should ideally be obtained from both parties to every financial transaction and/or position. This is very expensive and so in practice data are often only collected from one party to a financial transaction and/or position. Advantage is taken of the fact that financial transactions of numerous transactors, such as households, are mostly channelled through a much smaller number of other units, such as banks and other financial institutions. Thus surveys of financial information are heavily focused on financial institutions. Also, much data are available from the central bank and prudential regulation authorities.
- d. Producer price indices for goods have a much longer history and are much more commonly compiled than *producer price indices for services*. However, in recent years substantial progress has been made in developing the latter (see the IMF's *Producer Price Index Manual, 2004*). If producer price indices for services are unavailable, then input price

indices may be used, namely wage cost indices and the price indices of other inputs. Using such indices implicitly assumes no productivity growth and should therefore be seen as a last resort.

### Summary of main points

- 2.302. This chapter identifies the basic data requirements for compiling QNA, lists basic data commonly used and, in Annex 2.A, identifies data that are routinely collected to meet EU regulations. It describes the major problems encountered when using the data available and makes suggestions as to how these problems might be dealt with.
- 2.303. The two main measurement principles are to ensure that (i) estimates are compiled on an accrual basis as well as possible and (ii) they are recorded consistently throughout the accounts. Consistency with the financial accounts should not be forgotten and where cash figures are modified a corresponding adjustment is needed for the financial accounts. The need to differentiate between arrangements for unadjusted and seasonally adjusted data is also raised.
- 2.304. Some of the discussion concerns how quarterly estimates may be made when administrative arrangements or recording practices do not yield sensible quarterly figures, or where no quarterly data are available at all. The proposed approach is to make the best annual estimate for the current year and to establish the most appropriate quarterly profile. Annual estimates may be based on the historic run of data, together with any other information of relevance. The quarterly profile should make use of any appropriate information associated with the variable. Adjustment factors that seek to allow for any historic bias in the quarterly series may need to be included. In the complete absence of any directly related quarterly data, the profile may be based on a suitable indicator of related economic activity. Chapter 5 provides comprehensive guidance on the use of mathematical and statistical methods to impute quarterly values that are consistent with annual benchmarks, both in cases where there are quarterly indicators and in cases where there are none.
- 2.305. Some regular distortions that occur in the quarterly figures may be reduced or eliminated as a result of seasonal adjustment. Also, inconsistencies tend to be ironed out during the balancing process. However, this should not be viewed as the main way of dealing with the distortions, for it is important that the best possible estimates should enter the balancing exercise. The outcome for a given QNA variable and the accounts overall is likely to be better when such adjustments are made directly, rather than letting them be derived as a result of the general balancing process. When adjustments are repeatedly needed to quarterly series consideration should be given to possible changes in collection, recording or estimation practices so that such adjustments can be avoided in the future.
- 2.306. Estimating changes in inventories accurately is usually very difficult, and they are often derived residually or subject to major adjustments in the balancing process. A strategy is described for ensuring adjustments made to quarterly estimates of changes in inventories are consistent with the estimates of inventory levels from business surveys in the short to medium term. Thus ensuring estimates of changes in inventories are meaningful in the longer run.

## 2. Annex A — Community legislation in the field of short-term statistics

- 2.A1. Setting the ideal and minimum data requirements for QNA represent the first step towards the harmonization of basic statistics to be used in the compilation of QNA. As remarked in Chapter 2, the sources that can be used to collect quarterly information are quite disparate and so too are the approaches and methods.
- 2.A2. Community legislation in the field of statistics aims to suggest and recommend both principles and rules to obtain harmonized basic statistics so to allow an easier compilation and comparison of national accounts. In the following paragraphs, the Community legislation concerning short-term statistics and national accounts is introduced to illustrate some general principles to be applied and to illustrate the direction in which harmonized statistics are moving. Clearly, the principles that underlie Community legislation are general principles suitable to be used in any country to compile basic national accounts statistics.
- 2.A3. The objective of Community legislation is to establish a common framework for the production of Community statistics. Harmonization of concepts, norms, and standards is a prerequisite to the comparability of statistics. The evolution of the European Statistical System involves more statistical harmonization to supply firmly-based statistics fully comparable at all levels.
- 2.A4. The following paragraphs examine the Community legislation in more detail. The following areas are considered:
- the system of short-term business statistics;
  - final consumption statistics and consumer prices;
  - employment statistics;
  - trade statistics: trading of goods between Member States (Intrastat) and with third countries;
  - balance of payments and international investment statistics.

### ***Box 2.A.1. Council Regulation on European Statistics***

The main reference concerning European statistics is Regulation (EC) n° 223/2009 of the European Parliament and of the Council of 11 March 2009 on European statistics (“the Statistical Law”) whose purpose is to establish a legal framework for the development, production and dissemination of European statistics with a view to the formulation, application, monitoring and assessment of the policies of the Community.

Statistics means quantitative and qualitative, aggregated and representative information characterizing a collective phenomenon in a considered population. European statistics are relevant statistics necessary for the performance of the activities of the Community. European statistics are determined in the European statistical programme.

**Box 2.A.2. Basic statistics: principles for quality***(art. 2, Regulation n°52/2)**Statistical principles**(art. 2, Regulation n°223/2009)*• *Professional independence*

Statistics must be developed, produced and disseminated in an independent manner, particularly as regards the selection of techniques, definitions, methodologies and sources to be used, and the timing and content of all forms of dissemination, free from any pressures from political or interest groups or from Community or national authorities, without prejudice to institutional settings, such as Community or national institutional or budgetary provisions or definitions of statistical needs.

• *Impartiality*

Statistics must be developed, produced and disseminated in a neutral manner, and that all users must be given equal treatment.

• *Objectivity*

Statistics must be developed, produced and disseminated in a systematic, reliable and unbiased manner; it implies the use of professional and ethical standards, and that the policies and practices followed are transparent to users and survey respondents.

• *Reliability<sup>(1)</sup>*

Statistics must measure as faithfully, accurately and consistently as possible the reality that they are designed to represent and implying that scientific criteria are used for the selection of sources, methods and procedures.

• *Statistical confidentiality*

The protection of confidential data related to single statistical units which are obtained directly for statistical purposes or indirectly from administrative or other sources and implying the prohibition of use for non-statistical purposes of the data obtained and of their unlawful disclosure.

• *Cost-effectiveness*

The costs of producing statistics must be in proportion to the importance of the results and the benefits sought, that resources must be optimally used and the response burden minimized. The information requested shall, where possible, be readily extractable from available records or sources.

<sup>(1)</sup> This definition of reliability is different to that used elsewhere in the Handbook – see §10.9.

**The system of short-term business statistics*****Reference Community legislation***

- 2.A5. In the field of short-term business indicators, the main reference for the Community legislation is the regulation on short-term statistics and the corresponding manual “Methodology of short-term business statistics – Interpretation and guidelines”.

***Characteristics of the system of short-term business indicators***

- 2.A6. The system of short-term business indicators (STS) provides activity indicators for much of the economy (essentially the whole economy less agriculture and fishing and industries dominated by the general government sector), subdivided into “industry” (mining, manufacturing, electricity, gas, and water), construction, and services. The primary indicators are:

- a. Common indicators (apply to all industries covered):
  - employment;
  - hours worked;
  - wages and salaries.
- b. Industry indicators:
  - production;
  - turnover;
  - output prices (domestic and non-domestic markets);
  - import prices.
- c. Construction indicators:
  - production;
  - construction costs and prices;
  - building permits.
- d. Services indicators:
  - turnover;
  - deflator of sales;
  - output prices of services.

### ***Wages and salaries***

- 2.A7. Compensation of employees comprises wages and salaries and employers social contributions. The STS requires that the wages and salaries component should be collected for industry and construction.

### ***Production indices***

- 2.A8. Production indices are derived for the industry and construction sub-sectors. Ideally, production indices should measure the monthly growth in the volume of value added. In practice, they are derived by weighting together volume indices of output, or surrogates for output, at a detailed level (preferably the 4-digit level of NACE) using estimates of value added to form chain Laspeyres volume indices.
- 2.A9. If output indicators are not available for an industry then turnover may be used, and if turnover data are not available then input data may have to be used. Output may be measured for an industry, at say the 4-digit level, at current prices and then deflated using an output price index. Alternatively, the growth in the volume of output may be made by recording the change through time of quantities of representative products.
- 2.A10. The monthly (or quarterly) elemental volume indices of output (or a surrogate) are weighted together using annual current price values of value added. Ideally, these annual weights should be updated each year, but certainly no less frequently than every five years.
- 2.A11. If the annual estimates of value added used to derive the production indices are the same as the national accounts estimates of gross value added, then it may be possible to use the production indices directly in the national accounts (subject to balancing and validation — see Chapters 8

and 9). Otherwise, national accountants have to construct volume measures of gross value added themselves, using value added weights from the national accounts. In any case, the elemental volume estimates of output (and current price estimates of output if they exist) can be used to populate quarterly supply and use tables — see Chapter 8.

### *Turnover indices*

- 2.A12. Turnover indices are derived for the industry and services sub-sectors. Turnover is a measure of sales plus other income earned by a producer. It differs from the output of a producer of goods to the extent no account is taken of changes in inventories of finished goods and work in progress. In the case of producers of distributive services, such as wholesale and retail trade, there is an additional difference between output and turnover because in measuring turnover no account is taken of the cost of goods sold.
- 2.A13. Volume indices of turnover at a detailed level (preferably the 4-digit level of NACE) are aggregated together using annual current price values of turnover as weights to form chain Laspeyres volume indices. As for production indices, it is desirable that the weights be changed annually.
- 2.A14. In the absence of production indices or output data, current price and volume estimates of turnover may be used at a detailed level as indicators of growth to form chain-linked volume estimates of gross value added for service industries. Essentially, the turnover weights used to derive aggregate volume indices of turnover are replaced by gross value added weights at as detailed a level as possible.
- 2.A15. The current price and volume estimates of turnover can also be used to support the construction of quarterly supply and use tables, including the estimation of demand-side variables. In particular, they may be used to derive estimates of components of household final consumption expenditure.

### *Output and other price indices*

- 2.A16. The STS regulations require the compilation of various price indices, including output price indices for industry and services on a basic price basis. In the case of industry, price indices are required for exports and imports. In the case of services, output price indices are restricted to the provision of services produced by a domestic enterprise for another enterprise (or a person representing an enterprise). In addition, the STS regulations require price indices for retail sales and construction cost indices. Together, the various price indices compiled under the STS umbrella provide a large proportion of the price indices required to compile the national accounts.

### *Employment and hours worked*

- 2.A17. The STS regulation requires employment and hours worked be compiled for most of the economy, with the KAU as the survey unit. As a result, most countries choose to use a single survey vehicle to collect these labour statistics and other statistics, such as wages and salaries. Indices of labour input, like employment and hours worked, are valuable tools for assessing labour input during the business cycle and for calculating labour productivity growth. However, care needs to be taken in dealing with the limitations of labour input data collected from businesses, such as the employment numbers are likely to be job counts and the hours worked data may record hours paid, rather than hours worked.

## Other short-term business statistics

2.A18. Outside the scope of the STS regulation, it is common for NSIs to collect other high frequency business statistics that may be used to either compile QNA variables and auxiliary indicators (e.g. labour productivity indices), or be used for validation purposes (see Chapter 9). They may include the following:

- a. *Capacity utilisation*: gives a view on the utilisation of the capital stock of an enterprise in the production of goods and services.
- b. *Inventories*: quantifies opening and closing inventories and supports the estimation of changes in inventories. Ideally, the data should be available for each industry division and by subdivision for the major inventory-holding divisions. For at least manufacturing, a break down into raw materials, semi-finished goods and finished goods is required.
- c. *Investment*: brings together the information related to gross fixed capital formation.
- d. *Input price indices*: these indices, which should be calculated on a purchasers' prices basis, may be used to deflate the intermediate consumption of goods and to estimate the changes in inventories of intermediate consumption goods. They are particularly useful when compiling supply and use tables.
- e. *Foreign trade*: information on imports and exports (in volume and value) on an industry breakdown. It should be split into intra-EU and extra-EU markets.
- f. *New orders received*: a quantitative statistic that can be measured in two ways:
  - new orders received, which show the latest trend in future demand;
  - stock of orders, which shows the cumulated demand on a given branch for the near future.
- g. These data are useful for validation purposes, and may be useful for deriving flash estimates.
- h. *Enterprise success and failure*: measures the deaths and the births of enterprises, and is very helpful in assessing up-swings and down-swings of the economy.

2.A19. In order to describe the short-term path of the economy, the above-mentioned business statistics should satisfy certain requirements:

- accuracy and representativeness;
- timeliness;
- a wide range of complementary indicators;
- comparability of statistics between countries;
- clarity.

2.A20. For QNA the most important requirements are timeliness, harmonization and integration.

- timeliness is required to meet the short-term needs of business and government;
- harmonization across Member States is to maximize comparability and make it easier for analysts of multi-national data;
- integration underlies the role that each set of statistics has in the national accounts and the interrelations between the elements that compose the system.

## Final consumption statistics

- 2.A21. The main sources used in compiling quarterly estimates of household final consumption expenditure are the sales or turnover statistics available from STS collections and household expenditure surveys (see §2.101-2.106). Volume estimates of household final expenditure are commonly derived using consumer price indices. If the estimates are derived within supply and use tables, producer price indices may be used to deflate values transformed to be at basic prices.
- 2.A22. Estimates of government final consumption expenditure are usually derived using government finance statistics. Consumer price indices and producer price indices are used to deflate current price values of purchases, and wage cost indices are used to deflate compensation of employees, but some components of government final consumption expenditure may be derived using quantity indicators available from administrative sources.

## Employment

### *Reference Community legislation*

- 2.A23. The main Community statistical legislation in the field of employment is the Council Regulation concerning labour force surveys (LFSs). It is expressly conceived and conducted in order to collect information about a specific subject: the labour force, such as employment, unemployment and labour force participation.
- 2.A24. The quarterly LFS is part of the general population survey conducted, at present, by most of the EU Member States. This survey provides monthly and quarterly data, and is based on ANA analysis of random representative samples of the population. The samples are taken of households resident in the national economic territory when the survey is carried out. A questionnaire is completed for each household either by a survey enumerator who visits the household or by telephone. Each questionnaire is completed in respect of a particular reference week in the month. Some Member States are able to extract much of the required information from population registers.
- 2.A25. The main information collected by the population survey concerns: the demographic context (age, sex, birth date, marital status, nationality, etc.), the activity status (employment or unemployment during the reference week, reasons for the unemployment, job-search activities, etc.), characteristics of the actual job, hours worked, secondary activity, search for a job, education and professional qualifications, previous professional experience, one-year-before situation, principal employment status, and possibly wages and salaries. From a QNA perspective, the more relevant information is the data on hours worked and activity status, and wages and salaries if collected.

## Import and export data

### *Reference legislation*

- 2.A26. The EU legislation in the field of trade statistics comprises:
- Trade statistics related to the trading of goods between the Member States, whose legal basis is Regulation (EC) No 638/2004 of the European Parliament and of the Council amended by Regulation (EC) No 222/2009 of 31 March 2004 on Community statistics



relating to trading of goods between Member States and repealing Council Regulation (EEC) No 3330/91.

- b. Trade statistics related to the trading of goods with third countries, whose legal basis the Regulation (EC) No 471/2009 of the European Parliament and of the Council of 6 May 2009 on Community statistics relating to external trade with non-member countries and repealing Council Regulation (EC) No 1172/95.

### ***Statistics relating to the trading of goods with third countries***

- 2.A27. Statistics on the trading of goods by the EU and its Member States with non-member countries are compiled on the basis of customs declarations. They refer to all goods that on entering or leaving the statistical territory of the EU are subject to customs procedures or customs approved treatments which belong to the scope of extra-EU trade statistics.
- 2.A28. The statistical information in customs declarations must indicate, among others, the trade flow; the reference period; the statistical value of the goods; the quantity of goods; the partner country (the country of origin and the country of consignment for imports, the country of destination for exports); the commodity code, the customs procedure code to be used for determining the statistical procedures and the mode of transport.
- 2.A29. Member States have to transmit on a monthly basis statistics on their trade with non-member countries to Eurostat.

### ***Statistics relating to the trading of goods between Member States***

- 2.A30. EU statistics relating to the trading of goods between Member States have been developed to cover the statistical needs in measuring progress in integrating Europe's economies, helping European businesses conduct market analyses, providing information for balance of payments statistics, national accounts and short-term economic studies.
- 2.A31. The collection of the data necessary to compile statistics relating to the trading of goods is based on the data collection system called Intrastat. The Intrastat system can be characterised as follows: a) data are directly collected from traders, b) it is closely interlinked with the VAT system relating to intra-EU trade in order to ensure completeness and quality of the statistical data, and c) the threshold system is to simplify data provision and reduce overall burden on traders. The system covers both movements of goods leaving the Member State ("dispatches") and movements of goods entering the Member State ("arrivals").
- 2.A32. The statistical information provided by the Intrastat respondents includes the trade flow; the reference period; the commodity code, the partner Member State (country of consignment for arrivals, country of destination for dispatches); the value of goods; the quantity of goods and the nature of the transaction.

## **Balance of payments and international investment position**

### ***Reference legislation***

- 2.A33. The main reference in the balance of payments field is the sixth edition of the Balance of Payments and International Investment Position compiled by the International Monetary Fund, 2008 ("BPM6"). The balance of payments and IIP data are collected in the European Union and

are published by Eurostat in accordance with the procedures set out in the BPM6. BPM6 is totally consistent with ESA 2010/2008 SNA concepts and requirements.

### *The balance of payments and IIP statistics*

- 2.A34. The balance of payments and IIP data are not really a set of basic statistics in the sense of the previous paragraphs. They are in essence national accounts statistics, albeit presented in a different way than in the national accounts, and they can be viewed as a special and detailed subset of the national accounts. As such, the data can be used directly in QNA.
- 2.A35. The current account in the balance of payments and IIP shows flows of goods, services, primary income, and secondary income between residents and non-residents. Accordingly, it is subdivided into three sub-accounts: goods and services, primary income and secondary income.
- 2.A36. The balance on these accounts is known as the current account balance. The current account balance shows the difference between the sum of exports and income receivable and the sum of imports and income payable (exports and imports refer to both goods and services, while income refers to both primary and secondary income). The value of the current account balance equals the saving-investment gap for the economy. Thus, the current account balance is related to understanding domestic transactions.
- 2.A37. The capital account shows credit and debit entries for non-produced non-financial assets and capital transfers between residents and non-residents. It records acquisitions and disposals of non-produced non-financial assets, such as land sold to embassies and sales of leases and licences, as well as capital transfers, that is, the provision of resources for capital purposes by one party without anything of economic value being supplied as a direct return to that party.
- 2.A38. The financial account shows net acquisition and disposal of financial assets and liabilities.
- 2.A39. The sum of the balances of the capital and financial accounts give an aggregate balance, which is equal – in concept – to the balance on the current account.
- 2.A40. Alternatively, the sum of the balances on the current and capital accounts represents the net lending (surplus) or net borrowing (deficit) by the economy with the rest of the world. This is conceptually equal to the net balance of the financial account. In other words, the financial account measures how the net lending to or borrowing from non-residents is financed. The financial account plus the other changes account explain the change in the international investment position between beginning- and end-periods.

### *Current Account*

#### *Goods*

- 2.A41. Goods usually represent the biggest category of the current account. They cover general merchandise, non-monetary gold, goods for processing, repairs of goods and goods procured in ports by carriers. The evaluation of these items has to be made f.o.b. (free on board) for both imports and exports.
- 2.A42. It has to be noted that the balance of payments does not have a product breakdown. For this reason, for quarterly purposes, the use of foreign trade statistics represents a valid instrument to have a product breakdown for supply and use and deflation purposes.

### *Services*

- 2.A43. The breakdown of services foreseen by the BPM6 contains a higher level of detail than in the past. The main services identified are Transport, Travel, Construction, Insurance and pension services, Financial services, Charges for the use of intellectual property n.i.e., Telecommunications, computer, and information services, Other business services, Personal, cultural, and recreational services, Government goods and services n.i.e.

### *Primary income*

- 2.A44. This account contains three main items: compensation of employees, investment income and other primary income. The former records wages, salaries and other benefits, in cash or in kind, earned by individuals for work performed for foreign economic units (border workers, seasonal workers, employees of international organisations, etc.).
- 2.A45. Investment income covers income which a resident entity derives from the ownership of external financial assets (credit) and income non-residents derive from their financial assets invested in the compiling economy (debit). The components are classified as direct investment, portfolio investment, other investment income and reserve assets.
- 2.A46. Other primary income comprises rent, taxes on production and imports, and subsidies.

### *Secondary income*

- 2.A47. This account mainly comprises transfers: Personal transfers, Current taxes on income, wealth, etc., Social contributions, Social benefits, Net premiums on non-life insurance and standardised guarantees, Non-life insurance claims and calls under standardised guarantees, Current international cooperation, Miscellaneous current transfers. In addition, it records an adjustment for changes in pension entitlements.

### *Capital account*

- 2.A48. This account has two headings: Acquisitions/disposals of non-produced, non-financial assets (Natural resources, Contracts, leases, and licenses, and Marketing assets) and Capital transfers (Debt forgiveness and Other).

### *Financial account*

- 2.A49. This account records changes in the holdings by residents of financial assets and liabilities according to the following categories: Direct investment, Portfolio investment, Financial derivatives (other than reserves) and employee stock options, Other investment, and Reserve assets. There are also three “of which” items: Equity and investment fund shares, Debt instruments, and Other financial assets and liabilities.

### 3. Processes for acquiring basic data

In order to compile the best quality national accounts with the data available, it is crucial that national accounts compilers have a good understanding of the basic data they are using. They need to know how well the definitions and coverage match QNA variables they are being used to estimate, how the data are derived, their accuracy and any biases. They also need to be aware of any impending changes to their source data and any economic events that may not be adequately captured in them. For these reasons, national accounts compilers should endeavour to develop a good working relationship with their data suppliers in order to get the best possible service from them. Failure to do so can mean poor basic data, more work for the national accountants in trying to remedy the problems and inferior estimates at the end of it.

## Introduction

- 3.1. The major use of QNA is to find out where the economy is heading, hence the need for timeliness and sufficient accuracy and reliability. The principal interest is in short-term growth rates, hence attention is focused on seasonally adjusted data and volume estimates where available. It is clear, therefore, that in selecting, measuring and adjusting basic quarterly data, the emphasis is on the timely and accurate measurement of growth. But at the same time it is critical that QNA should portray a coherent and consistent picture of how the economy has performed.
- 3.2. Chapter 2 identifies the basic data requirements for compiling QNA. It discusses common occurrences of where the available basic data do not meet national accounts specifications and makes suggestions as to how these deficiencies can be addressed. Nevertheless, quarterly basic data are generally inferior to their annual counterparts and it is common practice to use annual data to improve the quality of quarterly data by modelling and benchmarking (see Chapters 4 and 5).
- 3.3. Modelling and benchmarking quarterly basic data to their annual counterparts have their limitations, however, particularly for the most recent quarters, i.e. those that fall after the latest annual benchmark. In order to obtain an accurate quarterly distribution within years and accurate measures of growth for the latest quarters, it is necessary to:
  - endeavour to obtain quarterly basic data that both adhere to national accounts definitions and accurately measure the growth of national accounts variables as well as possible;
  - make appropriate adjustments when the basic data fall short of these requirements;
  - make further adjustments to ensure that QNA are coherent and consistent.
- 3.4. In order to achieve these objectives it is crucial that national accounts compilers have a good understanding of the basic data they are using. They need to know how well the definitions and coverage match QNA variables they are being used to estimate, how the data are derived, their accuracy and any biases. This is not a one-off exercise; basic data need to be monitored continuously because new problems can emerge at any time. For this reason, national accounts compilers should endeavour to develop a good working relationship with their data suppliers in order to get the best possible service from them. Failure to do so can mean poor basic data, more work for the national accountant in trying to remedy the problems and inferior estimates at the end of it. This chapter is devoted to exploring these themes in detail.
- 3.5. Source data for the national accounts generally fall into one of five categories:
  - a. data from official business and labour force surveys (e.g. output, sales, compensation of employees, new capital expenditure, inventories and employment);
  - b. administrative data from government organisations (e.g. government finance (including VAT) statistics, international trade (customs), new motor vehicle registrations (in some countries), health and education output, financial assets and liabilities of financial institutions, and insurance data);
  - c. publicly available data from research institutes, news agencies, etc. (e.g. opinion surveys and other qualitative data);
  - d. data from professional unions and industry bodies (e.g. information relating to doctors, dentists, lawyers and pharmacists);
  - e. quarterly company reports or special, tailored surveys of a few very large private and public corporations (e.g. utilities and transport usage).

The remainder of this chapter focuses on sources (a) and (b) because they provide the bulk of the data for QNA and the recommendations made in respect of them can be readily applied to data from the other types of sources.

## Sample surveys

- 3.6. Ideally, basic data in category (a) would cover the entire population to which an economic phenomenon relates. While in theory information can be collected for the entire statistical population using exhaustive surveys (censuses) this is usually too costly, both for the NSI and the respondent population. In practice, the basic information is usually collected via sample surveys in which data are collected from a random sample and then grossed up to be representative of the entire population.
- 3.7. The basis for sample surveys of businesses is a business register. A business register is a database that holds information about businesses, such as their name, address, unique business number, type of business (partnership, company, etc.), institutional sector to which the business belongs, and the type of economic activity (NACE) it predominantly or exclusively undertakes. In order to make an estimate of retail sales, for example, those businesses categorized as retailers can be drawn from the business register, a random sample can be taken, questionnaires can be sent to those businesses in the sample and their responses tallied. An estimate of total sales by ALL retailers,  $X$ , can then be derived using “number-raised” estimation, via the following formula:

$$\hat{X} = \frac{N}{n} \sum_{j=1}^n x_j \quad \text{where}$$

$N$  is the number of businesses in the population (i.e. all retailers)

$n$  is the number of businesses in the sample

$x_j$  is the value of sales reported by the  $j^{\text{th}}$  business in the sample

- 3.8. [Different types of business unit](#) may be stored on the business register, such as: legal entities, enterprises, kind-of- activity unit (KAU), or local KAU (or establishments). The type of unit used in the survey can have an important bearing on the survey estimates. For measuring production, KAUs or local KAUs are the preferred kind of statistical unit (see Chapter 2 of the ESA 2010). If in the above example the population of retailers drawn from the business register are local KAUs and if all their sales in a period are known and if the register is up to date, then the aggregate sales made by all these business should give a close approximation of true retail sales. By contrast, if the statistical units are enterprises, then the approximation would not be as good because enterprises may undertake secondary activity: some enterprises might have sales other than retail sales and there might be some retail sales made by enterprises classified to a different industry, such as wholesale trade.
- 3.9. It is common for some economic data to be stored on the register, such as employment, that can be used as a benchmark variable. Such data allow the sample to be stratified by size; for example, businesses with 0-10 employees, businesses with 11-20 employees, businesses with 21-50 employees, etc. By selecting a higher proportion of businesses in the larger size categories, it is possible to achieve smaller sampling errors for a given number of units in the total sample.

3.10. An estimate of  $X$  is then derived as

$$\hat{X} = \sum_{i=1}^s \frac{N_i}{n_i} \sum_{j=1}^{n_i} x_{ij} \quad \text{where there are } s \text{ strata}$$

$N_i$  is the number of units in the population of the  $i^{\text{th}}$  stratum

$n_i$  is the number of units in the sample of the  $i^{\text{th}}$  stratum

$x_{ij}$  is the value of sales of the  $j^{\text{th}}$  unit in the  $i^{\text{th}}$  stratum

3.11. The ratio of  $N_i$ :  $n_i$  is the “expansion” factor of the  $i^{\text{th}}$  stratum. It is common to have a complete enumeration of the largest business strata, in which case the expansion factor is 1.

3.12. In practice, it is common to have quite detailed stratifications in order to meet the needs of the survey estimates. For example, in order to produce estimates by region by industry, then the sample would need to be stratified by region by industry by business size. If there are up-to-date ancillary data available for the population that are highly correlated with the target variable(s), then they may be used to produce estimates with even smaller sampling errors than estimates derived using number-raised estimation. For example, if sales and wages data are available from the tax office for the whole population of business units and they are highly correlated with the national accounts measures of output, intermediate consumption and compensation of employees collected in previous sample surveys, then generalized regression estimation<sup>(12)</sup> (GREG) may be used to reduce the sampling errors of the sampled strata. This is achieved by calibrating the number-raised expansion factors to take account of the representativeness of the random sample drawn for each stratum. For example, samples which, by chance, contain too many small units (as measured by the magnitude of their tax data benchmarks relative to those of the population average) will have their expansion factors adjusted upward.

3.13. For a comprehensive description of how to go about conducting a business survey, refer to the Eurostat *Handbook on the Design and Implementation of Business Surveys, 2000*.

### **Issues encountered with sample surveys**

3.14. The sampling errors of survey estimates may be estimated given the size of the population, the size of the sample, the variability of the data being estimated, the estimation method used and the characteristics of any benchmark data being used.

3.15. In addition to sampling errors, there are non-sampling errors that arise from a number of causes; the major ones are as follows:

- a. respondent errors in the questionnaire;
- b. deficiencies in the business register:
  - industry and institutional sector coding inaccuracies;
  - business register is not up to date and excludes some active businesses;
- c. a high level of non-response, which can lead to biased estimates;
- d. compilation errors.

<sup>(12)</sup> See for example DEVILLE, J.C. & SARNDAL, C.E. (1992). *Calibration estimators in survey sampling*. Journal of the American Statistical Association, 87, 376-382.

- 3.16. Reporting errors by respondents in the questionnaire can be minimized by careful questionnaire design and testing using pilot surveys, such that
- respondents understand the questions;
  - respondents are generally able to supply the required information;
  - built-in editing checks enable respondent errors to be detected;
  - the questionnaires are not overly burdensome.
- 3.17. Both sampling and non-sampling errors can be minimized by careful editing. This involves ensuring each survey response is internally consistent and by comparing each business's response with those reported by it in the previous period and those reported by similar businesses. It is common practice to have editing rules, whereby there is a prescribed action to be taken by the survey statisticians for each given circumstance.
- 3.18. It is important to achieve high response rates. There is the obvious benefit that for a given sample size the higher the response rate the lower the sampling error, but a low response rate can also mean that those who have responded are not representative of the population, in which case the estimates will be biased. It is therefore standard practice to make imputations for both incomplete responses and null responses using the data actually supplied in the case of an incomplete response, data supplied in the previous period, and data supplied by similar businesses. But, obviously, it is best if imputations are kept to a minimum.
- 3.19. An out-of-date business register includes units that have ceased to operate and it does not include new businesses. Having "dead" units on the register just reduces the efficiency of the sampling. In other words, the actual sampling error is greater than what was expected before the survey was undertaken. But the exclusion of new units on the register leads to estimates that are downwardly biased - unless a correction is made. Such corrections are called new business provisions. They are made by estimating the number, size, type of activity, extent of economic activity, etc. of new businesses that should be on the business register but which are not.
- 3.20. New businesses are not born and old businesses do not die at uniform rates; for example, the rates tend to vary according to the business cycle. Therefore it is necessary to develop models of the births and deaths of businesses so that estimates can be made of the current population. Also, new businesses may not behave like older businesses. For example, new businesses may have disproportionately high levels of gross fixed capital formation relative to their output and their number of employees. It is therefore evident that:
- the business register should be as up to date as possible so as to minimize the importance of new business provisions;
  - a good deal of care needs to be taken in estimating new business provisions.
- 3.21. It is standard practice to rotate the businesses in a sample survey in order to share the respondent burden among businesses. In addition, there is some involuntary rotation due to the births and deaths of businesses. While they are unavoidable, rotations increase the sampling error of movement. It can therefore be informative to calculate growth rates from the previous period using a sample common to both periods. Knowledge of a substantial difference between the growth rates from the common sample and that from the full samples can be useful during the balancing process.
- 3.22. A particular issue with stratified random samples concerns outliers. These are businesses that report levels of economic activity that are quite different from the other businesses in their sample stratum. For example, consider a printer who is rotated into the sample. He has only five



employees but he reports turnover of five million euros in the quarter, whereas the average turnover reported by the other printers in the 0-10 employment category is 100,000 euros. The survey statisticians contact the printer by telephone; he confirms the figure and explains that he subcontracts most of the orders he receives to other printers. Suppose the expansion factor for the printer's stratum is 50 (i.e. the sample size is 2% of the population), then the printer contributes 250 million (50 x 5 million) euros to the total number-raised estimate of turnover. If turnover is used as an indicator of output, then - with no special action taken - such an occurrence could lead to a significant overstatement of growth in the quarter. In this case, the stratification using employment has failed and this needs to be recognized. Therefore, it is vitally important that such cases are identified and appropriate action taken, such as taking the printer out of the 0-10 employment stratum and putting him in a special stratum of his own where his contribution to total turnover is simply 5 million euros.

- 3.23. Given all the factors that can influence estimates from sample surveys, it is vital that the national accounts compilers have a detailed knowledge of how the estimates are derived and of any deficiencies they may need to compensate for. But it is much better if the survey statisticians address any problems that diminish the quality of the data. For this reason it is a great advantage if the surveys are conducted within the same organization as where the national accounts are compiled, for this enables the national accountants and the survey statisticians to work closely together to achieve the best possible outcomes.
- 3.24. The way sample surveys are conducted and the issues relating to them have not changed very much over the last fifty years or so, but there is no reason to believe that things will not, or could not, change over the next fifty years. The relentless development and expansion of information technology is likely to lead to new opportunities that could improve the scope, accuracy and timeliness of survey estimates, and maybe reduce respondent burden at the same time.

### Administrative data

- 3.25. Administrative data play an important role in the compilation of QNA. Member States commonly use the following administrative data:
- a. government finance statistics to derive estimates relating to the general government sector;
  - b. customs data to compile estimates of exports and imports of goods;
  - c. tax office data for various purposes, such as deriving tax estimates, maintaining a business register, and making estimates of compensation of employees and gross operating surplus/mixed income;
  - d. components of household final consumption expenditure are derived using:
    - medical and hospital administrative data;
    - registrations of new motor vehicles;
    - data relating to finance and insurance from government supervisory authorities.
- 3.26. The above list is not exhaustive, and NSIs are generally opportunistic in using whatever useful sources are available. If anything, the use of administrative data is growing due to several factors:
- greater demand for data without a concomitant increase in resources for NSIs;
  - resistance to increasing respondent burden;
  - more administrative data being recorded on databases;
  - developments in standards for the electronic exchange of statistical data and metadata (SDMX).

- 3.27. Administrative data have statistical strengths and weaknesses vis-à-vis sample surveys. Apart from the low cost of obtaining administrative data, their major strength is that they commonly have complete, or nearly complete, coverage of whatever they relate to. So, there are no sampling errors and some non-sampling errors, such as those arising from an out-of-date business register and inadequate new business provisions, are either non-existent or minor. Their weaknesses arise from the fact that they are by-products of administrative systems, which are not generally designed to meet the needs of the national accounts. Weaknesses include the following:
- the available data do not meet national accounting definitions (e.g. wages rather than compensation of employees, or a measure of depreciation that differs from the national accounting concept of consumption of fixed capital);
  - the data are not recorded on an accrual basis (e.g. exports and imports from customs are recorded as they cross the customs frontier and not when they change ownership);
  - the data are incomplete (e.g. movement of oil rigs in and out of territorial waters are excluded from customs data);
  - the data may not be disaggregated in a desirable way (e.g. government expenditures may not distinguish between wages and intermediate consumption or new motor vehicle registrations may not distinguish between household and business use);
  - administrative data may be untimely (e.g. company tax data);
  - administrative data can undergo change as a result of a change in policy.

### Maximizing the quality of basic data

- 3.28. Maximizing the quality of the basic data begins with the data suppliers, for it is they who have access to the elemental data and are responsible for its aggregation. They are also the ones who are aware of, or can find out, what has contributed to the growth rates in their data over recent periods. If there are unexplained anomalies in the data, they are the ones who can make inquiries with their data sources. Therefore, a critical objective of the national accountant is to enlist the data supplier as a de facto member of the national accounts compilation team. The extent to which this objective can be achieved depends largely on the affiliation of the data supplier, i.e. whether they are another branch of the NSI, another government agency, trade body, non-profit organization, public corporation, or private corporation. But whatever the affiliation of the data supplier, it is vitally important to:
- develop a good rapport;
  - ensure the data supplier understands what the data are being used for and appreciates their importance in the national accounts.

### *Data obtained from another branch of the NSI*

- 3.29. For data suppliers within the NSI, the national accountant can expect a much higher level of service than from any other data suppliers. How this service is arranged depends on the organizational arrangements and circumstances within the NSI. In some instances, an informal arrangement may work well, while in other instances a formal service agreement may be required that specifies the obligations of both the national accounts branch and the data supplying branch.

### *Sample surveys*

- 3.30. Some surveys may be conducted primarily to meet the needs of the national accounts, such as economic activity surveys, while others may be conducted for more general purposes, such as labour force surveys, retail sales surveys, building approval surveys, construction activity surveys

and manufacturing production surveys. In the case of the former, the questionnaires are designed specifically according to national accounts definitions to the extent possible, whereas in the case of the latter, the relationships to national accounts variables will generally be looser. In either case, the service agreement should include a written report each survey period with the following elements:

- a. levels and growth rates from the previous period for each variable;
  - b. a disaggregation into sample strata, or groups of sample strata, that shows their contributions to growth;
  - c. details of changes in the sample from the previous period;
  - d. growth rates based on a common sample;
  - e. details of new business provisions and their impact on the estimates;
  - f. details of the response rate and details of imputations made for large businesses;
  - g. the treatment of outliers – typically units in a small business stratum that report unusually high values of sales or output – can sometimes have a major impact on growth rates;
  - h. when unusually large positive or negative growth rates occur, the survey statisticians should investigate the cause, contacting respondents if necessary, and either fix them if they are illegitimate or report their findings otherwise;
  - i. provide details of the actual sampling errors on level and movement for each variable;
  - j. provide details of revisions to earlier periods.
- 3.31. How up to date is the sample frame? Are the new business provisions adequate? There are usually established methods for dealing with units that have not responded by the date specified, and the national accountants should be satisfied with the methods used. If a large business does not respond in a particular period, the survey statisticians should do their utmost to get the data. If an imputation has to be made, it should be included in the report.
- 3.32. If imputations for non-responding units are not done well, it can lead to biased estimates that become evident later when responses are obtained and revisions to the survey estimates are made. Even if there is no evidence of bias in the revisions, it is worthwhile reviewing the methods used for making imputations from time to time to determine if they can be fine-tuned. The quality of imputations for non-response becomes critical if estimates are to be derived early with a low response rate to meet the deadline for deriving flash estimates.
- 3.33. The report should be delivered by the survey statisticians to the national accountants sometime before their meeting to discuss the data, so that the latter will have had the opportunity to carefully read the report and analyze the growth rates of the unadjusted and seasonally adjusted current price and volume estimates derived from the survey data and revisions to them.
- 3.34. When a process such as this is first introduced, it is common for the survey statisticians to be asked to do further work, such as undertake further investigations into the data for particular units, improve their response rates and maybe amend their methods. Experience has shown that such close attention by the national accountants to the running of surveys leads to better survey estimates. Also, over time, as the survey statisticians learn to anticipate the concerns of the national accountants, the need for further investigations by the survey statisticians becomes less frequent. It is important that the national accounts compilers respond to the reports and the accompanying data in an active way. Passivity by the national accountants can lead to a lowering of standards.

- 3.35. It can save time if the survey statisticians are able to see the same data that the national accountants see early in the process. Hence it can be beneficial if unadjusted and seasonally adjusted current price and volume estimates are derived from preliminary survey estimates to help the survey statisticians quickly focus on apparent anomalies.
- 3.36. Survey statisticians do a better job of editing and analyzing their data if they know how their data are being used to derive national accounts variables. It is easy for survey statisticians to be uninterested, and even become disillusioned, if they do not understand how their data are transformed into national accounts statistics and the processes that national accountants go through in finalizing their estimates. It is therefore recommended that survey statisticians should be provided with national accounts training so that they can get an appreciation of the big picture and where their data fit in. It is necessary to run training courses sufficiently regularly to keep up with staff turnover. It can also be beneficial to have staff transfer between national accounts and survey branches.
- 3.37. Aspects of good performance management within a working group (that maximize the performance, job satisfaction and development of group members, as well as the overall performance of the group) can be applied to relationships between national accountants and survey statisticians. In particular, it is important that national accountants and survey statisticians give each other feedback, both positive and negative, and that any grievances between the two groups are identified and resolved as quickly as possible.

### *Administrative data*

- 3.38. Arrangements for collecting and processing administrative data for statistical purposes vary from country to country. In some cases the national accounts branch has the responsibility, but in others a separate branch of the NSI has the responsibility. The latter are referred to here as the subject matter statisticians.
- 3.39. When the national accounts branch is obtaining administrative data from another branch in the NSI, the relationship between the two branches should be much the same as that between the national accounts branch and a branch conducting sample surveys, and the need for a service agreement is just as strong.
- 3.40. As for sample surveys, the subject matter statisticians should provide a report of the data of interest to the national accountants, followed by a meeting to discuss the data. The report should focus on anomalous-looking data and report what explanations have been found for them. As for sample surveys, it can be beneficial if unadjusted and seasonally adjusted current price and volume estimates are derived from preliminary data to help the subject matter statisticians quickly focus on apparent anomalies.
- 3.41. It is vitally important that both the national accountants and the subject matter statisticians understand the nature of the data being collected and how they differ from the national accounts statistics they are being used to estimate. The subject matter statisticians need to be on the lookout for any breaches of assumptions underlying the transformation of the source data to national accounts statistics. For example, wages data for general government may be reported on a cash basis and the transformation to accruals is based on an assumption of a certain number of pay days in a quarter. If the payments do not follow the expected pattern, then changes are required to the pay-day adjustment. Likewise, the subject matter statisticians need to be alert to any bonus payments or back pay payments following a wage increase.

- 3.42. National accounts training for subject matter statisticians processing administrative data is just as important as it is for survey statisticians, as is the need for on-going feedback.

### *Data obtained from outside the NSI*

#### *Sample surveys*

- 3.43. In Member States with a centralized statistical system, all the major economic surveys will be conducted by the NSI and it is likely that only relatively minor data will be sourced from surveys run outside the NSI. In Member States with decentralized statistical systems, it could well be that all, or most, of the major economic surveys are undertaken by other government agencies. In such cases, it is essential that the agency responsible for the national accounts develop a close working relationship with the agencies conducting the economic surveys. Ideally, the same sort of service agreements as those described above should be made between the national accounts branch and those undertaking the surveys.

#### *Administrative data*

- 3.44. In most, if not all, cases the collection of administrative data will be a census of the target population, such as general government finance statistics, exports and imports of goods from the customs department, and new motor vehicle registrations. Hence, the need for much of the information required about sample surveys, described earlier, does not generally apply. As discussed above, there are other issues, which often relate to scope and time of recording, that arise as a result of the fact that the use of the data for national accounts purposes is a by-product of their primary purpose. There are also some issues that are common to sample surveys, such as misreporting by respondents and errors made by those collecting the data.
- 3.45. Obviously, national accountants cannot expect the same level of service and commitment from data suppliers outside the NSI as from those inside the NSI. Nevertheless, for some very important data, such as government finance statistics from the department of finance, a high level of service is essential. For very important and complex data, such as these, it is best if a service agreement can be made between senior managers of the NSI and the donor organization. It is then up to the national accounts compilers to develop a good working relationship with their counterparts in the donor organization. Wherever possible, the relationship should begin with a personal visit at which they could:
- a. describe how it is intended to use the data supplied;
  - b. show their donor counterparts the national accounts variables to be derived from the donor's data by referring to a national accounts publication;
  - c. discuss the extent of the data available and when the data can be supplied;
  - d. discuss the strengths and weaknesses of the data for national accounts purposes and explore ways of improving the situation;
  - e. make arrangements for how the data are to be supplied, including revisions to data for previous periods;
  - f. arrange for the supply of ancillary information, such as the pay-day cycle;
  - g. ask to be kept informed of forthcoming developments.
- 3.46. For very important data suppliers, it may be worthwhile holding regular meetings to discuss how the arrangements are working and to resolve particular issues. For other data suppliers, it is a matter of judgement, based on the importance, volume and complexity of the data, how formal the

arrangements need to be. Nevertheless, for all but the simplest requests for data, it is best to begin the relationship with a personal visit. This has the important advantages of:

- demonstrating the importance of the request for data;
- enabling the national accountant to develop a rapport with the data supplier;
- providing an opportunity to explain how the data are to be used;
- exploring ways of making the most of the available data.

- 3.47. Subsequent meetings with data suppliers should be made from time to time, especially when there are changes in staff at the data supplier, in order to maintain a good working relationship. All data suppliers should be invited to attend specially tailored national accounts training courses.

### Summary of main points

- 3.48. National accounts compilers need to develop a good working relationship with their data suppliers. It is crucial that the national accounts compilers gain a good understanding of the basic data they receive and, conversely, it can be of great benefit if the data suppliers have a good understanding of how the basic data are used in the national accounts.
- 3.49. The quality of the service national accountants can expect to receive from their data suppliers is greatly affected by the affiliation of the data supplier. If they are in the same organization, then the national accountant can expect a very high quality service. By contrast, if the data supplier is outside government, then the national accountant has much less “leverage”. Nevertheless, it is often possible to develop a good rapport with such data suppliers if the effort is made. This may involve personal visits and taking the time to explain how the supplier’s data are used in the national accounts. Failure to engage with data suppliers in a satisfactory way not only results in lower quality data and a lack of background information, it also leads to more time being spent by national accountants in trying to resolve (most likely with limited success) the problems that arise.
- 3.50. Service agreements should be made with data suppliers within statistical offices that specify the responsibilities of each party. These should include reports of analyses of the data supplied and any follow-up inquiries. It is important that the national accounts compilers respond to the reports and the accompanying data in an active way. Passivity by the national accountants can lead to a lowering of standards. Data suppliers should be offered national accounts training so that they can better appreciate how their data are used. The two-way provision of feedback between national accountants and their data suppliers is an important part of a good working relationship.

## 4. The use of information in the compilation of QNA

Despite the best efforts to obtain good quality quarterly basic data, it is often the case that the data fall short of requirements. The recommended approach is a pragmatic one, based on a flow-chart system with a series of steps, and a decision process based on the information available, the quality of that information, and the general philosophy adopted by the compiling national statistical institute. Special attention is given to the derivation of flash estimates.

### Introduction

- 4.1. Chapters 2 and 3 discuss the data sources that are available for estimating QNA variables and the techniques which may be used to gather good quality data with minimum resource burden to government and the respondents. This chapter considers the next step in compiling QNA, which is using the available data to produce the best possible estimates prior to balancing.
- 4.2. The circumstances in which QNA and ANA are compiled differ considerably. ANA are usually more accurate, for the reasons given in §2.4. In addition, the objectives of the two differ. The principal function of QNA is to provide users with a timely and sufficiently accurate picture of short-term growth, while the principal function of ANA is to provide an accurate and comprehensive picture of the state of the economy and to support international comparisons. For these reasons the strategies used to derive QNA and ANA often differ.
- 4.3. The ESA 2010, [§12.27 -12.34](#) strongly recommends that ANA and QNA should be consistent and balanced. This means that both should be balanced in a supply and use framework and either the quarterly data should be benchmarked to the annual data or the annual should be derived by summing the quarterly data. Benchmarking quarterly data to annual data is the much more common of the latter two options. Chapter 5 describes various means of benchmarking single QNA variables to their annual counterparts, while Chapter 8 describes means of balancing QNA for a single quarter and the multivariate benchmarking of quarterly data such that both accounting and temporal consistency are achieved simultaneously.
- 4.4. QNA generally rely on more limited data sources than ANA and their compilation may require a more intensive use of mathematical and statistical techniques. Two approaches to the compilation of QNA can be followed: the direct and the indirect approach. The direct approach is based on the premise that the quarterly basic data and the corresponding data from ANA are quite consistent, at least in terms of growth rates. The indirect approach uses statistical techniques to quantify the relationship between a time series of annual data (from ANA) and the available quarterly indicators in order to generate quarterly estimates of a QNA variable. The choice between these two approaches depends, among other things, on how closely the available quarterly data corresponds to the annual data for the variable and on the philosophy underlying the compilation of QNA adopted by the NSI.
- 4.5. In the common case of benchmarking quarterly data to annual data, either in a univariate or a multivariate fashion, the difference between the direct and indirect approaches boils down to whether a purely mathematical or a statistical approach is used to achieve temporal consistency, or as it is sometimes called “temporal disaggregation”. Mathematical methods require no model estimation, and in general all QNA variables of the same type (flows, stocks, etc.) are benchmarked to their annual counterparts in the same way. Statistical methods may involve fitting a model to the annual and (annualized) quarterly data using regression analysis and benchmarking the quarterly to the annual data in either a one-step or two-step process. Other statistical methods may simply involve making an adjustment for bias in a quarterly indicator, which is then followed by benchmarking using a mathematical procedure.
- 4.6. The recommended approach is to decide for each QNA variable the best way to use the existing basic data; this may be described as a “pragmatic” approach. The approach, or scheme, is articulated as a flow chart in Figure 4.1. The chart is intended to depict the thought processes that national accounts compilers can follow to find the most appropriate method for estimating QNA variables. The order of the stages is intentionally designed to give emphasis to the first two stages. All national accounts compilers are agreed that one should make as much use as possible of good quality data sources that are directly related to the aggregate to be measured.

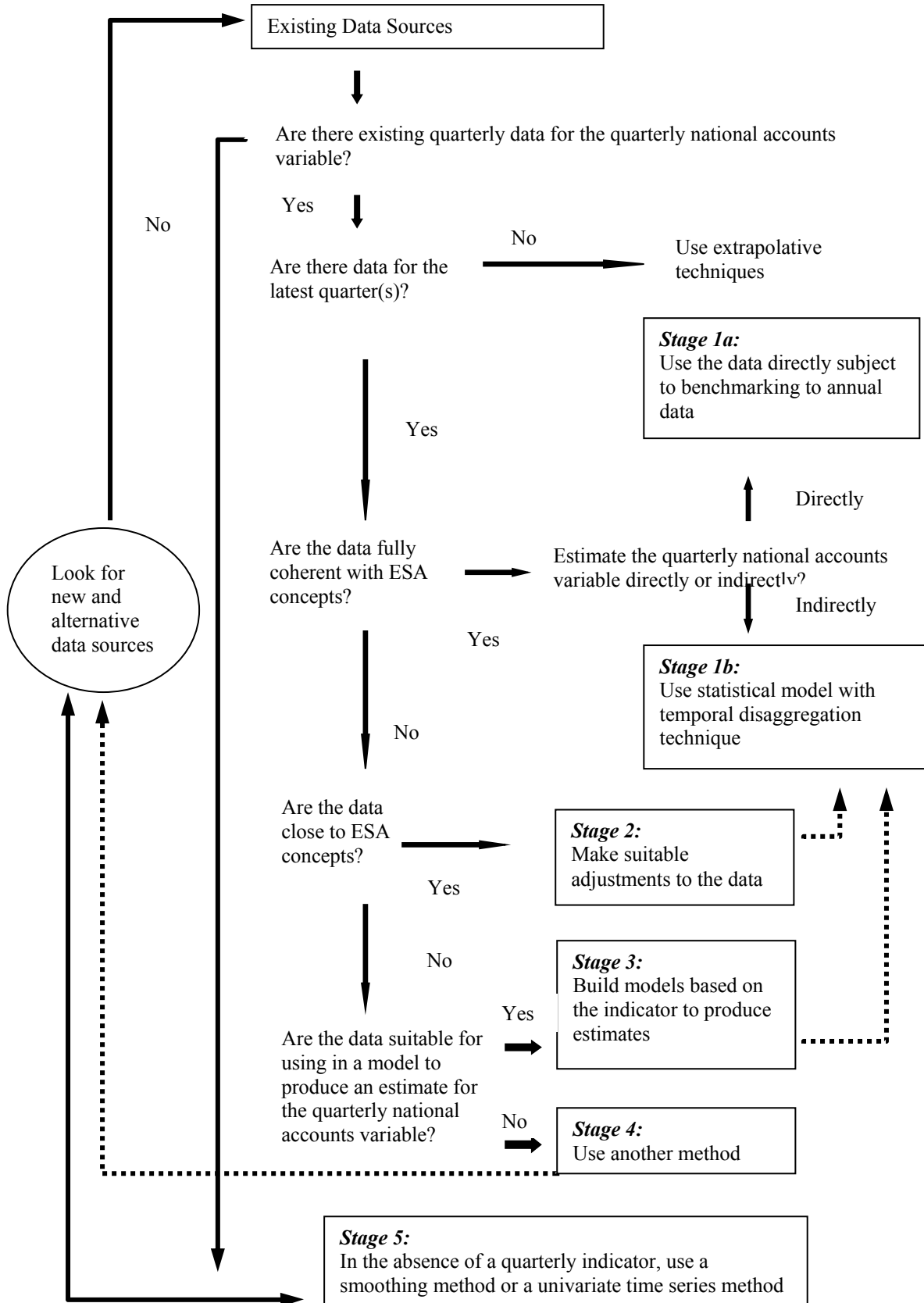


- 4.7. The scheme applies just as much to flash estimates as it does to later releases. The basic data available for compiling flash estimates are usually sparser than they are for later releases, and this chapter briefly describes measures that can be taken to ameliorate this problem.
- 4.8. When no data are available for the latest quarter, the only alternative is to extrapolate the latest estimates, and this, too, is briefly addressed. For a more comprehensive discussion of the issues and further guidance, refer to the Eurostat *Handbook on Flash Estimates, 2013*.

#### Description of the scheme (see figure 4.1)

- 4.9. The process starts from a given set of quarterly basic data and annual benchmarks that should have been balanced using supply and use tables. For the purposes of explaining the scheme, it is assumed that the quarterly data have been established over a period of time and are of variable quality; some of the data are specifically collected for national accounts purposes, but most are either collected for diverse purposes or are the by-product of an administrative system. The discussion of quarterly basic data and their sources in the previous chapter provides details of what is commonly available for the various QNA variables.
- 4.10. For each successive release of the national accounts for a particular quarter, the quality and range of data available gradually improves as time goes on. Therefore it is necessary to go through the system depicted in Figure 4.1 for each release to ensure that the maximum amount of basic data is being used in the most efficient way. The process of revision to the basic data is addressed in Chapter 10.
- 4.11. For each QNA variable, one proceeds to the first question in the system “are there existing quarterly data?” The range of data that would allow an affirmative answer is very wide: ranging from perfect data that exactly match the requirements to lower quality data (even qualitative data) which may be vaguely correlated to the target QNA variable. If the answer is ‘no’ then the national accountant moves to Stage 5 and has to resort to the use of smoothing methods or univariate time series methods, both of which are described in Chapter 5. These are the least satisfactory of methods, and the national accountant should look to find a new data source or improve the timeliness of an existing source.

Figure 4.1: The use of information in the estimation of a single QNA variable



- 4.12. If there are quarterly basic data, then the next question is “are there data for the latest quarter(s)?” It is possible that for early releases of QNA, particularly flash estimates, that basic data for the full quarterly period may not yet be available (for example there may be data for the first two months of the quarter, but not the third month). The methods to deal with this situation are discussed later in this chapter. There may of course be possibilities to improve the timeliness of the existing data source or to find a more timely data source so as to avoid the use of excessively incomplete information, even for early releases.
- 4.13. Stages 1 to 4 apply when there are some data available that are conceptually related to QNA variable; their use can be summarized as follows:

*Stage 1:* Using the basic data directly with no amendments required for measurement or coverage definitions, but possibly some classification changes for disaggregations. This is most commonly the case when the data source is a quarterly sample survey designed specifically to meet national accounts requirements.

*Stage 2:* Using techniques to correct defects in the basic data, such as conversion from cash to accruals or adjustments for coverage. These techniques need not be mathematical or use a model, but are based on the basic data being close to the definition given by the ESA 2010/2008 SNA so that the adjustments are relatively small and have a firm theoretical foundation. Examples of such basic data are government finance statistics and foreign trade data.

*Stage 3:* Using statistical techniques (i.e. an indirect approach) to improve the basic data (for example correcting for measurement bias), or using the data as an indicator in a statistical model to estimate QNA variable. The latter techniques are described more fully in Chapter 5.

*Stage 4:* Applying some other (non-mathematical/statistical) approach, often qualitative, to estimate the path of QNA variable using knowledge of the series and of the principal influences upon its level and growth.

- 4.14. If there are some complete data available to estimate QNA variable, then the national accountant has the choice of using Stages “1 to 4”; the options chosen will be determined by several factors described below:

*a. Closeness of the data to ESA definitions*

This is the most important factor in choosing between Stages 1 and 2/3 of the system. If the coverage and definition of the basic data match those required by the ESA, then Stage 1 is often the most appropriate method to use (i.e. using the data directly in the accounts, subject to benchmarking). However, most basic data differ from ESA definitions, whether in coverage (for example a section of the population is not measured by a survey, or is present in the data when it should not be) or in measurement concepts (the most common difficulty is converting cash-basis data onto an accrual basis). In Stage 2 appropriate adjustments are made to the data (see Chapter 2 for a discussion of the most common problems faced for QNA and how to resolve them).

*b. Quality of the data*

Moving on from the above point, there is clearly a decision to be made on the quality of the data that determines whether the source data are used in the accounts directly (whether with some correction for coverage/measurement or not) as in Stages 1/2 or whether statistical techniques are used to ‘improve’ the data as in Stage 3. This is partly a question of philosophy (discussed below) but also one of data quality standards: what is an ‘acceptable

level' of error for using the source data directly in the accounts? Given that the quarterly data are benchmarked to the annual data, the question of whether a direct (Stage 1/2) or indirect (Stage 3) approach is used effectively becomes “does the indirect approach reduce revisions for periods beyond the latest annual benchmark and if so are the reductions sufficiently large to warrant the extra cost of modelling?” The NSI should be very clear about this point.

When the source data are not good enough to be used directly and are also unsuitable for modelling, then Stage 4 applies. In such cases, the NSI should try to get better data from the source or find a new source.

### *c. Philosophy of accounts compilation*

Each Member State has its own general philosophy about the compilation of QNA, and will tend to adopt different criteria for moving between the stages of the scheme. Some will use the techniques of Stage 3 (discussed in Chapter 5) more readily than others, given that they have a tradition of using statistical modelling techniques to improve the quality of existing source data, and this may mean that they look less readily for new sources of data (see discussion below).

### *d. Suitability of the source data for modelling*

Once a decision has been taken to use the techniques that form part of Stage 3 in the outlined scheme, it is necessary to construct and estimate an appropriate model for the particular QNA variable. In some cases no suitable model can be found because the data are unstable (for example qualitative surveys of businesses may produce heavily categorised data that give an indication of the direction of movement without sufficient quantification to be useful). Another difficulty often faced by countries with only a short history of compiling ANA is that the time series available may not be sufficiently long to estimate the model accurately. Stage 4 is then the only alternative left open to the national accountant until new, alternative data sources become available.

- 4.15. Whichever method is used to estimate particular QNA variables, the estimates generated will feed into the processes of balancing and revision which are described in later chapters.

## **The properties of quarterly estimates**

- 4.16. QNA should be of sufficient quality to meet the needs of users, but how to assess their quality? Given that the “true” values of QNA variables are unknowable, it is very difficult, if not impossible, to determine the estimation error of QNA estimates. In the absence of a measure of accuracy, it is useful to identify a set of properties of QNA estimates that can be considered as desirable, at least from a user’s perspective. The following list is not a set of optimal properties since there is no methodological justification, but it is a set of suitable properties that might reasonably be expected of QNA estimates. This set of properties complements the ideal requirements for basic data described in Chapter 2 (see Box 2.1).

- 4.17. QNA series should have the following properties:

### *a. Neutrality of the estimates*

Even if it is recognised that subjective judgement plays an important role in the estimation and balancing of QNA, no specific economic theory should influence the compilation of accounts. The compilation process must essentially have a statistical (see Chapter 9) and accounting nature.

*b. Data must represent reality*

The magnitude of QNA variables for which there are no quarterly basic data, or there are no basic data for the latest quarter, should not be so great that the growth rates of major aggregates are significantly influenced by them.

*c. Optimal use of the available information*

QNA estimates must incorporate in an optimal way all the information contained in the relevant basic data. In consequence, the short-term profile of quarterly estimates should be closely related to the profile of the basic data (after any specific adjustments have been made for known inadequacies in the basic data).

*d. Invariance of the turning points*

QNA estimates must have approximately the same turning points as the corresponding basic data. This is a consequence of previous properties.

*e. Preservation of the growth rate*

The growth rates of QNA estimates and basic data must be as close as possible.

*f. Consistency between short-term and long-term movements*

QNA and ANA should be temporally consistent.

*g. Revisions should not be too large and they should be unbiased*

If revisions are so large that the picture portrayed by the early estimates is changed appreciably, then it is evident that QNA is not meeting the needs of its users. The basic statistics, the methods used to derive QNA estimates, or both need to be improved.

## Flash estimates

4.18. Countries (as of 2012) can be grouped into two categories:

- a. those that publish a preliminary estimate between 45 and 60 days and a second, revised, estimate at 90 days, usually at the same time as quarterly sector accounts;
- b. those that publish only one preliminary estimate between 60 and 70 days.

From 2014, the ESA 2010 Transmission Program will require the publication of QNA at 60 days. Countries will still be able to publish their accounts earlier and publish a revised estimate some time later within the same quarter.

4.19. Flash estimates are also published by some Member States prior to the preliminary estimates. They are part of a sequence of QNA estimates characterized by the different amount of basic data available at the time of compilation and the consequent trade-off between timeliness and accuracy. Flash estimates and the sequence portrayed in the previous paragraph are only a part of the continuum of QNA releases because there are many subsequent releases before QNA estimates become truly final, as this can only happen when the annual estimates become final and the seasonal and calendar adjustments have settled down (see Chapter 7). It can also be argued that the

continuum begins prior to flash estimates if one is prepared to include “nowcasts” compiled at, say, the end of the quarter, and which are based on some combination of forecasts and actual basic data.

- 4.20. The last point raises the question as to what differentiates flash estimates from earlier estimates, such as nowcasts. It is recommended here that flash estimates must be based primarily on basic data for the reference quarter, and extrapolative techniques that do not use a relevant indicator should only play a relatively minor role. Such techniques, which are described later in the chapter, should only be used as a last resort and then only to a minor extent.
- 4.21. Chapter 3 stresses the need to develop a good working relationship with the source data providers to ensure the data are of the best quality possible. Likewise, the best way to obtain basic data earlier is by working with the data suppliers to find solutions. Without the involvement of the data suppliers, the potential for improving the timeliness of basic data is very limited, if not zero.
- 4.22. It is recommended in ESA 2010 and this handbook that quarterly estimates of GDP should be derived using all three approaches (i.e. production, expenditure and income) and balanced using supply and use tables (see Chapter 8). Ideally, this recommendation should apply to flash estimates as well as the later estimates. Indeed, some NSIs may find it easier, as well as producing better results, to follow the same procedure for deriving all their editions of QNA, although the earlier estimates may be derived and balanced at a more aggregated level. Other NSIs may be in the position where they have relatively complete data to support one (or two) approach(es), but little data for the others. In such cases, compiling supply and use tables may be out of the question.
- 4.23. Pragmatism combined with data availability should determine the level at which flash estimates are derived. Generally, however, the more detailed the estimation the better. This can be of particular importance for volume estimation and for seasonal adjustment if it is done indirectly for the final estimates (see Chapter 7).

### ***Strategies for deriving flash estimates***

- 4.24. There are a number of strategies for obtaining basic data in time to compile flash estimates:
  - a. more rapid supply of data by businesses;
  - b. derive survey estimates earlier, but with lower response rates;
  - c. use data for the first two months of the quarter;
  - d. make arrangements with sources of administrative by-product data to supply data for the whole quarter quicker or for only part of the quarter at an earlier date.

### ***More rapid supply of data by businesses***

- 4.25. The most straightforward way of speeding up the supply of data by businesses is to bring forward the date by which they are asked to respond on survey forms, and then when that date has been reached follow-up with telephone calls to the non-respondents. But before changing the response date on the survey form, a letter should be sent to respondents advising them of the change, explaining why it is being made and expressing how much their assistance would be appreciated. It is crucial that data are obtained from all the very large respondents. This may require discussion and negotiation with them prior to the change being made.

- 4.26. A variation on this approach is to leave the survey response date unchanged for smaller businesses, but bring it forward for larger businesses. This would lead to early estimates having larger sampling errors than later ones.
- 4.27. A more radical solution is for the NSI to be able to directly access a business's accounts. This could involve businesses using business accounting software that formats data in a standardized form in conjunction with the use of SDMX. If a business's accounts are updated on a continuous basis, which may be the case for large businesses, then the NSI could choose a response date prior to the end of the quarter, if desired. Incidentally, this approach offers the possibility of accessing data daily and is probably the only way changes in inventories could be measured in accordance with the SNA definition, rather than using a model to derive approximate estimates (see Chapter 2).

#### *Use of data spanning less than three months*

- 4.28. If the basic data for QNA are obtained from a monthly business survey, then data for the first two months of a quarter may be used to compile flash estimates when data for the third month cannot be produced in time. The third month would need to be estimated using an extrapolative method – see below.
- 4.29. For basic data obtained from a quarterly survey, it may be possible for at least some respondents to supply data for the first two months. Clearly, such a strategy would require a good deal of investigation and testing before it could be introduced.
- 4.30. The prospects of obtaining data for part of a quarter from administrative sources may be possible if the administrative database is updated on a continuous basis. In those cases where the administrative database is updated once a quarter, then a solution is likely to be much more complicated and costly.

#### *Using an alternative indicator*

- 4.31. If the basic data normally used to produce estimates of a QNA variable are unavailable in time for compiling flash estimates and it is not possible to obtain the data earlier even for part of the quarter, then the next best alternative is to use another indicator that is directly related to QNA variable, and which may already be used for validation purposes. It is highly desirable that such an indicator should adhere to the principles listed in §4.17. A model may be needed to make best use of an auxiliary indicator.
- 4.32. When there is not even an auxiliary indicator available, then an indicator that breaches the principles listed in §4.17 but is related in a statistical or economic sense may be the best alternative. If there is a related indicator that is reasonably well correlated with the target variable, then a simple linear regression model (in level or growth rate) may suffice to provide a reasonable extrapolation. A more sophisticated approach is to use an ARIMA model with an exogenous variable.
- 4.33. If QNA variable with the missing observation is relatively minor, one possibility is to assume that it has grown at the same rate as the other components of an aggregate. For example, suppose there is no figure for the production of taxi services in the latest quarter, then it may be reasonable to assume that the production of taxis services has grown at the same rate as the production of other passenger transport services.

### *Seasonal adjustment of flash estimates*

- 4.34. Flash estimates derived in a different way than the later QNA estimates may have different seasonal patterns, which could lead to poor estimates of growth and large revisions if they are seasonally adjusted using factors that have been derived using final data. Solutions to this problem depend on exactly how the flash estimates have been derived. For example, if the flash estimates have been derived using actual monthly data for the first two months and an extrapolation for the third month, then the first two months could be seasonally adjusted in the normal way and the estimate for the third month could be derived by extrapolating the previous seasonally adjusted monthly data. Unadjusted quarterly data could be derived by unadjusting the seasonally adjusted estimate for the third month.
- 4.35. If the flash estimates have been derived using (non-monthly) data for part of a quarter or another indicator, then the best solution may be to construct a time series of flash estimates and use it to derive a seasonally adjusted estimate of the latest flash estimate.

### *Extrapolation methods that do not use a quarterly indicator*

- 4.36. Extrapolation methods that do not use a quarterly indicator are used when the basic data for the latest months or quarters are missing (e.g. some of the data normally used to derive the quarterly estimates are not available in time to produce the flash estimates) and there are no suitable alternative indicators available. In such cases, a mathematical or statistical procedure has to be used with the objective of deriving estimates that minimize revisions when the basic data normally used become available.
- 4.37. In this section it is assumed that only one quarterly observation is to be extrapolated, but the methods described can easily be used to extrapolate two or more months or quarters.
- 4.38. In order to ensure consistency between the unadjusted and seasonally adjusted data, only one of them should be extrapolated and the other should be derived from it. Thus, if the unadjusted data are extrapolated, the seasonally adjusted estimates should be derived from them in the usual way, or if the seasonally adjusted data are extrapolated then they should be unadjusted to obtain estimates of the unadjusted data.

### *Simple mathematical extrapolation*

- 4.39. In Chapter 7, §7.18-7.19, the decomposition of a QNA variable into five components is described, namely: trend, cycle, seasonal, calendar and irregular, but for seasonal adjustment purposes the first two are usually combined (i.e. trend-cycle). Seasonal adjustment methods, such as TRAMO/SEATS and X-12-ARIMA, decompose quarterly time series into the four components. All four components can usually be estimated with reasonable reliability (i.e. they are unlikely to be revised very much) in the middle of a time series, but as the end of a time series is approached the reliability declines. The seasonal and calendar components are usually the most predictable, and the reliability of their estimates is still generally quite high at the end of the series and for periods in the near future. It is therefore better to apply simple extrapolation methods to seasonally adjusted data, rather than unadjusted data, and to leave it to the seasonal adjustment method to take care of extrapolating the seasonal and calendar components.
- 4.40. Two straightforward purely mathematical procedures for extrapolating the latest observation of the seasonally adjusted data are by using:



- a. a (simple) average of the values of recent periods;
  - b. a (simple) arithmetic or geometric average of the growth rate over recent periods.
- 4.41. Trend-cycle estimates are a standard output of TRAMO/SEATS and X-12-ARIMA. In both cases a filter is applied to derive estimates of the trend-cycle. These filters are designed to produce trend-cycle estimates with certain desirable properties, and so they are preferred to taking simple arithmetic averages (see §7.31 and the associated footnote for a description of the properties of the Henderson moving average, which is applied to seasonally adjusted data in X-12-ARIMA). This raises the possibility of extrapolating trend-cycle estimates to obtain an extrapolated seasonally adjusted value. For if it is assumed that the irregular is zero in the period to be extrapolated, then the seasonally adjusted and trend-cycle estimates are equal.
- 4.42. Simple extrapolations of the seasonally adjusted or trend-cycle data can be expected to produce reasonable results as long as the growth rate of the seasonally adjusted data is fairly stable. If past observations of QNA variable display medium or long-term growth or decline, then procedure (b) would normally be chosen. But if no apparent change in trend-cycle is evident then procedure (a) would be preferred.
- 4.43. Economic growth rates usually vary over time and an automated procedure that makes extrapolations in the same way every quarter can be expected to produce poor results quite frequently and very poor results at turning points. This implies that every time an extrapolation is made the national accountant must use all the information available to make an informed judgement of the likely growth path of QNA variable, and then decide how to extrapolate the seasonally adjusted or trend-cycle estimates.

### *Time series methods*

- 4.44. Time series methods, particularly the use of ARIMA (autoregressive integrated moving average) models, can provide extrapolations that are superior to the simple methods described above because they make better use of the information contained in the time series of QNA variable. Also, standard computer software used to estimate ARIMA models provide diagnostics that show how well the model is performing and the degree of confidence one can have in an extrapolation.
- 4.45. Nevertheless, ARIMA models only use the past behaviour of QNA variable to make extrapolations and, as for simple extrapolation methods, national accountants must be prepared to use informed judgement to modify the ARIMA model extrapolations as required. This is particularly so at turning points.
- 4.46. If an ARIMA model is being used to support the seasonal adjustment of QNA variable to be extrapolated, such as in X-12-ARIMA or TRAMO/SEATS, then this model could be used to make extrapolations of the unadjusted estimates. However, the principal reason for using ARIMA models in seasonal adjustment methods is to either support or optimize the estimation of the seasonal component over the period for which there are quarterly data. They are not used for making forecasts of the unadjusted data per se. Indeed, given the arguments made above and the need to use all the information available, a strong case can be made for extrapolating the seasonally adjusted data using an ARIMA model.

### Summary of main points

- 4.47. This chapter addresses the matter of how best to use the available data to derive estimates of QNA variables prior to balancing. A scheme is proposed for determining the method to be used for estimating a QNA variable based on how well the basic data satisfies the ESA definition and coverage of the target QNA variable. There are five alternatives:
- a. use the basic data directly;
  - b. use the basic data directly after making relatively minor adjustments;
  - c. use the basic data indirectly by fitting a statistical model;
  - d. in the case of low quality basic data, including qualitative data, use an ad hoc approach;
  - e. in the absence of any quarterly basic data, use a smoothing or time series method (see Chapter 5).
- 4.48. In practice, the use of the direct and indirect approaches is determined partly by the quality of the quarterly basic data and partly by the philosophy of the NSI with regard to modelling. Some NSIs may choose to use models for the first three alternatives, while some may choose not to use any modelling at all.
- 4.49. It is recommended, both in the ESA 2010 and this handbook, that QNA variables should be temporally consistent with their annual counterparts. In general, this means benchmarking the quarterly data to the annual data, and both the direct and indirect approaches involve benchmarking to ensure temporal consistency. The question of whether to use the direct or indirect approach effectively becomes “does the indirect approach reduce revisions for quarters beyond the latest annual benchmark and if so are the reductions sufficiently large to warrant the extra cost of modelling?”
- 4.50. QNA should be of sufficient quality to meet the needs of users. It is recommended that QNA estimates should be assessed against a list of desirable properties in order to ensure that they are fit for purpose.
- 4.51. While it is accepted that the quality standards can be lower for flash estimates than later and less timely estimates, they should be based mostly on actual data for the reference quarter and imputations should play a relatively minor role. The chapter describes various means by which the quality of flash estimates can be maximized. The chapter also describes various techniques for imputing a value for the latest period when no relevant data are available.

## 5. Statistical methods for temporal disaggregation and benchmarking

This chapter describes some statistical methods for deriving estimates of QNA variables that are temporally consistent with annual benchmarks.

The methods are divided into three categories: methods when only annual estimates are available, methods that entail the direct use of quarterly basic data (i.e. no models are used) and methods that entail the indirect use of quarterly basic data (i.e. models are used).

There are three annexes to this chapter. Annex 5.A provides a mathematical description of the most commonly used mathematical and statistical methods. Annex 5.B describes the French indirect approach. Annex 5.C compares the direct approach with various indirect approaches.

## Introduction

- 5.1. This chapter deals with the use of mathematical and statistical methods for compiling estimates of QNA variables from the basic data. Nearly all of the methods described are predicated on the availability of annual data and the requirement to ensure that the quarterly estimates are consistent with those annual data - hence the reference to temporal disaggregation in the heading of this chapter.
- 5.2. The chapter is supplemented by three annexes. Annex 5.A presents, in a formal way, the most widely known, used and useful mathematical and statistical methods for temporal disaggregation. Annex 5.B describes the French approach to temporal disaggregation, which uses models and a quarterly indicator to impute values for QNA variables in a two-step process; it is illustrated using an example. Annex 5.C also uses examples to illustrate the use of a number of indirect methods, including the French approach, compares the results with those of the direct approach and draws some conclusions.
- 5.3. The chapter has to be read having in mind the pragmatic scheme for the compilation of QNA described in Chapter 4. The scheme prescribes, in a general way, how mathematical and statistical techniques may be used to make the best use of basic data of different quality and completeness. The quality of the basic data ranges from those that fully satisfy the ESA concepts of a national accounts variable to cases where there are no suitable quarterly indicators available at all.
- 5.4. As noted in Chapter 4, there are differences in philosophical approach to the compilation of QNA between NSIs. Some NSIs have embraced relatively sophisticated techniques that may involve fitting models to many variables, even in cases where the basic data well satisfy the ESA concept. While other NSIs use mathematical and statistical techniques in a more limited way, with little or no modelling. Hence the extent and sophistication in the use of mathematical and statistical methods by an NSI does not necessarily imply a lack of good quality basic information.
- 5.5. The rationale for using modelling and other statistical techniques is to make the best use of the available information, but it has to be stressed that it is necessary for the quarterly basic data to have at least some minimum relationship with QNA variables in order to derive meaningful quarterly estimates. Without this relationship, an adequate quarterly path cannot be established.
- 5.6. It is recommended, both in the ESA 2010 and this handbook, that the quarterly and annual estimates for a national accounts variable should be temporally consistent. In general, this entails forcing the quarterly estimates to be consistent with their annual counterparts. All the methods for estimating QNA variables described in this chapter achieve this objective. The methods can be classified as follows:
  - a. methods when no quarterly data are available;
  - b. direct methods: methods that benchmark preliminary quarterly estimates of a QNA variable, or a quarterly indicator, to the corresponding annual benchmarks using a mathematical procedure;
  - c. indirect methods: methods that impute values for a QNA variable by modelling the relationship between (annualized) preliminary quarterly estimates of a QNA variable, or a quarterly indicator, and the corresponding annual benchmarks.

*Methods when no quarterly data are available*

- 5.7. These methods are used when only annual data are available. Quarterly estimates are derived either by a weighted disaggregation of the available annual data according to some purely mathematical criterion or by using time series models. In either case, the objective is to provide sufficiently smooth quarterly estimates that are consistent with the annual data. Such methods are very much a last resort and national accountants should do their utmost to obtain and use a quarterly indicator that has some relationship with a QNA variable to be estimated.

*Methods that benchmark preliminary quarterly estimates of a QNA variable, or a quarterly indicator, to the corresponding annual benchmarks*

- 5.8. The preliminary estimates of a QNA variable may have been derived by making adjustments to the basic data, but there is no modelling of the basic quarterly data and annual benchmarks. Typically, preliminary estimates are derived by extrapolating a value of a QNA variable in a base period using a quarterly indicator. A mathematical procedure is then applied to the preliminary estimates in order to produce estimates consistent with their annual counterparts. In the case of a flow variable, this takes the form of spreading the differences between the annual benchmark and the sum of the quarterly estimates over a year by maximizing, or minimizing, an appropriate criterion that ensures that the aggregation constraint is satisfied whilst minimizing the disturbance to the path of the preliminary quarterly estimates.
- 5.9. Where the preliminary estimates of a QNA variable are showing different medium or long-term growth patterns to the annual benchmark data, then benchmarking methods may be enhanced to minimize revisions for the latest quarters.
- 5.10. In what follows, the derivation of preliminary quarterly estimates and the benchmarking process are presented separately.

*Methods that impute values for a QNA variable by modelling the relationship between (annualized) preliminary quarterly estimates of a QNA variable, or a quarterly indicator, and the corresponding annual benchmarks*

- 5.11. Methods that use a statistical model to estimate a QNA variable entail using regression analysis to fit the model to the annual benchmark data (dependent variable) and the annualized quarterly indicator data (independent variable). Prior transformations may be applied to one or both of the variables. The model is then used to impute a QNA variable using the quarterly indicator. Some methods then use a benchmarking procedure to ensure temporal consistency in a two-step process, but other methods impute estimates of a QNA variable that are temporally consistent with the annual benchmarks in a one-step process.
- 5.12. Some one-step and two-step model/benchmarking procedures have both univariate and multivariate versions. The latter are used to ensure temporal consistency with annual data and accounting consistency between variables simultaneously. This chapter deals with univariate benchmarking and Chapter 8 deals with multivariate benchmarking.
- 5.13. It is not the intention here to promote the more or less intensive use of statistical (i.e. modelling) methods, or any such methods in particular. Rather the intention is to acquaint national accounts compilers with currently available methods, particularly methods used by Member States. The statistical methods described come with a cost, including the need for staff with statistical modelling expertise. One thing is clear, if statistical methods are to be used they need to be used

competently. How this may be achieved is discussed later in this chapter. The upshot is that before embarking on the use of statistical methods and deciding the extent to which they are to be used, NSIs need to carefully assess the costs and benefits of doing so.

### Methods when no quarterly data are available

- 5.14. Two different approaches to disaggregating annual estimates when there is no quarterly indicator are:
- smoothing methods;
  - time series methods.

#### *Smoothing methods*

- 5.15. Smoothing methods are based on the premise that in the absence of quarterly information it is best to derive a smooth time series subject to the constraint that the quarterly estimates are consistent with the known annual data. Indeed, if there is no information about how a QNA variable behaves over the course of a year, then there is no justification for introducing volatility in the quarterly estimates.

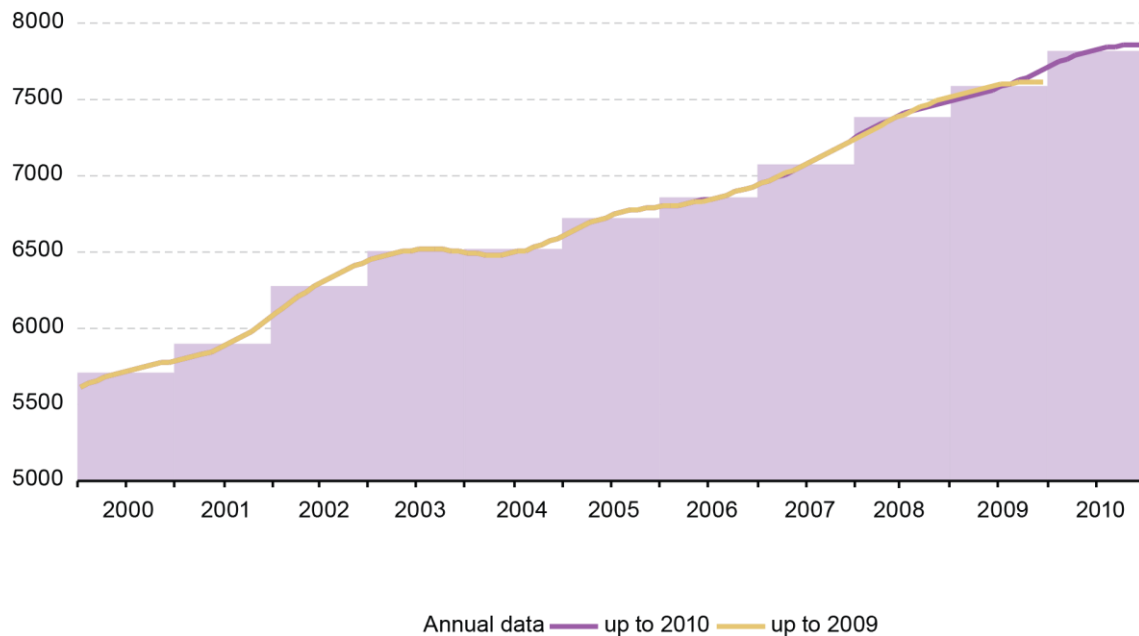
#### *Boot, Feibes and Lisman method*

- 5.16. One of the best known methods of this type was developed by Boot, Feibes and Lisman (BFL) over forty years ago. The most common variant is when quarterly estimates are derived such that the sum of their squared first differences is minimized and the annual aggregation constraint is satisfied<sup>(13)</sup>. The BFL method is described in detail in Annex 5.A.
- 5.17. When using methods of this type, the annual data need to be inspected before smoothing. In cases where the annual series has null values, then unsatisfactory quarterly estimates, including negative values, may be produced, and these should be amended manually. Null annual values are sometimes encountered when a product first appears or when it ceases to be produced or acquired, e.g. cell phones and leaded petrol. If there are consecutive annual null values, then the smoothing method may generate a quarterly seasonal pattern in those years that will require amendment.
- 5.18. The major difficulty with smoothing methods occurs in the latest year, when there are no annual data. In order to derive quarterly estimates in the latest year, it is necessary to make a forecast for that year, and it is better to make the best informed forecast possible rather than to make a forecast by default, such as by assuming that the growth observed in the previous year continues at the same rate in the current year.
- 5.19. If forecasts are only made for the current (i.e. the latest year),  $y$ , then “border” effects may result in substantial revisions to the fourth quarter estimate when estimates are made in the following year. For example, if a decrease is expected in year  $y$ , then forecasting only that year will lead to decreasing quarterly values up to  $yQ4$ . When estimates are derived one year later in year  $y+1$ , if the value for year  $y+1$  is expected to be greater than that for year  $y$ , the estimate for  $yQ1$  will be revised down and more importantly the growth rate in  $yQ4$  will be revised from negative to positive, even if the forecast for year  $y$  is correct! Therefore, if possible, it is better to make forecasts for both the current year and the following year. These forecasts can be amended as the current year unfolds. In any case, the accuracy of the forecast is not crucial in limiting revisions.

<sup>(13)</sup> Another variant of the BFL method is to minimize the sum of squares of the second differences.

- 5.20. Border effects can also affect the quality of quarterly estimates at the beginning of a time series. So, it is best to make a backcast for the year preceding the time series.

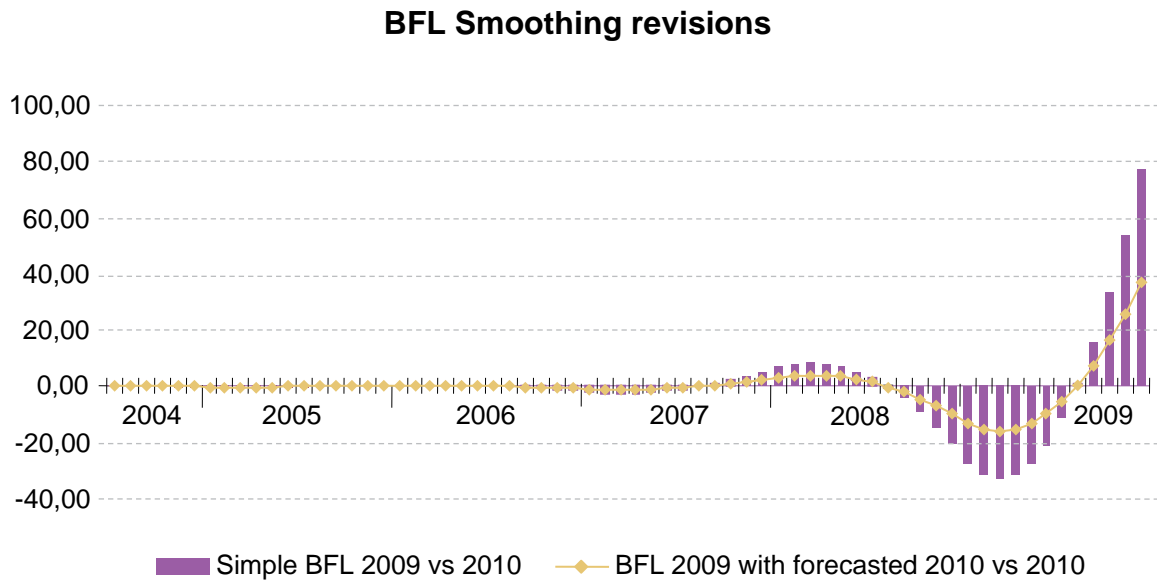
Figure 5.1: BFL method applied to French Government Individual Consumption Expenditure on Non-market Education Services, current prices (million €)



Source: INSEE.

- 5.21. Figure 5.1 depicts quarterly estimates of French Government Individual Consumption Expenditure on Non-market Education Services at current prices that have been derived using the BFL method, with annual data up to 2009 (yellow line) and 2010 (purple line).
- 5.22. Figure 5.2 illustrates how revisions may be reduced by making a forecast for an additional year. In this case, estimates have been derived up to the fourth quarter 2009 using (a) actual annual data up to 2008 and a forecast for 2009, and (b) actual annual data up to 2008 and forecasts for 2009 and 2010. The two sets of estimates are then compared with estimates derived using actual annual data up to 2010. The purple bars show the revisions that have occurred between the first set of estimates (a) and the final estimates, and the yellow line shows the revisions that have occurred between the second set of estimates (b) and the final estimates.

Figure 5.2: Revisions to estimates derived using the BFL method applied to French Government Individual Consumption Expenditure on Non-market Education Services, current prices (million €)



### *Time series methods*

- 5.23. Time series methods, in particular the use of ARIMA models, are discussed briefly in §4.44-4.46 in the context of extrapolating a QNA time series when there are no data for the latest periods. Time series methods can also be used to impute quarterly values when only annual data are available. This is achieved by capturing the dynamics of the annual data in a model and then using the model to infer quarterly values that are temporally consistent with the annual data.
- 5.24. Time series methods can readily produce quarterly estimates beyond the latest annual benchmark, but if exogenous information is available for the latest year, it is best to use it make a formal estimate. It is also possible to expand the model to incorporate information derived from quarterly related series in order to guide the infra-annual path.
- 5.25. The time series techniques of Wei and Stram and Al-Osh are formally described in Annex 5.A.



## Deriving preliminary quarterly estimates using an indicator

### Simple extrapolation

- 5.26. The simplest way to derive preliminary estimates of a QNA variable  $y_t$  using a quarterly indicator  $x_t$  is to assume that they have the same growth rate – at least in the first instance.

$$\Delta y_t = \Delta x_t$$

where

$$\Delta y_t = \frac{y_t - y_{t-1}}{y_{t-1}}$$

and the indicator is  $x_t$  and QNA variable is  $y_t$ .

- 5.27. This assumption is quite strong because it requires that the indicator accurately measures the behaviour of QNA variable in all economic phases, with no lags or leads. This is only likely to be the case if the indicator well satisfies the national accounts definition of the variable being estimated (e.g. if the indicator is derived in an identical way to the one used for ANA). It is therefore recommended that the hypothesis should be tested. For example, by fitting the simple model

$$\Delta y_t = \gamma + \beta \Delta x_t + u_t \quad (5.1)$$

to the annual benchmarks and the annualized quarterly indicator.

- 5.28. If  $\gamma$  is significantly different from 0, then simple extrapolation will introduce a systematic bias in QNA. If  $\beta$  is significantly different from 1, then simple extrapolation will introduce a cyclical bias (i.e. an error in the volatility of QNA variable).
- 5.29. If the hypothesis that  $\beta = 1$  and  $\gamma = 0$  is satisfied and  $u_t$  has a relatively small variance, then the simple extrapolation method can be expected to produce satisfactory results:

$$y_{t+1} = y_t (1 + \Delta x_{t+1}) \quad (5.2)$$

Of course, if the values of  $x_t$  are revised then the estimates of  $y_t$  must be re-computed.

- 5.30. An alternative formula may be used when the indicator displays seasonal variation (see Chapter 7 for a discussion of seasonal and calendar adjustment):

$$y_{t+1} = y_{t-3} (1 + \Delta_4 x_{t+1}) \quad (5.3)$$

where

$$\Delta_4 x_t = \frac{x_t - x_{t-4}}{x_{t-4}}$$

- 5.31. In this case it is implicitly assumed that the indicator and QNA variable have the same growth rate at the seasonal lag (4):

$$\Delta_4 y_t = \Delta_4 x_t$$

This relation implies that for each quarter of the year the extrapolation is independent of each of the three other quarters.

- 5.32. A recursive back-calculation of formula (5.2) leads to:

$$y_{t+1} = y_0 \prod_{i=1}^{t+1} (1 + \Delta x_i) \quad (5.4)$$

- 5.33. It is evident that while the growth rate of  $y$  is totally independent of the initial condition, the level of  $y_{t+1}$  depends on the initial condition  $y_0$ .  $y_0$  can be any of the four quarters in a chosen reference year if they are constrained to be consistent with the annual estimate. In the case of flow variables they are constrained to sum to the annual estimate:

$$Y = \sum_{i=1}^4 y_i$$

- 5.34. In the case of stock variables the value of the fourth quarter should equal that of the annual value. When using formula 5.3, each of the four quarters in the reference year provides the starting quarter for the recursive calculation of the  $y$  values for each type of quarter. If the same initial conditions are used when applying formula 5.2 and formula 5.3, then they produce the same results.
- 5.35. Formula 5.3 has the advantage of explicitly calculating growth rates free of seasonal variation, which can be useful for editing and validation purposes. Of course, a similar validation process can be undertaken for a QNA variable that has been derived using formula 5.2, either by seasonally adjusting the series and then calculating the quarter-on-quarter growth rates or by calculating the through year growth rates of the unadjusted data.

### ***Refinements to simple extrapolation***

- 5.36. Both formulae 5.2 and 5.3 are based on the assumption that the quarterly indicator describes the behaviour of QNA variable very well, if not perfectly. But it is often the case that  $y$  and  $x$  have similar growth in the long run but they are not so well correlated in the short run.
- 5.37. Various factors can perturb the relationship between the indicator and QNA variable in the short term, including:
- differences in time of reaction during the business cycle;
  - sampling error;
  - random non-sampling error.

- 5.38. Starting from this consideration, it is possible to formulate a new version of the simple extrapolation formula that takes into account some corrections to the basic relationship used in formulae 5.2 and 5.3. Many different correction mechanisms can be considered. The simplest and most used is:

$$y_{t+1} = y_t(1 + \Delta x_{t+1}) + w_t \quad (5.5)$$

- 5.39. Various factors may lead the national accounts compiler to believe a correction factor is required. They include:
- evidence from external variables used to validate the estimates;
  - experience from past errors made in similar situations or by learning from revisions (see Chapter 10);
  - a compiler's own appraisal of the economic situation.
- 5.40. All these factors play a role in QNA compilation. The first two are purely judgemental ones, even if they have some statistical foundation. The third one is purely subjective and carries the risk that QNA could reflect some personal opinion/judgement rather than the real economic situation. It is, nonetheless, important to recognize that personal intervention, if limited and correctly used with the benefit of experience, can improve the quality of QNA estimates.
- 5.41. This last modification of the simple extrapolation method is appropriate when the corrections required are independent of each other or one-offs. But when the growth rate of the indicator is thought to deviate from that of QNA variable over a number of successive quarters, or even the whole time series, in a systematic way then evidently the estimates could be improved. The best option, of course, is to improve the quality of the quarterly indicator (see Chapter 3). But this may not be possible, and so it falls to the national accounts compiler to seek a remedy. Two different approaches are described here for taking account of deficiencies in the quarterly indicator.
- 5.42. Differences between the medium and long-term growth rates of the quarterly indicator and the annual benchmarks are mostly resolved by the benchmarking process and it is the quarters beyond the latest annual benchmark that are of primary concern. If the quarterly indicator is growing at a different rate than the annual benchmark, then substantial revisions can be expected to those quarterly values when annual data eventually become available. The first approach is to adjust the latest estimates of QNA variable in order to minimize the revisions. This approach is described following the discussion on benchmarking.
- 5.43. The second approach is to estimate a statistical model that captures the relationship between the time paths followed by the (annualized) quarterly indicator and ANA benchmark and to use this model to generate improved estimates of QNA variable. Benchmarking of these quarterly estimates to the annual data is either done at the same time or separately in a second step.
- 5.44. When QNA are balanced, either in a supply and use framework or in some other way (see Chapter 8), then the corrections (or adjustments) will be further informed by the discrepancies in the unbalanced accounts. The general approach is to begin the balancing process with quarterly estimates that have been adjusted for any systematic deficiencies in the quarterly indicators (as described in §5.42-43) but postpone making any one-off adjustments until the balancing process begins, except in those cases where the national accounts compiler is confident that an adjustment is required.

## Benchmarking methods

5.45. Three commonly used statistical benchmarking procedures are:

- pro rata adjustment;
- Denton difference method;
- Denton proportional method.

### *Pro rata adjustment*

5.46. This benchmarking method simply consists of multiplying the preliminary quarterly estimates in a year by the ratio of ANA variable to the sum of the preliminary estimates of the four quarters.

5.47. While this method preserves the quarterly growth rates within the year it changes the growth rate between the last quarter of one year and the first quarter of the next. The extent of the change to this growth rate is determined by how much the annual benchmark-to-preliminary estimate ratio (i.e. the ratio of the annual benchmark to the sum of the preliminary estimates for the corresponding four quarters, which is commonly referred to as the benchmark-to-indicator (BI) ratio) has changed between the two years. For example, if the ratio were to change from 1.02 in year  $y$  to 1.00 in year  $y+1$ , then the growth rate of the preliminary estimates from the fourth quarter of year  $y$  to the first quarter of year  $y+1$  would be reduced by two percentage points after benchmarking. For this reason, pro rata adjustment is not recommended.

### *Denton difference method*

5.48. In both the Denton (1971) <sup>(14)</sup> difference method and the Denton proportional method the benchmarked estimates are obtained by allocating the discrepancy between the sum of four preliminary quarterly estimates and the corresponding ANA estimate to the four quarters in each year by minimizing a quadratic loss function over the whole, or overlapping lengthy spans, of the time series. Different versions of the quadratic loss function may be chosen.

5.49. In the Denton difference method the loss function is defined as the sum of squares of either the first or second order differences of each preliminary quarterly estimate and the benchmarked quarterly estimate. In the first difference case, which is the one most commonly used and the one referred to elsewhere in the handbook, the benchmarked values are those that minimize the following

$$\min \sum_{t=1}^n ((b_t - p_t) - (b_{t-1} - p_{t-1}))^2, \text{ subject to satisfying the annual constraints, where there}$$

are  $n$  quarterly observations and  $b_t$  is the benchmarked quarterly estimate at time  $t$  and  $p_t$  is the preliminary quarterly estimate at time  $t$ .

5.50. Minimizing the following loss function,

$$\sum_{t=1}^n (b_t - p_t)^2$$

subject to satisfying the annual constraints, should not be used. Indeed, its solution is to add one fourth of the annual discrepancy each quarter, and thereby create a step between the estimate of the fourth quarter one year and the first quarter of the next.

<sup>(14)</sup> In practice, a slightly modified version (developed by Pierre Cholette (1979, 1984)) of the original Denton method is used.

***Denton proportional method***

- 5.51. A combination of the pro rata adjustment and the Denton difference methods consists of minimizing the sum of squares of the first differences of the quotient of the benchmarked quarterly estimate and the preliminary quarterly estimate, i.e.

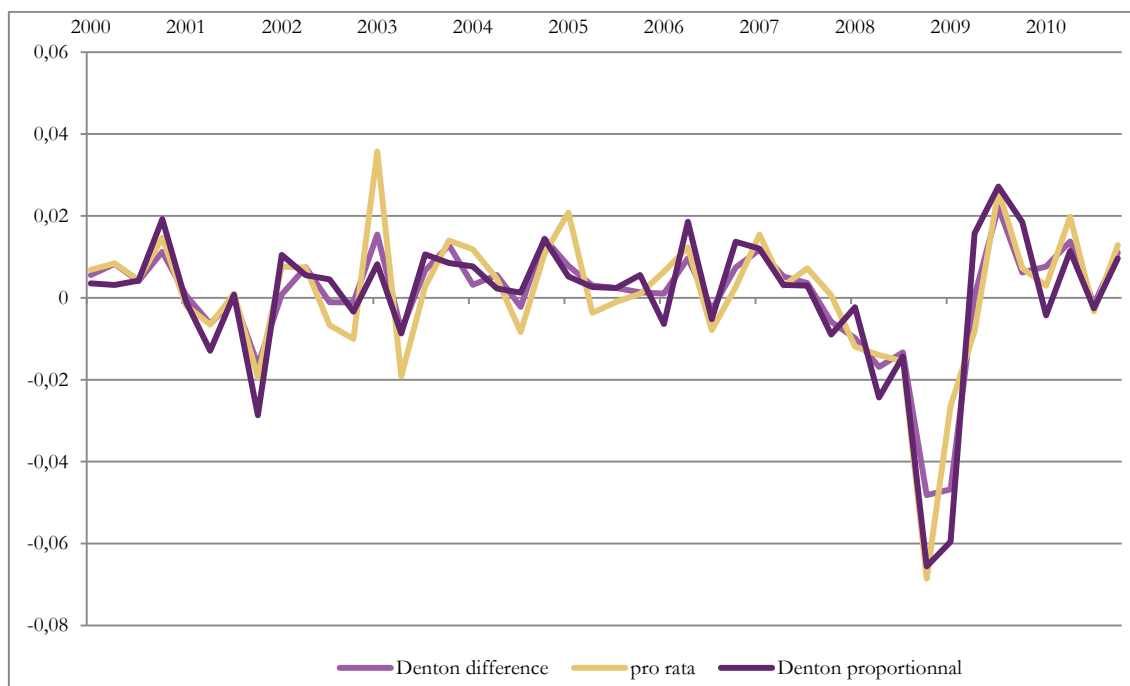
$$\min \sum_{t=2}^n \left( \frac{b_t}{p_t} - \frac{b_{t-1}}{p_{t-1}} \right)^2, \text{ subject to satisfying the annual constraints.}$$

This method can only be performed when the quotient  $b/p$  never changes sign and  $b$  and  $p$  are never zero.

***Characteristics of the two Denton methods***

- 5.52. The Denton difference method minimizes the (sum of squares of the) adjustments made to the difference between two neighbouring quarters, whilst the Denton proportional method minimizes the (sum of squares of the) differences of proportional adjustments of two neighbouring quarters. Therefore, the Denton difference method results in a smooth additive distribution of the differences between the annualized indicator and the benchmark series and the Denton proportional method results in a smooth multiplicative distribution of these differences. As a result, the Denton difference method tends to produce a smoother series, but the Denton proportional method changes the quarterly growth rates of the preliminary estimates the least.
- 5.53. Given these characteristics, the choice between the two methods largely depends on the qualities of the preliminary estimates of QNA variable. On the one hand, if the BI ratio is volatile then the Denton difference method is preferred because it minimizes the changes to the indicator at turning points and dampens volatility. On the other hand, if the BI ratio is smooth and it is thought that the short-term growth rates of the preliminary estimates are quite accurate and it is their medium, or long, term growth rates that differ from the annual benchmark series, then the Denton proportional method is favoured.

Figure 5.3: Comparison of the three benchmarking methods on the volume estimates of gross value added of the French manufacturing industry: quarter-on-quarter growth rates



- 5.54. The Denton proportional method produces the same result whether it is applied to the quarterly indicator or the preliminary estimates of QNA variable if they have been derived using simple extrapolation, because they have the same quarter-on-quarter growth rates. This is not the case for the Denton difference method because it is sensitive to the relative levels of the annualized quarterly indicator and the annual benchmarks. If the quarterly indicator is at quite a different level to QNA variable, it could lead to a significantly different outcome. If output is the indicator for quarterly gross value added and one wants to replicate its growth rate as closely as possible, then one should either use the Denton proportional method or use the output indicator to derive preliminary estimates of gross value added prior to benchmarking using the Denton difference method. If the indicator is actually an estimate of gross value added, but its level is unknown because of an undetermined constant (see §5.B.13), then one would choose the Denton difference method.
- 5.55. As noted above, the Denton difference method can be applied to any time series, whilst the proportional method should only be applied to data when the quotient  $b/p$  never changes sign and  $b$  and  $p$  are never zero.
- 5.56. All of the above phenomena need to be considered when choosing which alternative to use.

**Benchmarking the current year (when no annual data are available)**

- 5.57. When the simple extrapolation method is used to derive the preliminary estimates of a QNA variable, then one of the standard Denton methods can be used to benchmark them up to the fourth quarter of the latest benchmark year, year  $y$ . Preliminary quarterly estimates for subsequent quarters cannot be benchmarked until the annual benchmark for year  $y+1$  becomes available. In the interim, estimates for the first quarter of year  $y+1$  and all subsequent quarters are simply

derived by using the quarterly growth rates of the indicator, or preliminary estimates, to extrapolate from the benchmarked value for the fourth quarter of year  $y$ .

- 5.58. Depending on the behaviour of the BI ratio over recent years, this may subsequently lead to larger revisions than necessary. For example, suppose the ratio appears to be random with a mean of 1, and further suppose that the latest year for which a benchmark is available is year  $y$ . If the ratio has a value of 1.02 in year  $y$  it means that one of the standard Denton methods would raise the preliminary quarterly values for year  $y$  by 2% on average. Quarterly estimates for year  $y+1$  derived by simple extrapolation from the fourth quarter of year  $y$  would be raised by the same amount as the fourth quarter value of year  $y$ . Given that the expected value of the BI ratio is 1 in year  $y+1$ , revisions can be expected when the annual benchmark for year  $y+1$  becomes available. In this and other scenarios, the revisions can be reduced by forecasting the BI ratio for quarters beyond the latest annual benchmark.
- 5.59. This issue is similar to that concerning smoothing, described in §5.18, where it is advantageous to make as good a forecast as possible for the year ahead. However, it is much less demanding to make a forecast of the BI ratio than it is to make a forecast of the actual annual value of the national accounts variable.
- 5.60. Chapter 6 of the IMF's QNA Manual provides a comprehensive description and analysis of the various versions of the Denton method. It also provides guidance on how to use an enhanced version of the Denton proportional method that allows forecasting of the BI ratio for quarters beyond the latest annual benchmark. Software to run the enhanced version is available from the IMF.
- 5.61. Finally, while forecasting the BI ratio can be used as an alternative to the use of models (described below), some NSIs use it in conjunction with modelling.

### **Methods that impute values for a QNA variable by modelling the relationship between (annualized) preliminary quarterly estimates of a QNA variable, or a quarterly indicator, and the corresponding annual benchmarks**

- 5.62. A more sophisticated way of dealing with differences between the growth rates of the annual benchmarks and preliminary estimates of a QNA variable is to model their relationship. However, the use of statistical models has to respect some principles in order to avoid the possibility that the compilation of QNA becomes purely an econometric modelling exercise. These principles are largely based on the set of desirable properties of QNA estimates listed in §4.14:
- The set of basic information should only include statistical variables that are considered good proxies of the variables to be estimated.
  - All the variables that have a high explanatory power with respect to a specific national accounts aggregate but which do not satisfy (a) have to be eliminated from the set of basic information; for example, the use of interests rate for the estimation of components of GDP other than FISIM.
  - The statistical models should not incorporate any relationships based on economic hypotheses, such as the relationship between consumption and disposable income.
  - The set of basic information should only include variables associated with the economy of the country for which QNA are compiled. This means that any relationship between quarterly aggregates of different countries, except those regarding international trade, should not be included in the formulation of mathematical and statistical models.

- 5.63. QNA data are commonly used to test economic hypotheses, undertake simulations of economic policies given different scenarios and different paths of the economy, and undertake forecasting. If an economic hypothesis is used in the estimation process it could heavily influence the estimates and thereby affect the results of these economic analyses. So, the compilation of QNA must be neutral with respect to economic hypotheses.
- 5.64. As noted earlier, even if the basic data fully satisfy the concepts and coverage of the target QNA variables, the use of statistical models may still offer some advantages (stage 1b of Figure 4.1). In particular, their use may reduce the revisions to estimates for the latest quarters that result from the introduction of a new benchmark year.

### **Chow and Lin method**

- 5.65. The classical univariate temporal disaggregation problem is how to estimate the unknown quarterly values of a QNA variable when given the annual observations for it and quarterly values for one or more related time series.
- 5.66. Chow and Lin (1971) worked out a least-square optimal solution on the basis that a linear regression model involving the QNA variable  $y$  and one or more related quarterly indicators  $x$  can be estimated using the annual data for QNA variable and the annualized quarterly data for the indicator(s). This model can be written as:

$$y_{a,t} = \gamma + \beta x_{a,t} + u_{a,t} \quad (5.6)$$

where  $y_{a,t}$  is the value of an annual time series in year  $t$ , etc.

- 5.67. Unlike the subjective corrections made as per formula 5.5, the corrections made using this method are systematic and come from the model. However, manual intervention is always possible if economically justified.
- 5.68. The Chow and Lin method has a several desirable features:
- It is very general in that it produces identical solutions to other methods, such as the BFL and the Denton difference benchmarking procedure, under certain assumptions.
  - It is possible to evaluate the precision of the estimates by means of all the standard regression analysis tools. In particular:
    - compute confidence intervals for the estimates according to suitable distribution hypotheses;
    - assess the quality of the quarterly indicators;
    - perform econometric analyses that take into account the ‘noisy’ nature of the data.
  - The concepts of the Chow and Lin method can be easily extended to the multivariate case (see Chapter 8) and to more complex models.
- 5.69. The Chow and Lin method produces estimates for QNA variable that are temporally consistent with the annual benchmark values in one step.
- 5.70. Estimates for the quarters of the latest year, for which no annual benchmark data exist, are directly obtained from the quarterly regression model and the quarterly residuals are inferred.



- 5.71. The general method proposed by Chow and Lin has been intensively used by some NSIs, especially by those in Spain and in Italy. Different variants of the method have been developed according to different hypotheses of the structure of the residual in the regression model ( $u_{a,t}$ ).

The stochastic error models usually considered when estimating QNA variables are the following:

- a. AR(1) model (Chow and Lin, 1971);
  - b. random walk model (Fernández, 1981);
  - c. random walk-Markov model (Litterman, 1983, Di Fonzo, 1987).
- 5.72. Annex 5.C presents a comparative analysis of these three models and the French two-step method (described below) when applied to actual national accounts variables. The objective is not to identify a preferred model, but rather to demonstrate how a preferred model may be identified for a particular QNA variable. For each model, regression statistics are presented and assessments are made of their predictive and distributive performance. ANA analysis also includes simple extrapolation used in conjunction with benchmarking to the annual data.

#### *Developments of Chow and Lin's optimal method (dynamic models and Kalman filter)*

- 5.73. The regression model used in the Chow and Lin method has no dynamic components, i.e. no lags or leads of  $y$  and  $x$ . The temporal disaggregation and interpolation processes are based only on the dynamic of the indicator. Substantial developments have been made to include dynamic features (Santos, Silva and Cardoso (2001)) or to imbed them in the more general framework of the Kalman filter (Pierse (1984) or Moauro and Savio (2005)).

#### *Optimal methods using two steps <sup>(15)</sup>*

- 5.74. The former methods are designed to produce estimates for QNA variable that are temporally consistent with the annual benchmark values in one step. An analytically and computationally simpler approach is to use two steps, namely:
- fit a model to the annualized quarterly indicator and annual benchmark time series, and then use the model to generate preliminary estimates of QNA variable;
  - use a benchmarking procedure to ensure temporal consistency.

Static models, such as those used in the Chow and Lin method, or lagged dynamic models may be used, such as

$$y_{a,t} = \alpha y_{a,t-1} + \gamma + \beta_1 x_{a,t} + \beta_2 x_{a,t-1} + u_{a,t} \quad (5.7)$$

- 5.75. A commonly used model is a regression in first differences:

$$\delta y_{a,t} = \gamma + \beta \delta x_{a,t} + u_{a,t}, \quad (5.8)$$

$$\text{where } \delta y_{a,t} = y_{a,t} - y_{a,t-1}$$

In all these examples a stochastic error model may be required.

<sup>(15)</sup> In the literature on temporal disaggregation, Chow and Lin methods are commonly referred to as "optimal methods" and "one-step methods". In the handbook, the descriptor "optimal" is also used for the two-step method because the difference between one-step and two-step methods is less than usually thought; under slightly different hypotheses than those of the classical Chow and Lin method and its variations, two-step procedures can be optimally performed.

- 5.76. The French NSI (INSEE) uses such a two-step procedure, and experience has shown that QNA variables in the French national accounts can be adequately modeled using one of six models (four static and two dynamic). The French approach is described in Annex 5.B.

### *Optimal methods versus simple extrapolation*

- 5.77. The use of statistical models in the compilation of QNA has proved to be of considerable benefit in several European countries (such as France, Italy, Spain and Switzerland). Indeed, the benefit may be such that it provides an alternative to spending more resources on improving the quality of the quarterly indicator or developing a new quarterly indicator. However, there are three important caveats:
- The indicator needs to have a reasonably strong relationship with the corresponding national accounts variable.
  - There needs to be sufficient annual data on a consistent basis to apply the models. Short time series and time series which have structural breaks can lead to unstable estimates of the coefficients that, in turn, lead to poor outcomes. Having said that, the a priori assumption that the indicator can be used directly will not necessarily lead to the best possible outcome in such circumstances.
  - The application of statistical models needs to be done well, which implies personnel with the necessary skills. This matter is discussed further, below.
- 5.78. Three graphs are presented below, Figures 5.4 - a, b and c. They show the results of using two optimal methods for deriving seasonally adjusted volume estimates of French manufacturing gross value added for various periods of distribution (i.e. periods for which there are annual benchmarks) and extrapolation (i.e. periods for which there are no annual benchmarks). In addition, simple extrapolation (i.e. using the growth rate of the indicator, subject to benchmarking when annual data are available) is included. The manufacturing production index (see Annex 2.A) is the quarterly indicator. Five time series are presented in each figure:
- volume estimates of manufacturing gross value added derived using the French two-step method, currently used at INSEE, benchmarked to the annual data up to the fourth quarter 2007 (Figure 5.4a), up to the fourth quarter of 2008 (Figure 5.4b) and up to the fourth quarter of 2009 (Figure 5.4c) and then extrapolations for the next four quarters using the fitted statistical model;
  - as per (a), but using the Fernandez variant of the Chow and Lin method;
  - as per (a), but using simple extrapolation based on the growth rate of the indicator;
  - as per (a), but using the French two-step method up to the fourth quarter 2010 and then extrapolated from the first quarter 2011 using the fitted statistical model;
  - the annual value of manufacturing gross value added (divided by four), (grey bars for the data used to estimate the regression models and white bars for the annual values that are not used to estimate the regression models, except for (d)).
- 5.79. Until the end of 2010 the only quarterly estimates that are benchmarked to annual estimates are those derived in (d), and by using them as the yardstick an assessment can be made of the relative performance of the different methods for periods of extrapolation. While the statistical models produce different results for the extrapolations in 2008 and 2010, at least one of them performs better than simple extrapolation using the quarterly indicator (c). The best performing method for 2008 and 2010 in this example is the Fernandez variant of the traditional Chow-Lin approach. While the best performer for 2009 is simple extrapolation, but not by much.

Figure 5.4a: Use of an output volume index to derive volume estimates of French manufacturing gross value added, extrapolation for 2008 (million €)

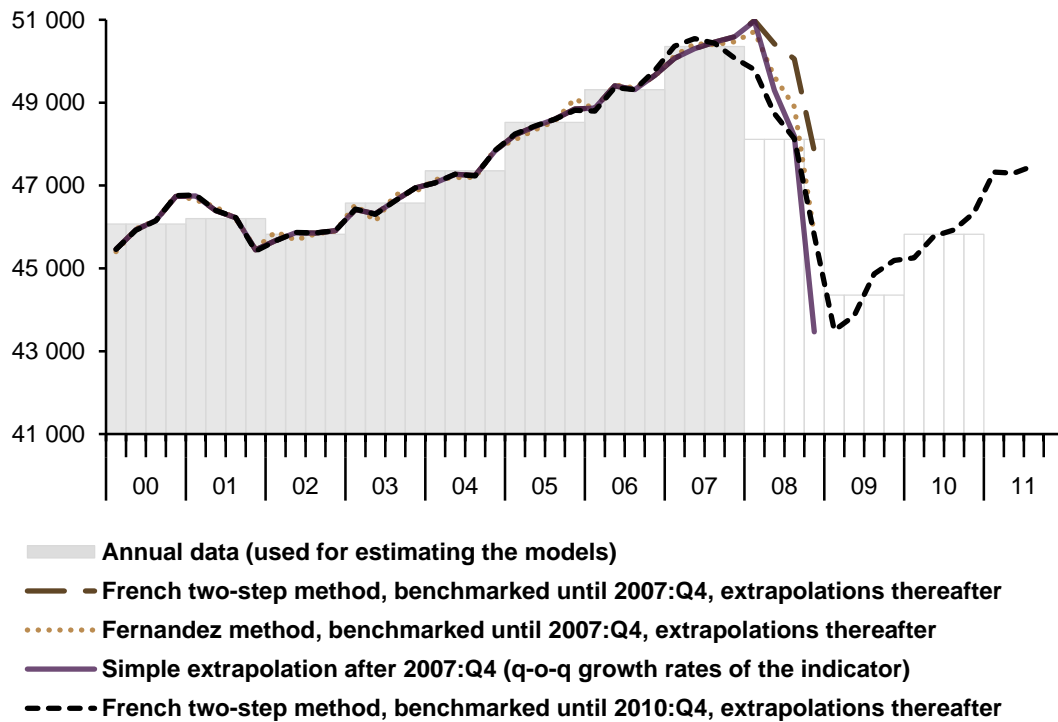


Figure 5.4b: Use of an output volume index to derive volume estimates of French manufacturing gross value added, extrapolation for 2009 (million €)

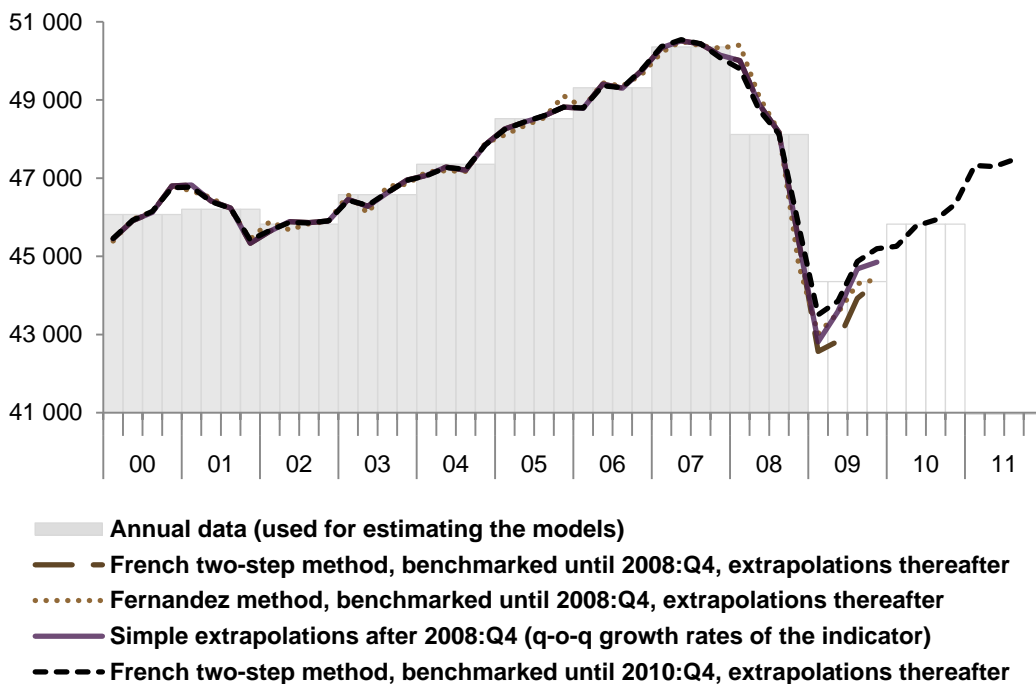
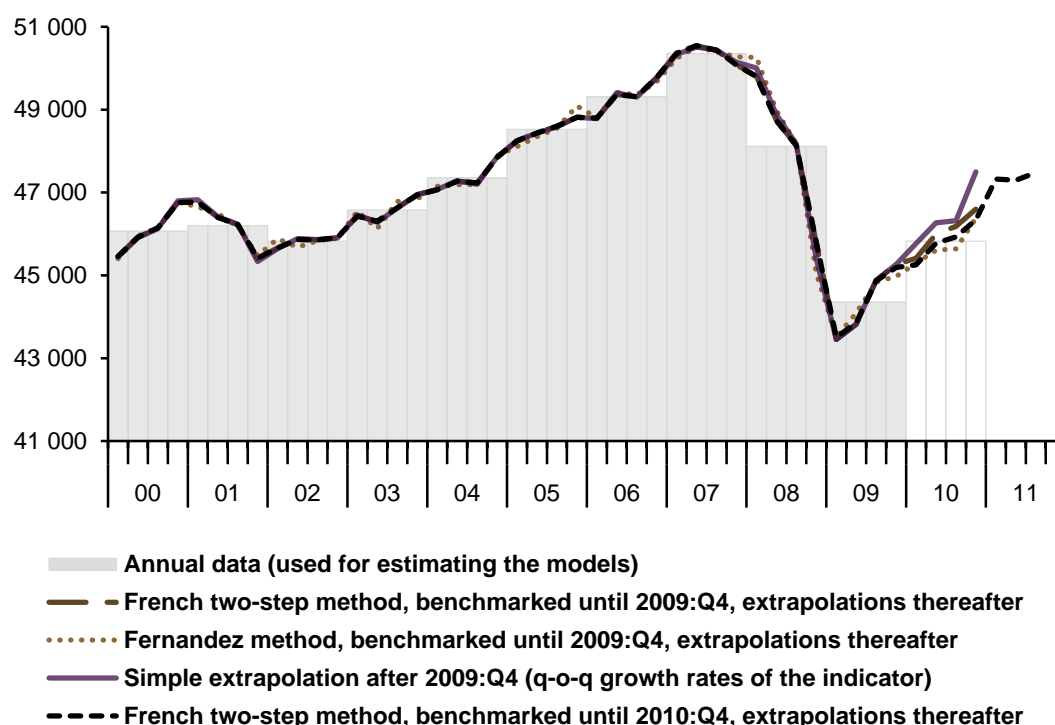


Figure 5.4c: Use of an output volume index to derive volume estimates of French manufacturing gross value added, extrapolation for 2010 (million €)



- 5.80. As noted earlier, a comprehensive comparison of various methods/models is presented in Annex 5.C. The results show that the choice between “simple extrapolation” and using a more sophisticated technique is not necessarily a black-and-white issue. Four QNA variables are included in the comparison. For two of them, there is quite a strong relationship between the growth rates of the annualized indicator and the national accounts variable. For these variables (including the one presented in Figures 5.4 - a, b and c), simple extrapolation performs quite well. For the other two national accounts variables, the relationship with the indicator is weaker and simple extrapolation performs significantly less well than the best performing models. This result lends support to the recommendation made in §5.27: if contemplating using simple extrapolation, it is advisable to test how strong the relationship is between the indicator and the corresponding national accounts variable, such as by fitting a simple difference model (equation 5.1) to the data.

## Organizational arrangements for the use of statistical methods in QNA

- 5.81. The use of statistical methods in compiling QNA has much in common with seasonal adjustment. Both involve selecting an appropriate model and either estimating or selecting parameter values based on the results of statistical diagnostics and tests. Decisions have to be made about prior adjustments and assessments have to be made of the on-going performance of the models as time goes by. Special interventions may be needed from time to time (such as for the sudden downturn in many European economies in 2008). As for seasonal adjustment, there is a clear need for technical expertise. But unlike seasonal adjustment, the use of statistical methods to estimate QNA variables is unique to the national accounts (and possibly the balance of payments); they are not ubiquitous like seasonal adjustment. This means that it may not be feasible to have a team of dedicated specialists available to help maintain the models for QNA in the way that it is for seasonal adjustment (§7.61-7.64).

- 5.82. If the NSI is responsible for making forecasts using econometric models, then those responsible for this work could also provide assistance in establishing and maintaining the models used for QNA. In the absence of suitably qualified and experienced staff elsewhere in the NSI, the national accounts compilers have to take full responsibility themselves.

### Seasonal adjustment and benchmarking

- 5.83. The issue of whether to benchmark seasonally adjusted data to annual benchmarks is addressed in §7.74-7.76. Mainly for practical reasons, it is recommended that the seasonally adjusted estimates should be temporally consistent with the corresponding calendar-adjusted annual estimates. Furthermore, the unadjusted and seasonally adjusted QNA variables should be derived in a consistent way.

### Summary of main points

- 5.84. This chapter has described some of the univariate methods that can be used to derive estimates of QNA variables from the basic data. To some extent the choice of method to be used is governed by the quality of the available data, but it is also influenced by philosophical considerations, such as the NSIs views on the role of modelling, and practical considerations.
- 5.85. Some NSIs, in particular those of France, Spain, Switzerland and Italy, have long experience in the use of modelling and they believe there is a substantial benefit to be gained from it. Obviously, successful modelling does not come without a cost. It requires national accounts compilers (or some other NSI staff) with the requisite modelling skills and it involves more work. On the other hand, the use of models may allow for greater automation of the compilation process, which may allow more time for validation.
- 5.86. The biggest difference in the performance of methods involving the use of optimal statistical models and simple extrapolation/standard benchmarking methods generally lies in the periods beyond the latest annual benchmark (and may be a few preceding quarters to a lesser extent) and is reflected in the extent of the revisions to the quarter-on-quarter growth rates when new annual benchmarks become available. This is because extrapolations using optimal methods take account of the past relationship between the annual benchmarks and the annualized quarterly indicators, whereas simple extrapolations assume that QNA variable and the indicator are growing at the same rate. Providing the modeling is done reasonably well then smaller revisions can be expected. Having said that, experience has shown that the choice of model is important, and it can have a significant impact on both the susceptibility to revision of the latest quarterly estimates and the quarterly movements for earlier periods, for which there are annual benchmarks.
- 5.87. An enhanced version of the Denton proportional method is to make forecasts of the benchmark-to-indicator ratio for the latest year or two. This can be used either as an alternative to modelling or as a complement to modelling.
- 5.88. NSIs that currently do not use any modelling but who are interested in doing so may wish to consult their French, Spanish, Swiss and Italian colleagues before undertaking their own experimental analyses.

## 5. Annex A — A formal presentation of mathematical and statistical models

### Introduction

- 5.A1. In this annex to Chapter 5, mathematical and statistical methods are formally presented. The hypotheses associated with each method and with each technique are stated and the advantages of the use of one or the other technique are discussed.
- 5.A2. The annex starts with smoothing methods and time series methods (applicable when no quarterly indicator is available), continues with benchmarking techniques followed by optimal methods and dynamic models. Emphasis is put on the extrapolation aspect of the estimation process due to its importance in compiling QNA. The French two-step method is described in Annex 5.B, and a comparative analysis of this method and three variants of the Chow and Lin method is presented in Annex 5.C.
- 5.A3. The aim of the annex is to present the mathematical and statistical methods most frequently used in compiling QNA in a rigorous statistical way, but it is far from being a complete overview of temporal disaggregation techniques. All the methods described are available in ECOTRIM, the temporal disaggregation program developed by Eurostat.

### Basic principles

- 5.A4. Depending on the nature of the series, the processes for temporal disaggregation of annual data is described as:

*Distribution:* when the annual data are either sums or averages of quarterly data (e.g. GDP, consumption, and, in general, all flow variables, price indexes, employment, unemployment, and, in general, all average stock variables).

*Interpolation:* this category includes the case of stock variables observed annually at the beginning or end of the year. (e.g. population at the end of the year, money stock, inventories).

*Extrapolation:* when estimates of quarterly data are made where the relevant annual data are not yet available. This third type of process is conceptually different from the first two because the extrapolated estimates do not have to satisfy any annual constraint. Nevertheless, all three types of process can be included within a common framework.

- 5.A5. Denote  $y_{j,4(t-1)+i}$  as the unknown value of QNA variable  $y$ ,  $j=1, \dots, M$ , in quarter  $i$  of year  $t$ , and let  $y_{j,a,t}$ ,  $t=1, \dots, n$ , be the corresponding known annual value. Omitting index  $j$  for the sake of simplicity, the linkage between  $y_{4(t-1)+i}$  and  $y_{a,t}$  in the distribution case is:

$$y_{a,t} = \sum_{i=1}^4 y_{4(t-1)+i}, \quad t=1, \dots, n,$$

when the quarterly values sum to the annual, or

$$y_{a,t} = \frac{1}{4} \sum_{i=1}^4 y_{4(t-1)+i}, \quad t=1, \dots, n,$$

when the annual figure is the average of the quarterly ones.

In the interpolation case it is:

$$y_{a,t} = y_{4t}, \quad t=1, \dots, n,$$

when the annual figure is the same as the fourth quarter, such as when inventory (closing) levels are recorded at the end of the period (quarterly and annually), or

$$y_{a,t} = y_{4t-3}, \quad t=1, \dots, n,$$

when the annual figure is the same as the first quarter, such as when inventory (opening) levels are recorded at the beginning of the period (quarterly and annually).

5.A6. The linkage between quarterly and annual series can be reformulated in matrix form as

$$\mathbf{B}\mathbf{y} = \mathbf{y}_a$$

where  $\mathbf{y}$  is the  $(N \times 1)$  vector of the unknown quarterly data and  $\mathbf{y}_a$  is the vector containing the  $(n \times 1)$  annual series to be disaggregated.  $N$  is generally equal to  $4n$ ; however, when dealing with extrapolation problems it will be convenient to assume  $N=4n+q$ , with  $q>0$ .  $\mathbf{B}$  is an  $(n \times N)$  aggregation matrix whose form depends on the type of temporal aggregation we consider.

More precisely, it is:

$$\mathbf{B} = \begin{bmatrix} \mathbf{b} & 0 & \dots & 0 \\ 0 & \mathbf{b} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \mathbf{b} \end{bmatrix}$$

where

$$\mathbf{b} = [1 \quad 1 \quad 1 \quad 1] \quad \text{for flow variable distribution problems;}$$

$$\mathbf{b} = \frac{1}{4}[1 \quad 1 \quad 1 \quad 1] \quad \text{for index variable distribution problems;}$$

$$\mathbf{b} = [1 \quad 0 \quad 0 \quad 0] \quad \text{for stock variable interpolation problems;}$$

$$\mathbf{b} = [0 \quad 0 \quad 0 \quad 1] \quad \text{for stock variable interpolation problems.}$$

- 5.A7. As far as extrapolations are concerned ( $q \geq 1$ ), either for a distribution or an interpolation problem,  $q$  ( $n \times 1$ ) null vectors must be adjoined to the corresponding aggregation matrix.

### Smoothing methods

- 5.A8. The most commonly used methods of disaggregation in which no quarterly related indicators are involved are smoothing methods. These methods typically assume that the unknown quarterly trend can be conveniently described by a function of time, either given *a priori* or to be chosen within a larger class, such that the necessary condition of aggregation constraints and the desirable condition of smoothness are satisfied.
- 5.A9. A widely used purely mathematical method has been provided by Boot, Feibes and Lisman (1967), hereafter BFL. According to this approach, the estimated quarterly series consistent with a given annual series is the solution of a constrained quadratic minimization problem.

$$\underset{y}{\text{Min}} \mathbf{y}'\mathbf{M}\mathbf{y} \text{ constrained by } \mathbf{B}\mathbf{y} = \mathbf{y}_a$$

where  $\mathbf{M}$  is a ( $N \times N$ ) symmetric, non-singular matrix.

- 5.A10. Two versions of the BFL method are currently in use:
- First Difference (FD);
  - Second Difference (SD).
- 5.A11. For the first order differences (FD) case, matrix  $\mathbf{M}$  is given by  $\mathbf{M}=\mathbf{D}'\mathbf{D}$ , where  $\mathbf{D}$  is the ( $N \times N$ ) matrix :

$$\mathbf{D} = \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 & 0 \\ -1 & 1 & 0 & \cdots & 0 & 0 \\ 0 & -1 & 1 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & -1 & 1 \end{bmatrix}$$

- 5.A12. As far as second order differences (SD) are concerned, matrix  $\mathbf{M}$  is given by  $\mathbf{M} = \mathbf{D}'\mathbf{D}'\mathbf{D}\mathbf{D}$ .

The BFL estimates are the solution in  $\mathbf{y}$  of the following linear system:

$$\begin{bmatrix} \mathbf{M} & -\mathbf{B}' \\ \mathbf{B} & 0 \end{bmatrix} \begin{bmatrix} \mathbf{y} \\ \lambda \end{bmatrix} = \begin{bmatrix} 0 \\ \mathbf{y}_a \end{bmatrix}$$

where  $\lambda$  is a vector ( $n \times 1$ ) of Lagrange multipliers,  $\mathbf{B}$  is the aggregation matrix defined above.

The solution is  $\mathbf{y} = \mathbf{M}^{-1}\mathbf{B}'(\mathbf{B}\mathbf{M}^{-1}\mathbf{B}')^{-1}\mathbf{y}_a$



- 5.A13. Further technical details and a simplified way to perform the calculations can be found in the original BFL paper.

Note that all the quarterly estimates need to be recalculated when new annual data become available. As will be seen, this characteristic is common to all methods considered in this annex.

### Time series methods

- 5.A14. Time series methods, in particular those derived from ARIMA processes (AutoRegressive, Integrated, Moving Averages) are extensively documented. As discussed in Chapter 7, ARIMA models are commonly used for seasonal adjustment purposes. In this section, procedures developed by Wei and Stram and Al-Osh are briefly described.
- 5.A15. As was explained in Chapter 5, time series methods aim to incorporate into the temporal disaggregation model all the information on dynamics contained in the historical time series. These methods are essentially based on models of the ARIMA type. They estimate the high-frequency (i.e. quarterly) series by using the information supplied both by the aggregate ARIMA model associated with the available low-frequency (i.e. annual) series and by the theoretical relationships that link aggregate (annual) and disaggregate (quarterly) ARIMA models.
- 5.A16. As a result of the ARIMA model based approach, some further information can be obtained using time series methods. In particular, all the techniques considered provide for confidence intervals and some of them supply an estimate of the disaggregated ARIMA model as well as the opportunity to predict future values. It should be noted that, with reference to the two procedures which are analyzed here, the only information available corresponds to the aggregate (annual) series and to its ARIMA model. The problem is therefore one for which information is very much lacking. Nevertheless, in practice these methods require more computational resources and a more active role on the part of the researcher/compiler than smoothing methods.

### Wei and Stram's procedure

- 5.A17. Since the ARIMA model and its autocovariance structure are closely related, Stram and Wei (1986) and Wei and Stram (1990) considered the possibility of estimating the autocovariance structure for the unknown quarterly series from the available autocovariances of the annual model.

The relationship between the annual and the quarterly structure of covariance is the basis of the approach.

Define the stationary process  $w_{4(-1)t+i} = (1 - \mathbf{B})^d y_{4(t-1)+i}$  and  $u_{a,t} = (1 - \mathbf{B})^d y_{a,t}$  obtained by differencing the quarterly and the annual series, respectively, where  $\mathbf{B}$  denotes the backward shift operator  $\mathbf{B}x_t = x_{t-1}$ . A result by Barcellan and Di Fonzo (1994) states the relationship between the covariances of  $w_{4(-1)t+i}$  and  $u_{a,t}$  permit the use of a generalised least squares procedure able to supply estimates which fulfil the aggregation constraint. Accordingly,

$$\hat{\mathbf{y}} = \begin{bmatrix} \Delta_n^d \\ \mathbf{0} \mathbf{I}_d \otimes \mathbf{c}' \end{bmatrix}^{-1} \begin{bmatrix} \mathbf{V}_w (\mathbf{C}^d)' \mathbf{V}_u^{-1} \Delta_n^d \\ \mathbf{0} \mathbf{I}_d \end{bmatrix} \mathbf{y}_a$$

Where  $\mathbf{V}_u$  and  $\mathbf{V}_w$  are the variance-covariance matrix derived from the relation between the autocovariances of the stationary aggregated and disaggregated model,  $\mathbf{C}^d$  is a matrix which includes the information derived from the aggregation type and the differentiation, and  $\otimes$  is the Kronecker product.

- 5.A18. In practice, the matrices  $\mathbf{V}_u$  and  $\mathbf{V}_w$  are usually unknown and have to be estimated using the available data. While  $\mathbf{V}_u$  can be easily calculated by using the aggregated model parameter estimates, the estimation of  $\mathbf{V}_w$  is not straightforward. Wei and Stram (1990) founded their disaggregation procedure on the relationship between the autocovariances of the aggregated and the disaggregated model. This is not generally a one to one relationship but, under suitable assumptions, it permits estimation of the disaggregated ARIMA model and then the associated autocovariance matrix (see Wei and Stram, 1990). As was seen for the optimal approach, the extrapolation problem can be solved by using the augmented aggregation matrix  $[\mathbf{0} \ \mathbf{B}]$  instead of  $\mathbf{B}$ .

#### *Al-Osh's procedure*

- 5.A19. Al-Osh (1989) considered a dynamic linear model approach for disaggregating time series. He used an appropriate state space representation of the ARIMA model which describes the unknown series and which takes care of the temporal aggregation constraint. The estimated state vectors and the corresponding covariance matrices are obtained by using the Kalman filter with reference to the state space representation.

#### *Further information about time series methods*

- 5.A20. For further information about time series methods, some widely used books are: Hamilton, *Time Series Analysis*, Princeton University Press, and Greene, *Econometric Analysis*, Prentice Hall.

#### **Annual benchmarking**

- 5.A21. As stated in Chapter 5, all of the methods described in the handbook that use an indicator to estimate a QNA variable do so in two notionally separate phases: preliminary estimation and benchmarking to ensure consistency with the annual benchmarks. However it is obtained, the  $(N \times 1)$  vector  $\mathbf{p}$  of preliminary quarterly estimates does not satisfy the temporal aggregation constraints (for flow variables), so that:

$$\sum_{i=1}^4 p_{j,4(t-1)+i} \neq y_{a,t}, \quad t=1, \dots, n$$

or, in matrix form,  $\mathbf{Bp} \neq \mathbf{y}_a$

$\mathbf{u}_a = \mathbf{y}_a - \mathbf{Bp}$  is the  $(n \times 1)$  vector of annual discrepancies between the annual benchmark and the annualized preliminary estimates. Benchmarking procedures operate to 'distribute'  $\mathbf{u}_a$

in order to fit the annual constraints and, ideally, should do so by altering the quarterly path of  $\mathbf{p}$  to the least extent possible.

- 5.A22. Some estimation methods, such as the Chow and Lin method, combine the use of models to make preliminary estimates with a second step to amend these estimates to satisfy the annual benchmarking constraints. Other estimation methods stop with the estimation of preliminary estimates. In such cases, a mathematical procedure is used to do the benchmarking. Over the years several procedures have been widely used, with the simplest and least satisfactory being pro rata adjustment. But the most commonly used mathematical methods that are “optimal” are based on Denton (1971).

### *Denton methods*

- 5.A23. The final quarterly estimates are calculated by minimizing a quadratic loss function of  $\mathbf{y}$  and  $\mathbf{p}$ , subject to satisfying the annual constraint. The quadratic loss function is the sum of squares of either the first or second differences of a function of the preliminary and final estimates of QNA variable.

### *Denton difference method*

- 5.A24.  $\mathbf{y}$  is estimated by minimizing either the sum of squares of the first or second difference of  $\mathbf{y}$  and  $\mathbf{p}$

$$\underset{\mathbf{y}}{\text{Min}} (\mathbf{y} - \mathbf{p})' \mathbf{M} (\mathbf{y} - \mathbf{p}) \text{ constrained by } \mathbf{B}\mathbf{y} = \mathbf{y}_a$$

or identically

$$\underset{\mathbf{u}}{\text{Min}} \mathbf{u}' \mathbf{M} \mathbf{u} \text{ constrained by } \mathbf{B}\mathbf{u} = \mathbf{u}_a$$

where  $\mathbf{M}$  is a  $(N \times N)$  symmetric, non-singular matrix

- 5.A25. For the first order differences (FD) case, matrix  $\mathbf{M}$  is given by  $\mathbf{M} = \mathbf{D}'\mathbf{D}$ , where  $\mathbf{D}$  is the  $(N \times N)$  matrix:

$$\mathbf{D} = \begin{bmatrix} 1 & 0 & 0 & \dots & 0 & 0 \\ -1 & 1 & 0 & \dots & 0 & 0 \\ 0 & -1 & 1 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \dots & -1 & 1 \end{bmatrix}$$

- 5.A26. The objective function to be minimized is the sum of the squared quarterly changes of the residual under the annual benchmarking constraint, i.e. the exact same problem as BFL. As far as second order differences are concerned, the matrix  $\mathbf{M}$  is given by  $\mathbf{M} = \mathbf{D}'\mathbf{D}'\mathbf{D}\mathbf{D}$ .
- 5.A27. The solution to this benchmarking problem is given by:

$$\hat{\mathbf{y}}^D = \mathbf{p} + \mathbf{M}^{-1} \mathbf{B}' (\mathbf{B} \mathbf{M}^{-1} \mathbf{B}')^{-1} \mathbf{u}_a$$

Note that the benchmarking used in the Chow and Lin method is a specific case of benchmarking *à la* Denton, i.e. where  $\mathbf{M} = \mathbf{V}^{-1}$  (compare the formulae in §5.A27 and §5.A33).

**Denton proportional method**

- 5.A28.  $\mathbf{y}$  is estimated by minimizing the sum of squares of the first difference of the quotient  $y/p$ , subject to satisfying annual temporal constraint i.e.

$$\underset{\mathbf{y}}{\text{Min}} (\mathbf{y} - \mathbf{p})' \mathbf{Q} (\mathbf{y} - \mathbf{p})$$

with  $\mathbf{Q} = \hat{\mathbf{p}}^{-1} \mathbf{D}' \mathbf{D} \hat{\mathbf{p}}^{-1}$  and where  $\hat{\mathbf{p}}$  is a diagonal matrix of the preliminary estimates  $p$ , subject to the annual constraint  $\mathbf{B}\mathbf{y} = \mathbf{y}_a$

- 5.A29. Di Fonzo (2003) provides the following solution:

$$\begin{bmatrix} \mathbf{y} \\ \lambda \end{bmatrix} = \begin{bmatrix} \hat{\mathbf{p}} & 0 \\ 0 & \mathbf{I} \end{bmatrix} \begin{bmatrix} \mathbf{D}' \mathbf{D} & \hat{\mathbf{p}} \mathbf{B}' \\ \mathbf{B} \hat{\mathbf{p}} & 0 \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ \mathbf{y}_a \end{bmatrix},$$

where  $\lambda$  is a vector of Lagrange multipliers to be estimated

- 5.A30. This benchmarking solution can be extended to include quarterly observations beyond the latest annual benchmark. Suppose there are  $k$  additional preliminary quarterly observations available. The length of the preliminary vector  $\hat{\mathbf{p}}$  becomes  $k$  observations longer. To obtain the corresponding estimates of  $y$ , it is only necessary to enlarge the aggregation matrix  $\mathbf{B}$  by a sequence of  $k$  columns of zero. This formulation implies that for the extrapolated quarters the annual benchmark to preliminary estimate, or indicator, (BI) ratio is kept constant and equal to the last available ratio, which leads to an implicit forecast of the ratio. If the annual BI ratios can be modelled somehow, then a better forecast can be made.
- 5.A31. Chapter 6 of the IMF *Manual on QNA* provides detailed guidance on the best ways of dealing with various scenarios of annual benchmark-to-indicator (BI) ratio behaviour. Di Fonzo and Marini (2009) describe how the standard PFD can be enhanced to allow for forecasts of the annual BI ratios.

**Optimal methods**

- 5.A32. Chow and Lin (1971) worked out the optimal (in a least squares sense) solution to the following univariate temporal disaggregation problem: given the  $(n \times 1)$  vector  $\mathbf{y}_a$  of annual observations for an accounts aggregate and given the  $(N \times k)$  matrix  $\mathbf{X}$  of quarterly observations of  $k$  related series, estimate the unknown quarterly values contained in the  $(N \times 1)$  vector  $\mathbf{y}$ . Suppose that the following linear regression model holds:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{u}$$

where  $\boldsymbol{\beta}$  is a vector  $(\kappa \times 1)$  of unknown parameters and  $\mathbf{u}$  is a vector of  $(N \times 1)$  random disturbances such that:

$$E(\mathbf{u}|\mathbf{X}) = 0 \quad E(\mathbf{u}\mathbf{u}'|\mathbf{X}) = \mathbf{V}$$

Note that  $\mathbf{V}$  cannot be estimated without a further hypothesis on the stochastic structure of the quarterly residual.

- 5.A33. The best linear unbiased estimator of  $\mathbf{y}$  consistent with the temporal aggregation constraints  $\mathbf{B}\mathbf{y} = \mathbf{y}_a$  is given by

$$\hat{\mathbf{y}} = \mathbf{X}\hat{\boldsymbol{\beta}} + \mathbf{V}\mathbf{B}'\mathbf{V}_a^{-1}\hat{\mathbf{u}}_a$$

where  $\hat{\mathbf{u}}_a = \mathbf{y}_a - \mathbf{X}_a\hat{\boldsymbol{\beta}}$  is the estimated annual residual,  $\mathbf{V}_a$  is the covariance matrix of these residuals and

$$\hat{\boldsymbol{\beta}} = (\mathbf{X}'_a \mathbf{V}_a^{-1} \mathbf{X}_a)^{-1} \mathbf{X}'_a \mathbf{V}_a^{-1} \mathbf{y}_a$$

- 5.A34. It is observed that  $\hat{\boldsymbol{\beta}}$  is the generalised least squares estimate of  $\boldsymbol{\beta}$  in the annual model of observed data:

$$\mathbf{B}\mathbf{y} = \mathbf{B}\mathbf{X}\boldsymbol{\beta} + \mathbf{B}\mathbf{u} \text{ i.e. } \mathbf{y}_a = \mathbf{X}_a\boldsymbol{\beta} + \mathbf{u}_a$$

where the  $(n \times 1)$  vector of annually aggregated random disturbances is such that:

$$E(\mathbf{u}_a | \mathbf{X}_a) = 0, \quad E(\mathbf{u}_a \mathbf{u}_a' | \mathbf{X}_a) = \mathbf{V}_a = \mathbf{B}\mathbf{V}\mathbf{B}'$$

Contrary to its quarterly counterpart, the annual residual and its covariance matrix are directly derived from this estimation.

The aggregation constraint is satisfied:

$$\mathbf{B}\hat{\mathbf{y}} = \mathbf{B}\mathbf{X}\hat{\boldsymbol{\beta}} + \mathbf{B}\mathbf{V}\mathbf{B}'\mathbf{V}_a^{-1}\hat{\mathbf{u}}_a = \mathbf{y}_a$$

- 5.A35. The estimates of QNA variables are the sum of two components (see 5.A33): the preliminary estimate, given by  $\mathbf{X}\hat{\boldsymbol{\beta}}$ , which can be directly derived from the estimation of the annualized data and a benchmarking residual, given by  $\mathbf{L}\hat{\mathbf{u}}_a$ , where  $\mathbf{L}$  is the  $(N \times n)$  smoothing matrix  $\mathbf{L} = \mathbf{V}\mathbf{B}'\mathbf{V}_a^{-1}$ .

- 5.A36. Chow and Lin's method therefore notionally has two steps: first, estimating  $\hat{\boldsymbol{\beta}}$  and  $(\hat{\mathbf{u}}_a, \mathbf{V}_a)$  using annualized data; second, estimating  $\mathbf{V}$  and then  $\mathbf{L}$ , which performs the benchmarking, but both steps are done simultaneously in an integrated way. The estimation of  $\mathbf{V}$  requires an additional hypothesis (see §5.A40).

- 5.A37. A very important feature of this estimation approach is the capability to get an evaluation of the precision of the estimates by means of the covariance matrix of the estimation errors (Bournay and Laroque, 1979):

$$E[(\hat{\mathbf{y}} - \mathbf{y})(\hat{\mathbf{y}} - \mathbf{y})'] = (\mathbf{I}_N - \mathbf{L}\mathbf{B})\mathbf{V} + (\mathbf{X} - \mathbf{L}\mathbf{X}_a)(\mathbf{X}'_a \mathbf{V}_a^{-1} \mathbf{X}_a)(\mathbf{X} - \mathbf{L}\mathbf{X}_a)'$$

The solution comprises two components: the first is only related to  $\mathbf{B}$  and  $\mathbf{V}$ , but the second is a systematic one arising from the term  $(\mathbf{X} - \mathbf{L}\mathbf{X}_a)$ .

5.A38. The estimation errors covariance matrix can be used to:

- compute confidence intervals for  $\hat{y}$  under the hypothesis  $\mathbf{u} \sim N(0, \mathbf{V})$ ;
- assess the relative accuracy of the estimates with measures such as  $\frac{\hat{\sigma}_y}{\hat{y}}100$  (Van der Ploeg, 1985, p.9);
- take into account the ‘noisy’ nature of the data when undertaking econometric analyses.

5.A39. The optimal estimation approach offers a natural and coherent solution to the extrapolation problem. Given the  $(\mathbf{K} \times 1)$  vectors of related series  $X_{4n+i}, i=1, \dots, q$ , the optimal forecasts for  $y_{4n+i}, i=1, \dots, q$ , are:

$$\hat{y}_{4n+i} = X_{4n+i}\hat{\beta} + w_{4n+i}V_a^{-1}\hat{u}_a$$

where  $w_{4n+i} = E(u_{4n+i}u)$  is a  $(\mathbf{N} \times 1)$  covariance vector.

Computationally, the extrapolated estimates can be obtained according to the general disaggregation formula  $\hat{\mathbf{y}} = \mathbf{X}\hat{\beta} + \mathbf{V}\mathbf{B}'\mathbf{V}_a^{-1}\hat{\mathbf{u}}_a$ , provided the last  $q$  columns of the aggregation matrix  $\mathbf{B}$  are null vectors.

5.A40. Matrix  $\mathbf{V}$  is unknown *a priori* and must be estimated or calculated according to suitable assumptions about  $\mathbf{u}$ . The stochastic models usually considered when estimating QNA variables are the following:

- AR(1) model (Chow and Lin, 1971)

$$u_t = \rho u_{t-1} + \varepsilon_t, |\rho| < 1$$

- Random walk model (Fernández, 1981):

$$u_t = u_{t-1} + \varepsilon_t, u_0 = 0$$

- Random walk-Markov model (Litterman, 1983, Di Fonzo, 1987):

$$u_t = u_{t-1} + e_t, e_t = \mu e_{t-1} + \varepsilon_t, |\mu| < 1, u_0 = e_0 = 0$$

### Dynamic models

5.A41. Dynamic models may be more efficient in estimating a QNA variable than a static optimal model when, in particular, the indicator does not track the long-term growth of the annual benchmark very well. As for static optimal methods, the first step is to estimate (using OLS or GLS) a statistical relationship between the annualized data, such as

$$\delta y_{a,t} = \gamma + \beta \delta x_{a,t} + \varepsilon_{a,t}$$

with  $\delta y_{a,t} = y_{a,t} - y_{a,t-1}$

- 5.A42. Once the coefficients have been estimated, this relationship in first differences can be used recursively to derive an annual relationship in levels:

$$\hat{y}_{a,t} = T_{a,t} + \hat{\beta}x_{a,t} + \hat{u}_{a,t}$$

with  $T_{a,t} = \hat{\gamma}t$  a linear trend and  $\hat{u}_{a,t} = \hat{u}_{a,t-1} + \hat{\varepsilon}_{a,t}$  an integrated residual that can be used on a quarterly basis:

$$\hat{y}_{4(t-1)+i} = T_{4(t-1)+i} + \hat{\beta}x_{4(t-1)+i} + \hat{u}_{4(t-1)+i}, \quad i = 1 \text{ to } 4$$

where within each year  $t$

$$T_{4(t-1)+i} = \frac{\hat{\gamma}}{16}(4(t-1) + i)$$

is a linear quarterly trend and

$$\hat{u}_{4(t-1)+i} = L\hat{u}_{a,t}$$

is a smoothing of the annual residual that ensures benchmarking to annual data with a function  $L$  to be determined (see the previous section on optimal methods).

- 5.A43. It is observed that the quarterly linear trend matches the annual one when the four quarters are summed each year,  $\mathbf{T}_a = \mathbf{BT}$ .

Hence, the aggregation constraint is satisfied,  $\mathbf{y}_a = \mathbf{BT} + \mathbf{Bx}\beta + \mathbf{Bu}$

and the residual  $\hat{u}_a$  can be forecast one year ahead (knowing it is I(1)) and smoothed to anticipate forthcoming benchmarking of the current year (see previous section on benchmarking). In addition to the model presented here, there are many other possibilities.

## 5. Annex B — Two-step optimal methods — French approach

### Introduction

5.B1. This annex provides some details of how the French NSI employs the two-step optimal method (see §5.74-5.76) to estimate QNA variables. The estimation of quarterly gross value added in the manufacturing industry (in the constant prices of the reference year) is used to illustrate the French approach. The notation used is the same as that in Annex 5A.

### Fitting a model between the annualized quarterly indicator and the annual benchmark

#### *Models used*

5.B2. The French NSI has found that the relationship between time series of an annualized quarterly indicator and the corresponding ANA benchmark can be adequately modelled by one of six models, of which four are static and two are dynamic. The four static models are of the form:

$$y_{a,t} = \gamma + \beta x_{a,t} + u_{a,t}$$

where  $y_{a,t}$  is the annual benchmark value for year t,  $x_{a,t}$  is the annualized quarterly indicator for year t and  $u_{a,t}$  is the annual residual for year t.  $\gamma$  (a constant) and  $\beta$  (a linear parameter) are estimated using either ordinary or generalised least squares. In two of the models the constant term is zero. Also, in two of the models the residual is assumed to be white noise and in the other two models it is assumed to be autocorrelated at lag 1 and is modelled using an AR(1) model. Hence the four static models are as follows:

- a.  $y_{a,t} = \gamma + \beta x_{a,t} + \varepsilon_{a,t}$
- b.  $y_{a,t} = \gamma + \beta x_{a,t} + u_{a,t}$ ,  $u_{a,t} = \rho u_{a,(t-1)} + \varepsilon_{a,t}$ ,  $|\rho| < 1$
- c.  $y_{a,t} = \beta x_{a,t} + \varepsilon_{a,t}$
- d.  $y_{a,t} = \beta x_{a,t} + u_{a,t}$ ,  $u_{a,t} = \rho u_{a,(t-1)} + \varepsilon_{a,t}$ ,  $|\rho| < 1$

where  $\varepsilon_{a,t}$  is assumed to be white noise.



- 5.B3. The two dynamic models have the same form as the static models (a) and (c), except the annual benchmark and annualized quarterly indicator time series are first differenced:

$$e. \delta y_{a,t} = \gamma + \beta \delta x_{a,t} + \varepsilon_{a,t}$$

$$f. \delta y_{a,t} = \beta \delta x_{a,t} + \varepsilon_{a,t}$$

### Selecting the best model

- 5.B4. Numerous criteria can be used to select the best model. First, the estimated coefficient  $\hat{\beta}$  should be significant (student t-statistic). A  $\hat{\beta}$  that is not significant indicates that the indicator is inadequate and either requires further pre-treatment (see Chapter 3) or another indicator needs to be found.
- 5.B5. The student t-statistic also determines whether a constant term is required.
- 5.B6. The Ljung - Box test is used to test the null hypothesis that the annual residual  $\varepsilon_{a,t}$  is white noise.
- 5.B7. The model is then chosen by examining the in-sample and out-of-sample fit of the model (graphically and using RMSE). This is followed by a validation process (see Chapter 9) to determine whether the quarter-on-quarter growth rates of QNA variable are statistically and economically plausible.
- 5.B8. The French experience is that the best model for most QNA variables is usually one of the dynamic models ((e) and (f)) or the static model without a constant but with an autoregressive model fitted to the residual (d).

### From the annual model to the preliminary quarterly estimates

- 5.B9. Having chosen a model, the next step is to use it to generate preliminary estimates of QNA variable. How this is done for models (a), (b), (e) and (f) is described below. Models (c) and (d) are used in the same way as models (a) and (b), respectively, except there is no constant term.

*Static models (a), (b), (c) and (d)*

- 5.B10. The preliminary QNA estimate  $\hat{y}_{4(t-1)+i}$  for quarter  $i$  in year  $t$  is simply derived from the quarterly indicator as follows:

$$\hat{y}_{4(t-1)+i} = \frac{\hat{\gamma}}{4} + \hat{\beta} x_{4(t-1)+i}$$

Or

$$\hat{y}_{4(t-1)+i} = \hat{\beta} x_{4(t-1)+i}$$

in cases where there is no constant

*Dynamic model (e)*

- 5.B11. This dynamic model has a constant term and so the preliminary QNA estimate is derived as shown in 5.A.42.:

$$\hat{y}_{4(t-1)+i} = T_{4(t-1)+i} + \hat{\beta}x_{4(t-1)+i} + \hat{u}_{4(t-1)+i}$$

where  $T_{4(t-1)+i} = \frac{\hat{\gamma}}{16}(4(t-1) + i)$ , which satisfies the constraint  $\sum_{i=1}^4 T_{4(t-1)+i} = T_{a,t}$

*Dynamic model (f)*

- 5.B12. Dynamic model (f) is without a constant and so the preliminary QNA estimates are simply derived as:

$$\hat{y}_{4(t-1)+i} = \hat{\beta}x_{4(t-1)+i}$$

### **Benchmarking**

- 5.B13. After the chosen model has been applied to the quarterly indicator to generate preliminary estimates of QNA variable, the data are benchmarked to the annual estimates of the national accounts variable, i.e. the annual residuals  $\hat{u}_{a,t} = y_{a,t} - \sum_{i=1}^4 \hat{y}_{4(t-1)+i}$  are distributed amongst the quarters.

By construction, the annual residuals of the dynamic models (e and f) follow a random walk that incorporates a constant term that cannot be determined. The annual residuals of the static models (a to d) are stationary (white noise or AR(1)).

The French NSI uses the Denton (first) difference method (see §5.48-5.50 and §5.A24-5.A27) to do the benchmarking. This method is preferred because it minimizes the quarter-on-quarter changes of the unexplained component of the final estimate of the quarterly variable. Furthermore, it is invariant to any additive transformation of the residual, i.e. it is robust to the undetermined constant term included in the residual when the dynamic (difference) models (e and f) are used.

### **Example: deriving quarterly constant price estimates of gross value added in the French manufacturing industry**

#### ***Fitting and choosing a model***

- 5.B14. In this example the quarterly manufacturing production index (see Annex 2.A) is the indicator used to derive quarterly volume estimates of gross value added in the French manufacturing industry - subject to being temporally consistent with the annual estimates. Table 5.B1 presents the results of fitting each of the six models to the annualized production index (independent variable) and the annual benchmarks (dependent variable).

- 5.B15. The results show that the two static models without the AR(1) model to correct for autocorrelation in the residual (a and c) perform poorly; they fail the Ljung –Box test (for autocorrelation at lag 1) and have relatively high RMSEs. Of the two other static models, (b) is preferred: the coefficient of the constant term is statistically significant and it has a lower RMSE than model (d). Both of the two dynamic models perform satisfactorily, but (e) is preferred because the coefficient for the constant term is statistically significant and it has the lower out-of-sample RMSE, which is calculated using the difference between each one-year ahead extrapolation and the actual annual benchmark value for that year. Hence the choice of model comes down to choosing between the static model (b) and the dynamic model (e).
- 5.B16. While (b) has the lower in-sample RMSE, (e) has the lower out-of sample RMSE and is therefore preferred.

Table 5.B.1: Models fitted to gross value added in the French manufacturing industry

| Models                      | Static          |                |               |               | Dynamic       |              |
|-----------------------------|-----------------|----------------|---------------|---------------|---------------|--------------|
|                             | (a)             | (b)            | (c)           | (d)           | (e)           | (f)          |
| Out-of-sample fit (RMSE)    | 5.6             | 2.2            | 5.7           | 2.5           | 1.4           | 1.7          |
| In-sample fit (RMSE)        | 2.5             | 1.1            | 1.8           | 1.8           | 1.8           | 1.8          |
| Ljung-Box test<br>(p-value) | 0.01            | 0.58           | 0             | 0.54          | 0.45          | 0.54         |
| $\gamma$<br>(student t)     | -3642<br>(-1.6) | 4695<br>(3.5)  |               |               | 1528<br>(3.2) |              |
| $\beta$<br>(student t)      | 192<br>(7.9)    | 104<br>(8.2)   | 154<br>(90.7) | 151<br>(26.8) | 105<br>(10.3) | 104<br>(8.2) |
| $\rho$<br>(student t)       |                 | 0.97<br>(16.3) |               | 0.91<br>(8.4) |               |              |

#### *From the annual model to the preliminary quarterly estimates*

- 5.B17. When fitted to the gross value added for French manufacturing, model (e) has the following form:

$$\delta y_{a,t} = 1528 + 105 \times \delta x_{a,t} + \varepsilon_{a,t}, \text{ where } \varepsilon_{a,t} \text{ is white noise}$$

When applied to the quarterly estimates of the indicator  $x_{4(t-1)+i}$  (the manufacturing production index in this case) and following a transformation to levels, the preliminary estimate of gross value added for French manufacturing industry is derived as:

$$\hat{y}_{4(t-1)+i} = T_{4(t-1)+i} + 105 \times x_{4(t-1)+i} + \hat{u}_{4(t-1)+i}$$

$$T_{4(t-1)+i} = \frac{1528}{16} (4(t-1) + i)$$

The values for  $\hat{u}_{4(t-1)+i}$  cannot be determined and are set to an arbitrary value, such as zero, in order to obtain preliminary estimates. Subsequently, estimates are derived implicitly via the benchmarking process.

### ***Benchmarking***

- 5.B18. The preliminary quarterly estimates are then benchmarked to the annual volume estimates of gross value added in the French manufacturing industry using the Denton (first) difference method.

## 5. Annex C — Temporal disaggregation of national accounts time series: an illustrated example using different methods and models

### Introduction

- 5.C1. This annex illustrates the use of some of the temporal disaggregation techniques described in Chapter 5 and Annexes 5.A and 5.B with real-world data from France. In addition to using different methods and models, different parameter estimation techniques are also used. The different methods, models and estimation techniques are subject to standard statistical tests and comparisons are made of their predictive performance.
- 5.C2. As discussed a number of times in this handbook, it is recommended that estimates of QNA variables should be temporally consistent with their annual counterparts, which generally means benchmarking the quarterly estimates to the annual ones. Accordingly, all the disaggregation techniques described in Chapter 5 achieve this outcome and they generally produce similar results (when applied to the same quarterly indicator) for those years for which there are annual benchmarks. Furthermore, in the absence of knowing what the true quarterly values are, it may be difficult to judge which methods produce the best estimates solely on the basis of statistical tests applied to annual data. This limitation in making comparisons does not apply, however, to estimates made for quarters beyond the latest annual benchmark, because for these quarters it is possible to compare the preliminary estimates (made without the constraint of an annual benchmark) with final estimates (made with the constraint of an annual benchmark). This technique is employed in Chapter 5 (§5.77-5.78) to compare the performance of the French two-step method with the Fernandez variant of the Chow and Lin method and simple extrapolations using the quarterly indicator. A similar approach is employed in this annex. Such “out-of-sample” comparisons should play an important part in the selection of the most appropriate model/method for each QNA variable to be modelled.
- 5.C3. It is generally best to compile national accounts at the most detailed level practicable, and this applies just as much to modelling QNA variables as it does to any other aspect of national accounts compilation. However, for the illustrative purposes of this analysis four major QNA variables have been chosen: the current price and chain-linked volume estimates of gross value added for French “industry” and manufacturing. In this annex, the annual values of these variables are temporally disaggregated and extrapolated by using, in each case, only one quarterly indicator. Thus, for most of the analysis it is assumed that annual values for the four national accounts variables exist but the quarterly values do not, and models are applied to estimate the latter. In the final part of the annex, an in-sample assessment of the quality of the temporal distributions is made by comparing the *actual* quarterly values published by the French NSI (INSEE) with the *estimated* quarterly values obtained using models. For all four QNA variables, the official estimates computed by INSEE are derived using much more detailed data and not by using the indicators presented in this annex (see below).
- 5.C4. The intention of this annex is not to present a model which could be applied in every possible case, but rather to illustrate the fact that working with the same data and with different methods and models the differences in the results obtained may be substantial, especially for extrapolations beyond the latest benchmark year. It turns out that the specification of the regression model used (regression in terms of level, difference or growth rate, allowance for a constant or linear trend in addition to the chosen indicator) can be, at least in some cases, more important than the choice of whether to use a one-step (Chow and Lin) or (French NSI) two-step method.

- 5.C5. Another result is that models and methods that fit the annual data relatively well in-sample (for the period when the annual data are known) can vary substantially in respect of their predictive performance. This is the reason why in this annex the strategy of testing the predictive power of candidate regression models for out years, as if the annual values years were not yet known, is recommended and should allow for more accurate decision-making. In general, the choice of the best specification of regression model to be used for disaggregating national accounts variables remains an empirical issue.
- 5.C6. While the result of an analysis confined to only a few QNA variables for one country and to only five years of extrapolations should be treated with caution, the conclusions reached are consistent with the experience of those NSIs that have been using the methods described here for many years.
- 5.C7. Finally, a word of warning: it is very important that all the knowledge at the disposal of the national accountant concerning the treatment of non-stationary time series should not be forgotten when undertaking the temporal disaggregation of time series using regression models. Recent developments on this subject can be consulted, together with the advice provided in the expert report produced for ISTAT (2005), and in particular the text by di Fonzo (2005) in the final version of the report.

### Description of the models used

- 5.C8. Consistent with the notation used in Chapter 5 and its Annexes 5.A and 5.B, QNA variable to be estimated in quarter  $i$  of year  $t$  is denoted by  $y_{4(t-1)+i}$ , and is estimated using a quarterly indicator  $x_{4(t-1)+i}$ . When a single indicator is used, the standard form of the Chow and Lin model is

$$y_{4(t-1)+i} = \gamma + \beta x_{4(t-1)+i} + u_{4(t-1)+i} \quad \text{where the residual } u_{4(t-1)+i} \text{ is a random variable}$$

Three specifications for the stochastic structure of the residual are described in Annex 5.A (§5.A32-5.A40): attributable to Chow and Lin, Fernandez and Litterman, respectively. Some other alternatives are of course possible (see for instance di Fonzo (2005) for more developments). These three models are compared with the French two-step method applied to the best of the six models tested (see Annex 5.B). As described in §5.C2, the extrapolative performance of each method and model is compared. To provide two further points of comparison, extrapolations are made with a simple OLS regression model (specified in growth rates) and simple extrapolation.

- 5.C9. The classical Chow and Lin model and the Fernandez and Litterman extensions are as follows:

$$y_{4(t-1)+i} = \beta x_{4(t-1)+i} + u_{4(t-1)+i}, \text{ with } (1 - \rho B)u_{4(t-1)+i} = \varepsilon_{4(t-1)+i} \text{ and } |\rho| < 1 \quad (1)$$

$$y_{4(t-1)+i} = \beta x_{4(t-1)+i} + u_{4(t-1)+i}, \text{ with } (1 - B)u_{4(t-1)+i} = \varepsilon_{4(t-1)+i} \text{ and } u_0 = 0 \quad (2)$$

$$y_{4(t-1)+i} = \beta x_{4(t-1)+i} + u_{4(t-1)+i}, \text{ with } (1 - \rho B)(1 - B)u_{4(t-1)+i} = \varepsilon_{4(t-1)+i} \text{ and}$$

$$|\rho| < 1, u_0 = 0 \quad (3)$$

where  $\mathbf{B}$  is the backward shift operator,  $\mathbf{B}x_t = x_{t-1}$

In all three cases  $\varepsilon_{4(t-1)+i} \sim \text{NID}(0, \sigma^2)$  and  $\sum_{i=1}^4 y_{4(t-1)+i} = y_{a,t}$ , the annual benchmark, for each year  $t$ .

(1), (2) and (3) are respectively the “classical” Chow and Lin model, the “Fernandez” and the “Litterman” variations. From (2) and (3) it is obvious that Fernandez is a special case of the Litterman variation: when  $\rho = 0$  in (3), the vector of residuals is a random walk and cannot be distinguished from (2).

- 5.C10. It is interesting to note that if  $y$  and  $x$  are non-stationary, the “classical” Chow and Lin model postulates co-integration between the annualized indicator series and ANA variable. Co-integration (Engle and Granger (1987)) is important in the sense that a high “Rbar-squared” for a model estimated with data in levels is not necessarily indicative of good predictive ability if the variable is non-stationary. It is well known that standard regression analysis fails when dealing with non-stationary variables (variables that have a stochastic trend). Without taking into account the degree of integration of the variables used and without testing for the presence of co-integration, OLS or GLS techniques can lead to the so-called “spurious regressions” problem, i.e. statistical results that would suggest a relationship between the variables used even when there is none. Given that the indicators used should at least approximate the national account definitions of QNA variables to be estimated, the case of pure “spurious regressions” should be less of an issue when using temporal disaggregation methods in the national accounts than when testing for an economic relationship between variables in general. Nevertheless, the presence or absence of co-integration between some QNA variables and indicators when regressions in level are considered cannot be totally ignored.
- 5.C11. As co-integration means that two (or more) time series fluctuate conjointly in a long-run relationship (that is sometimes seen as an equilibrium relationship) but short-run deviations from that long-run relationship are possible, it is easy to see why co-integration alone is neither a necessary nor a sufficient condition to make a good short-term prediction, particularly in the context of estimating the value of a quarter beyond the latest annual benchmark.
- 5.C12. It is evident that when using the Chow and Lin method, or other time series disaggregation techniques based on linear regressions, the estimation of quarterly data for periods when there are annual benchmarks (i.e. distribution) does not pose the same challenge as the situation encountered for periods beyond the latest annual benchmark (i.e. extrapolation). Indeed, the absence of co-integration when using a model in levels raises the potential (via a spurious regression) for large revisions when extrapolated values are later replaced by distributed ones. It is therefore recommended not to rely on a regression in levels for extrapolation if the results of a test for co-integration are not positive. Many users use regressions in level and regressions in difference in parallel to assess the quality of an indicator. This strategy seems to be effective and is recommended. The degree of co-integration may also vary. A high degree of co-integration between two variables means that they cannot wander too far away from each other, while a low degree of co-integration means that they may be out of their long-run equilibrium for a prolonged period. The predictive power of a model with a high degree of co-integration is therefore better than one with a low degree of co-integration. The quality of the estimated regression, through the usual calculated statistics, will show these differences.
- 5.C13. The work of Granger, Engle and others has had the objective of enabling macroeconomic models containing non-stationary stochastic variables to be constructed in such a way that the results are both statistically sound and economically meaningful - without the need to difference the variables beforehand to achieve approximate stationarity. Many macroeconomic relationships are

described in terms of levels and differencing incurs a loss of information and is therefore undesirable. But in the case of using indicators to estimate QNA variables, this is not a concern. All that matters is the accuracy and reliability of the distributions and extrapolations that the model generates. The co-integration assumption is relaxed within the Fernandez and Litterman extensions of the classical Chow and Lin model, which are therefore more flexible when dealing with integrated time series. For Chow and Lin model 2, the Fernandez approach, it can be seen that this model for variables in level and integrated residuals corresponds to a model with variables in first differences and with stationary residuals. For the underlying non-estimable quarterly model, the Fernandez approach postulates a linear relationship between the first difference of QNA variable and the chosen indicator (i.e. between the quarter-on-quarter growth rates), although only a relationship between the yearly growth rates of the data can be tested and estimated.

- 5.C14. The parameters in all the models are estimated using the annual benchmark data  $y_{a,t}$  and the annualized quarterly indicator  $x_{a,t}$ . For Chow and Lin models (1) and (3), various methods have been proposed for estimating the autoregressive coefficient  $\rho$ . Two estimation techniques are often mentioned in the literature. The first is defined as a minimum of the sum of squares of the residuals (MinSSR), while the second maximizes a log-likelihood function (MaxLog). The MaxLog method seems to have better small sample properties but has the drawback that it can deliver a negative  $\rho$  coefficient (and sometimes values very close to the boundary of -1) when the true coefficient of simulated data is zero. The MinSSR method seems to be less accurate on average but does not suffer from the latter drawback. Interesting developments on this issue can be found in Di Fonzo (2005). Dagum and Cholette (2006) propose a survey of all these different estimation methods. It is important to bear in mind that different estimation methods can lead to different results, even with the same model specification. ECOTRIM, a program for the temporal disaggregation of time series from Eurostat, has been used to make the estimates for this annex <sup>(16)</sup>
- 5.C15. The three variants of the Chow and Lin method are applied to the data with a constant and with or without a linear trend. In addition, the classical Chow and Lin model (model 1) is applied to annual growth rates with a constant. By combining the different variants of the Chow and Lin method, the different estimation approaches and the different specifications of the annual data, a total of 12 models are considered. At least some of these models are used by European NSIs for temporal disaggregation and extrapolation, with the traditional Chow and Lin model (model 1: regression estimated in level) and the Fernandez extension (model 2), being the most popular. Models of the same form are used by the French NSI, albeit in a two-step process (see Annex 5.B).
- 5.C16. The French two-step method, a simple OLS regression model and simple extrapolation are also included in the comparison. The first comprises fitting a simple dynamic model (chosen for these particular national accounts variables) to the annual data, using the estimated parameters in the quarterly version of the model to generate preliminary values of QNA variable, followed by benchmarking them to their annual counterparts using the Denton (first difference) procedure (see Annex 5.B). The second comprises fitting a simple linear model to the growth rates of the annual data and using the estimated parameters to derive quarterly estimates. The third is an example of a “method that benchmarks preliminary quarterly estimates of a QNA variable, or a quarterly indicator, to the corresponding annual benchmarks”, described in §5.6. Estimates for

<sup>(16)</sup> ECOTRIM is a free software package specifically created by Eurostat to support the statistical methods described in the handbook. It can be accessed at <http://circa.europa.eu/Public/irc/dsis/ecotrim/library>. In recent years, several other software packages have been developed to support the different variants of the Chow and Lin and other temporal disaggregation methods. For example, R, a software environment for statistical computing and graphics, a “tempdisagg” package is also available free of charge at (<http://cran.r-project.org/web/packages/tempdisagg/tempdisagg.pdf>). The Rats time series analysis software ([www.estima.com](http://www.estima.com)) entails a procedure “disaggregate.src” (<http://www.estima.com/cgi-bin/procbrowser.cgi>) enabling calculations of this kind to be performed. A suitable module of the Matlab software also exists: <http://www.mathworks.com/matlabcentral/fileexchange/24438-temporal-disaggregation-library>.



quarters beyond the latest annual benchmark are derived by simply extrapolating the fourth quarter of the latest benchmark year using the growth rate of the indicator. All 15 methods/models are listed in Table 5.C.1.

- 5.C17. For each of the 15 methods/models, a series of rolling extrapolations are made, i.e. four quarterly estimates are made at the end of the series without the constraint of an annual benchmark. At the beginning of each year, starting in 2006, estimates are made for the next four quarters using the current values of the indicator, but with annual benchmarks only up to the latest year and model parameters estimated on data up to the latest year. In the case of quarterly extrapolations for 2006, the annual benchmark data are up to 2005 and the model parameters are estimated on annual data up to 2005. At the beginning of the next year (2007), the annual models are re-estimated with benchmark data up to 2006. The re-estimated parameters are then used to re-estimate the quarterly values up to the end of 2006 and make extrapolations for the four quarters of the next year (2007) with the benefit of an additional benchmark year (2006). At the end of this exercise there are four quarterly extrapolated values for each year from 2006 until 2010. The extrapolations made using the various methods and models are then compared with each other and the annual benchmark values.
- 5.C18. In Table 5.C.1, the letter “c.” stands for “constant”, the abbreviation “ind.” for the quarterly indicator, “LR” means a regression specified in level, “GRR” means a regression specified in growth rates, “RD” means a regression specified in first differences - the only case is the French two-step. The acronym “CL.” stands for classical Chow and Lin, “Fern.” for Fernandez and “Litt.” for Litterman.

Table 5.C.1: Models and methods considered

|   |                                    |    |                                      |
|---|------------------------------------|----|--------------------------------------|
| 1 | CL. MinSSR: c. + ind. (LR)         | 8  | Litt. MinSSR: c. + ind. + trend (LR) |
| 2 | CL. MinSSR: c. + ind. + trend (LR) | 9  | Litt. MaxLog: c. + ind. (LR)         |
| 3 | CL. MaxLog: c. + ind. (LR)         | 10 | Litt. MaxLog: c. + ind. + trend (LR) |
| 4 | CL. MaxLog: c. + ind. + trend (LR) | 11 | CL. MinSSR: c. + ind. (GRR)          |
| 5 | Fern.: c. + ind. (LR)              | 12 | CL. MaxLog: c. + ind. (GRR)          |
| 6 | Fern.: c. + ind. + trend (LR)      | 13 | French two-step: c. + ind. (RD)      |
| 7 | Litt. MinSSR: c. + ind. (LR)       | 14 | OLS: c. + ind. (GRR)                 |
|   |                                    | 15 | Simple extrapolation (GRR)           |

### The data used in Analysis

- 5.C19. French national accounts data from INSEE are used in the exercise. Gross value added for “industry” (i.e. the sum of mining, manufacturing, electricity, gas, and water) and for the manufacturing industry are available both on an annual and quarterly basis, (a) at current prices (VA\_IND\_N and VA\_INDM\_N) and (b) in volume terms (VA\_IND\_R and VA\_INDM\_R). For the purpose of the exercise, it is supposed that gross value added is only available on an annual frequency and therefore it is necessary to estimate the quarterly figures by using indicators. This assumption allows an assessment to be made of the quality of the extrapolations obtained over the period 2006 until 2010 and distributions for those years for which the actual quarterly values are subject to annual constraint. The following quarterly indicators are used for this exercise:

- Turnover in industry (“TOVER\_IND”) and in manufacturing industry (“TOVER\_INDM”) to estimate gross value added on a quarterly basis at current prices.

- Industrial production in industry (“PIND”) and in manufacturing industry (“PINDM”) to estimate gross value added on a quarterly basis in volume.

5.C20. The various annual data considered in this exercise are presented in the four graphs shown in Figure 5.C.1. In order to improve the visual presentation of the results in the exercise, the quarterly indicator series are adjusted for seasonal and working/trading day variation. The annual figures that are temporally disaggregated are also recalculated on the basis of the seasonal and working/trading day adjusted data in order to ensure the best comparability possible with the indicators. In a “real-life” context, a national accountant would have to perform the same exercise with unadjusted annual data. In Figure 5.C.2, the quarterly values of the four indicators are presented (turnover and industrial production, for industry and for manufacturing industry).

5.C21. The actual quarterly current price and volume estimates of gross value added in the French QNA are derived as the difference between output and intermediate consumption. Volume estimates of output are derived for at least 48 product groups, and the corresponding current price values are derived by inflating them using producer price indices. Intermediate consumption at a detailed level (48 product groups x 48 industry groups) is derived from the output estimates using projections of technical coefficients from recent annual supply and use tables. The estimates of output and intermediate consumption for “industry” and manufacturing are derived by summing the values for 18 and 15 elemental industry groups, respectively.

Figure 5.C.1: Gross value added in industry and manufacturing industry compared with the indicators used for the quarterly disaggregation: turnover (for gross value added in current prices – top two graphs) and industrial production index (for gross value added in volume terms – bottom two graphs)

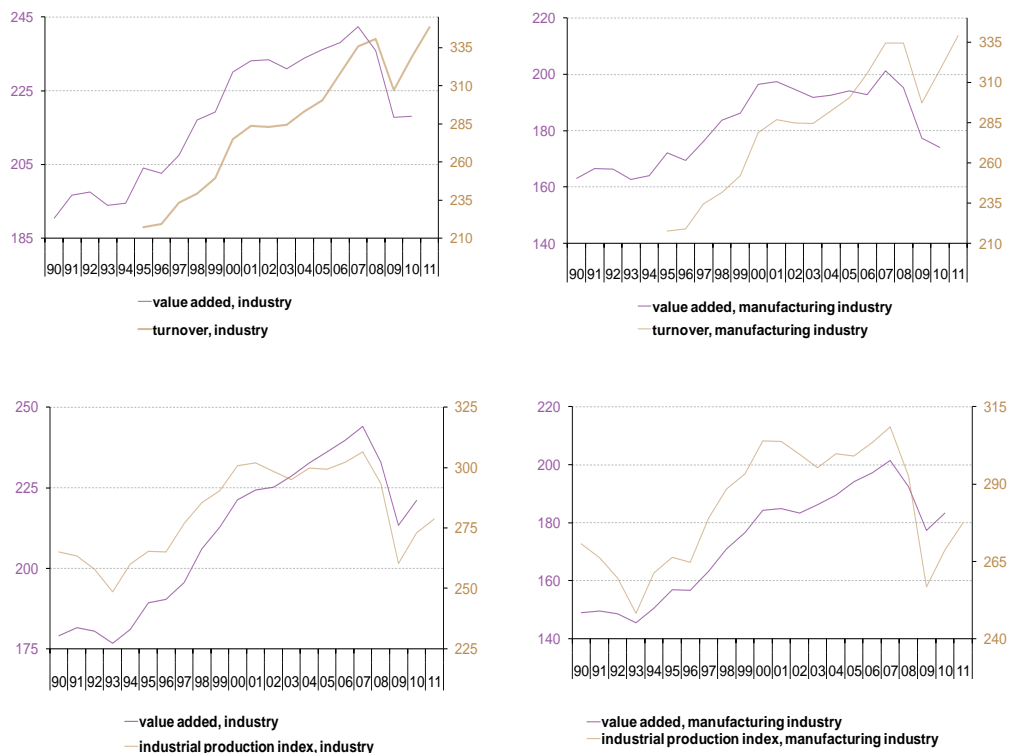
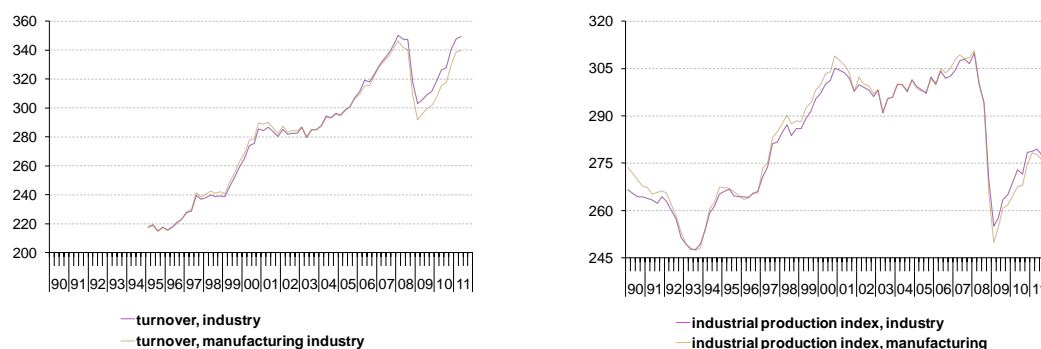


Figure 5.C.2: Quarterly indicators used for the temporal disaggregation of gross value added in industry and manufacturing industry (turnover for gross value added in current prices, industrial production index for gross value added in volume terms)



### Fitting models to the data

- 5.C22. A visual inspection of the data suggests that the levels of the annual gross value added series of “industry” and manufacturing industry at current prices and in volume terms are non-stationary. The well-known augmented Dickey-Fuller test is applied, which takes the presence of a unit root (i.e. non-stationarity) as the null hypothesis. The augmented Dickey-Fuller <sup>(17)</sup> test fails to reject the null hypothesis (of a unit root) in both the growth rates and first differences of the data; thus implying that QNA variables are non-stationary. The Engle-Granger test for co-integration (1987) is also performed on each pair of variables to be modelled. At the 5 per cent level, the null hypothesis of no co-integration among the time series is accepted, but at the 10 per cent level it is rejected for the volume estimates of gross value added and the production indices. This leads to the conclusion that models in levels for these time series should be handled with care, but not necessarily excluded, when performing extrapolations.
- 5.C23. As noted earlier, positive test results for co-integration are not a sufficient condition to expect good extrapolations of quarterly values with regressions in levels. It is thus always good practice to test models in first difference (growth rates specification or specification in first difference) in parallel with models in levels.
- 5.C24. To quantify the explanatory power of quarterly indicators, simple OLS linear regressions are often first performed on the level and the growth rates of the data. This is always a useful step, and is recommended here. Then the three variants of the Chow and Lin method and French two-step method are estimated.
- 5.C25. The main results are presented in Table 5.C.2 (current price estimates) and Table 5.C.3 (volume estimates) for the 14 methods/models listed in Table 5.C.1 that require estimation. The coefficients associated with the constant, the trend (in some specifications) and the indicator, as well as the estimated coefficient for the autoregressive structure of the unknown quarterly residuals (coefficient “ $\rho$ ”), and various standard diagnostics are presented.
- 5.C26. The coefficient of determination (Rbar-squared) is higher in all the models for volume estimates of gross value added than it is for the corresponding models for gross value added at current prices. The inclusion of a linear trend in the traditional Chow and Lin models (regression in levels) leads to a substantial improvement in the Rbar-squared and mostly, but not in all cases, to a slight improvement

<sup>(17)</sup> See, for example, Greene (2008).

for the Fernandez and Litterman extensions. The diagnostic statistics reveal little difference between models estimated by minimizing the sum of squares and maximizing the log-likelihood.

- 5.C27. Independently of the methods used and of the level of sophistication of the disaggregation techniques, one might expect the explanatory power of the indicator used to dictate to a considerable extent the quality of the extrapolations, but this cannot be taken for granted and so it is advisable to test the predictive performance on past data.

Table 5.C.2: Linear regression estimation of models fitted to "industry" and manufacturing gross value added at current prices

| Dependent Variable<br>Annual Data<br>from 1995 to 2010<br>(or 1996 to 2010) | Model and estimation method          | Explanatory Variables |        |        |        |                 |                     | autocorr. coeff.     |                            |              |
|---|--------------------------------------|-----------------------|--------|--------|--------|-----------------|---------------------|----------------------|----------------------------|--------------|
|   |                                      | constant<br>Coeff.    | T-Stat | Coeff. | T-Stat | trend<br>T-Stat | TOVER_IND<br>Coeff. | TOVER_INDM<br>T-Stat | $\rho$<br>quart. residuals | Rbar-Squared |
| VA_IND_N  | CL. MinSSR: c. + ind. (LR)           | 38357.0               | 8.90   | --     | 62.0   | 4.11            | --                  | 0.85                 | 0.51                       | 0.72         |
|   | CL. MinSSR: c. + ind. + trend (LR)   | 28323.0               | 4.88   | -138.4 | 114.0  | 4.34            | --                  | 0.83                 | 0.63                       | 1.08         |
|   | CL. MaxLog: c. + ind. (LR)           | 37455.0               | 8.31   | --     | 64.5   | 4.11            | --                  | 0.90                 | 0.51                       | 0.90         |
|   | CL. MaxLog: c. + ind. + trend (LR)   | 30492.0               | 5.83   | -122.4 | 103.8  | 4.44            | --                  | 0.89                 | 0.61                       | 1.22         |
|   | Fern.: c. + ind. (LR)                | 33345.0               | 8.74   | --     | 81.8   | 4.77            | --                  | per Def = 1          | 0.59                       | 1.46         |
|   | Fern.: c. + ind. + trend (LR)        | 31234.0               | 7.85   | -118.4 | 92.5   | 5.08            | --                  | per Def = 1          | 0.62                       | 1.74         |
|   | Litt. MinSSR: c. + ind. (LR)         | 34564.0               | 9.61   | --     | 76.2   | 4.66            | --                  | 0.93                 | 0.58                       | 3.36         |
|   | Litt. MinSSR: c. + ind. + trend (LR) | 34571.0               | 9.33   | -111.4 | 76.8   | 4.53            | --                  | 0.91                 | 0.55                       | 3.38         |
|   | Litt. MaxLog: c. + ind. (LR)         | 34675.0               | 9.74   | --     | 75.7   | 4.68            | --                  | 0.80                 | 0.58                       | 2.93         |
|   | Litt. MaxLog: c. + ind. + trend (LR) | 34154.0               | 9.22   | -103.4 | 78.7   | 4.63            | --                  | 0.77                 | 0.57                       | 2.96         |
|   | CL. MinSSR: c. + ind. (GRR)          | -1.0                  | -1.46  | --     | 0.5    | 5.16            | --                  | 0.63                 | 0.66                       | 2.44         |
|   | CL. MaxLog: c. + ind. (GRR)          | -1.0                  | -1.57  | --     | 0.6    | 5.33            | --                  | 0.57                 | 0.68                       | 2.35         |
|   | Denton twos-steps: c. + ind. (RD)    | -1243.4               | -1.2   | --     | 78.6   | 12.8            | --                  | --                   | 0.92                       | 1.21         |
|   | OLS: c. + ind. (GRR)                 | -0.8                  | -1.9   | --     | 0.5    | 14.1            | --                  | --                   | 0.93                       | 1.44         |
|   | CL. MinSSR: c. + ind. (LR)           | 32946.0               | 7.08   | --     | 48.1   | 2.9             | 48.1                | 0.83                 | 0.34                       | 0.79         |
|   | CL. MinSSR: c. + ind. + trend (LR)   | 17546.0               | 3.51   | -189.9 | --     | --              | 125.7               | 0.73                 | 0.69                       | 1.48         |
|   | CL. MaxLog: c. + ind. (LR)           | 31510.0               | 6.45   | --     | --     | --              | 52.6                | 0.89                 | 0.36                       | 0.95         |
|   | CL. MaxLog: c. + ind. + trend (LR)   | 18643.0               | 3.74   | -181.9 | --     | --              | 120.8               | 0.77                 | 0.67                       | 1.47         |
|   | Fern.: c. + ind. (LR)                | 26206.0               | 6.64   | --     | --     | --              | 78.2                | 4.4                  | per Def = 1                | 1.51         |
|   | Fern.: c. + ind. + trend (LR)        | 23971.0               | 6.19   | -150.8 | --     | --              | 89.7                | 5.1                  | per Def = 1                | 1.90         |
| Litt. MinSSR: c. + ind. (LR)  | 27737.0                              | 7.15                  | --     | --     | --     | 71.9            | 4.1                 | 0.94                 | 3.27                       |              |
| Litt. MinSSR: c. + ind. + trend (LR)  | 27892.0                              | 7.06                  | -231.5 | --     | --     | 72.4            | 4.0                 | 0.93                 | 3.31                       |              |
| Litt. MaxLog: c. + ind. (LR)  | 28085.0                              | 7.31                  | --     | --     | --     | 70.3            | 4.0                 | 0.80                 | 2.81                       |              |
| Litt. MaxLog: c. + ind. + trend (LR)  | 27346.0                              | 6.99                  | -153.4 | --     | --     | 74.5            | 4.2                 | 0.76                 | 2.86                       |              |
| CL. MinSSR: c. + ind. (GRR)   | -1.0                                 | -2.21                 | --     | --     | --     | 0.7             | 6.8                 | 0.56                 | 0.78                       |              |
| CL. MaxLog: c. + ind. (GRR)   | -1.0                                 | -2.44                 | --     | --     | --     | 0.7             | 6.8                 | 0.47                 | 0.79                       |              |
| Denton twos-steps: c. + ind. (RD)   | -1301.0                              | -1.2                  | --     | --     | --     | 62.7            | 9.0                 | --                   | 2.73                       |              |
| OLS: c. + ind. (GRR)  | -0.9                                 | -1.71                 | --     | --     | --     | 0.4             | 10.4                | --                   | 1.53                       |              |
|   |                                      |                       |        |        |        |                 |                     |                      | 0.84                       | 1.64         |

Table 5.C.3: Linear regression estimation of models fitted to volume estimates of "industry" and manufacturing gross value added

| Dependent Variable<br>Annual Data<br>from 1990 to 2010<br>(or 1991 to 2010) | Model and<br>estimation method       | Explanatory Variables              |         |        |        |        |        | autocorr. coeff.<br>$\rho$<br>quart. residuals | Rbar-Squared | Durbin-Watson |              |        |      |
|---|--------------------------------------|------------------------------------|---------|--------|--------|--------|--------|--|--------------|---------------|--------------|--------|------|
|   |                                      | constant                           |         | trend  |        | PIND   |        |  |              |               | PINDM        |        |      |
|   |                                      | Coeff.                             | T-Stat  | Coeff. | T-Stat | Coeff. | T-Stat |  |              |               | Coeff.       | T-Stat |      |
| VA_IND_R  | CL. MinSSR: c. + ind. (LR)           | 3682.0                             | 0.52    | --     | --     | 173.2  | 6.83   | --   | --           | 0.93          | 0.70         | 1.13   |      |
|   | CL. MinSSR: c. + ind. + trend (LR)   | 54.0                               | 0.02    | 125.6  | 14.1   | 167.4  | 14.08  | --   | --           | 0.74          | 0.97         | 1.74   |      |
|   | CL. MaxLog: c. + ind. (LR)           | 8387.0                             | 1.44    | --     | --     | 155.9  | 7.64   | --   | --           | 0.96          | 0.74         | 1.50   |      |
|   | CL. MaxLog: c. + ind. + trend (LR)   | 291.0                              | 0.09    | 125.8  | 13.8   | 166.5  | 13.83  | --   | --           | 0.75          | 0.97         | 1.79   |      |
|   | Ferm.: c. + ind. (LR)                | 5459.0                             | 1.28    | --     | --     | 147.4  | 9.29   | --   | --           | per Def. = 1  | 0.81         | 1.76   |      |
|   | Ferm.: c. + ind. + trend (LR)        | 5731.0                             | 1.56    | 117.6  | 10.6   | 145.6  | 10.59  | --   | --           | per Def. = 1  | 0.86         | 2.38   |      |
|   | Litt. MinSSR: c. + ind. (LR)         | 12146.0                            | 3.00    | --     | --     | 121.6  | 8.01   | --   | --           | 0.93          | 0.76         | 2.96   |      |
|   | Litt. MinSSR: c. + ind. + trend (LR) | 11951.0                            | 2.94    | 163.8  | 8.0    | 121.6  | 7.97   | --   | --           | 0.91          | 0.76         | 3.01   |      |
|   | Litt. MaxLog: c. + ind. (LR)         | 10861.0                            | 2.69    | --     | --     | 126.5  | 8.34   | --   | --           | 0.81          | 0.77         | 2.73   |      |
|   | Litt. MaxLog: c. + ind. + trend (LR) | 10141.0                            | 2.58    | 125.9  | 8.7    | 128.6  | 8.72   | --   | --           | 0.74          | 0.80         | 2.84   |      |
|   | CL. MinSSR: c. + ind. (GRR)          | 1.0                                | 2.57    | --     | --     | 0.8    | 8.76   | --   | --           | 0.62          | 0.81         | 2.47   |      |
|   | CL. MaxLog: c. + ind. (GRR)          | 1.0                                | 2.80    | --     | --     | 0.8    | 9.22   | --   | --           | 0.55          | 0.82         | 2.42   |      |
|   | Denton twos-steps: c. + ind. (RD)    | 1558.1                             | 2.3     | --     | --     | 195.3  | 19.5   | --   | --           | --            | 0.95         | 2.04   |      |
|   | OLS: c. + ind. (GRR)                 | 0.8                                | 2.6     | --     | --     | 1.0    | 19.6   | --   | --           | --            | 0.95         | 2.16   |      |
|   | VA_INDM_R                            | CL. MinSSR: c. + ind. (LR)         | 8963.0  | 1.57   | --     | --     | --     | --   | 121.5        | 6.1           | 0.93         | 0.64   | 1.05 |
|   |                                      | CL. MinSSR: c. + ind. + trend (LR) | 3846.0  | 1.98   | 115.9  | 17.0   | --     | --   | 122.4        | 17.0          | 0.67         | 0.98   | 2.10 |
|   |                                      | CL. MaxLog: c. + ind. (LR)         | 11241.0 | 2.42   | --     | --     | --     | --   | 113.1        | 7.1           | 0.97         | 0.71   | 1.47 |
|   |                                      | CL. MaxLog: c. + ind. + trend (LR) | 3773.0  | 1.97   | 115.9  | 17.3   | --     | --   | 122.7        | 17.3          | 0.66         | 0.98   | 2.06 |
|   |                                      | Ferm.: c. + ind. (LR)              | 7444.0  | 2.20   | --     | --     | --     | --   | 109.6        | 8.9           | per Def. = 1 | 0.80   | 1.85 |
|   |                                      | Ferm.: c. + ind. + trend (LR)      | 7311.0  | 2.60   | 109.7  | 10.7   | --     | --   | 109.4        | 10.7          | per Def. = 1 | 0.86   | 2.78 |
| Litt. MinSSR: c. + ind. (LR)  |                                      | 12348.0                            | 3.50    | --     | --     | --     | --     | 91.2   | 7.1          | 0.91          | 0.71         | 3.29   |      |
| Litt. MinSSR: c. + ind. + trend (LR)  |                                      | 11983.0                            | 3.40    | 120.9  | 7.1    | --     | --     | 92.0   | 7.1          | 0.87          | 0.72         | 3.34   |      |
| Litt. MaxLog: c. + ind. (LR)  |                                      | 11021.0                            | 3.18    | --     | --     | --     | --     | 96.1   | 7.6          | 0.77          | 0.74         | 2.95   |      |
| Litt. MaxLog: c. + ind. + trend (LR)  |                                      | 9843.0                             | 3.07    | 110.7  | 8.5    | --     | --     | 99.9   | 8.5          | 0.64          | 0.79         | 3.12   |      |
| CL. MinSSR: c. + ind. (GRR)   | 1.0                                  | 3.21                               | --      | --     | --     | --     | 0.7    | 10.0   | 0.57         | 0.85          | 2.78         |        |      |
| CL. MaxLog: c. + ind. (GRR)   | 1.0                                  | 3.60                               | --      | --     | --     | --     | 0.7    | 10.7   | 0.48         | 0.86          | 2.69         |        |      |
| Denton twos-steps: c. + ind. (RD)   | 1458.8                               | 2.2                                | --      | --     | --     | --     | 155.3  | 16.0   | --           | 0.93          | 1.89         |        |      |
| OLS: c. + ind. (GRR)  | 0.9                                  | 2.65                               | --      | --     | --     | --     | 0.9    | 17.4   | --           | 0.94          | 2.05         |        |      |

## Comparing the quarterly extrapolations with the actual data

- 5.C28. As already described above, the predictive performance of the extrapolations made using the various methods (listed in Table 5.C.1) is evaluated in this annex using a recursive procedure for the four quarters of 2006, 2007, 2008, 2009 and 2010, respectively. In Figures 5.C.3 and 5.C.4, the 15 methods/models are ranked according to their mean absolute errors - expressed in terms of absolute deviations from the actual over-the-year (i.e. quarter on same quarter of previous year) growth rate (in per cent) of QNA variable (determined after the introduction of the current benchmark year). The small green triangle on the horizontal axis indicates the mean value of the absolute errors of all 15 methods/models.
- 5.C29. Note that the values for the current price estimates of gross value added for “industry” and manufacturing (roughly 2.5% and 3.7%, respectively) are substantially larger than the values for the corresponding volume estimates (roughly 1.5% and 1.6%, respectively). This coincides with the generally inferior fit of all the models to the current price data than to the volume data (see results in the Tables 5.C.2 and 5.C.3). This is due to the greater explanatory power of the quarterly indicators used to derive the volume estimates (production indices) than those of the quarterly indicators used to derive the current price estimates (turnover).
- 5.C30. Figure 5.C.5 presents the average of the results presented in Figures 5.C.3 and 5.C.4 for each method/model. They have been derived by normalizing the 15 mean absolute errors for each of the 4 QNA variables, i.e. re-scaling them so that the average of the mean absolute errors for each of the 15 method/models for each QNA variable is equal to 1. Thus in Figure 5.C.5, the value “1” represents the average of the mean absolute revision errors obtained for the whole exercise (i.e. 4 quarterly extrapolations, for 5 successive years, for 4 QNA variables, with 15 method/models, which equals exactly 1200 quarterly extrapolations).
- 5.C31. An examination of Figure 5.C.5 reveals that the models specified in growth rates or first differences are the best on average for the four variables, namely: the classical Chow and Lin method (applied to growth rates), the Fernandez variant of the Chow and Lin method (equivalent to a model in first differences), the French two-step method (which uses a model in first differences for these QNA variables) and the OLS extrapolations (a model specified in growth rates). The regressions specified in level, with positive autocorrelation in the quarterly residuals, are, on average, the worst. The lack of co-integration may be an explanation for these results. The hypothesis and the use of positive autocorrelation in the quarterly residuals for regressions in level might also have in some circumstances some drawbacks, in particular when the non-observed residuals behave more stochastically.
- 5.C32. The simple extrapolation method uses the growth rate of the indicator to extrapolate the quarterly values for periods after the latest annual benchmark. In the context of a simple linear regression model, this is equivalent to having a constant term equal to zero and a coefficient for the independent variable equal to 1. These values are very close to the OLS estimates for the volume measures of “industry” and manufacturing gross value added, but quite different from the OLS estimates of their current price counterparts. Consequently, it is not surprising that the simple extrapolation method performs well for the volume estimates, but rather poorly for the current price estimates. These results support the recommendation, made in §5.27, to test whether the simple extrapolation can be expected to perform satisfactorily (by fitting a simple difference model to the annual data of QNA variable and the indicator) before using it.

Figure 5.C.3: Mean absolute revision errors of extrapolations (in terms of over-the-year growth rate errors in %), period 2006-2010, gross value added in “industry” (top) and in manufacturing industry (bottom), current prices (indicators: turnover)

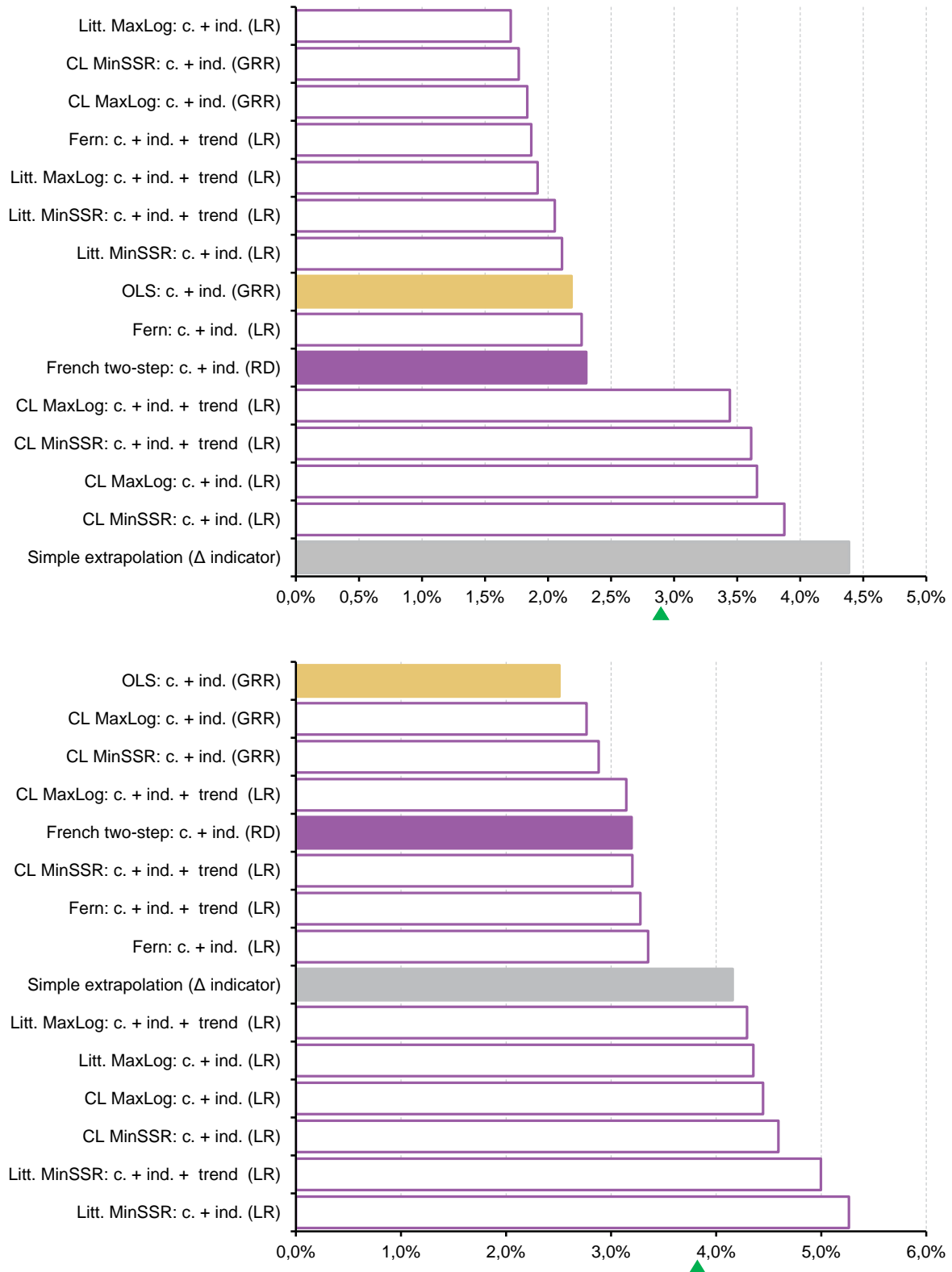




Figure 5.C.4: Mean absolute revision errors of extrapolations (in terms of over-the-year growth rate errors in %), period 2006-2010, gross value added in “industry” (top) and in manufacturing industry (bottom), volume estimates (indicators: production indices)

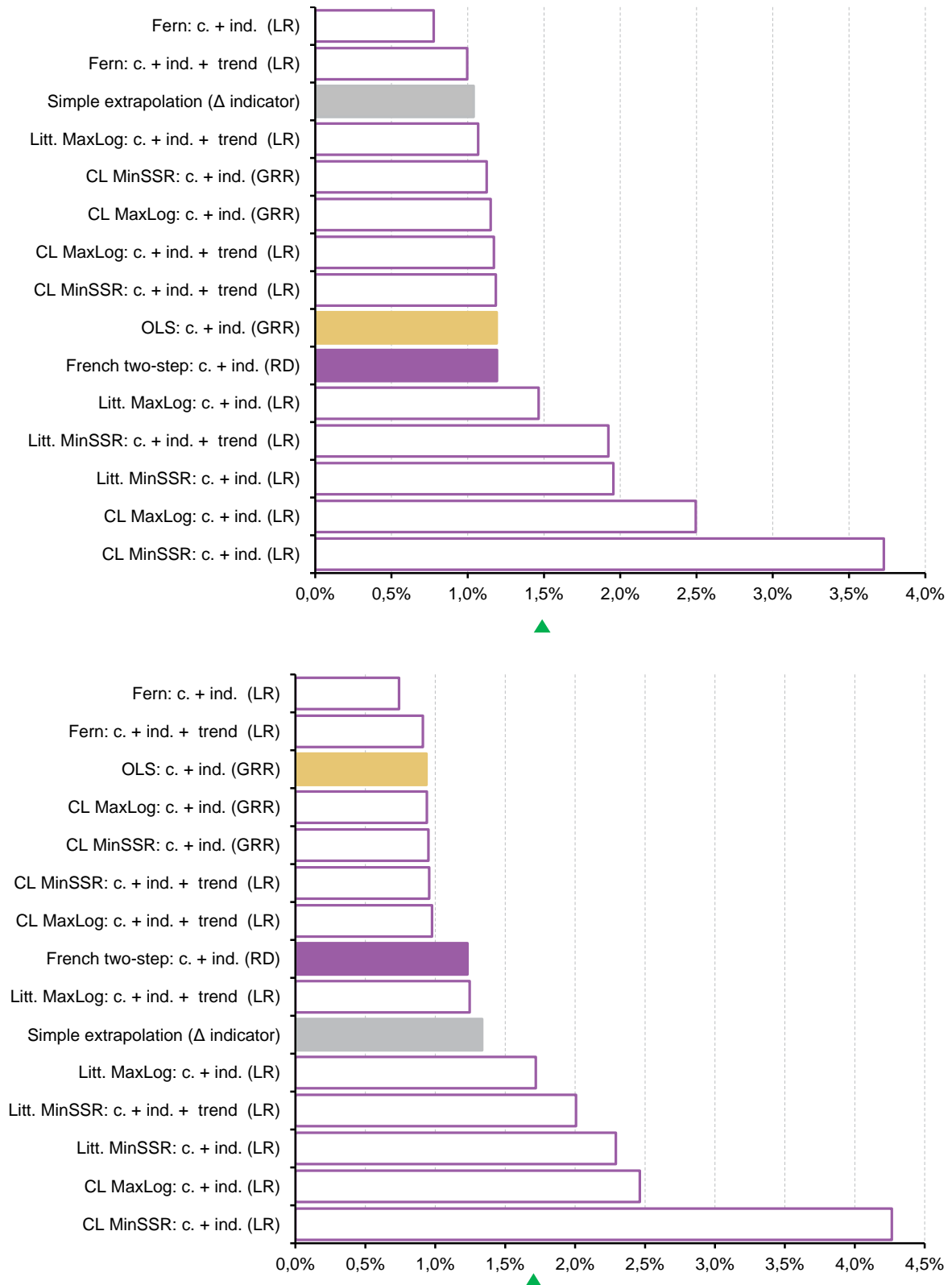
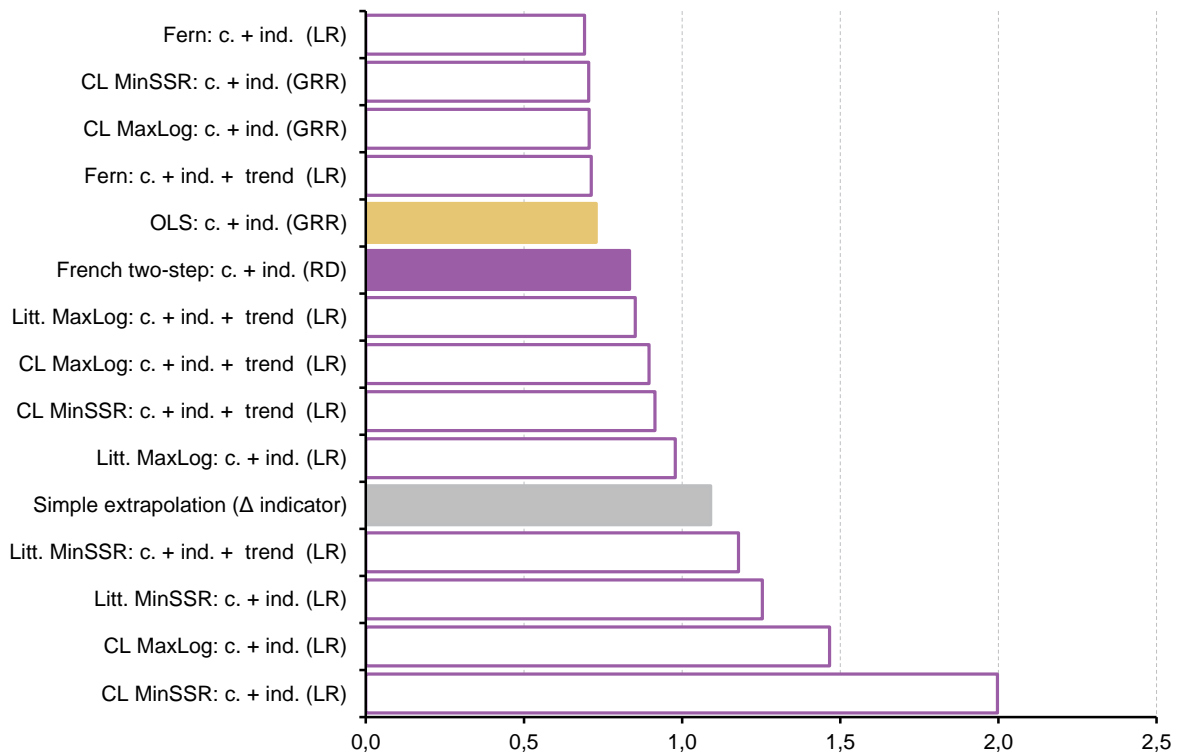


Figure 5.C.5: Mean absolute revision errors of extrapolations (in terms of over-the-year growth rate errors in %), period 2006-2010 – average of results from Figures 5.C.3 and 5.C.4



5.C33. In Figures 5.C.6 and 5.C.7, extrapolations for two models, Litterman and Fernandez, both with a constant but no trend term, and the French two-step method are presented for the volume estimates of gross value added in “industry”, together with distributed quarterly values from the first quarter of 2000. In Figure 5.C.6, the extrapolations are for the eight quarters in the difficult years of 2008 and 2009, with the estimation period and annual benchmarks ending with data up to 2007. In Figure 5.C.7, the extrapolations are only for the four quarters of 2009, with the estimation period and annual benchmarks being advanced one year to the end of 2008. In each figure, the left graph presents the level estimates and the right graph presents over-the-year growth rates (i.e. the growth rate from the same quarter of the previous year).

Figure 5.C.6: Distribution until 2007, extrapolations for 2008 and 2009, observed annual values until 2010, level (left) and over-the-year growth rates (right), gross value added volume estimates for “industry”

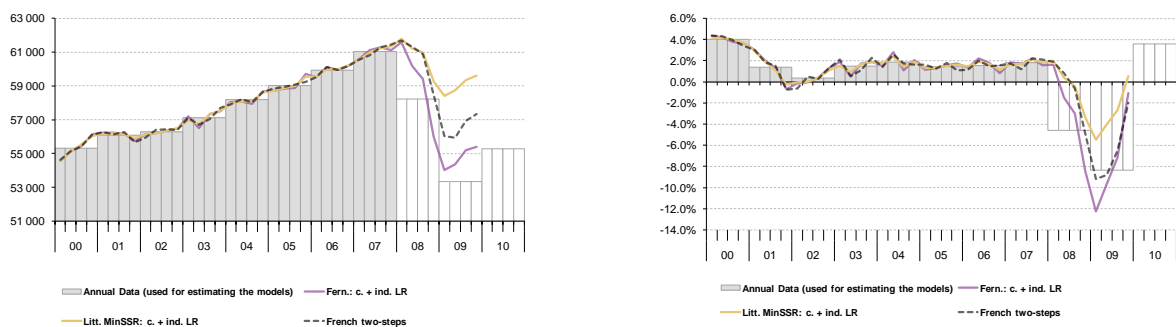
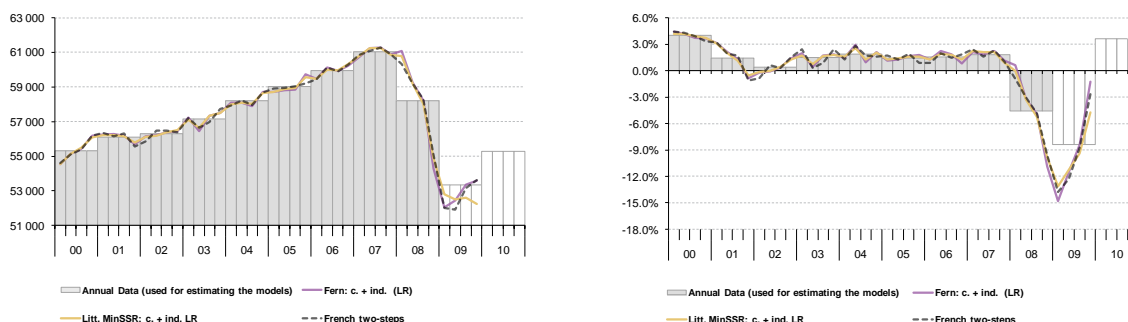


Figure 5.C.7: Distribution until 2008, extrapolations for 2009, observed annual values until 2010, level (left) and over-the-year growth rates (right), gross value added volume estimates for “industry”



5.C34. Figure 5.C.6 reveals a distinct difference in the performance of the three models during both the downturn and the recovery. In Figure 5.C.7, with the advancement of the estimation period and the annual benchmark, the differences between the extrapolations during the recovery period in 2009 are quite small. These results show that there can be a large difference in the predictive performance of different models at turning points. Note that extrapolations for more than 4 to 5 quarters should be the exception and certainly not the rule.

### Comparing the quarterly distributions with the actual data

5.C35. In the previous section comparisons are made as to how well the various models perform in making extrapolations for quarters beyond the latest annual benchmark. In this section, comparisons are made as to how well the various models perform during the period for which there are annual benchmarks. All three variations of the Chow and Lin method and the French two-step method ensure that the quarterly values during this period sum to the annual benchmarks. However, since there are actual quarterly estimates of gross value added for French “industry” and manufacturing in both current prices and volume terms that have been independently derived, it is possible to assess how well each of the methods/models distribute the annual values. The assessment is made here by calculating correlations between the quarter-on-quarter and the over-the-year growth rates of the quarterly series estimated by the different methods and the actual quarterly data published by INSEE — see first part of Table 5.C.4.

5.C36. In the second part of Table 5.C.4, the correlations between the quarterly indicators (turnover in “industry” (TOVER\_IND) and in manufacturing (TOVER\_INDM), industrial production in “industry” (PIND) and in manufacturing (PINDM)) and the corresponding actual estimates of gross value added are shown. In almost every case, as one might expect, these correlations are lower than those of the modelled and benchmarked quarterly estimates.

Table 5.C.4: Distribution performance of different temporal disaggregation methods. Correlations between the growth rates of estimated quarterly values and actual quarterly values (published by INSEE). Correlations between the growth rates of indicators and actual quarterly estimates (second part of the table).

|                    |                        | Quarterly Data 1995:1 - 2010:4 |           |               |           | Quarterly Data 1990:1 - 2010:4 |           |               |           |
|--------------------|------------------------|--------------------------------|-----------|---------------|-----------|--------------------------------|-----------|---------------|-----------|
|                    |                        | Quarter on quarter             |           | Over the year |           | Quarter on quarter             |           | Over the year |           |
| <i>models:</i>     |                        | <i>dependent variables:</i>    |           |               |           |                                |           |               |           |
|                    |                        | VA_IND_N                       | VA_INDM_N | VA_IND_N      | VA_INDM_N | VA_IND_R                       | VA_INDM_R | VA_IND_R      | VA_INDM_R |
| CL. MinSSR         | c. + ind. (LR)         | 0.587                          | 0.755     | 0.914         | 0.945     | 0.842                          | 0.882     | 0.977         | 0.983     |
|                    | c. + ind. + trend (LR) | 0.478                          | 0.660     | 0.881         | 0.914     | 0.848                          | 0.884     | 0.981         | 0.984     |
| CL. MaxLog         | c. + ind. (LR)         | 0.582                          | 0.752     | 0.913         | 0.945     | 0.858                          | 0.890     | 0.983         | 0.986     |
|                    | c. + ind. + trend (LR) | 0.498                          | 0.668     | 0.888         | 0.918     | 0.849                          | 0.883     | 0.981         | 0.984     |
| Fernandez          | c. + ind. (LR)         | 0.544                          | 0.725     | 0.904         | 0.940     | 0.867                          | 0.894     | 0.985         | 0.987     |
|                    | c. + ind. + trend (LR) | 0.520                          | 0.707     | 0.895         | 0.934     | 0.868                          | 0.895     | 0.986         | 0.987     |
| Litterman MinSSR   | c. + ind. (LR)         | 0.551                          | 0.714     | 0.905         | 0.938     | 0.882                          | 0.903     | 0.989         | 0.989     |
|                    | c. + ind. + trend (LR) | 0.548                          | 0.710     | 0.905         | 0.936     | 0.882                          | 0.903     | 0.989         | 0.989     |
| Litterman MaxLog   | c. + ind. (LR)         | 0.554                          | 0.723     | 0.907         | 0.941     | 0.880                          | 0.902     | 0.989         | 0.989     |
|                    | c. + ind. + trend (LR) | 0.547                          | 0.717     | 0.904         | 0.938     | 0.879                          | 0.900     | 0.988         | 0.989     |
| French two-step    | c. + ind. (LR)         | 0.656                          | 0.789     | 0.932         | 0.962     | 0.947                          | 0.962     | 0.995         | 0.997     |
| <i>indicators:</i> |                        |                                |           |               |           |                                |           |               |           |
|                    | tover_ind              | 0.407                          |           | 0.722         |           |                                |           |               |           |
|                    | tover_indm             |                                | 0.593     |               | 0.782     |                                |           |               |           |
|                    | pind                   |                                |           |               |           | 0.816                          |           | 0.920         |           |
|                    | prindm                 |                                |           |               |           |                                | 0.853     |               | 0.935     |

5.C37. In the first part of Table 5.C.4, it can be seen that the correlations are higher for the volume estimates than for the current price estimates of gross value added in “industry” and manufacturing. Also, the correlations differ from one method to another for the same variables, but these differences are relatively minor compared to the differences observed in situations of extrapolation. When the constraint of temporal consistency between the quarterly and annual data is respected (as is the case for all the methods presented here), the trend (and of course the quarterly changes) of the estimated quarterly series is “constrained”. In the absence of this constraint, more substantial differences in the estimated quarterly values can be expected, such as when performing extrapolations. It is also apparent that for the data analysed here, the best methods for extrapolation are not necessarily the best methods for distribution. The French two-step method, for example, yields excellent results, indeed the best in the comparison, for the distribution of quarters within a year when there are known annual data but not necessarily (although the results are again very good) in terms of extrapolation.

5.C38. Some care should be taken when interpreting correlation coefficients above 0.9, particularly for the over-the-year growth rates, which are highly auto-correlated. Nevertheless, these results confirm that excellent results can be obtained when a good indicator is used and an appropriate choice of method is made.

### Some conclusions

5.C39. In the examples considered here, the inclusion of a linear trend (in addition to the indicator and a constant term) improves considerably both the explanatory power (i.e. higher Rbar-squared – Tables 5.C.2 and 5.C.3) and the predictive performance of the classical Chow and Lin model applied to level data (Figures 5.C.3, 5.C.4 and 5.C.5), but it does not improve the distribution performance (Table 5.C.4). While the classical Chow and Lin model with a trend term applied to level data has a higher Rbar-squared than the classical Chin and Lin model applied to growth rate data, it generally has less predictive power. This is symptomatic of the problems encountered when undertaking a simple OLS regression of levels of non-stationary data, described above: the Rbar-squared of a regression on level data overstates the explanatory power of the model.

- 5.C40. The regression diagnostics and distribution performance reveal little difference between the performance of maximum likelihood (MaxLog) and minimizing the sum of squares (MinSSR) when applied to the classical Chow-Lin and Litterman models. However, there are differences between their predictive performances: MaxLog generally performs better.
- 5.C41. It is evident from this analysis that the regression results are an imperfect indicator of the relative predictive and distributive performance of the models. An assessment of the predictive performance of models over past periods is therefore essential.
- 5.C42. The predictive performance of simple extrapolation compared with the statistical models differs considerably between the four QNA variables. For the two volume measures of gross value added, there is quite a strong relationship between the growth rates of the annualized indicator (production indices) and the national accounts variable. For these variables, simple extrapolation performs quite well - better than most of the models. For the two current price series, the relationship with the indicator (turnover) is weaker and simple extrapolation performs significantly less well than the best performing models. This implies that before using simple extrapolation, the relationship between the ANA variable and the annualized indicator needs to be assessed.
- 5.C43. If models are to be used for distributing and extrapolating QNA variables, they need to be well specified and chosen in accordance with the characteristics of the data. On the one hand, poorly specified regression models are likely to produce poor results, which may be worse than using simple extrapolation. On the other hand, well specified models, with parameters estimated over a sufficiently long period of annual observations, are likely to outperform simple extrapolations when the relationship between the indicator and the national accounts variable is imperfect. In this exercise, samples of no more than 20 observations of annual data were available, and in some cases there were as few as 10 (e.g. for the extrapolation of value added at current prices for the year 2006 data were only available from 1995). Even in such a difficult context, the superior models considered performed reasonably well.
- 5.C44. The Fernandez model, the use of which assumes that the variables are not co-integrated and is equivalent to a model expressed in first differences with a white noise residual (a random walk hypothesis for a regression in level implies stationary residuals for the same regression expressed in first differences) performs very well on the volume data and reasonably well on the current price data considered in this analysis. The French two-step method, which for QNA variables considered here also involves using a model in first differences (see Annex 5.B), has the best distribution results, has high values of  $R^2$  and has a relatively good predictive performance.

### Further comments

- 5.C45. There is, a priori, no reason why the values of the parameters in a model of the annual benchmarks and the annualized quarterly indicator should remain unchanged over many decades. Thus, particularly for the purpose of extrapolation, the length of the time series to be used for estimating the parameters should be reviewed from time to time. Both diagnostic results from the model estimation and recursive revision analysis of extrapolations can, of course, be used for this purpose.

## 6. Chain-linked volume estimates

This chapter explains why chain-linked volume estimates are needed and discusses the pros and cons of the most commonly-used formulae around the world. The chapter describes efficient ways of deriving chain-linked volume estimates using the annually-weighted chain Laspeyres formula, which has been adopted by EU Member States, and also describes how the contributions of components to the growth of major aggregates may be calculated. Extensive use is made of numerical examples to clarify the exposition. General principles for deriving elemental volume estimates are also discussed.

## Introduction

- 6.1. This chapter is primarily concerned with the derivation of chain-linked volume estimates <sup>(18)</sup> for QNA. It describes different formulae that can be used for aggregating elemental volume estimates to form chain-linked volume estimates and analyses their properties. It then goes on to discuss practical issues concerning the [aggregation methods recommended in ESA 2010](#). The third part of the chapter briefly discusses issues concerning elemental volume estimation. The first and second parts of the chapter make extensive use of numerical examples.
- 6.2. For many purposes economists and other analysts wish to measure the “real” growth of national accounts data ( i.e. growth free of the direct effects of price change), but the current price values in the national accounts are subject to the effects of changing prices and so they are unsatisfactory for these purposes.
- 6.3. All flows of goods and services can be decomposed into a price component  $p$  and a volume component  $q$ . For example, consider the sale of beef and chicken:
- In period 1, 20 kilos of beef are sold at €1.00 per kilo for a value of €20.00 and 10 kilos of chicken are sold at €2.00 per kilo for a value of €20.00. Total sales of meat are valued at €40.00.
  - In period 2, 18 kilos of beef are sold at €1.10 per kilo for a value of €19.80 and 12 kilos of chicken are sold at €2.00 per kilo for a value of €24.00. Total sales of meat are valued at €43.80.
- 6.4. Total sales of meat have increased from €40.00 in period 1 to €43.80 in period 2. But what is the growth in “real” terms? One way of answering this question is to hold prices constant in the two periods, at say period 1 prices. The total value of sales in period 2 at period 1 prices is €42.00 (18 kilos of beef @ €1.00 plus 12 kilos of chicken @ €2.00). At period 1 prices, the total value of meat sales has increased from €40.00 to €42.00, which is an increase of 5%.

This can be expressed algebraically as

$$\frac{P_{beef}^1 Q_{beef}^2 + P_{chicken}^1 Q_{chicken}^2}{P_{beef}^1 Q_{beef}^1 + P_{chicken}^1 Q_{chicken}^1} = \frac{(1.00 \times 18) + (2.00 \times 12)}{(1.00 \times 20) + (2.00 \times 10)} = \frac{18.00 + 24.00}{20.00 + 20.00} = \frac{42.00}{40.00} = 1.05$$

This expression is called a Laspeyres volume index. The defining feature is that in calculating growth from one period to another, the prices of the earlier period are applied to both periods.

- 6.5. Another way of estimating the volume growth of meat sales is to hold prices constant at period 2 prices. The value of meat sales in period 1 at period 2 prices is €42.00 (20 kilos of beef @ €1.10 per kilo plus 10 kilos of chicken @ €2.00 per kilo). This gives volume growth of 4.3% between the two periods. This can be written algebraically as:

$$\frac{P_{beef}^2 Q_{beef}^2 + P_{chicken}^2 Q_{chicken}^2}{P_{beef}^2 Q_{beef}^1 + P_{chicken}^2 Q_{chicken}^1} = \frac{(1.10 \times 18) + (2.00 \times 12)}{(1.10 \times 20) + (2.00 \times 10)} = \frac{19.80 + 24.00}{22.00 + 20.00} = \frac{43.80}{42.00} = 1.043$$

This expression is called a Paasche volume index. The defining feature is that in calculating growth from one period to another, the prices of the later period are applied to both periods.

<sup>(18)</sup> The terms chain-linked volume estimates and chain-linked volume indices are used extensively in the handbook, and they are essentially the same thing. The former is term is used when the values are expressed in currency units and the second is used when the values are expressed as index numbers. They are synonymous with chain-linked estimates and indices.

- 6.6. Both the Laspeyres and Paasche indices are equally valid for calculating the volume growth of meat sales between period 1 and period 2, yet they give different answers. This suggests that an average of the two may be a better estimate than either of them. Fisher's Ideal Index (hereafter referred to as the Fisher index) is the geometric mean of the Laspeyres and Paasche and is considered to be a superior index <sup>(19)</sup>.
- 6.7. There are two principal steps in deriving volume estimates of national accounts aggregates:
- the derivation of elemental volume indices at the most detailed level practicable;
  - the aggregation of the elemental volume indices to the desired level, such as GDP.
- 6.8. Up until the beginning of the twenty first century, most OECD and EU Member States derived volume estimates of aggregates by holding prices constant in a particular base year, i.e. constant price estimates. In effect, constant price estimates are a sequence of Laspeyres indices from the base year to the current period multiplied by the current price value in the base year. Over time, price relativities change and when estimating volume growth from one period to another it is best to use prices at or about the current period. Both ESA 2010 and the 2008 SNA recommend the abandonment of constant price estimates in favour of chain-linked volume estimates. Chain-linked volume indices are derived by linking together period-to-period indices, such as Laspeyres, Paasche or Fisher indices. Chain-linked volume estimates are formed by referencing chain-linked volume indices to the current price value of the aggregate in the chosen reference year.
- 6.9. While chain-linked volume estimates are generally superior to constant price estimates in terms of deriving volume growth rates, their use raises a number of issues such as:
- which index formula should be used (Laspeyres, Paasche or Fisher)?
  - how frequently should the prices used to calculate the quarterly indices change – quarterly or annually?
  - if annually, how should quarterly volume indices be derived and how should they be linked together?
  - unlike constant price estimates, chain indices are not generally additive; how should contributions to growth be derived?
- 6.10. Extensive guidance on volume estimation and aggregation in the national accounts is available in a number of manuals:
- the Eurostat *Handbook on prices and volumes measures in national accounts*;
  - the United Nations *Manual on National Accounts at Constant Prices* (M64) provides an extremely useful guide to overcoming the various problems of compiling elemental volume estimates;
  - further guidance on deriving elemental volume estimates in the national accounts and their aggregation to form chain-linked volume indices is provided in Chapter 15 of the 2008 SNA and Chapter 10 of ESA 2010;
  - Chapter 9 of the Eurostat *Manual of Supply, Use and Input-Output Tables* provides detailed guidance on compiling balanced volume estimates in a supply and use framework;
  - Chapter 9 of the IMF *Manual on QNA* provides detailed guidance on the aggregation of elemental volume estimates to form chain-linked volume indices.
- 6.11. Rather than repeat what is in these manuals, this chapter focuses on issues that are of particular interest to EU Member States, but some overlap is inevitable.

<sup>(19)</sup> See Chapter 15 of the IMF's *Producer Price Index Manual*.



- 6.12. The notation used in the formulae in the first part of this chapter is similar, but not quite the same, as that used in Chapter 15 of the 2008 SNA and Chapter 10 of ESA 2010. This has been done to make it easier for the user who wishes to consult both of these manuals as well as this handbook. As a result, the notation differs from the notational conventions used elsewhere in the handbook.

## Formulae for the aggregation of elemental components to form quarterly chain-linked volume indices

### Terminology

- 6.13. Before proceeding to discuss the aggregation of volume estimates it is necessary to define some of the key terminology to be used in order to minimize the risk of confusion.
- 6.14. The base period for an elemental volume index is the period for which the prices are fixed. Hence an elemental Laspeyres volume index from time 0 to time t can be written <sup>(20)</sup> as  $q^t p^0 / q^0 p^0$  and a constant price estimate can be written as  $q^t p^0$ . The Laspeyres volume index is equal to the constant price value for period t divided by the current price value for period 0. When elemental volume indices are aggregated, the current price values in the base period are used to form the weights for combining the elemental volume indices (see formula 6.13, below).
- 6.15. The reference period is the period for which an index series is set equal to 100 or the period for which a volume index series may be set equal to the current price value in order to express the index series in terms of currency units.
- 6.16. For constant price estimates the base period and the reference period coincide. For chain-linked volume indices there is only one reference period, but there are many base periods.

### Different index formulae

- 6.17. A Laspeyres volume index from year  $y-1$  to year  $y$  is of the form:

$$L_Q^y = \frac{\sum_{i=1}^n \bar{P}_i^{y-1} Q_i^y}{\sum_{i=1}^n P_i^{y-1} Q_i^{y-1}}, \quad (6.1)$$

The denominator is the current price value of the aggregate in year  $y-1$ , and  $P_i^{y-1}$  and  $Q_i^{y-1}$  denote the prices and quantities of the  $i^{\text{th}}$  product in year  $y-1$ , and there are  $n$  products. This is a major simplification, because for most national accounts aggregates there are a multitude of transactions concerning each type of product within a year and it would be more realistic to write the current price value for an aggregate in

year  $y-1$  as  $\sum_{i=1}^n \sum_{j=1}^{r_i} P_{i,j}^{y-1} Q_{i,j}^{y-1}$ , where there are  $r_i$  transactions of each type of product  $i$  in year  $y-1$  and

$P_{i,j}^{y-1}$  and  $Q_{i,j}^{y-1}$  are the prices and quantities of the  $j^{\text{th}}$  transaction concerning product  $i$  in year  $y-1$ . But the for the sake of simplicity, the expression in formula 6.1 is used; upper case  $P$ s and  $Q$ s are used to indicate that the aggregation is of all the transactions of each type of product in the year.

The numerator in formula 6.1 is the value of the aggregate in year  $y$  in the average prices of year  $y-1$ . In concept, this means that the quantity in each transaction  $j$  concerning product  $i$  in year  $y$  is multiplied by

<sup>(20)</sup> Likewise, an elemental Laspeyres price index can be written as  $q^t p / q^0 p^0$

the average unit price of all transactions of product  $i$  in the aggregate in year  $y-1$ . The latter is denoted as  $\bar{P}_i^{y-1}$

6.18. A Paasche volume index from year  $y-1$  to year  $y$  is defined as:

$$P_Q^y = \frac{\sum_{i=1}^n P_i^y Q_i^y}{\sum_{i=1}^n \bar{P}_i^y Q_i^{y-1}}, \quad (6.2)$$

6.19. A Fisher index is derived as the geometric mean of a Laspeyres and Paasche index:

$$F_Q^y = \left( L_Q^y \times P_Q^y \right)^{1/2} \quad (6.3)$$

6.20. A Paasche price index from year  $y-1$  to year  $y$  can be derived as:

$$P_P^y = \frac{\sum_{i=1}^n P_i^y Q_i^y}{\sum_{i=1}^n \bar{P}_i^{y-1} Q_i^y}, \quad (6.4)$$

6.21. When this Paasche price index is divided into the current price value for year  $y$  a constant price estimate is produced

$$\frac{\sum_{i=1}^n P_i^y Q_i^y}{P_P^y} = \sum_{i=1}^n P_i^y Q_i^y \times \frac{\sum_{i=1}^n \bar{P}_i^{y-1} Q_i^y}{\sum_{i=1}^n P_i^y Q_i^y} = \sum_{i=1}^n \bar{P}_i^{y-1} Q_i^y \quad (6.5)$$

6.22. Dividing this by the current price value of the previous year, year  $y-1$ , yields a Laspeyres volume index from year  $y-1$  to year  $y$ . Evidently, Laspeyres volume indices and Paasche price indices complement each other, and vice versa.

$$\frac{\sum_{i=1}^n \bar{P}_i^{y-1} Q_i^y}{\sum_{i=1}^n P_i^{y-1} Q_i^{y-1}} = L_Q^y \quad (6.6)$$

Note in practice, the required Paasche price indices are generally unavailable, and Laspeyres price indices are used to deflate current price values instead. This issue is addressed later in this chapter.

Table 6.1a: Laspeyres, Paasche and Fisher volume indices

| Sales of beef and chicken   |         |                             |             |              |             |
|---|---------|-----------------------------|-------------|--------------|-------------|
|   |         | Year 1                      | Year 2      | Year 3       | Year 4      |
| Quantity (kilos)  | Beef    | 20                          | 18          | 16           | 17          |
|   | Chicken | 10                          | 12          | 14           | 17          |
| Average price per kilo (€)  | Beef    | 1.00                        | 1.10        | 1.20         | 1.30        |
|   | Chicken | 2.00                        | 2.00        | 2.10         | 2.15        |
| Value (€)   | Beef    | 20.00                       | 19.80       | 19.20        | 22.10       |
|   | Chicken | 20.00                       | 24.00       | 29.40        | 36.55       |
|   | Total   | 40.00                       | 43.80       | 48.60        | 58.65       |
| <b>Laspeyres volume index: year 1 to year 2 using year 1 prices</b> |         |                             |             |              |             |
|   |         | Values at year 1 prices (€) |             |              |             |
|   |         | Year 1                      | Year 2      | Volume index | Growth rate |
|   | Beef    | 20.00                       | 18.00       | 0.9          | -10.00%     |
|   | Chicken | 20.00                       | 24.00       | 1.2          | 20.00%      |
|   | Total   | 40.00                       | 42.00       | 1.05         | 5.00%       |
| <b>Laspeyres volume index: year 2 to year 3 using year 2 prices</b> |         |                             |             |              |             |
|   |         | Values at year 2 prices (€) |             |              |             |
|   |         | Year 2                      | Year 3      | Volume index | Growth rate |
|   | Beef    | 19.80                       | 17.60       | 0.8889       | -11.11%     |
|   | Chicken | 24.00                       | 28.00       | 1.1667       | 16.67%      |
|   | Total   | 43.80                       | 45.60       | 1.0411       | 4.11%       |
| <b>Laspeyres volume index: year 3 to year 4 using year 3 prices</b> |         |                             |             |              |             |
|   |         | Values at year 3 prices (€) |             |              |             |
|   |         | Year 3                      | Year 4      | Volume index | Growth rate |
|   | Beef    | 19.20                       | 20.40       | 1.0625       | 6.25%       |
|   | Chicken | 29.40                       | 35.70       | 1.2143       | 21.43%      |
|   | Total   | 48.60                       | 56.10       | 1.1543       | 15.43%      |
| <b>Paasche volume index: year 1 to year 2 using year 2 prices</b>   |         |                             |             |              |             |
|   |         | Values at year 2 prices (€) |             |              |             |
|   |         | Year 1                      | Year 2      | Volume index | Growth rate |
|   | Beef    | 22.00                       | 19.80       | 0.9          | -10.00%     |
|   | Chicken | 20.00                       | 24.00       | 1.2          | 20.00%      |
|   | Total   | 42.00                       | 43.80       | 1.0429       | 4.29%       |
| <b>Paasche volume index: year 2 to year 3 using year 3 prices</b>   |         |                             |             |              |             |
|   |         | Values at year 3 prices (€) |             |              |             |
|   |         | Year 2                      | Year 3      | Volume index | Growth rate |
|   | Beef    | 21.60                       | 19.20       | 0.8889       | -11.11%     |
|   | Chicken | 25.20                       | 29.40       | 1.1667       | 16.67%      |
|   | Total   | 46.80                       | 48.60       | 1.0385       | 3.85%       |
| <b>Paasche volume index: year 3 to year 4 using year 4 prices</b>   |         |                             |             |              |             |
|   |         | Values at year 4 prices (€) |             |              |             |
|   |         | Year 3                      | Year 4      | Volume index | Growth rate |
|   | Beef    | 20.80                       | 22.10       | 1.0625       | 6.25%       |
|   | Chicken | 30.10                       | 36.55       | 1.2143       | 21.43%      |
|   | Total   | 50.90                       | 58.65       | 1.1523       | 15.23%      |
|   |         | Year 1 to 2                 | Year 2 to 3 | Year 3 to 4  |             |
| <b>Laspeyres</b>  |         | 1.05                        | 1.0411      | 1.1543       |             |
| <b>Paasche</b>  |         | 1.0429                      | 1.0385      | 1.1523       |             |
| <b>Fisher</b>   |         | 1.0464                      | 1.0398      | 1.1533       |             |

Table 6.1b: Derivation of Laspeyres volume indices by deflation

| Sales of beef and chicken                                     |                        |                                 |             |             |             |
|---|------------------------|---------------------------------|-------------|-------------|-------------|
| Paasche price index: year 1 to year 2 using year 2 quantities |                        |                                 |             |             |             |
|   |                        | Values at year 2 quantities (€) |             | Price index | Growth rate |
|   |                        | Year 1                          | Year 2      |             |             |
|   | Beef                   | 18.00                           | 19.80       | 1.1         | 10.00%      |
|   | Chicken                | 24.00                           | 24.00       | 1           | 0.00%       |
|   | Total                  | 42.00                           | 43.80       | 1.0429      | 4.29%       |
| Paasche price index: year 2 to year 3 using year 3 quantities |                        |                                 |             |             |             |
|   |                        | Values at year 3 quantities (€) |             | Price index | Growth rate |
|   |                        | Year 2                          | Year 3      |             |             |
|   | Beef                   | 17.60                           | 19.20       | 1.0909      | 9.09%       |
|   | Chicken                | 28.00                           | 29.40       | 1.0500      | 5.00%       |
|   | Total                  | 45.60                           | 48.60       | 1.0658      | 6.58%       |
| Paasche price index: year 3 to year 4 using year 4 quantities |                        |                                 |             |             |             |
|   |                        | Values at year 4 quantities (€) |             | Price index | Growth rate |
|   |                        | Year 3                          | Year 4      |             |             |
|   | Beef                   | 20.40                           | 22.10       | 1.0833      | 8.33%       |
|   | Chicken                | 35.70                           | 36.55       | 1.0238      | 2.38%       |
|   | Total                  | 56.10                           | 58.65       | 1.0455      | 4.55%       |
| Laspeyres volume indices derived by deflation                 |                        |                                 |             |             |             |
|   |                        | Year 1 to 2                     | Year 2 to 3 | Year 3 to 4 |             |
|   | Value index            | 1.0950                          | 1.1096      | 1.2068      |             |
|   | Paasche price index    | 1.0429                          | 1.0658      | 1.0455      |             |
|   | Laspeyres volume index | 1.0500                          | 1.0411      | 1.1543      |             |

**Requirements of an integrated system of price and volume indices**

6.23. In its discussion of an integrated system of price and volume indices, ESA 2010 (§10.08) notes that:

The use of the accounting framework imposes a double constraint on the calculation of the data:

- a. the balance of the goods and services account must for any sequence of two years be obtained at both current prices and in volume terms;
- b. each flow at the level of the total economy must be equal to the sum of the corresponding flows for the various industries.

6.24. Fisher indices do not meet these constraints. They are not only non-additive they are also only approximately consistent in aggregation <sup>(21)</sup>. By contrast, Laspeyres volume indices are additive. As can be seen in formula 6.1, for a Laspeyres volume index from year  $y-1$  to year  $y$  the denominator is the current price value of the aggregate in year  $y-1$  and the numerator is the value of the aggregate in year  $y$  in the average prices of year  $y-1$ . Therefore, a Laspeyres index is entirely consistent with constraints (a) and (b). It is also immediately evident that supply and use tables balanced in both current prices and in the average prices of the previous year lend themselves to the formation of annual Laspeyres indices.

<sup>(21)</sup> A Fisher index derived from elemental components does not exactly equal a Fisher index derived from Fisher indices of sub-aggregates.

**Chain indices**

- 6.25. Annual chain Laspeyres and Paasche indices can be formed by multiplying consecutive year-to-year indices. Chain Fisher indices can be derived by taking their geometric mean.

$$L_{CV}^{0 \rightarrow y} = \frac{\sum_{i=1}^n \bar{P}_i^0 Q_i^1}{\sum_{i=1}^n P_i^0 Q_i^0} \times \frac{\sum_{i=1}^n \bar{P}_i^1 Q_i^2}{\sum_{i=1}^n P_i^1 Q_i^1} \times \frac{\sum_{i=1}^n \bar{P}_i^2 Q_i^3}{\sum_{i=1}^n P_i^2 Q_i^2} \times \dots \times \frac{\sum_{i=1}^n \bar{P}_i^{y-1} Q_i^y}{\sum_{i=1}^n P_i^{y-1} Q_i^{y-1}} \quad (6.7)$$

$$P_{CV}^{0 \rightarrow y} = \frac{\sum_{i=1}^n P_i^1 Q_i^1}{\sum_{i=1}^n \bar{P}_i^1 Q_i^0} \times \frac{\sum_{i=1}^n P_i^2 Q_i^2}{\sum_{i=1}^n \bar{P}_i^2 Q_i^1} \times \frac{\sum_{i=1}^n P_i^3 Q_i^3}{\sum_{i=1}^n \bar{P}_i^3 Q_i^2} \times \dots \times \frac{\sum_{i=1}^n P_i^y Q_i^y}{\sum_{i=1}^n \bar{P}_i^y Q_i^{y-1}} \quad (6.8)$$

$$F_{CV}^{0 \rightarrow y} = \left( L_{CV}^{0 \rightarrow y} \times P_{CV}^{0 \rightarrow y} \right)^{1/2} \quad (6.9)$$

- 6.26. From formula 6.7 it can be seen that the value of a chain Laspeyres volume index for year  $y$  is equal to the chain Laspeyres volume index for year  $y-1$  multiplied by the Laspeyres volume index from year  $y-1$  to year  $y$ :

$$L_{CV}^{0 \rightarrow y} = \frac{\sum_{i=1}^n \bar{P}_i^{y-1} Q_i^y}{\sum_{i=1}^n P_i^{y-1} Q_i^{y-1}} L_{CV}^{0 \rightarrow (y-1)} \quad (6.10)$$

The Laspeyres volume index from year  $y-1$  to year  $y$  is simply the quotient of the value at year  $y$  in the average prices of year  $y-1$  and the current price value in year  $y-1$ . Similar expressions can be derived for the Paasche and Fisher volume indices.

- 6.27. All of these indices can be re-referenced by dividing them by the index value in the chosen reference year and multiplying by 1 or 100 to get an indexed series, or by multiplying by the current price value in the reference year to get a series in monetary values, i.e.

$$L_{CV}^{0 \rightarrow y} \times \frac{\sum_{i=1}^n P_i^m Q_i^m}{L_{CV}^{0 \rightarrow m}}, \quad 0 \leq m \leq y \quad (6.11)$$

is a chain Laspeyres volume index (or estimate) for year  $y$  referenced to the current price value in year

$$m, \text{ and } L_{CV}^{0 \rightarrow y} \sum_{i=1}^n P_i^0 Q_i^0 \quad (6.12)$$

is a chain Laspeyres volume index (or estimate) for year  $y$  referenced to the current price value in year 0.

**The case for using chain indices**

- 6.28. Frequent linking is beneficial when price and volume relativities change monotonically. For example, volume estimates of gross fixed capital formation are much better derived as chain indices than as fixed-weighted indices (or constant price estimates) mainly because of the steady decline in the relative prices

of computer equipment and the corresponding increase in their relative volumes. While chain Fisher indices perform best in such circumstances, and are a much better indicator than fixed-weighted indices, chain Laspeyres indices capture much of the improvement from frequent linking.

- 6.29. Conversely, frequent linking is least beneficial when price and volume relativities are volatile. All chained series are subject to drift (see Box 6.1) when there is price and volume instability, but chain Fisher indices usually drift less than either chain Laspeyres or chain Paasche indices.

**Box 6.1 Drift and long-term accuracy**

Suppose the prices and quantities are  $p_i^t$  and  $q_i^t$  at time  $t$  and  $p_i^{t+n}$  and  $q_i^{t+n}$   $n$  periods later at time  $t+n$ . Further suppose that  $p_i^t = p_i^{t+n}$  and  $q_i^t = q_i^{t+n}$  then the drift of a particular type of index is given by the difference between the index's values at time  $t$  and time  $t+n$ .

In reality it is very uncommon for prices and volumes to return to the values observed in an earlier period. Therefore, in practice, the drift and long-term accuracy of a chain or fixed-weighted index can be assessed over a period of time by comparing it with a direct Fisher index, i.e. a Fisher index calculated directly from the first to the last observation in the period.

- 6.30. Table 6.1c, below, compares the chain Laspeyres, chain Paasche and chain Fisher volume indices of meat sales. It shows that in this example:

- the chain Fisher volume index and the Fisher volume index calculated directly from the first year to the fourth year have almost the same growth rate over the four year period, i.e. the chain Fisher volume index shows very little drift;
- both the chain Laspeyres and chain Paasche volume indices come much closer to the two Fisher volume indices than their fixed-weighted counterparts.

It is important to note that this is just an example. In the real world, the differences between the different indices are usually much less.

- 6.31. For aggregates such as gross value added of mining and agriculture, and maybe exports and imports, where volatility in price and volume relativities are common, the advantages of frequent linking may be doubtful, particularly using the Laspeyres (or Paasche) formula. For reasons of practicality and consistency, the same approach to volume aggregation has to be followed throughout the accounts. So when choosing which formula to use, it is necessary to make an overall assessment of drift, accuracy and practical matters (discussed below).
- 6.32. In considering the benefits of chain indices vis-à-vis fixed-weighted indices, the 2008 SNA (§15.44) concludes that it is generally recommended that annual indices be chained. The price and volume components of monthly and quarterly data are usually subject to much greater variation than their annual counterparts due to seasonality and short-term irregularities. Therefore, the advantages of chaining at these higher frequencies are less and chaining should definitely not be applied to seasonal data that are not adjusted for seasonal fluctuations.

Table 6.1c: Chain-linked volume indices, direct indices and drift

| Sales of beef and chicken          |   |         |                              |   |         |                              |                                |         |
|------------------------------------|---|---------|------------------------------|---|---------|------------------------------|--------------------------------|---------|
| Laspeyres                          |   |         | Paasche                      |   |         | Fisher                       |                                |         |
| <b>Chain-linked volume indices</b> |   |         |                              |   |         |                              |                                |         |
| $L_{CV}^1 =$                       | 100.00  | =100.00 | $P_{CV}^1 =$                 | 100.00  | =100.00 | $F_{CV}^1 =$                 | 100.00                         | =100.00 |
| $L_{CV}^{1 \rightarrow 2} =$       | 100.00 x 1.050                                  | =105.00 | $P_{CV}^{1 \rightarrow 2} =$ | 100.00 x 1.043                                  | =104.29 | $F_{CV}^{1 \rightarrow 2} =$ | (105.00x104.29) <sup>0.5</sup> | =104.64 |
| $L_{CV}^{1 \rightarrow 3} =$       | 105.00 x 1.041                                  | =109.32 | $P_{CV}^{1 \rightarrow 3} =$ | 104.29 x 1.039                                  | =108.30 | $F_{CV}^{1 \rightarrow 3} =$ | (109.32x108.32) <sup>0.5</sup> | =108.80 |
| $L_{CV}^{1 \rightarrow 4} =$       | 109.32 x 1.154                                  | =126.18 | $P_{CV}^{1 \rightarrow 4} =$ | 108.30 x 1.152                                  | =124.79 | $F_{CV}^{1 \rightarrow 4} =$ | (126.18x124.79) <sup>0.5</sup> | =125.48 |
| <b>Direct volume indices</b>       |   |         |                              |   |         |                              |                                |         |
| $L_{DV}^{1 \rightarrow 4} =$       | $\frac{17 \times 1.00 + 17 \times 2.00}{40.00}$ | =127.50 | $P_{DV}^{1 \rightarrow 4} =$ | $\frac{58.65}{20 \times 1.30 + 10 \times 2.15}$ | =123.47 | $F_{DV}^{1 \rightarrow 4} =$ | (127.50x123.47) <sup>0.5</sup> | =125.47 |

#### *Deriving annual chain-linked volume indices in the national accounts*

- 6.33. It is recommended in both [ESA 2010](#) and the 2008 SNA that ANA should be balanced in both current prices and in volume terms using supply and use tables. In most cases, the volume estimates are best derived in the average prices of the previous year rather than some distant base year:
- assumptions of fixed relationships in volume terms are usually more likely to hold in the previous year's average prices than in the prices of some distant base year;
  - the growth rates of volumes and prices are less affected by compositional change.
- 6.34. As already noted, the compilation of annual supply and use tables in current prices and in the average prices of the previous year lends itself to the compilation of annual Laspeyres volume indices and to the formation of annual chain Laspeyres volume indices.
- 6.35. In order to compute annual Fisher volume indices from data balanced data in supply and use tables (SUTs), it is conceptually desirable to derive both the constituent Laspeyres and Paasche volume indices from data balanced in SUTs. To derive the numerator of the Laspeyres volume index from year  $y-1$  to year  $y$  requires balancing the SUT for the current year ( $y$ ) in the average prices of the previous year ( $y-1$ ) and to derive the denominator of the Laspeyres volume index requires balancing the SUT for the previous year ( $y-1$ ) in the average prices of the previous year ( $y-1$ ). To derive the numerator for the Paasche volume index from year  $y-1$  to year  $y$  requires balancing the SUT for the current year ( $y$ ) in the average prices of the current year ( $y$ ) and to derive the denominator requires balancing the SUT for the previous year ( $y-1$ ) in the average prices of the current year ( $y$ ). This last SUT (values for year  $y-1$  in the average prices of year  $y$ ) is not required for compiling annual chain Laspeyres indices, and so the compilation of annual chain Fisher indices from balanced SUTs is somewhat more demanding.

#### *Deriving quarterly chain-linked volume indices in the national accounts*

- 6.36. Computationally, the derivation of quarterly chain-linked volume indices from quarterly data with quarterly base periods is no different to compiling annual chain-linked volume indices from annual data with annual base periods. But, as recommended by the 2008 SNA, if quarterly volume indices are to

have quarterly base periods and be linked each quarter, then it should only be done using seasonally adjusted data. Furthermore, if the quarterly seasonally adjusted data are subject to substantial volatility in relative prices and volumes, then chain indices should not be formed from indices with quarterly base periods at all. Even if the quarterly volatility is not so severe, quarterly base periods and quarterly linking are not recommended using the Laspeyres formula because of its greater susceptibility to drift than the Fisher formula.

- 6.37. A way round this problem is to derive quarterly volume indices from a year to quarters. In other words, use annual base years (i.e. annual weights) to derive quarterly volume indices. Consider the Laspeyres annual volume index in formula 6.1. It can be expressed as a weighted average of elemental volume indices:

$$L_Q^y = \frac{\sum_{i=1}^n \bar{P}_i^{y-1} Q_i^y}{\sum_{i=1}^n P_i^{y-1} Q_i^{y-1}} = \sum_{i=1}^n \left( \frac{Q_i^y}{Q_i^{y-1}} \right) s_i^{y-1}, \text{ where } s_i^{y-1} = \frac{P_i^{y-1} Q_i^{y-1}}{\sum_{i=1}^n P_i^{y-1} Q_i^{y-1}} \quad (6.13)$$

Paasche volume indices can also be expressed in terms of a weighted average of the elemental volume indices, but as the harmonic, rather than arithmetic, mean.

- 6.38. A Laspeyres-type <sup>(22)</sup> volume index from year  $y-1$  to quarter  $c$  in year  $y$  takes the form

$$L_Q^{\overline{(y-1)} \rightarrow (c,y)} = \frac{\sum_{i=1}^n \bar{P}_i^{y-1} q_i^{c,y}}{\frac{1}{4} \sum_{i=1}^n P_i^{y-1} Q_i^{y-1}} = \sum_{i=1}^n \frac{4q_i^{c,y}}{Q_i^{y-1}} s_i^{y-1}, \quad (6.14)$$

where  $q_i^{c,y}$  is the quantity of product  $i$  in the  $c^{\text{th}}$  quarter of year  $y$ ,  $p_i^{c,y}$  is the corresponding price and

$$s_i^{y-1} = \frac{P_i^{y-1} Q_i^{y-1}}{\sum_{i=1}^n P_i^{y-1} Q_i^{y-1}} = \frac{\sum_{c=1}^4 P_i^{c,y-1} q_i^{c,y-1}}{\sum_{i=1}^n \sum_{c=1}^4 P_i^{c,y-1} q_i^{c,y-1}} \quad (6.15)$$

In concept, the annual current price data in year  $y-1$  are used to weight together elemental volume indices from year  $y-1$  to each of the quarters in year  $y$ . In practice, there is usually no quantity data and

$\sum_{i=1}^n \bar{P}_i^{y-1} q_i^{c,y}$  is estimated by deflating the quarterly current price values by a price index. How to go about doing this is discussed later in this chapter.

- 6.39. §15.53-15.54 of the 2008 SNA describe how chain Fisher-type indices of quarterly data with annual base periods can be derived. Consider two consecutive years: year  $y-1$  and year  $y$ , then quarterly Laspeyres-type volume indices are formed from year  $y-1$  to the last two quarters of year  $y-1$  and the first two quarters of year  $y$ . Likewise, Paasche-type volume indices are formed from year  $y$  to each of the same quarters. In effect, the Laspeyres-type volume indices are formed using the current price data for year  $y-1$  to weight together the quarterly elemental volume indices and the Paasche-type volume indices are formed using the current price data for year  $y$  to weight the same quarterly elemental volume indices. Fisher-type indices are then formed for the four quarters by taking the geometric mean of the Laspeyres-

<sup>(22)</sup> The terms Laspeyres-type and Fisher-type indices are used to describe quarterly indices with annual weights.



type and Paasche-type indices. But when year  $y-1$  is the latest complete year then, as §15.55 of the 2008 SNA notes, it is not possible to derive quarterly Paasche-type indices because there are no annual data for year  $y$ , and so annually-based quarterly Fisher-type volume indices cannot be derived for the latest quarters of a time series. One solution is to construct quarter-on-quarter chain Fisher volume indices with quarterly base periods for the quarters of the latest year or two and use them to extrapolate Fisher-type indices derived using annual base period weights. Note, however, that this requires quarterly volume estimates and either quarterly current price estimates or price indices. While these are generally available for expenditure estimates they are often unavailable for gross value added by industry.

- 6.40. Another, simpler, approach is to derive quarterly Fisher chain-linked volume indices with quarterly base periods for the entire time series and then benchmark them to the corresponding annual chain Fisher volume indices. As both of these approaches entail deriving quarterly chain Fisher volume indices with quarterly base periods, they should only be implemented using quarterly seasonally adjusted data.

#### *Choosing between chain Laspeyres and chain Fisher indices*

- 6.41. Chapter 10 of the [ESA 2010 recommends](#) using the Laspeyres formula when deriving chain-linked volume indices. There are several advantages in using the Laspeyres formula:
- its adoption is consistent with compiling additive supply and use tables in both current prices and in the average prices of the previous year;
  - quarterly chain-linked volume estimates of both seasonally adjusted and unadjusted data can be derived;
  - it is unnecessary to seasonally adjust volume data at the most detailed level, if desired;
  - it is simpler to construct chain Laspeyres indices than Fisher indices and the risk of error is correspondingly less.
- 6.42. The advantages of using the Fisher formula are
- it is more accurate than the Laspeyres formula;
  - it is more robust and less susceptible to drift when price and volume relativities are volatile.
- 6.43. In practice it is generally found that there is little difference between chain Laspeyres and Fisher indices for most aggregates. The major threat to the efficacy of the use of the Laspeyres formula in the national accounts has been computer equipment. The prices of computer equipment have been falling rapidly and the volumes of production and expenditure have been rising rapidly for many years. Consequently, the chain Laspeyres and chain Fisher indices for aggregates for which computer equipment is a significant component are likely to show differences. Until now, these differences have been insufficient to cause concern in EU Member States and have not been judged to outweigh the advantages of using the Laspeyres formula. Of course, when little production of computers occurs in a country the volume growth of GDP cannot be affected, and inaccuracies in the measurement of the volume growth of expenditures on computer equipment are offset by inaccuracies in the measurement of the volume growth of imports. Nevertheless, it is a good policy to review the performance of chain Laspeyres volume indices from time to time. Drift and long-term accuracy can be assessed by comparing them and chain Fisher volume indices with direct Fisher indices using annual data over, say, the last ten years.

#### *Deriving annually-linked quarterly Laspeyres-type volume indices*

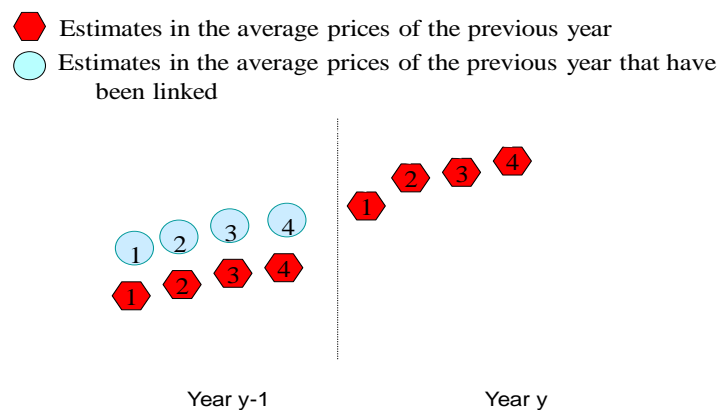
- 6.44. While there are different ways of linking annual Laspeyres volume indices, they all produce the same result. But this is not true when it comes to linking annual-to-quarter Laspeyres-type volume indices for consecutive years. §15.46-15.50 of the 2008 SNA discusses three methods for linking these Laspeyres-type volume indices; they are:

- a. annual overlap;
  - b. one-quarter overlap;
  - c. over the year.
- 6.45. When a Laspeyres-type quarterly volume index from year  $y-1$  to quarter  $c$  in year  $y$  is referenced to year  $y-1$ , by multiplying it by the average quarterly current price value for year  $y-1$ , then a value for quarter  $c$  is obtained in the average prices of year  $y-1$ .

$$\frac{\sum_{i=1}^n \bar{P}_i^{y-1} q_i^{c,y}}{\frac{1}{4} \sum_{i=1}^n P_i^{y-1} Q_i^{y-1}} \frac{1}{4} \sum_{i=1}^n P_i^{y-1} Q_i^{y-1} = \sum_{i=1}^n \bar{P}_i^{y-1} q_i^{c,y} \quad (6.16)$$

- 6.46. Hence the task of linking quarterly Laspeyres-type volume indices for two consecutive years, year  $y-1$  and year  $y$ , amounts to linking the quarterly values of year  $y-1$  in the average prices of year  $y-2$  with the values of year  $y$  in the average prices of year  $y-1$ .

Figure 6.1: Linking quarterly estimates in the prices of the previous year



**Annual overlap method**

- 6.47. One way of putting the eight quarters described in the previous paragraph onto a comparable valuation basis is to calculate and apply a link factor from an annual overlap. Values for year  $y-1$  are derived in the average prices of both  $y-1$  and  $y-2$  and then the former is divided by the latter. In the case of the former, this is simply the sum of the quarterly current price values in year  $y-1$ .

The annual overlap link factor for year  $y-1$  to year  $y = \frac{\sum_{i=1}^n \sum_{c=1}^4 P_i^{c,y-1} q_i^{c,y-1}}{\sum_{i=1}^n \sum_{c=1}^4 \bar{P}_i^{y-2} q_i^{c,y-1}} \quad (6.17)$

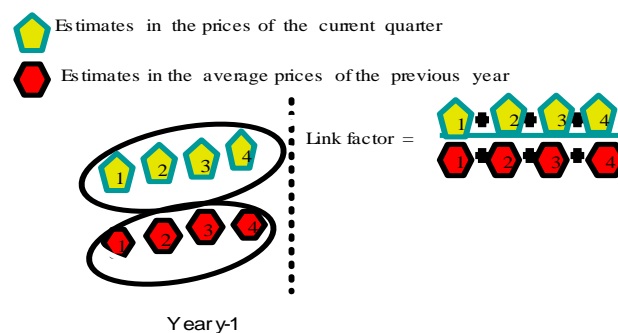
- 6.48. Multiplying the quarterly values for year  $y-1$  in the average prices of year  $y-2$  with this link factor puts them on to a comparable valuation basis with the quarterly estimates for year  $y$  in the average prices of

year  $y-1$ . If the quarterly current price values and the quarterly values in the average prices of the previous year are temporally consistent with their corresponding annual counterparts, then this link factor is identical to the one that can be used to link the annual value for year  $y-1$  in the average prices of  $y-2$  with the annual value for year  $y$  in the average prices of year  $y-1$ :

$$\frac{\sum_{i=1}^n \sum_{c=1}^4 p_i^{c,y-1} q_i^{c,y-1}}{\sum_{i=1}^n \sum_{c=1}^4 \bar{P}_i^{y-2} q_i^{c,y-1}} = \frac{\sum_{i=1}^n P_i^{y-1} Q_i^{y-1}}{\sum_{i=1}^n \bar{P}_i^{y-2} Q_i^{y-1}} \quad (6.18)$$

Therefore, if the quarterly values for every year  $y$  in the average prices of year  $y-1$  and the quarterly current price values are temporally consistent with their annual counterparts, then the chain-linked quarterly series will be temporally consistent with the corresponding chain-linked annual series.

Figure 6.2: Link factor derived using the annual overlap method



### One-quarter overlap method

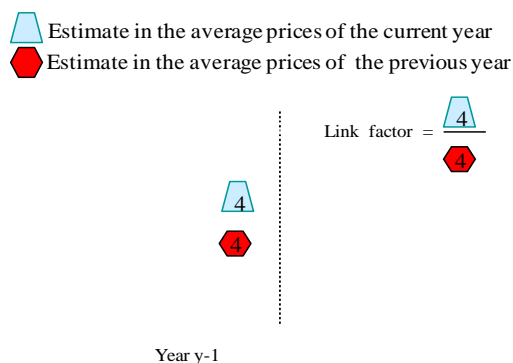
- 6.49. The one-quarter overlap method, as its name suggests, involves calculating a link factor using overlap values for a single quarter. To link the four quarters of year  $y-1$  in the average prices of year  $y-2$  with the four quarters of year  $y$  in the average prices of year  $y-1$ , a one-quarter overlap can be created for either the fourth quarter of year  $y-1$  or the first quarter of year  $y$ , but it is common practice to use the former. The link factor derived from an overlap for the fourth quarter of year  $y-1$

$$= \frac{\sum_{i=1}^n \bar{P}_i^{y-1} q_i^{4,y-1}}{\sum_{i=1}^n \bar{P}_i^{y-2} q_i^{4,y-1}} \quad (6.19)$$

- 6.50. Multiplying the quarterly values for year  $y-1$  in the average prices of year  $y-2$  with this link factor puts them on to a comparable valuation basis with the quarterly estimates for year  $y$  in the average prices of year  $y-1$ .
- 6.51. A key property of the one-quarter overlap method is that it preserves the quarter-on-quarter growth rate between the fourth quarter of year  $y-1$  and the first quarter of year  $y$  – unlike the annual overlap method. The “damage” done to that growth rate by the annual overlap method is determined by the difference between the annual and quarter overlap link factors. Conversely, this difference also means that the sum of the linked quarterly values in year  $y-1$  differ from the annual overlap-linked data by the ratio of the two

link factors. Temporal consistency can be achieved by benchmarking the quarterly chain-linked volume estimates derived using the one-quarter overlap method to their annual counterparts. By using an optimal benchmarking procedure (see Chapter 5), the difference between the two link factors for each year is spread over many quarters such that the amendments to the quarter-on-quarter movements are minimized.

Figure 6.3: Link factor derived using the one-quarter overlap method



### Over-the-year method

- 6.52. The over-the-year method requires compiling a separate link factor for each type of quarter. Each of the quarterly values in year  $y-1$  in the average prices of year  $y-2$  is multiplied by its own link factor. The over-the-year quarterly link factor to link quarter  $c$  in year  $y-1$  in the average prices of year  $y-2$  to quarter  $c$  in year  $y$  in the average prices of year  $y-1$

$$\begin{aligned}
 & \frac{\sum_{i=1}^n \bar{P}_i^{y-1} q_i^{c,y-1}}{\sum_{i=1}^n \bar{P}_i^{y-2} q_i^{c,y-1}} \\
 & = \frac{\sum_{i=1}^n \bar{P}_i^{y-1} q_i^{c,y-1}}{\sum_{i=1}^n \bar{P}_i^{y-2} q_i^{c,y-1}} \tag{6.20}
 \end{aligned}$$

- 6.53. In effect, four separate chain-linked volume indices are formed – one for first quarters, one for second quarters, etc. The over-the-year method does not distort the growth rates of quarter on the same quarter of the previous year, since the chain-links refer to the volumes of the same quarter in the respective previous year valued in the average prices of that year, but it does distort quarter-on-quarter growth rates. As the latter are of primary interest (in seasonally adjusted terms), this is most unsatisfactory. Furthermore, the linked quarterly data are temporally inconsistent with the annual-linked data and so benchmarking is needed. Given these shortcomings, the over-the-year method is best avoided.

Figure 6.4: Link factors derived using the over-the-year method

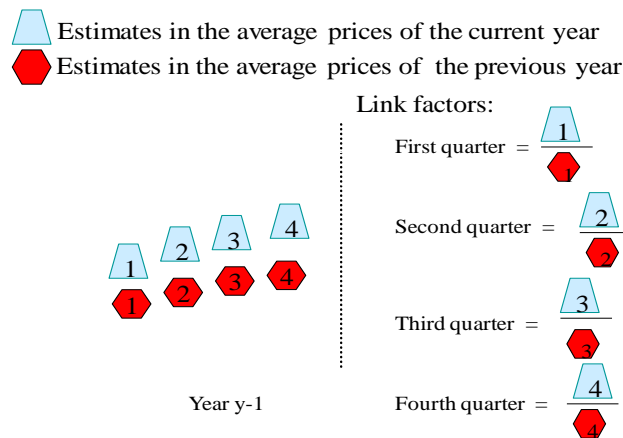


Table 6.1d: Deriving link factors using the annual and one-quarter overlap methods

| <b>Sales of beef and chicken</b>   |  |
|--|--|
| Year 2 to Year 3   | Year 3 to Year 4   |
| <b>Annual overlap method</b>   |  |
| $\frac{\sum_{i=1}^2 P_i^2 Q_i^2}{\sum_{i=1}^2 P_i^1 Q_i^2}$ $\frac{(1.1 \times 18) + (2 \times 12)}{(1 \times 18) + (2 \times 12)} = 1.0429$         | $\frac{\sum_{i=1}^2 P_i^3 Q_i^3}{\sum_{i=1}^2 P_i^2 Q_i^3}$ $\frac{(1.2 \times 16) + (2.1 \times 14)}{(1.1 \times 16) + (2 \times 14)} = 1.0658$       |
| <b>One-quarter overlap method (see quarterly data in Table 6.1f)</b>   |  |
| $\frac{\sum_{i=1}^2 P_i^2 q_i^{4,2}}{\sum_{i=1}^2 P_i^1 q_i^{4,2}}$ $\frac{(1.1 \times 6) + (2.0 \times 3)}{(1.0 \times 6) + (2.0 \times 3)} = 1.05$ | $\frac{\sum_{i=1}^2 P_i^3 q_i^{4,3}}{\sum_{i=1}^2 P_i^2 q_i^{4,3}}$ $\frac{(1.2 \times 4) + (2.1 \times 3)}{(1.1 \times 4) + (2.0 \times 3)} = 1.0673$ |

Table 6.1e: Deriving quarterly chain-linked volume estimates (referenced to year 2) - annual overlap method

Sales of beef and chicken

| Year   | 2      |        |        |        | 3       |        |        |         | 4      |        |        |         |
|--|--------|--------|--------|--------|---------|--------|--------|---------|--------|--------|--------|---------|
|  | 1      | 2      | 3      | 4      | 1       | 2      | 3      | 4       | 1      | 2      | 3      | 4       |
| Beef (kilos)                                 | 5      | 4      | 3      | 6      | 4       | 5      | 3      | 4       | 4      | 4      | 5      | 4       |
| Chicken(kilos)                               | 2      | 3      | 4      | 3      | 2       | 4      | 5      | 3       | 3      | 4      | 6      | 4       |
| Price of beef in previous year               | €1.00  | €1.00  | €1.00  | €1.00  | €1.10   | €1.10  | €1.10  | €1.10   | €1.20  | €1.20  | €1.20  | €1.20   |
| Price of chicken in previous year            | €2.00  | €2.00  | €2.00  | €2.00  | €2.00   | €2.00  | €2.00  | €2.00   | €2.10  | €2.10  | €2.10  | €2.10   |
| Value of beef at previous year's prices      | €5.00  | €4.00  | €3.00  | €6.00  | €4.40   | €5.50  | €3.30  | €4.40   | €4.80  | €4.80  | €6.00  | €4.80   |
| Value of chicken at previous year's prices   | €4.00  | €6.00  | €8.00  | €6.00  | €4.00   | €8.00  | €10.00 | €6.00   | €6.30  | €8.40  | €12.60 | €8.40   |
| Totalsales of meat in previous year's prices | €9.00  | €10.00 | €11.00 | €12.00 | €8.40   | €13.50 | €13.30 | €10.40  | €11.10 | €13.20 | €18.60 | €13.20  |
| Link factor year 2 to 3                      | 1.0429 | 1.0429 | 1.0429 | 1.0429 |         |        |        |         |        |        |        |         |
| Linking year 2 to year 3                     | €9.39  | €10.43 | €11.47 | €12.51 | €8.40   | €13.50 | €13.30 | €10.40  |        |        |        |         |
| Link factor year 3 to 4                      | 1.0658 | 1.0658 | 1.0658 | 1.0658 | 1.0658  | 1.0658 | 1.0658 | 1.0658  |        |        |        |         |
| Linking year 2 and 3 to year 4               | €10.00 | €11.11 | €12.23 | €13.34 | €8.95   | €14.39 | €14.18 | €11.08  | €11.10 | €13.20 | €18.60 | €13.20  |
| Factor to reference to year 2                | 0.9383 | 0.9383 | 0.9383 | 0.9383 | 0.9383  | 0.9383 | 0.9383 | 0.9383  | 0.9383 | 0.9383 | 0.9383 | 0.9383  |
| Referenced to year 2                         | €9.39  | €10.43 | €11.47 | €12.51 | €8.40   | €13.50 | €13.30 | €10.40  | €10.41 | €12.39 | €17.45 | €12.39  |
| Annualized                                   | €43.80 |        |        |        | €45.60  |        |        |         | €52.64 |        |        |         |
| Quarterly growth rate                        |        | 11.11% | 10.00% | 9.09%  | -32.88% | 60.71% | -1.48% | -21.80% | 0.14%  | 18.92% | 40.91% | -29.03% |

Table 6.1f: Deriving quarterly chain-linked volume estimates (referenced to year 2) - one-quarter overlap method

| Year  | 2      |        |        |        | 3       |        |        |         | 4      |        |        |         |
|---|--------|--------|--------|--------|---------|--------|--------|---------|--------|--------|--------|---------|
|   | 1      | 2      | 3      | 4      | 1       | 2      | 3      | 4       | 1      | 2      | 3      | 4       |
| Beef (kilos)                                  | 5      | 4      | 3      | 6      | 4       | 5      | 3      | 4       | 4      | 4      | 5      | 4       |
| Chicken (kilos)                               | 1      | 2      | 4      | 3      | 2       | 4      | 5      | 3       | 3      | 4      | 6      | 4       |
| Price of beef in previous year                | €1.00  | €1.00  | €1.00  | €1.00  | €1.10   | €1.10  | €1.10  | €1.10   | €1.20  | €1.20  | €1.20  | €1.20   |
| Price of chicken in previous year             | €2.00  | €2.00  | €2.00  | €2.00  | €2.00   | €2.00  | €2.00  | €2.00   | €2.10  | €2.10  | €2.10  | €2.10   |
| Value of beef at previous year's prices       | €5.00  | €4.00  | €3.00  | €6.00  | €4.40   | €5.50  | €3.30  | €4.40   | €4.80  | €4.80  | €6.00  | €4.80   |
| Value of chicken at previous year's prices    | €4.00  | €6.00  | €8.00  | €6.00  | €4.00   | €8.00  | €10.00 | €6.00   | €6.30  | €8.40  | €12.60 | €8.40   |
| Total sales of meat in previous year's prices | €9.00  | €10.00 | €11.00 | €12.00 | €8.40   | €13.50 | €13.30 | €10.40  | €11.10 | €13.20 | €18.60 | €13.20  |
| Link factor year 2 to 3                       | 1.05   | 1.05   | 1.05   | 1.05   |         |        |        |         |        |        |        |         |
| Linking year 2 to year 3                      | €9.45  | €10.50 | €11.55 | €12.60 | €8.40   | €13.50 | €13.30 | €10.40  |        |        |        |         |
| Link factor year 3 to 4                       | 1.0673 | 1.0673 | 1.0673 | 1.0673 | 1.0673  | 1.0673 | 1.0673 | 1.0673  |        |        |        |         |
| Linking year 2 and 3 to year 4                | €10.09 | €11.21 | €12.33 | €13.45 | €8.97   | €14.41 | €14.20 | €11.10  | €11.10 | €13.20 | €18.60 | €13.20  |
| Factor to reference to year 2                 | 0.9306 | 0.9306 | 0.9306 | 0.9306 | 0.9306  | 0.9306 | 0.9306 | 0.9306  | 0.9306 | 0.9306 | 0.9306 | 0.9306  |
| Referenced to year 2                          | €9.39  | €10.43 | €11.47 | €12.51 | €8.34   | €13.41 | €13.21 | €10.33  | €10.33 | €12.28 | €17.31 | €12.28  |
| Annualized                                    | €43.80 |        |        |        | €45.29  |        |        |         | €52.20 |        |        |         |
| Quarterly growth rate                         |        | 11.1%  | 10.0%  | 9.09%  | -33.33% | 60.71% | -1.48% | -21.80% | 0.00%  | 18.92% | 40.91% | -29.03% |

**Practical issues concerning chain Laspeyres volume indices**

*Alternative ways of linking and unlinking quarterly Laspeyres-type volume indices*

6.54. Calculating and using link factors, as described above, is a rather laborious process and is not computationally efficient. There is also often a need to unlink chain-linked volume indices, such as when deriving seasonally adjusted chain-linked volume estimates of major aggregates indirectly (see Chapter 7). This section discusses efficient methods for linking estimates in the prices of the previous year and reversing the process for both the annual and one-quarter overlap methods.

6.55. For the sake of clarity, some new notation is introduced: the measure of a given aggregate  $X$  at quarter  $c$  of year  $y$  is denoted by  $X_{CP}^{c,y}$  in current prices,  $X_{PPY}^{c,y}$  in the average prices of the previous year and  $X_{CV}^{c,y}$  for chain-linked volume indices. The implicit price deflator of the chain-linked volume indices is

$$P_X^{c,y} = \frac{X_{CP}^{c,y}}{X_{CV}^{c,y}}$$

Measures indexed by a year only denote annual data, e.g.  $X_{CP}^y$  is the current price value

of aggregate  $X$  in year  $y$  and  $P_X^y = \frac{X_{CP}^y}{X_{CV}^y}$  is the implicit price deflator of  $X$  in the same year.

6.56. As explained in § 6.27, chain-linked volume indices have to be referenced to a value in a particular period. Usually, this value is set at 100 or the current price value in the reference year. Here the chain-linked volume index is referenced to the current price value in year 0:

$$X_{CV}^0 = X_{CP}^0$$

Using this notation, equation 6.10 becomes

$$\frac{X_{CV}^y}{X_{CV}^{y-1}} = \frac{X_{PPY}^y}{X_{CP}^{y-1}} \tag{6.21}$$

Therefore an annual chain Laspeyres volume index referenced to the current price value in year 0 can be expressed as

$$X_{CV}^y = \prod_{m=1}^y \frac{X_{PPY}^m}{X_{CP}^{m-1}} X_{CP}^0 \tag{6.22}$$

**Annual overlap method**

6.57. When the annual overlap method is used and there is temporal consistency between the quarterly and annual data, the link factors used to construct quarterly chain Laspeyres volume estimates are exactly the same as those used to construct the corresponding annual chain-linked volume estimates, i.e. (from formula 6.18) the annual link factor for year  $y-1$  to year  $y$

$$= \frac{X_{CP}^{y-1}}{X_{PPY}^{y-1}}$$



Therefore the quotients of each quarterly estimate in the prices of the previous year and the corresponding chain-linked volume estimate are the same as that for the whole year, i.e.

$$\frac{X_{PPY}^{c,y}}{X_{CV}^{c,y}} = \frac{X_{PPY}^y}{X_{CV}^y} \quad (6.23)$$

for every quarter  $c$  in year  $y$ .

6.58. From equation 6.21

$$\frac{X_{PPY}^y}{X_{CV}^y} = \frac{X_{CP}^{y-1}}{X_{CV}^{y-1}} = P_X^{y-1} \quad (6.24)$$

6.59. From equations 6.23 and 6.24 it follows that

$$\frac{X_{PPY}^{c,y}}{X_{CV}^{c,y}} = \frac{X_{PPY}^y}{X_{CV}^y} = \frac{X_{CP}^{y-1}}{X_{CV}^{y-1}} = P_X^{y-1} \quad (6.25)$$

This means that the quotient of a value in the prices of the previous year and the corresponding chain-linked volume estimate is equal to the annual implicit price deflator of the previous year - irrespective of whether the quotients are derived from quarterly or annual data.

6.60. By inverting equation 6.25 and re-arranging terms

$$X_{CV}^{c,y} = X_{PPY}^{c,y} \times \frac{1}{P_X^{y-1}} \quad (6.26)$$

Hence when the annual overlap method is used, the quarterly chain-linked volume estimate of an aggregate can be derived simply by dividing the corresponding value in the average prices of the previous year by the annual implicit price deflator of the previous year.

6.61. Conversely, the quarterly chain-linked volume estimate of an aggregate can be unlinked to derive a quarterly estimate in the average prices of the previous year by multiplying the former by the implicit price deflator of the previous year:

$$X_{PPY}^{c,y} = X_{CV}^{c,y} \times P_X^{y-1} \quad (6.27)$$

6.62. Note that equations 6.26 and 6.27 apply to all years, including those prior to the reference year.

#### *Linking and unlinking seasonally adjusted data*

6.63. Seasonally adjusted chain-linked volume estimates of aggregates can be derived either by directly seasonally adjusting the unadjusted chain-linked volume estimates of the aggregate or indirectly by aggregating the seasonally adjusted estimates of its components in the prices of the previous year and then linking (see Chapter 7).

6.64. Implicit in the derivation of equations 6.25 to 6.27 is the assumption that the quarterly current price and chain-linked volume estimates are temporally consistent with their annual counterparts. Although it is generally recommended (see Chapter 7) that seasonally adjusted estimates should be benchmarked to the corresponding annual estimates (after adjustment for calendar variation), there may be circumstances where it is decided not to benchmark the seasonally adjusted estimates. When this occurs, it is conceptually correct to calculate annual link factors, or annual implicit price deflators, using the

annualized seasonally adjusted data. However, in practice it may make little difference if the link factors of the unadjusted annual data are used instead.

### *One-quarter overlap method*

- 6.65. When the one-quarter overlap method is used, the annual link factor for linking the quarters in year  $y-1$  in the average prices of year  $y-2$  with the quarters in year  $y$  in the average prices of year  $y-1$  is

$$= \frac{X_{CP}^{4,y-1}}{X_{PPY}^{4,y-1}} \quad (6.28)$$

where  $X_{CP}^{4,y-1}$  is the value of the fourth quarter in year  $y-1$  in the average prices of year  $y-1$  and  $X_{PPY}^{4,y-1}$  is the value for the same quarter in the average prices of year  $y-2$ .

- 6.66. As noted earlier, a critical feature of the one-quarter overlap method is that it preserves in a quarterly chain-linked volume index the quarter-on-quarter growth rates of estimates in the prices of the previous year, including those between the fourth quarter of one year and the first quarter of the next when expressed in the earlier year's average prices:

$$\frac{X_{CV}^{c,y}}{X_{CV}^{c-1,y}} = \frac{X_{PPY}^{c,y}}{X_{PPY}^{c-1,y}} \quad (6.29)$$

for quarters 2, 3 and 4 in year  $y$ , and

$$\frac{X_{CV}^{1,y+1}}{X_{CV}^{4,y}} = \frac{X_{PPY}^{1,y+1}}{X_{PPY}^{4,y}} \quad (6.30)$$

for the fourth quarter of year  $y$  to the first quarter of year  $y+1$ .

- 6.67. The fourth quarter of each year has two volume values. In equation 6.29, when deriving a volume index from the third quarter to the fourth quarter of year  $y$ , the fourth quarter of year  $y$  is in the average prices of year  $y-1$ . In equation 6.30, when deriving a volume index from the fourth quarter of year  $y$  to the first quarter of year  $y+1$ , it is in the average prices of year  $y$ . The quotient of these values is, of course, the one-quarter overlap link factor between year  $y$  and year  $y+1$ .
- 6.68. Equations 6.29 and 6.30 suggest a more efficient way of constructing a chain-linked volume index than sequentially applying annual link factors:
1. Derive a time series (i.e. a vector) of quarterly estimates in the average prices of the previous year (PPY) at the lowest level of compilation.
  2. Aggregate (1) to the desired level.
  3. Derive a time series of quarterly estimates such that the fourth quarter of one year to the third quarter of the following year are expressed in the average prices of the earlier year (PPY(-1)), i.e. the fourth quarter of the year 2000 to the third quarter of the year 2001 are in the average prices of the year 2000.
  4. Aggregate (3) to the desired level.

5. Divide the data from (2) by the data from (4) shifted forward a quarter to give quarter-on-quarter volume indices, i.e. for each year divide the first quarter to fourth quarter of year  $y$  in the average prices of year  $y-1$  by the fourth quarter of year  $y-1$  to the third quarter of year  $y$  in the average prices of year  $y-1$ .
6. Compound the quarter-on-quarter indices from (5) (setting the first quarter = 1) to form a quarterly chain-linked volume index.
7. Re-reference to the desired reference year.

Figure 6.5: Deriving quarter-on-quarter volume indices using the one-quarter overlap method

Step 5. The quarterly values for the first to fourth quarters for year  $y$  expressed in the average prices of year  $y-1$  are divided by quarterly values for the fourth quarter of year  $y-1$  to the third quarter of year  $y$  expressed in the same prices

|         |                              |     |     |            |                            |         |         |         |
|---------|------------------------------|-----|-----|------------|----------------------------|---------|---------|---------|
| PPY     | yQ1                          | yQ2 | yQ3 | yQ4        | (y+1)Q1                    | (y+1)Q2 | (y+1)Q3 | (y+1)Q4 |
|         |                              |     |     | Divided by |                            |         |         |         |
| PPY(-1) | (y-1)Q4                      | yQ1 | yQ2 | yQ3        | yQ4                        | (y+1)Q1 | (y+1)Q2 | (y+1)Q3 |
|         | in average year $y-1$ prices |     |     |            | in average year $y$ prices |         |         |         |

- 6.69. The derived quarterly chain-linked volume estimates should be benchmarked to the corresponding annual chain-linked volume estimates to ensure temporal consistency. This has implications for unlinking the resulting estimates. For while the benchmarked quarterly chain-linked volume estimates (derived using the one-quarter overlap method) differ from the corresponding quarterly chain-linked volume estimates derived using the annual overlap method, they are both temporally consistent with the annual chain-linked volume estimates. They therefore should be unlinked in the same way, by using equation 6.27.

**Example: UK final consumption expenditure**

- 6.70. In this example the methods described above are used to derive annual and quarterly chain Laspeyres volume estimates of the UK's total final consumption expenditure from current price and chain-linked volume estimates of household, NPISH and general government final consumption expenditure. Annual data for the years 2006 to 2010 and quarterly seasonally adjusted data for 2008 to 2010 are presented in Table 6.2a. The implicit price deflators (IPDs) are also shown in the table. Note that in practice, the chain-linked volume estimates of total final consumption expenditure should not be derived by aggregating such major aggregates, but rather by aggregating the most detailed components available.

*Deriving annual chain-linked volume estimates*

- 6.71. The following steps are taken to derive annual chain-linked volume estimates of total final consumption expenditure (refer to Table 6.2b):

- a. Derive estimates of each component in the average prices of the previous year (PPY)

$$X_{PPY}^y = X_{CV}^y \times P_X^{y-1}$$

Table 6.2a: Annual and quarterly seasonally adjusted current price and chain-linked volume estimates (reference year 2008)

**UK final consumption expenditure (£million)**

|      | Households     |                      |          | NPISH          |                      |          | General government |                      |          |
|------|----------------|----------------------|----------|----------------|----------------------|----------|--------------------|----------------------|----------|
|      | Current prices | Chain-linked volumes | IPD      | Current prices | Chain-linked volumes | IPD      | Current prices     | Chain-linked volumes | IPD      |
| 2006 | 819164         | 867082               | 0.944736 | 32408          | 36421                | 0.889816 | 285126             | 308668               | 0.923730 |
| 2007 | 862242         | 890872               | 0.967863 | 34324          | 36582                | 0.938276 | 295154             | 310551               | 0.950420 |
| 2008 | 878024         | 878024               | 1.000000 | 35767          | 35767                | 1.000000 | 315566             | 315566               | 1.000000 |
| 2009 | 858242         | 846961               | 1.013319 | 35863          | 34487                | 1.039899 | 327349             | 315381               | 1.037948 |
| 2010 | 904497         | 857428               | 1.054896 | 37548          | 34925                | 1.075104 | 337364             | 320054               | 1.054085 |
| 08Q1 | 220318         | 223457               | 0.985953 | 8874           | 9161                 | 0.968672 | 77624              | 78544                | 0.988287 |
| 08Q2 | 220232         | 221557               | 0.994020 | 8996           | 8994                 | 1.000222 | 78808              | 78587                | 1.002812 |
| 08Q3 | 220936         | 218879               | 1.009398 | 9009           | 8921                 | 1.009864 | 78120              | 78831                | 0.990981 |
| 08Q4 | 216538         | 214131               | 1.011241 | 8888           | 8691                 | 1.022667 | 81014              | 79604                | 1.017713 |
| 09Q1 | 213694         | 211969               | 1.008138 | 8804           | 8599                 | 1.023840 | 80670              | 78791                | 1.023848 |
| 09Q2 | 212196         | 210586               | 1.007645 | 8961           | 8605                 | 1.041371 | 81091              | 78313                | 1.035473 |
| 09Q3 | 214290         | 211158               | 1.014832 | 8999           | 8628                 | 1.043000 | 82742              | 78901                | 1.048681 |
| 09Q4 | 218062         | 213248               | 1.022575 | 9099           | 8655                 | 1.051300 | 82846              | 79376                | 1.043716 |
| 10Q1 | 221569         | 213326               | 1.038640 | 9038           | 8482                 | 1.065551 | 83924              | 79714                | 1.052814 |
| 10Q2 | 226345         | 214918               | 1.053169 | 9360           | 8730                 | 1.072165 | 84456              | 80245                | 1.052477 |
| 10Q3 | 227781         | 214937               | 1.059757 | 9505           | 8823                 | 1.077298 | 84109              | 80077                | 1.050352 |
| 10Q4 | 228802         | 214247               | 1.067936 | 9645           | 8890                 | 1.084927 | 84875              | 80018                | 1.060699 |

For example,  $X_{PPY}^{2007}$  for household final consumption expenditure (in 2007)  
 $= 890872 \times 0.944736 = 841639$

- b. Obtain estimates in the prices of the previous year for total final consumption expenditure by summing the PPYs of each component.
- c. Derive year-to-year Laspeyres volume indices for total final consumption expenditure

$$L_Q^y = \frac{X_{PPY}^y}{X_{CP}^{y-1}}$$

For example, the Laspeyres volume index for total final consumption expenditure from 2006 to 2007 =  $\frac{1161056}{1136698} = 1.021429$

- d. Derive chain-linked volume estimates referenced to the current price value in 2008

$$X_{CV}^y = L_Q^y \times X_{CV}^{y-1}, \text{ where } X_{CV}^{2008} = X_{CP}^{2008}$$

For example, the chain-linked volume estimate for 2009 =  $0.973541 \times 1229357 = 1196829$  and the chain-linked volume estimate for 2007 =  $\frac{1}{0.992923} \times 1229357 = 1238119$ . Note that when going back in time (i.e. from the reference year 2008 to 2007) the annual index is inverted.

Table 6.2b: Deriving annual chain-linked volume estimates for total final consumption expenditure

| UK final consumption expenditure (£million) |                |        |                |       |                    |        |                |         |                |                      |         |          |
|---|----------------|--------|----------------|-------|--------------------|--------|----------------|---------|----------------|----------------------|---------|----------|
|   | Households     |        | NPISH          |       | General government |        | Total          |         |                |                      |         |          |
|   | Current prices | PPY    | Current prices | PPY   | Current prices     | PPY    | Current prices | PPY     | Annual indices | Chain-linked volumes | IPD     |          |
| 2006  | 819164         |        | 32408          |       | 285126             |        | 1136698        |         |                |                      | 1212144 | 0.937758 |
| 2007  | 862242         | 841639 | 34324          | 32551 | 295154             | 286865 | 1191720        | 1161056 | 1.021429       | 1238119              |         | 0.962525 |
| 2008  | 878024         | 849807 | 35767          | 33559 | 315566             | 299920 | 1229357        | 1183287 | 0.992923       | 1229357              |         | 1.000000 |
| 2009  | 858242         | 846961 | 35863          | 34487 | 327349             | 315381 | 1221454        | 1196829 | 0.973541       | 1196829              |         | 1.020575 |
| 2010  | 904497         | 868848 | 37548          | 36318 | 337364             | 332199 | 1279409        | 1237366 | 1.013027       | 1212420              |         | 1.055252 |

*Deriving quarterly chain-linked volume estimates – annual overlap method*

6.72. Deriving quarterly chain-linked volume estimates using the annual overlap method is quite simple (refer to Table 6.2c):

- a. Derive quarterly estimates in the average prices of the previous year for each component:

$$X_{PPY}^{c,y} = X_{CV}^{c,y} \times P_X^{y-1}$$

- b. Obtain estimates in the average prices of the previous year for total final consumption expenditure by summing the PPYs of each component.

- c. Divide the quarterly estimates of total final consumption expenditure in the prices of the previous year by the annual implicit price deflator of the previous year:

$$X_{CV}^{c,y} = \frac{X_{PPY}^{c,y}}{P_X^{y-1}}$$

Table 6.2c: Deriving quarterly chain-linked volume estimates for total final consumption expenditure: Annual overlap method

| UK final consumption expenditure (£million) |  |       |       |        |                                |   |
|---|--|-------|-------|--------|--------------------------------|---|
|   | Final consumption expenditure in the average prices of the previous year (PPY) |       |       |        | IPDs of total in previous year | Chain-linked volumes total referenced to 2008 CPV |
|   | Households   | NPISH | GG    | Total  |                                |   |
| 08Q1  | 216276   | 8596  | 74650 | 299521 | 0.962525                       | 311183  |
| 08Q2  | 214437   | 8439  | 74691 | 297566 | 0.962525                       | 309152  |
| 08Q3  | 211845   | 8370  | 74923 | 295138 | 0.962525                       | 306629  |
| 08Q4  | 207249   | 8155  | 75657 | 291061 | 0.962525                       | 302394  |
| 09Q1  | 211969   | 8599  | 78791 | 299359 | 1.000000                       | 299359  |
| 09Q2  | 210586   | 8605  | 78313 | 297504 | 1.000000                       | 297504  |
| 09Q3  | 211158   | 8628  | 78901 | 298687 | 1.000000                       | 298687  |
| 09Q4  | 213248   | 8655  | 79376 | 301279 | 1.000000                       | 301279  |
| 10Q1  | 216167   | 8820  | 82739 | 307727 | 1.020575                       | 301523  |
| 10Q2  | 217781   | 9078  | 83290 | 310149 | 1.020575                       | 303896  |
| 10Q3  | 217800   | 9175  | 83116 | 310091 | 1.020575                       | 303839  |
| 10Q4  | 217101   | 9245  | 83055 | 309400 | 1.020575                       | 303162  |

*Deriving quarterly chain-linked volume estimates – one-quarter overlap method*

6.73. Having derived estimates of total final consumption expenditure in the average prices of the previous year in Table 6.2c, the next step is to derive estimates in the average prices of the previous year offset one quarter (i.e. the fourth quarter of year  $y-1$  and the first, second and third quarters of year  $y$  are derived in the average prices of year  $y-1$ ) and lagged one quarter (refer to Table 6.2d):

a. Derive quarterly estimates in the average prices of the previous year for each component

$$X_{PPY}^{c,y} = X_{CV}^{c,y} \times P_X^{y-1}, c = 1, 2 \text{ and } 3, \text{ and}$$

$$X_{PPY}^{4,y-1} = X_{CV}^{4,y-1} \times P_X^{y-1}, c=4$$

b. Obtain estimates in the average prices of the previous year offset a quarter and lagged one quarter (PPY(-1)) for total final consumption expenditure by summing the PPY(-1)s of each component.

c. Divide the quarterly estimates of total final consumption expenditure in the prices of the previous year (PPYs) by the estimates in the average prices of the previous year offset a quarter and lagged one quarter (PPY(-1)s) to obtain quarter-on-quarter Laspeyres-type volume indices:

$$L_Q^{c,y} = \frac{X_{PPY}^{c,y}}{X_{PPY(-1)}^{c,y}}$$

d. Derive chain-linked volume estimates referenced to 1 in the first quarter

$$X_{CV}^{c,y} = L_Q^{c,y} \times X_{CV}^{c-1,y} \text{ for quarters } 2, 3 \text{ and } 4, \text{ and}$$

$$X_{CV}^{1,y} = L_Q^{1,y} \times X_{CV}^{4,y-1} \text{ for quarter } 1$$

e. Re-reference the chain-linked volume index to the current price value in the reference year, which is 2008 in this case.

f. The final step, not done here, is to benchmark the quarterly chain-linked volume estimates to their annual counterparts.

6.74. It can be seen that the approach used here to derive quarterly chain-linked volume estimates using the one-quarter overlap method is very much like the method described above to derive annual chain-linked volume estimates.

6.75. As to be expected, the quarter-on-quarter growth rates of the chain-linked volume estimates derived using the annual and one-quarter overlap methods are exactly the same for all but the growth rate from the fourth quarter of one year to the first quarter of the next. In this example, the differences in the latter are quite small: for 08Q4 to 09Q1 the growth rates are -1.004% using the annual overlap method and -1.0141% using the one-quarter overlap method – a difference of about 0.01%. The corresponding growth rates a year later are 0.0809% and 0.0813%, and the difference is even smaller. Bigger differences can be expected in QNA variables that display greater volatility in volumes within a year and greater differences in average annual price growth.

Table 6.2d: Deriving quarterly chain-linked volume estimates for total final consumption expenditure: One-quarter overlap method

| UK final consumption expenditure (£million) |  |       |       |        |  |                            |                               |
|---|--|-------|-------|--------|--|----------------------------|-------------------------------|
|   | Final consumption expenditure in the average prices of the previous year lagged and offset one quarter (PPY(-1)) |       |       |        | Quarter-on-quarter volume indices, total (PPY/PPY(-1)) | Chain-linked volumes total |                               |
|   | Households   | NPISH | GG    | Total  |  | Indices referenced to 08Q1 | Values referenced to 2008 CPV |
| 08Q1  |  |       |       |        |  | 1.000000                   | 311183                        |
| 08Q2  | 216276   | 8596  | 74650 | 299521 | 0.993474   | 0.993474                   | 309152                        |
| 08Q3  | 214437   | 8439  | 74691 | 297566 | 0.991839   | 0.985366                   | 306629                        |
| 08Q4  | 211845   | 8370  | 74923 | 295138 | 0.986188   | 0.971755                   | 302394                        |
| 09Q1  | 214131   | 8691  | 79604 | 302426 | 0.989859   | 0.961901                   | 299327                        |
| 09Q2  | 211969   | 8599  | 78791 | 299359 | 0.993803   | 0.955940                   | 297472                        |
| 09Q3  | 210586   | 8605  | 78313 | 297504 | 1.003976   | 0.959741                   | 298655                        |
| 09Q4  | 211158   | 8628  | 78901 | 298687 | 1.008678   | 0.968070                   | 301247                        |
| 10Q1  | 216088   | 9000  | 82388 | 307477 | 1.000813   | 0.968857                   | 301492                        |
| 10Q2  | 216167   | 8820  | 82739 | 307727 | 1.007871   | 0.976483                   | 303865                        |
| 10Q3  | 217781   | 9078  | 83290 | 310149 | 0.999812   | 0.976299                   | 303808                        |
| 10Q4  | 217800   | 9175  | 83116 | 310091 | 0.997772   | 0.974125                   | 303131                        |

### Deriving chain-linked volume indices of time series that are not strictly positive

- 6.76. Some QNA variables can take positive, negative or zero values, and so it is not possible to derive chain-linked volume estimates for them. The best known example is changes in inventories, but any variable which is a net measure is susceptible. For example, gross fixed capital formation (GFCF) is defined to be the acquisition *less* disposal of fixed assets; if disposals exceed acquisitions in a period, then negative GFCF is recorded. In some countries there has been a spate of privatisations of public enterprises and the sale of assets by public enterprises to private enterprises over the last twenty years. Privatisations result in the sold enterprise being re-classified from the public sector to the private sector and the only impact on GFCF is that future capital formation by the enterprise is recorded in the private sector. Asset sales, however, are recorded as disposals and if they are large enough they can result in negative GFCF for public enterprises in the periods in which they are sold. Although strictly speaking not a national accounts aggregate, net exports (i.e. exports *less* imports) is commonly derived and is obviously not strictly positive in concept.
- 6.77. While it is not possible to derive true chain-linked volume estimates for variables that can change sign or take zero values, it is possible to derive pseudo chain-linked volume estimates. The most commonly used approach<sup>(23)</sup> is to:
- identify two strictly positive series that when differenced yield the target series;
  - derive chain-linked volume estimates of these two series expressed in currency units;
  - difference the two chain-linked volume series.
- 6.78. Exactly the same approach can be used to derive seasonally adjusted pseudo chain-linked volume estimates except that after step (b) the two series are seasonally adjusted before proceeding to step (c).

<sup>(23)</sup> See §15.62 of the 2008 SNA.

- 6.79. There are two cases to consider: one where the strictly positive series are flow series and one where they are stock series.

### *Strictly positive flow series*

- 6.80. The obvious candidates for the two strictly positive series for GFCF are acquisitions and disposals. If they are unavailable, then one solution is to make an educated guess of either acquisitions or disposals and then derive the other as a residual.
- 6.81. The two strictly positive series are linked and referenced just like any other flow series. If the annual or quarterly estimates of their difference (i.e. the target series) are subject to adjustment in the balancing process, then corresponding adjustments need to be made to the two strictly positive series.

### *Strictly positive stock series (inventories)*

- 6.82. In the case of changes in inventories, the obvious candidates for the two strictly positive series are the opening and closing inventory levels. The chain-linked volume index of opening inventories should be referenced to the opening value in the reference year expressed in the average prices of the reference year. Likewise, the chain-linked volume index of closing inventories should be referenced to the closing value of inventories expressed in the average prices of the reference year. This will ensure that the value of the pseudo chain-linked volume measure of changes in inventories is equal to the current price value in the reference year if the current price value has been derived as described in Chapter 2.
- 6.83. Seasonally adjusted current price estimates of changes in inventories can be obtained by inflating the pseudo chain-linked volume estimates by a suitable price index centred on the middle of each quarter and with the same reference year as the volume estimates.
- 6.84. It is evident that the processes just described are conditional on the inventory levels being consistent with the current price estimates of changes in inventories. This means that if any adjustments are made to changes in inventories in the balancing process, then corresponding adjustments also need to be made to the opening and closing inventory levels (see Chapter 2).

### *Availability of base year data*

- 6.85. The requirements to derive estimates for a quarter in the prices of the previous year are volume indices from the base year to the quarter and price (or current price) data for the base year— see formula 6.14. These requirements are always met for the final expenditure components of GDP(E), but the price data may not be available for the gross value added by industry components of GDP(P). This is likely to be the case if quarterly current price estimates of gross value added are not derived and the quarterly volume estimates of gross value added are derived, in the main, by extrapolation using volume indicators of output. In such cases, the timing of the introduction of a new base year may need to coincide with the introduction of new annual estimates, including first estimates of gross value added for the new base year.
- 6.86. The timing and consequences of this approach is best explained using an example. Suppose in country A new annual estimates and a new base year are introduced with the release of data for the second quarter each year. Further suppose the current year is year  $y$  and the new annual estimates are in respect of year  $y-2$ , then country A may choose to make the year  $y-2$  the new base year. This means that (prior to linking) the volume estimates for the four quarters in year  $y-1$  and the first two quarters of year  $y$  are now derived in the average prices of year  $y-2$ . By contrast, in the preceding release (i.e. that for the first quarter of year  $y$ ) the volume estimates for the four quarters of year  $y-1$  and the first quarter of year  $y$  were derived in the average prices of year  $y-3$ . The change of base year, from year  $y-3$  to year  $y-2$ , is likely to change the



growth rates of the five quarters concerned. For the majority of national accounts statistics, price and volume relativities do not change very much between one year and the next, and so in most cases the revisions to growth rates are small.

### **Seasonal and calendar adjustment**

- 6.87. Chapter 7 of the handbook addresses the seasonal and calendar adjustment of both current price and volume data. In general, volume estimates should be seasonally adjusted in the same way as their current price counterparts. The major exceptions relate to non-market output where different methods and different data have been used to derive the current price and volume estimates. In the case of changes in inventories, seasonally adjusted current price estimates are usually derived from the seasonally adjusted volume estimates.
- 6.88. An important issue addressed in Chapter 7 is whether the sum of the seasonally adjusted (and unadjusted) quarterly data should be the same as the annual totals. For practical reasons this is generally required when compiling chain-linked volume indices in a supply and use framework.

### **Contributions to growth**

- 6.89. In the dissemination of QNA, contributions to growth play a prominent role – a role that has become more important with the loss of additivity that has accompanied the introduction of chain-linked volume estimates. While the chain-linked volume estimates of the components of an aggregate do not generally add up to the chain-linked volume estimate of the aggregate, it is possible to calculate the contributions of each component to the growth rate of the aggregate that are additive.
- 6.90. Deriving contributions to growth from additive data, such as constant price estimates, is straightforward. Unsurprisingly, deriving the contributions to growth of quarterly chain-linked volume estimates is more complex and, unlike constant price estimates, there is no one formula that can be applied in all cases. Rather, the methods that can be used depend on how the chain-linked volume estimates have been derived:
- the index formula used (e.g. Laspeyres or Fisher);
  - annual or quarterly base years;
  - method of linking in the case of annual base years;
  - the period over which the contributions to growth are calculated (e.g. quarter-on-quarter or quarter on same quarter of previous year);
  - special features of a component (e.g. changes in inventories).
- 6.91. This section presents an overview of different approaches to compute the contributions to growth of quarterly chain-linked volume estimates derived using the Laspeyres formula with annual base years and linked using either the annual or one-quarter overlap methods. It begins by considering the different ways of deriving the contributions to growth of additive data. To make it easier to distinguish between an aggregate and its components in the formulae, the  $i^{\text{th}}$  component of an aggregate has a subscript  $i$ , and is denoted using the lower case, e.g. the current price value of the  $i^{\text{th}}$  component in quarter  $c$  of year  $y$  is  $x_{CP_i}^{c,y}$ .

### **The additive case**

- 6.92. In the case of additive volume measures, the formula for deriving the contribution of a component  $x_i$  to the change in an aggregate  $X$  from quarter  $c-1$  of year  $y$  to quarter  $c$  of year  $y$  is straightforward:

$$C(x_i, X)^{c,y} = \frac{(x_i^{c,y} - x_i^{c-1,y})}{X^{c-1,y}} = \frac{x_i^{c-1,y} (x_i^{c,y} - x_i^{c-1,y})}{X^{c-1,y} x_i^{y-1,y}} = \frac{X^{c,y} - X^{c-1,y}}{X^{c-1,y}} - \frac{(X^{c,y} - (x_i^{c,y} - x_i^{c-1,y})) - X^{c-1,y}}{X^{c-1,y}}$$

where  $X^{c,y} = \sum_{i=1}^n x_i^{c,y}$  and there are  $n$  components (6.31)

- 6.93. This additive contribution can be expressed in three ways:
- The quotient of the change in the component to the value of the aggregate in the earlier quarter.
  - The growth rate of the component weighted by its share in the aggregate in the previous quarter <sup>(24)</sup>.
  - The contributions to growth are derived as partial contributions. The basic idea can be illustrated with an example: the contribution to GDP growth made by net exports can be expressed as the difference between GDP growth and the growth in GDP if net exports had not changed between the two quarters. If GDP grew by 1% and GDP with net exports not changing grew by 0.6%, then it can be deduced that net exports contributed 0.4 percentage points to GDP growth.
- 6.94. The first way decomposes the increase in the aggregate as the sum of its components' proportional increases, whereas the second one expresses the increase in the aggregate as the weighted average of its components' growth rates. The third one gives a direct interpretation of the contributions to growth as partial contributions. The equivalence between all the approaches is due to the additivity of the volume estimates.

### *Non-additive case*

- 6.95. Chain-linked volume indices are not generally additive and the above formulae do not yield satisfactory results when applied to chain-linked volume estimates when this is the case. A number of methods have been proposed to overcome this problem and, following the three expressions of the additive contribution formula, one can classify the different methods into three broad categories:
- the first transforms chain-linked volume estimates into additive measures to compute the contributions, and corresponds to (a);
  - the second uses weighting systems to weight the components' growth rates, and corresponds to (b);
  - the third is based on the partial contribution concept, and corresponds (c).
- 6.96. At this point the notion of additivity for contributions to growth must be properly defined. A contribution formula is additive if the sum of the contributions from two or more separate components to an aggregate equals the contribution of their sum to the aggregate (e.g. the contribution from household final consumption expenditure to GDP growth equals the sum of the contributions of household final consumption expenditure on goods and household final consumption expenditure on services to GDP). In particular, for any decomposition of an aggregate the sum of the contributions from all its components equals the aggregate's growth rate.

### *Additive Volume Data (AVD) Method*

- 6.97. This method exploits the additivity of chain Laspeyres-type volume estimates in the year following the reference year. This phenomenon arises because the chain-linked volume estimates in this year are in the average prices of the previous year.

<sup>(24)</sup> Note that the sum of the weights over the components of an aggregate is unity, given the additivity of the measure.

$$\text{Contrib.AVD}(x_i, X)^{c,y} = \frac{P_{x_i}^{y-1} (x_{CVi}^{c,y} - x_{CVi}^{c-1,y})}{P_X^{y-1} X_{CV}^{c-1,y}} \quad (6.32)$$

- 6.98. The quotient on the right-hand side of formula 6.32 is of the same form as the first equation in 6.31. To this, formula 6.27 is applied to the numerator and denominator to transform the chain-linked volume estimates of the components (numerator) and the aggregate (denominator) to obtain estimates in the prices of the previous year.

*Annual overlap method*

- 6.99. When the annual overlap method is used, formula 6.32 is exact for within-year, quarter-on-quarter growth rates. But the quarterly growth rate of the aggregate from the fourth quarter of one year to the first quarter of the following year is affected by the linking, and so the contributions to growth of the components using formula 6.32 do not sum exactly to the growth rate of the aggregate, although the difference is usually small. The discrepancy can be completely eliminated by adding an extra term to formula 6.32, which, it must be stressed, is only needed when calculating contributions to growth over the link period:

$$+ \left( \frac{x_{CVi}^{4,y-1}}{X_{CV}^{4,y-1}} - \frac{x_{CVi}^{y-1}}{X_{CV}^{y-1}} \right) \cdot \left( \frac{P_{x_i}^{y-1}}{P_X^{y-1}} - \frac{P_{x_i}^{y-2}}{P_X^{y-2}} \right), \quad (6.33)$$

- 6.100. Table 6.2e presents contributions to growth for the three components of UK final consumption expenditure in which the annual overlap method has been used to derive the chain-linked volume estimates of total final consumption expenditure. Columns 1, 3 and 5 show the contributions to growth of the three components using formula 6.32. Their sum is shown in column 7: the values are exactly the same as the growth rates of the chain-linked volume estimates of total final consumption expenditure (column 9), except for fourth quarter to first quarter growth rates, where they are slightly different. In this example, the biggest difference occurs in respect of the growth from the fourth quarter of 2008 to the first quarter of 2009, when it is about 0.01%.

- 6.101. Columns 2, 4 and 6 show the contributions to growth of the three components calculated using formula 6.32 augmented with formula 6.33. Their sum is shown in column 8, and the values are exactly the same as those in column 9.

- 6.102. The AVD method can also be used to derive contributions to growth over the year (i.e. growth to a quarter from the same quarter of the previous year). As noted earlier, when deriving contributions to quarter-on-quarter growth, the AVD method exploits the fact that chain Laspeyres-type volume estimates are additive in the year following the reference year. In the reference year itself, the sum of the components over the four quarters are additively consistent with the chain-linked volume estimate of the aggregate by construction. While they are not generally additive<sup>(25)</sup> for each quarter, the discrepancies are usually minor. Also, the quarters on either side of the link boundary are being compared. Therefore, the contributions to growth of the components are unlikely to sum exactly to the growth rate of the aggregate when formula 6.34 – the over-the-year version of formula 6.32 - is used.

$$\text{Contrib.AVD}(x_i, X)^{c,y-1 \rightarrow c,y} = \frac{P_{x_i}^{y-1} (x_{CVi}^{c,y} - x_{CVi}^{c,y-1})}{P_X^{y-1} X_{CV}^{c,y-1}} \quad (6.34)$$

If the contributions to growth using formula 6.34 are insufficiently accurate, then an extra term 6.35 – the over-the-year version of 6.33 - may be used to calculate contributions to growth that are exactly additive.

<sup>(25)</sup> This is because the values in year y-1 are derived in the average prices of year y-2. After referencing to year y-1 they are non-additive to the extent that price and volume relativities have changed between year y-2 and year y-1.

$$+ \left( \frac{x_{CV_i}^{c,y-1}}{X_{CV}^{c,y-1}} - \frac{x_{CV_i}^{y-1}}{X_{CV}^{y-1}} \right) \cdot \left( \frac{P_{x_i}^{y-1}}{P_X^{y-1}} - \frac{P_{x_i}^{y-2}}{P_X^{y-2}} \right) \quad (6.35)$$

Table 6.2e: Contributions to quarterly growth: AVD method

**Chain-linked volume estimates derived using the annual overlap method  
UK final consumption expenditure**

|      | Contributions to growth – percentage points |        |        |        |        |        |        |        | Quarterly growth rate of total (%) |
|------|---|--------|--------|--------|--------|--------|--------|--------|------------------------------------|
|      | Households                                  |        | NPISH  |        | GG     |        | Total  |        |                                    |
|      |   | Aug.   |        | Aug.   |        | Aug.   |        | Aug.   |                                    |
|      | (1)   | (2)    | (3)    | (4)    | (5)    | (6)    | (7)    | (8)    | (9)                                |
| 08Q1 | -0.534                                      | -0.534 | -0.012 | -0.012 | 0.432  | 0.431  | -0.114 | -0.115 | -0.115                             |
| 08Q2 | -0.614                                      |        | -0.052 |        | 0.014  |        | -0.653 |        | -0.653                             |
| 08Q3 | -0.871                                      |        | -0.023 |        | 0.078  |        | -0.816 |        | -0.816                             |
| 08Q4 | -1.557                                      |        | -0.073 |        | 0.249  |        | -1.381 |        | -1.381                             |
| 09Q1 | -0.715                                      | -0.712 | -0.030 | -0.031 | -0.269 | -0.261 | -1.014 | -1.004 | -1.004                             |
| 09Q2 | -0.462                                      |        | 0.002  |        | -0.160 |        | -0.620 |        | -0.620                             |
| 09Q3 | 0.192                                       |        | 0.008  |        | 0.198  |        | 0.398  |        | 0.398                              |
| 09Q4 | 0.700                                       |        | 0.009  |        | 0.159  |        | 0.868  |        | 0.868                              |
| 10Q1 | 0.026                                       | 0.026  | -0.059 | -0.059 | 0.114  | 0.114  | 0.081  | 0.081  | 0.081                              |
| 10Q2 | 0.524                                       |        | 0.084  |        | 0.179  |        | 0.787  |        | 0.787                              |
| 10Q3 | 0.006                                       |        | 0.031  |        | -0.056 |        | -0.019 |        | -0.019                             |
| 10Q4 | -0.225                                      |        | 0.022  |        | -0.020 |        | -0.223 |        | -0.223                             |

*One-quarter overlap method*

6.103. Formula 6.27 only strictly applies when chain-linked volume estimates are derived using the annual overlap method. Nevertheless, when chain-linked volume estimates derived using the one-quarter overlap method are multiplied by the implicit price deflator of the previous year it is generally the case that the resulting values closely approximate the true values of estimates in the prices of the previous year. Hence, formula 6.32 generally provides estimates of contributions to growth that are very nearly additive. As linking using the one-quarter overlap method does not affect the growth rate from the fourth quarter of one year to the first quarter of the next, there is no particular problem for deriving contributions to growth over this period. If no transformations have been made to the chain-linked volume estimates subsequent to linking, then exact contributions to growth can be derived by simply using the estimates in the average prices of the previous year that were used to derive the chain-linked volume estimates in formula 6.31.

6.104. Table 6.2f presents contributions to growth for the three components of UK final consumption expenditure in which the one-quarter overlap method has been used to derive the chain-linked volume estimates of total final consumption expenditure, but prior to benchmarking to the annual chain-linked volume estimates. Columns 1, 2 and 3 show the contributions to growth of the three components using formula 6.32. Their sum is shown in column 4: the values are the same as the quarterly growth rates of the aggregate to at least three decimal places.

6.105. Elsewhere in this handbook (chapters 5, 7 and 8) it is recommended that quarterly current price and chain-linked volume estimates should be temporally consistent with their corresponding annual estimates. Also, earlier in this chapter it is recommended that if the one-quarter overlap method is used then the resulting quarterly chain-linked volume estimates should be benchmarked to the annual chain-linked

volume estimates. Benchmarking QNA variables individually, however, generally leads to a loss of additivity between them, i.e. variables that were additive when expressed in the prices of the previous year are no longer so after they have been chain-linked, benchmarked and then unlinked. This phenomenon arises because when QNA variables are independently benchmarked <sup>(26)</sup> to their annual counterparts the adjustments made to the quarterly estimates of the components are unlikely to be exactly consistent with the adjustments made to the aggregate. The upshot is that if formula 6.32 is used to calculate the contributions to quarter-on-quarter growth of chain-linked volume estimates derived using the one-quarter overlap method, the discrepancies between the sum of the contributions to growth made by each component and the quarterly growth rate of the aggregate are likely to be greater after benchmarking. Nevertheless, they can usually be expected to be sufficiently close to being additive for practical purposes.

6.106. Contributions to growth over the year, that are approximately additive, can be derived using formula 6.34.

Table 6.2f: Contributions to quarterly growth: AVD method

**Chain-linked volume estimates (unbenchmarked) derived using the one-quarter overlap method**

**UK final consumption expenditure**

|      | Contributions to growth – percentage points |        |        |        | Quarterly growth rate of total (%) |
|------|---|--------|--------|--------|------------------------------------|
|      | Households                                  | NPISH  | GG     | Total  |                                    |
|      | (1)   | (2)    | (3)    | (4)    | (5)                                |
| 08Q1 | -0.534                                      | -0.012 | 0.432  | -0.114 | -0.114                             |
| 08Q2 | -0.614                                      | -0.052 | 0.014  | -0.653 | -0.653                             |
| 08Q3 | -0.871                                      | -0.023 | 0.078  | -0.816 | -0.816                             |
| 08Q4 | -1.557                                      | -0.073 | 0.249  | -1.381 | -1.381                             |
| 09Q1 | -0.715                                      | -0.030 | -0.269 | -1.014 | -1.014                             |
| 09Q2 | -0.462                                      | 0.002  | -0.160 | -0.620 | -0.620                             |
| 09Q3 | 0.192                                       | 0.008  | 0.198  | 0.398  | 0.398                              |
| 09Q4 | 0.700                                       | 0.009  | 0.159  | 0.868  | 0.868                              |
| 10Q1 | 0.026                                       | -0.059 | 0.114  | 0.081  | 0.081                              |
| 10Q2 | 0.524                                       | 0.084  | 0.179  | 0.787  | 0.787                              |
| 10Q3 | 0.006                                       | 0.031  | -0.056 | -0.019 | -0.019                             |
| 10Q4 | -0.225                                      | 0.022  | -0.020 | -0.223 | -0.223                             |

**Weighted Growth Rates (WGR) Method**

6.107. For additive volume data, approach (b) in §6.92 uses volume data in the previous quarter to form the weights. In the WGR approach for non-additive data, the weights are derived from additive current price data. Two alternatives are presented below: one using the previous year's current price values and one use the previous quarter's current price values.

*Annual weighting system*

In this approach, the contribution from a component to an aggregate is expressed as:

$$\text{Contrib.WGR}^Y(x_i, X)^{c,y} = \frac{x_{CPI}^{y-1} (x_{CVi}^{c,y} - x_{CVi}^{c-1,y})}{X_{CP}^{y-1} x_{CVi}^{c-1,y}} \quad (6.36)$$

<sup>(26)</sup> Multivariate benchmarking that overcomes this problem is discussed in Chapter 8.

The weighting system is based on the previous year's current price values.

*Quarterly weighting system*

In this alternative approach, the weighting system is based on the previous quarter's current price values.

$$Contrib.WGR^Q(x_i, X)^{y,c} = \frac{x_{CPi}^{c-1,y} (x_{CVi}^{c,y} - x_{CVi}^{c-1,y})}{X_{CP}^{c-1,y} x_{CVi}^{c-1,y}} \quad (6.37)$$

6.108. The WGR approach has the attractions of simplicity of use, is easy to understand and is independent of the quarterly linking method. However, the resulting estimates of contributions to growth are not exactly additive.

***Partial Contributions to Growth (PCG) Method***

6.109. In the PCG approach (approach (c) in §6.92), the contribution to GDP growth of a component is calculated as the difference between GDP growth and the growth obtained assuming that the component has not changed. This approach can be applied to any chain-linked volume indices, including Fisher indices. However, instead of using simple sums and differences the rules for aggregating and disaggregating chained indices have to be applied. This is done in Germany based on an Excel macro that is available free of charge from the Deutsche Bundesbank.

6.110. This approach ensures additive contributions for quarter-on-quarter growth rates within a year, but not across the link boundary unless the one-quarter overlap method is used.

***Relationships between the different methods***

6.111. The following relations hold for contributions to quarter-on-quarter growth within a year y:

$$Contrib.AVD(x_i, X) = \frac{\left( \frac{P_{x_i}^y}{P_X^{y-1}} \right)}{\left( \frac{P_{x_i}^{c-1,y}}{P_X^{c-1,y}} \right)} Contrib.WGR^Q(x_i, X)^{c,y} = \frac{\left( \frac{x_{CVi}^{c-1,y}}{X_{CV}^{c-1,y}} \right)}{\left( \frac{x_{CVi}^{y-1}}{X_{CV}^{y-1}} \right)} Contrib.WGR^A(x_i, X)^{y,c}$$

This shows that the weighted growth rates approach can be adjusted to give the same results as the additive volume data method.

***Choice of method***

6.112. All of the methods described above provide similar results, but the additive volume data method is the one recommended here. It has the following advantages:

- a. it produces quarter-on-quarter contributions to growth that are likely to come closest to being perfectly additive for all four quarters;

- b. in its basic form (formula 6.32), it is simple to apply and simple to understand. The augmentation for the annual overlap method (6.33) is not so easy to understand, but it ensures exact additivity for the growth between the fourth quarter of one year and the first quarter of the next;
- c. it provides the means to derive contributions to growth for quarter-on-same-quarter of previous year;
- d. it supports both the one-quarter and annual overlap methods.

6.113. The AVD method should not be applied directly to those QNA variables that can take positive and negative values, such as changes in inventories and a statistical discrepancy. The contributions to growth of such variables can be derived residually by taking advantage of the fact that contributions to growth are exactly additive, or almost additive, using this method. For example, the contribution to growth in GDP of changes in inventories can be derived as the difference between the contribution of gross capital formation and the contribution of gross fixed capital formation.

## Issues concerning volume estimation at the elemental level

### *Conceptual and definitional issues*

- 6.114. In Chapter 2, §2.13-2.32, some general issues concerning the recording of QNA data are discussed:
- a. time of recording;
  - b. consistency in recording and work-in-progress;
  - c. the meaningfulness of the quarterly data.

It is just as important to adhere to these strictures in volume terms as it is in current prices.

- 6.115. Volume estimates should be derived on an accrual basis and should be recorded consistently throughout the accounts. Where volume estimates are derived by deflation, provided the current price data are on an accrual basis, the only issue is whether the price indices used for deflation are consistent in terms of timing, valuation and scope with the current price estimates being deflated (see §15.107-15.109 of the 2008 SNA). However, where the volume estimates are based on direct quantity measurement or obtained by extrapolation, it is essential to ensure that the proper accrual basis is observed.
- 6.116. Volume estimates should be meaningful. In other words, the quarterly data should be sensible in an economic sense. The same points relating to accruals (above) apply here.
- 6.117. An issue that does not apply to current price data but which concerns volume data is the measurement of non-market output (and consumption) and, in particular, whether these data should reflect the impact of productivity changes. This issue is addressed in §15.111-15.120 of the 2008 SNA.

### *Data issues*

- 6.118. This heading brings together the main issues related to the methods used for compiling certain quarterly components. As mentioned elsewhere in this handbook, where estimates are based on annual information, ideally, a broadly similar approach should also be adopted for the quarterly figures. However, for many components of the accounts the range of information which can be collected quarterly is much less than is available annually. This aspect pertains mainly to current price or actual quantity data. Price indices used for deflation are usually available on a monthly basis.
- 6.119. The reduction in the availability of quarterly information means that estimates are often derived by using either:

- a. the same broad method used for the annual figures, but with more aggregated and less accurate data; or
- b. a different method that is determined by the data available.

The main areas of concern are given below.

### *Value added*

- 6.120. Double deflation should be adopted for deriving annual volume estimates, preferably within a supply and use framework. For quarterly figures, however, in the absence of accurate data for both output and intermediate consumption, double deflation is not generally recommended unless it is applied in quarterly balanced supply and use tables. The principal alternative is to extrapolate value added in the base year at a detailed level by indicator series which are deemed to represent the volume movement of value added, such as a volume indicator of output. Such an approach may be adequate in the short-term, but requires that the figures are subsequently aligned with what should be firmer annual data, based on double deflation. This issue is discussed briefly in Chapter 2 (see §2.34-2.39) and in more detail in §15.123-15.132 of the 2008 SNA.

### *Changes in inventories*

- 6.121. The derivation of pseudo chain-linked volume estimates of changes in inventories is addressed above, in §6.81-6.83. Issues relating to deriving elemental volume estimates, current price estimates of changes in inventories and the inventory valuation adjustment are discussed in Chapter 2, §2.136-2.161.

### *Agriculture*

- 6.122. The problems encountered with measuring production and expenditure relating to agriculture at current prices (see Chapter 2, §2.54-2.72) apply equally to volume estimation. In brief, volume estimation needs to be considered in two separate parts. The first concerns activity, such as the production of milk and eggs, where output is largely produced and sold in the same quarter. The second, more problematical, issue relates to those parts of production that extend over a number of quarters, such as crop production.

### *Prices*

- 6.123. The main approach to volume estimation is by deflation of current price data. Thus the nature and quality of the available price statistics has a major bearing on the quality of the derived volume estimates. The paragraphs below set out the main issues of the role of prices in the deflation process. Some of these issues have been considered elsewhere in the handbook.

#### *Price index formulae*

- 6.124. Deflating an index derived from current price data with a Paasche price index yields a Laspeyres volume index and vice versa (see §6.22-6.23). Most price indices are compiled using the Laspeyres formula and so Paasche volume indices are obtained. Using the Laspeyres formula to aggregate these elemental volume estimates means that the resulting aggregates are a Laspeyres-Paasche hybrid. The more detailed level at which the current price values are deflated the more Laspeyres-like the volume estimates of aggregates will be.



*Consistency with current price data*

- 6.125. As noted above, the price indices used for deflation should be consistent in terms of timing, valuation and scope with the current price estimates being deflated. If price information is collected only quarterly, then, depending on where this point of time occurs in the quarter, some weighting of neighbouring price data may be necessary for deflation of a value relating to the whole quarter. For example, if prices are collected only for the end of the quarter, then the average of that price index and the price index for the end of the previous quarter may be the more appropriate figure for the quarterly deflation of flows. Whereas in the case of stock data, such as the opening and closing book values of inventories, then the indices should be timed to coincide with the valuation practices of the businesses recording the data (see Chapter 2, §2.141-2.152).
- 6.126. As far as possible the price indices used for deflation should be on the same valuation basis as the current price data, e.g. at basic prices for outputs and purchaser's prices for final and intermediate expenditures. If a price index with an inappropriate valuation has to be used, then the national accounts compiler has to ensure that suitable adjustments are made if an event occurs that invalidates the assumption that the price index is a suitable proxy. For instance, suppose a CPI is used to deflate the intermediate usage of a service. If there were a change in the VAT rate, then an adjustment would need to be made to the CPI-based deflator.
- 6.127. It is sometimes the case that the scope of a price index differs from the national accounts variable. It is also often the case that the weights used to form a Laspeyres price index from more elemental indices differ considerably from those implicit in the current price value to be deflated. This is particularly likely to be the case if the base year or weight period <sup>(27)</sup> for the Laspeyres price index is distant. It is therefore usually best to deflate current price values at the most detailed level practicable in order to ameliorate these problems. This, of course, also leads to the volume estimates being more Laspeyres-like.
- 6.128. When current price figures are only at quite an aggregate level, but more detailed prices are available for their components, it is preferable to attempt some disaggregation of the total and deflate with the separate price series, rather than deflating at the level of the total. A variation on this approach is to use a model to decompose the current price aggregate, deflate the components and then create a Paasche price index from the aggregate current price and volume data. For example, suppose gross fixed capital formation of equipment is only available at an aggregate level from a quarterly business survey. A product-flow model could be created, using information from the latest annual supply and use tables and current quarterly manufacturing and trade data, to produce estimates of GFCF of equipment by detailed category. These could be separately deflated, using the most appropriate price indices available, aggregated and then divided into the corresponding current price aggregate to derive a Paasche price index for GFCF of equipment.

*Consistency between expenditure and production deflators*

- 6.129. Deflation should be undertaken consistently both within and between the expenditure and production measures of GDP. For example, within the expenditure estimates, there should be consistency between imports and GFCF. Similarly, goods which are produced for export should be deflated consistently between output in the production measure and exports in the expenditure statistics. Within supply and use tables this can be achieved by transforming expenditures in the use table to basic prices and then using the same basic price indices (PPIs and IPIs) for the supply and use of the same product categories (see Chapter 9 of the *Eurostat Manual on Supply, Use and Input-Output Tables*).

<sup>(27)</sup> The weight period is the period to which the weights (derived from current price values) used to weight together elemental price indices relate. The weight period, the base period and the reference period can all be different.

### *Quality differences, price variation and price discrimination*

- 6.130. Seemingly identical products, produced and consumed at different times of the year, should be regarded as different products, with different prices series and separate deflation. See §15.64-15.76 of the 2008 SNA for further details. An example for agriculture (potatoes) is given in Chapter 2, §2.72.

### *Quality change*

- 6.131. Changes in volumes estimates must incorporate the effects of quality changes in goods and services. This allowance is more readily made through price data. The issue of allowance for quality changes is considered in §15.77-15.94 of the 2008 SNA and in the IMF's *Producer Price Index Manual* and *Consumer Price Index Manual*.

### **Summary of main points**

- 6.132. Deriving quarterly chain-linked volume estimates with annual weights using the Laspeyres formula is the recommended approach, as it has several practical, but not conceptual, advantages over the alternative Fisher formula. Only if there are indications of substantial drift should the Fisher formula be considered.
- 6.133. In order to derive quarterly chain Laspeyres-type volume estimates, estimates in the prices of the previous year need to be linked together. Either the annual overlap method or the one-quarter overlap method should be used to do the linking. If the latter is used then benchmarking the quarterly chain-linked volume estimates to their annual counterparts is essential.
- 6.134. There are various ways of estimating the contributions to growth of chain-linked volume estimates, but the additive volume data method (AVD) is the one recommended. It is easy apply, easy to understand, can be used in conjunction with either the annual or one-quarter lap methods and can be used to calculate contributions to growth for both quarter-on-quarter and quarter on same quarter of previous year.
- 6.135. The need to compile estimates on an accruals basis and with consistency throughout the accounts applies as much to volume estimates as it does to current price estimates. Most elemental volume estimates are derived by deflation, so the major issue is using price indices that match the timing, scope and valuation of the current price data being deflated. For a number of reasons it is generally best to deflate at the most detailed level practicable. Care should also be taken to ensure that volume estimates of production and expenditure are derived in a consistent manner.

## 7. Seasonal and calendar adjustment

The treatment of seasonal and calendar effects is a key consideration for QNA. This chapter introduces the underlying theory, the models and methods currently available for undertaking seasonal and calendar adjustment, and the various methodological considerations involved, such as the derivation of seasonally adjusted chain-linked volume estimates, their benchmarking to annual data and the question of whether to seasonally adjust major aggregates directly or indirectly. The issues of publishing trend-cycle estimates in addition to seasonally adjusted estimates and the publication of metadata are also addressed.

## Introduction

- 7.1. Due to the periodicity at which they are recorded, quarterly time series quite often show short-term movements that tend to repeat themselves in the same period (month or quarter) each year, and which are caused by the weather, habits, legislation, etc. These effects are usually defined as seasonal variations. In addition, there are calendar variations, such as Easter, that affect different periods in different years<sup>(28)</sup>.
- 7.2. Although seasonal and calendar variation is an integral part of quarterly data, it is generally considered an impediment to effective analysis of recent economic developments or the business cycle. Therefore, the derivation of series with the seasonal and calendar variations removed, and which are generally referred to simply as seasonally adjusted series, has become commonplace. Seasonally adjusted series are much more heavily used and much more prominently reported in the media than the unadjusted series<sup>(29)</sup>.
- 7.3. Seasonal adjustment of QNA should cover at least Table 1 of the ESA transmission programme. All series should be tested for the existence of seasonal and calendar variation and adjusted accordingly if they are present. Adjusted results should be produced for data in current prices, volumes and deflators by adjusting any two of these and deriving the third from the other two series after they have been seasonally adjusted and benchmarked. When the deflator is the derived one, care should be taken to prevent its path being affected by arbitrary differences in the separate adjustment of current price and volume data.
- 7.4. Seasonal adjustment is a complex process, which is comprehensively addressed in the Handbook on Seasonal Adjustment<sup>(30)</sup>. This chapter briefly discusses the causes and nature of seasonality, and gives a summary description of the most commonly used seasonal adjustment methods and their application. The chapter also addresses issues that are of special importance to the national accounts. Further guidelines specific to QNA are provided in the *Final Report of the Task Force on Seasonal Adjustment of QNA*<sup>(31)</sup>, which was endorsed by the European Committee on Monetary, Financial and Balance of Payments Statistics (CMFB) in 2008. Further, more general, guidelines on seasonal adjustment are provided in the 2009 edition of *ESS Guidelines on Seasonal Adjustment*<sup>(32)</sup>.

## Causes of seasonal variation<sup>(33)</sup>

- 7.5. There are at least four, not totally distinct, classes of causes of seasonal and calendar variation in economic data:

### A. Calendar

The timing of certain public holidays, such as Christmas and Easter, clearly affect the quarter-on-quarter, or month-on-month, movements of some time series, particularly those related to production and consumption. Also, the number and distribution of days in a month/quarter varies from one month/quarter to another and contributes to period-on-period variations.

<sup>(28)</sup> In accordance to the revised guidelines on seasonal adjustment non-seasonally adjusted data are typically referred to as "raw data" are referred or "unadjusted data", while "calendar adjusted data" is used for data where calendar effects are removed and "seasonally adjusted data" is used for data where both calendar effects (if significant) and seasonal effects are removed; see: <http://www.cros-portal.eu/content/guidelines-sa>.

<sup>(29)</sup> Hereafter, unadjusted data are referred to as "raw" data.

<sup>(30)</sup> Eurostat (2013).

<sup>(31)</sup> Eurostat (2008).

<sup>(32)</sup> Eurostat (2009).

<sup>(33)</sup> §7.05-7.08 are mainly derived from Granger C. W. J. (2001), *Essays in econometrics*, CUP New York, USA ©2001.

### *B. Timing decisions*

The timing of school vacations, the ending of university sessions, the payment of company dividends, the choice of the end of a tax-year or accounting period are all examples of decisions made by individuals or institutions that cause important seasonal effects, as these events are inclined to occur at similar times each year. They are generally deterministic, or pre-announced, and are decisions that produce very pronounced seasonal components in series such as employment rates. These timing decisions are generally not necessarily tied to any particular time in the year but by tradition have become so.

### *C. Weather*

Changes in temperature, rainfall and other weather variables have direct effects on various economic series, such as those concerned with agricultural production, construction and transportation, and consequent indirect effects on other series. It could be argued that these weather-related factors are the true seasonal effect, being a consequence of the annual movement of the earth's axis relative to the sun which leads to the seasons. Weather can lead to major random effects, too.

### *D. Expectations*

The expectation of a seasonal pattern in a variable can cause an actual seasonal effect in that or some other variable, since expectations can lead to plans that then ensure seasonality. An example is toy production in the expectation of a sales peak during the Christmas period. Without the expectation-planning aspect, the seasonal pattern may still occur but might be of a different shape or nature. Expectations may arise because it has been noted that the series being considered has in the past contained a seasonal pattern, or because it is observed that acknowledged causal series have a seasonal component.

- 7.6. These four groups may be thought of as basic causes of seasonal variation, but there may be others. They are not always easily distinguishable and may often merge together. Some series may have seasonal components that are only indirectly due to these basic causes. Weather may cause a seasonal pattern in grape production which then causes a seasonal distribution in grape prices, for example. For many series, the actual causation of a seasonal effect may be due to a complicated mix of many factors or reasons, due to the direct impact of basic causes and many indirect impacts via other economic variables. Even if only a single basic cause is operating, the causal function need not be a simple one and could involve both a variety of lags and non-linear terms.
- 7.7. Two important conclusions can be reached from such considerations:
- a. the causes of the seasonal components can be expected to have differing properties;
  - b. the seasonal components cannot be assumed to be deterministic. It is common to observe the seasonality of a series changing over time, and often one can only hypothesise what the cause may be.
- 7.8. There are no hard and fast “rules” about which series are seasonal and which are not, but some types of series are commonly seasonal and others are not. In general, flows, such as production and consumption, are seasonal but there may be exceptions (purchases of toothpaste). Stock variables, such as unemployment, employment and inventories, are commonly seasonal by virtue of the seasonality of their inflows and outflows but, since the inflows and outflows are small relative to the stock level, they display a proportionately lower degree of seasonality. By contrast, many prices, including interest rates and exchange rates, are not seasonal but there are exceptions, such as the prices of agricultural products and holiday accommodation.

- 7.9. While seasonality always has to be determined empirically, one should always try to understand what the causal factors may be. If the seasonality is contrary to what might be expected one should investigate the possibility of it being created as an artefact of how it is reported. A special case is where there is no apparent seasonality for a series where one would expect to find it.
- 7.10. Any stationary time series can be represented as the sum of sine and cosine waves of different frequencies, phase and amplitude. The seasonal frequencies for quarterly data correspond to waves of length two and four quarters, as these are the only waves that recur in the same quarter(s) each year. Similarly, there are six seasonal frequencies for monthly data, corresponding to waves of length 2, 2.4, 3, 4, 6 and 12.
- 7.11. In simple terms, monthly/quarterly time series can be considered to have seasonality if the amplitudes of the sinusoidal waves with these wavelengths are large relative to those of other wavelengths, and seasonal adjustment can be thought of as filtering out these waves.

### Calendar variation

- 7.12. The calendar effect is the impact of working/trading-days, fixed and moving holidays, leap year and other calendar related phenomena (e.g. bridging days <sup>(34)</sup>) on a time series. These calendar effects can be divided into a seasonal and a non-seasonal component. The former corresponds to the average calendar situation that repeats each year in the same month or quarter, and the latter corresponds to the deviation of the calendar variables (such as numbers of trading/working days, moving holidays, leap year days) from the long-term month-or quarter-specific average. The seasonal component of the calendar effect is part of the seasonal component of the time series and is removed by seasonal adjustment. The non-seasonal part of the calendar effect is commonly referred to as “calendar variation”, and it has essentially three different elements:
- effects related to moving holidays;
  - effects related to working-days/trading-days;
  - leap years.

#### *Moving holidays*

- 7.13. Easter, as well as other moving holidays, may concern different months or quarters according to the year (Catholic Easter can affect March or April, that is the first or the second quarter, and Orthodox Easter can affect April or May). Different dates of such holidays (mainly Easter) from one year to another imply instability of the seasonal pattern related to the corresponding quarter or month. For this reason, Easter and moving holiday effects require a special statistical treatment.
- 7.14. The impact of moving holidays varies between products and industries. For example, while Easter and the associated holidays may reduce production in some industries, they can increase production in others because of increased consumption. Also, the extent and duration of the effects can vary between products and industries. This implies that each time series needs to be carefully analysed for calendar effects individually.

#### *Working-days*

- 7.15. Many industries undertake a lot more production on normal weekdays (weekdays that are not public holidays) than on weekend days, and given that the number of normal weekdays and weekend days in a

<sup>(34)</sup> Bridging days are days (up to two) lying between a public holiday and a weekend. They may generate effects on the time series under review as a result of people taking holidays on them.

particular month, or quarter, varies from year to year, then one would expect to see a working-day variation. An adjustment for the effect is sometimes based on the proportion of normal weekdays and weekend days in a month or a quarter. However, proportional adjustment has proved to be not very accurate, and it is not recommended. The preferred approach to calendar adjustment is based on appropriate regression methods, possibly assuming an autoregressive integrated moving average dynamic (ARIMA) process for the error term (as currently implemented in TRAMO/SEATS and X-12-ARIMA).

### **Trading-days**

- 7.16. Whilst the working-day effect highlights the differences of business activity between weekdays and weekend days, the trading-day effect catches the differences in economic activity between every day of the week. The word “trading” suggests that it relates only to distributive industries, but in practice it is applied to all industries and products where activity varies according to the day of the week. Therefore, working-day variation can be considered a subset of trading-day variation.

### **Leap year/length of the month**

- 7.17. Some time series may be affected by the fact that every four years February, and therefore the first quarter, has one extra day.

## **Seasonal adjustment models**

- 7.18. Seasonality is intrinsically an unobserved component in time series. Consequently, all seasonal adjustment methods are based on a model that decomposes the unadjusted data into a seasonal component, calendar component and non-seasonal unobserved components on the basis of a set of assumptions of their characteristics. The simplest decomposition model to apply to a time series is the additive model:

$$X_t = T_t + C_t + S_t + K_t + U_t,$$

where:

- $T_t$  is the trend component;
  - $C_t$  is the cyclical component;
  - $S_t$  is the seasonal component;
  - $K_t$  is the calendar component;
  - $U_t$  is the irregular component.
- 7.19. These components are usually defined in the following way:
- *Trend* is the underlying level of the time series, and changes in trend reflect the long-term growth of the phenomenon being considered.
  - *Cycle* comprises short to medium-term fluctuations characterised by alternate periods of expansion and contraction, which are commonly related to fluctuations in economic activity, such as the business cycle.
  - *Seasonal* reflects the effects of weather-related or institutional events, decisions or expectations, which repeat themselves more or less regularly each year in the same period.
  - *Calendar* captures the effects related to the calendar that do not repeat themselves in the same period each year, e.g. the number of working-days per month or special situations like the dating of Easter.

- *Irregular* fluctuations represent movements related to events other than those previously considered.

7.20. The trend and cycle components are often combined together as a single (trend-cycle) component because for seasonal adjustment purposes there is no need to separate them, and so the additive model simplifies to:

$$X_t = TC_t + S_t + K_t + U_t,$$

where  $TC_t$  denotes the combined trend-cycle.  $S_t$ ,  $K_t$  and  $U_t$  all describe fluctuations around the trend-cycle and take positive and negative values in the additive model.

7.21. Besides the additive model there is the multiplicative model:

$$X_t = TC_t \times S_t \times K_t \times U_t,$$

where the relationship among the components is multiplicative. As in the additive model,  $S_t$ ,  $K_t$  and  $U_t$  all describe fluctuations around the trend-cycle, but in this case they take values around 1.

7.22. A variant of the multiplicative model is the log-additive model, which is obtained by taking logarithms of the multiplicative model:

$$\log X_t = \log (TC_t) + \log (S_t) + \log (K_t) + \log (U_t)$$

This transformation allows the unadjusted series to be decomposed using additive procedures. Note that while taking the logarithm of the multiplicative model does not change the model in concept it can lead to different outcomes in practice, depending on the methods used to estimate each of the components – see §7.52-7.53.

7.23. A fourth model, the pseudo-additive, is a combination of the multiplicative and additive models:

$$X_t = T_t(S_t + K_t + U_t - 1)$$

7.24. Seasonal and calendar variations affect the level of the economic activity in specific periods in a predictable way, and it makes sense to remove such variations in order to get a clearer picture of the underlying growth of economic activity. In the additive model the calendar and seasonal components are subtracted from the unadjusted data to yield calendar and seasonally adjusted data:

$$Y_t^{SKA} = TC_t + U_t = X_t - S_t - K_t$$

7.25. The presence of calendar (and possibly other deterministic) effects can have an adverse effect on the estimation of the seasonal component, resulting in low quality seasonally adjusted data. Therefore, it is recommended calendar adjustments be made prior to the estimation of the seasonal component, or simultaneously if a model is to be estimated that includes both calendar and seasonal components.

7.26. As mentioned in §7.2, seasonally and calendar adjusted data are commonly referred to as seasonally adjusted data. If the unadjusted data show the effects of both calendar and seasonal variation, data adjusted for only one of them are often not published, but the ESA transmission programme offers the possibility to transmit also series which are only seasonal or calendar day adjusted for QNA. However, unadjusted data adjusted only for calendar variation are required for analytical purposes (see §7.42) and to derive annual calendar adjusted data (see §7.75).



- 7.27. Having derived a seasonally and calendar adjusted time series, it is then possible to go one step further and remove the irregular component to obtain the trend-cycle component (see §7.65-7.73):

$$Y_t^T = TC_t$$

- 7.28. In a similar way, all the other models (such as the multiplicative and the log-additive) can be used to isolate seasonally adjusted and trend-cycle series.

### Choice of seasonal adjustment method

- 7.29. At present, several techniques are used by EU Member States to obtain seasonally adjusted data. Two main groups of methods can be distinguished:

- moving average-based methods;
- model-based methods.

- 7.30. Moving average-based methods are based on the use of different kinds of moving average filter<sup>(35)</sup>. They do not rely on an underlying explicit model and were developed mainly on an empirical basis.

- 7.31. The best known moving average-based method is the US Bureau of the Census's X-11 (and its upgrades). It is also one of the most commonly used seasonal adjustment methods worldwide. Recently, X13-Arima-Seats has been released but the latest upgrade in common use is X-12-ARIMA. All of the X-11 family involve the repeated application of suitable moving average filters that leads to a decomposition of the unadjusted data into its trend-cycle, seasonal and irregular components. The process is quite complex and involves many steps, but, leaving aside calendar variation, the basic steps are as follows when using the additive model:

- a. derive an initial estimate of the trend-cycle by applying a moving average to the unadjusted data;
- b. subtract this estimate from the unadjusted data to obtain an initial estimate of the seasonal-irregular (SI) and apply a moving average to the SIs for each type of quarter separately to obtain initial estimates of the seasonal component;
- c. subtract the initial seasonal factors from the unadjusted data to obtain an initial estimate of the seasonally adjusted series (i.e. the trend-cycle/irregular) and apply a Henderson<sup>(36)</sup> moving average to obtain a second estimate of the trend-cycle;
- d. subtract the second estimate of the trend-cycle from the unadjusted data to obtain a second estimate of the SIs, and apply a moving average for each type of quarter separately to obtain final estimates of the seasonal component;
- e. subtract the seasonal factors from the unadjusted data to obtain a final estimate of the seasonally adjusted series and apply a Henderson moving average to obtain a final estimate of the trend-cycle.

If the log-additive model is being used then the logarithm of the unadjusted data is taken before step 1, and antilogarithms are taken of the final results. If the multiplicative model is being used then subtraction is replaced by division.

- 7.32. Model-based seasonal adjustment methods estimate the trend-cycle, seasonal and irregular components with signal extraction techniques applied to an ARIMA model fitted to the unadjusted or transformed (e.g. logged) data. Each component is then represented by an ARIMA expression and some parameter restrictions are imposed to obtain orthogonal components. TRAMO/SEATS is one of the best known and

<sup>(35)</sup> A moving average is a weighted sum of a certain number of values of a time series comprising the observation under consideration and neighbouring observations. While the number of values in the average is kept constant, the time periods covered "move" successively, hence the adjective 'moving'.

<sup>(36)</sup> Henderson moving averages are optimum in the sense that they maximize smoothing whilst being able to reproduce a local cubic polynomial, i.e. if the observations lie on a local cubic polynomial then the averaged observations will also lie on the cubic polynomial. Henderson moving averages of different lengths are available: the greater the degree of irregularity relative to trend-cycle growth the longer the Henderson moving average required.

most widely used methods of this type. In order to isolate a unique decomposition (i.e. the “canonical one”), TRAMO/SEATS imposes further constraints: the variance of the irregular component is maximized and, conversely, the other components are kept as stable as possible (compatible with the stochastic nature of the model used for their representations). There are other model-based methods that use different approaches to model estimation and decomposition <sup>(37)</sup>.

**Box 7.1: Seasonal adjustment using Demetra+**

Demetra+ is an IT tool, developed by Eurostat, for seasonal and calendar adjustment. It offers a choice of two seasonal adjustment methods: X-12-ARIMA and TRAMO/SEATS, and provides user-friendly tools to check the quality of the results. It is designed as an open, free and flexible piece of software that supports a wide range of uses. The .NET version (1.04) of Demetra+ was released in December 2012, and supports the implementation of the 2009 ESS guidelines on seasonal adjustment. A Java version (JDemetra+) was released in December 2012.

As a result of the experience gained with the previous versions of Demetra, the 2012 release offers multi-processing (i.e. a large number of series can be seasonally adjusted at the same time), more advanced diagnostic tools, and are able to work with .xml files.

Seasonally adjusted official statistics are the headline figures, and so it is very important that seasonal adjustment is done well. Accordingly, since the 1990s, Eurostat has played a leading role in the promotion, development and maintenance of freely available seasonal adjustment software that supports established best practices. The adoption of the ESS guidelines and the support for their implementation in Demetra+ takes this advocacy one step further.

The ESS guidelines cover all the key steps of the seasonal and calendar adjustment process and represent an important step towards the harmonisation of seasonal and calendar adjustment practices within the European statistical system and in Eurostat. A common policy for seasonal and calendar adjustment of all infra-annual statistics is essential for maximising the quality and comparability of national data as well as enhancing the overall quality of European statistics.

The ESS guidelines are not restricted to seasonal adjustment per se, they also cover the pre-treatment of series, revision policies, quality assessment, documentation and specific issues related to the limitations of seasonal adjustment. Throughout the document the reader is presented with a step-by-step process with explanations and reasons as to which options to choose either when analysing individual series, or when adjusting a large number of series for production purposes.

To download the Demetra+ and the JDemetra+ software and access the ESS guidelines and other documents, visit the CROS portal at:

<http://www.cros-portal.eu/content/seasonal-adjustment>.

- 7.33. TRAMO/SEATS and X-12-ARIMA are currently the most commonly used seasonal adjustment methods used by EU Member States and are the only ones presented in this manual<sup>(38)</sup>. Either TRAMO/SEATS or X-12-ARIMA, together with well-documented and stable interfaces to these tools, provide a sound basis for seasonal adjustment. The choice between TRAMO/SEATS and X-12-ARIMA can be based on past experience, subjective appreciation and characteristics of the time series. Both methods are supported by Eurostat’s seasonal adjustment software package Demetra+ - see Box 7.1.
- 7.34. Both TRAMO/SEATS and X-12-ARIMA have a number of parameters and specifications whose settings vary according to the characteristics of the series being adjusted. These should be reviewed on a regular basis and, if necessary, updated after satisfactory testing. The methods and specifications currently used in seasonal adjustment should be clearly communicated to users.

<sup>(37)</sup> For example, STAMP, in which estimation and signal extraction are carried out using state space methods and Kalman filtering <http://www.stamp-software.com>.

<sup>(38)</sup> For example, the recently released X-13 ARIMA-SEATS method or the BV 4.1 procedure, are not described.

- 7.35. Whichever method is used, there should not be a complete dependence on the automatic default options of the programs. Seasonal adjustment (see §7.40) and QNA expertise should be used to verify and supplement decisions about the options used (e.g. for outlier treatment, model selection).

### Calculating and applying adjustments for calendar variation

- 7.36. Unless suitable information is available to make a direct adjustment, the calendar effect is usually quantified by using an appropriate regression model with regressors that reflect the different calendar situations in the respective quarters or months. This is indeed the approach adopted both in TRAMO/SEATS and X-12-ARIMA.

For example, if the (Catholic) Easter effect is assumed:

- to start on the Saturday 8 days before Easter Sunday and to stop on the Saturday before Easter Sunday,
- be evenly spread over this 8-day period, and
- in a particular year is divided between March (2 days), and April (6 days),

then the regressor to capture the Easter effect will have weights of 0.25 in March and 0.75 in April in this particular year and zeros in the other ten months of the year.

- 7.37. Each month has 28, 29 (leap year Februarys), 30 or 31 days, or put another way: 4 weeks, 4 weeks plus 1 day, 4 weeks plus 2 days, or 4 weeks plus 3 days. Similarly, each quarter has 13 weeks, 13 weeks *less* 1 day, or 13 weeks *plus* 1 day. The “extra” day(s) vary from month to month and quarter to quarter. For example, in one quarter the extra day may be a Monday, and in the following quarter it may be a Tuesday. By using appropriate regression analysis, it is possible to estimate the trading-day effect with respect to every day of the week.
- 7.38. In general, better estimates of calendar variation are obtained from monthly data than quarterly data. This is partly because there are usually more monthly observations than quarterly ones, and partly because the moving holiday and working/trading-day effects are relatively larger for monthly data than they are for quarterly data. Therefore it is better to use monthly data, if available, to calculate the adjustments. For the same reason, the calendar adjustments for an aggregate should be derived from its components when the calendar effect is well defined within them. This applies to all decompositions, including regional, industry, etc.
- 7.39. It is preferable that all calendar variation (moving holidays, working/trading-day effects and leap year) be estimated using a single regression model, rather than separately. It is also recommended that an ARIMA model be fitted to the error term. The RegARIMA facility in X-12-ARIMA provides such functionality to do all of this, and is applied to initial seasonally adjusted data. When using TRAMO/SEATS, however, the regression model for calendar variation is combined with the ARIMA model to be fitted to the time series, and so the parameters for the calendar and seasonal adjustment are estimated simultaneously (when the ARIMA model chosen in TRAMO is also used for the decomposition by SEATS).
- 7.40. Calendar adjustments should be made for those variables for which there is both statistical evidence and an economic explanation for calendar variation. This information can also be used to inform an assessment of the plausibility of the calendar variation estimates. When deciding whether or not to perform a calendar adjustment, consideration may also be given to related variables in the accounts in order to ensure accounting coherence.
- 7.41. Calendar variation should be identifiable and sufficiently stable over time or, alternatively, it should be possible to model its changing impact over time appropriately. In order to ensure that the estimated

calendar variation component is sufficiently stable over time, the selection of the relevant calendar effects to remove should be kept constant over appropriately long time periods, even if the value of the estimated effects might be at the border of the significance threshold for some periods.

- 7.42. The ESA 2010 transmission programme requires that unadjusted data adjusted only for calendar variation should be supplied for at least GDP and total gross value added and all the other items in Table 1 on a voluntary basis. However, it is advisable to derive calendar adjusted data whenever calendar effects are economically meaningful and statistically significant and stable in order to enable analysis of the impact of the non-seasonal calendar effects and to make adjustments to annual data for benchmarking purposes (see §7.75).
- 7.43. Information about calendar adjustment should be provided in the metadata template on seasonal adjustment (see §7.98).
- 7.44. Chapter 4 of the *Handbook on Seasonal Adjustment* provides comprehensive guidance on the estimation of calendar variation, including strategies for dealing with those that change over time.

## Principal steps in undertaking seasonal adjustment

- 7.45. The first step in seasonally adjusting a time series for the first time is to run it through a seasonal adjustment program, such as TRAMO/SEATS or X-12-ARIMA. The battery of diagnostics will provide much information about the series, such as whether it is seasonal, the nature of the seasonality, whether prior adjustments are needed and whether a prior transformation is needed.

### *Prior transformations and adjustments (commonly referred to as 'linearization')*

- 7.46. Prior transformations are undertaken to achieve a stationary autocovariance function and they are commonly applied prior to fitting an ARMA model. They can take a number of forms, such as taking the logarithm, square root, inverse, differencing or more generally the Box-Cox transformation <sup>(39)</sup>, but taking logarithms is by far the most common. Both TRAMO/SEATS and X-12-ARIMA provide the user with an automatic test for log-transformation in order to determine the choice between an additive, multiplicative or log-additive model.
- 7.47. Most prior adjustments fall into five categories:
  - a. adjustments for extreme values (i.e. additive outliers), such as those due to strikes, etc.;
  - b. adjustments for abrupt changes in level, mostly due to administrative changes (e.g. increase in the VAT rate), commonly referred to as 'level shift outliers';
  - c. adjustments for transitory changes, mostly due to extraordinary events that manifest themselves over a limited number of periods with declining magnitude, commonly referred to 'transitory change outliers';
  - d. calendar adjustment for the effects of trading-day and moving holiday variation;
  - e. adjustments for abrupt changes in seasonality, mostly due to administrative changes (e.g. changes in school terms) or changes in statistical concepts and methods (e.g. classification or compilation changes).
- 7.48. The first three types of adjustment (a, b and c) are applied solely for the purpose of estimating the seasonal factors as well as possible, and they need to be reversed in deriving the final seasonally adjusted figures. In general, additive outliers and transitory changes are assigned to the irregular component,

<sup>(39)</sup>  $x \rightarrow f_a(x) = [x^a - 1]/a$  for  $a$  not equal to 0;  $f_a(x) = \log(x)$  for  $a = 0$

because of their temporary character. Level shift outliers are assigned to the trend-cycle component. In contrast, the fourth and fifth adjustments (d and e) are still applied in the final seasonally adjusted figures because they are part of the seasonal and calendar adjustment.

- 7.49. When abrupt changes occur, the application of prior adjustments can dramatically improve the quality of the estimated seasonal factors. Both X-12-ARIMA and TRAMO/SEATS have built-in facilities for detecting, estimating and adjusting for outliers, but better results are usually obtained by analyst making a careful estimate of the adjustment needed or, better still, by using actual data (e.g. the value of a large used-asset sale/purchase in seasonally adjusting gross fixed capital formation).
- 7.50. Making prior adjustments can be most important for the most recent quarters, which is when the seasonal component is most difficult to estimate. Experience has shown that when abrupt changes occur in recent quarters, it is best to make the best estimates possible of prior adjustments at the time each seasonal reanalysis is undertaken, rather than wait until a clearer picture emerges. Users should be informed when new prior adjustments are introduced. As well as providing superior seasonal adjustments, the application of prior adjustments tends to reduce revisions.

### *Choice of seasonal adjustment model*

- 7.51. The additive and the log-additive models are available in both TRAMO/SEATS and X-12-ARIMA; and the multiplicative model and pseudo-additive model are available in X-12-ARIMA only.
- 7.52. Usually, the preferred model is multiplicative (either pure multiplicative or log-additive) because in most economic time series the magnitude of the seasonal component appears to vary proportionally to the level of the series. While the multiplicative model and the use of logged data with the additive model are conceptually identical, they are in fact different when using X-12-ARIMA. The reason is that for both the additive and multiplicative models the decomposition into trend-cycle, seasonal and irregular components is accomplished using arithmetic moving averages. Consequently, when the additive version of X-12-ARIMA is applied to logged data it is equivalent to using the multiplicative model with geometric moving averages.
- 7.53. If a time series has strong exponential growth due to strong volume growth, inflation, or both, then one would expect geometric averages to do better than arithmetic averages in estimating the trend-cycle. If the amplitude of the seasonal/irregular is growing quite rapidly (i.e. the degree of variation in the seasonal and/or the irregular components is growing relative to trend), then again the log-additive model can be expected to do better than the multiplicative model. However, the use of geometric averages can result in seasonally adjusted and trend-cycles estimates that are biased. In particular, if the seasonal variation is substantial, then the seasonally adjusted estimates may be subject to a severe bias. Hence the multiplicative version of X-12-ARIMA is generally preferred.
- 7.54. The additive model is used for time series with a seasonal component that does not depend on the level of the trend-cycle. It can also be useful for those time series that can take both positive and negative values, such as changes in inventories. However, if the seasonality is changing in amplitude over time, which is particularly common for current price data, then the additive model is unsatisfactory and another solution is needed. If two appropriate strictly positive series are available such that when differenced they yield the target series, then the multiplicative or log-additive models may be used for these series, and a seasonal adjustment of the target series is derived as a residual. This approach can be used for changes inventories (see §7.91). If this approach is inapplicable, then another option is to use the pseudo-additive model. For example, if crop production is measured on the basis of what is harvested then there will be some quarters with zero values and some with non-zero values <sup>(40)</sup>.

<sup>(40)</sup> This approach to measuring the output of crops is contrary to that recommended by both ESA 2010 and the 2008 SNA – see §2.54-2.68 of the handbook.

## ARIMA models

- 7.55. ARIMA models are used in both X-12-ARIMA and TRAMO/SEATS, albeit for different purposes.
- 7.56. As described above (see §7.31), X-12-ARIMA decomposes a time series into its trend-cycle, seasonal and irregular components by the iterative application of moving averages. In the middle part of longer time series these moving averages are symmetrical with an odd-number of terms so that there is the same number of terms prior to the current observation as there is after it and the weights following the current observation are the mirror image of those preceding the current observation. The outcome of the averaging is therefore ‘centred’ on the observation in question. However, as the end (or beginning) of the time series is approached it is no longer possible to have symmetric averages because there are insufficient observations following (preceding) the current one. To overcome this problem, ARIMA models are used to extrapolate (the beginning and) the end of series. It has been found that this approach tends to produce smaller revisions compared with the alternative of using asymmetric moving averages. In X-12-ARIMA, ARIMA models are also fitted to the residuals of the regression model in the pre-adjustment phase.
- 7.57. As described in §7.32, ARIMA models are fundamental to TRAMO/SEATS. In fact, not only are they used by TRAMO to model the error term in the pre-adjustment phase but they are also used by SEATS in the decomposition phase; they are the basis for the Wiener-Kolmogorov filters applied to derive the trend-cycle, the seasonal and the irregular components according to a canonical decomposition.
- 7.58. While correct model specification is important for both X-12-ARIMA and TRAMO/SEATS, it is much more important for the latter, and the automated model selection may warrant close scrutiny. Unstable parameter estimation can cause problems for both the ARIMA forecasts used in X-12-ARIMA and the component decomposition in TRAMO/SEATS. In extreme cases, parameters near feasible region boundaries may suddenly shift dramatically with the addition of data. In other cases parameters may converge to a local minimum well away from a global minimum, especially for quadratic or greater operators. Also, the automatic options in TRAMO/SEATS may lead to rather exotic models being selected, particularly when strong trading-day variation has not been estimated correctly.
- 7.59. The general principles for specifying ARIMA and regression models are:
- parsimony: when faced with alternative models that explain the observed data equally well always choose the simplest;
  - models should not be fully data driven: a model needs to be validated by testing it under different circumstances and tested for robustness.
- 7.60. In order to limit the size and extent of revisions, especially in model-based methods, the specification of the ARIMA models for extrapolation and decomposition should not be changed more than once a year, unless an exceptional event occurs. Parameters may be re-estimated more frequently <sup>(41)</sup>.

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<sup>(41)</sup> See: ESS guidelines on seasonal adjustment at <http://www.cros-portal.eu/content/guidelines-sa>.

## Organizational arrangements for seasonal adjustment in QNA

- 7.61. Seasonal adjustment of QNA is a substantial endeavour. While both TRAMO/SEATS and X-12-ARIMA provide extensive aids for helping analyst achieve high quality seasonal adjustments, the range of options and diagnostics can be quite bewildering for the newcomer.
- 7.62. While both programs can be used in an automatic way, the automated choices made by the software should never be accepted blindly. In fact, there are often instances when an intervention is needed to ensure that the seasonal adjustment is of high quality. Thus there is a strong argument for having seasonal adjustment specialists doing the seasonal adjustment of QNA. However, there are also advantages in national accounts compilers undertaking the seasonal adjustment:
- the national accounts compilers are the ones who know most about the data they use and their characteristics;
  - it gives the national accounts compilers control and responsibility for the preparation of the most important national accounts statistics;
  - there are matters of practicality; it is common for NSIs to seasonally adjust thousands of series each month and quarter, and the time available for seasonal adjustment is often very short.
- 7.63. An arrangement that has proved to be successful in a number of countries is one where there is a small team of seasonal adjustment specialists who serve the seasonal adjustment needs of the whole NSI. They are responsible for monitoring the seasonal adjustments of QNA and other time series, and they provide solutions when problems arise. Other key functions of the seasonal adjustment specialists are to provide training, ensure that best practices are being followed across the NSI and that QNA and related series are seasonally adjusted in a consistent way. The subject matter statisticians, including the national accounts compilers, are responsible for the routine seasonal adjustment of the data each month or quarter. The exact demarcation of responsibilities between the seasonal adjustment specialists and the subject matter statisticians may vary between countries, but one option is for the former to have responsibility for annual reanalyses and the latter to have responsibility for seasonally adjusting the data between annual reanalyses, but with the ability of the specialists to step in should a problem suddenly arise.
- 7.64. Given their use in the short-term analysis of the economic situation, the most important aggregates in QNA are seasonally adjusted. Whatever the arrangements are within an NSI, it is imperative that there are people responsible for the seasonal adjustment of QNA with a high degree of seasonal adjustment expertise.

## Trend-cycle estimates

- 7.65. Seasonally and calendar adjusted data are ubiquitous; all OECD countries, all EU Member States and international organisations, such as the OECD, Eurostat, the IMF, the ECB and the World Bank, publish them. This reflects the fact that the seasonal and calendar adjustments can generally be estimated with a high degree of reliability based solely on past observations of the time series, i.e. when more data become available, revisions are usually quite small.
- 7.66. By contrast, only a few NSIs <sup>(42)</sup> also publish trend-cycle data. Possible reasons for the reluctance of most statistical organisations to publish trend-cycle data are:
- by its nature, the irregular component is unpredictable and cannot be distinguished from the trend-cycle component with the same degree of assurance until sometime after the latest quarter;

<sup>(42)</sup> The NSIs of Austria and Germany publish trend-cycle estimates.

- producing trend-cycle estimates adds another layer of complication on what is already a complicated process that has to be accomplished in a short space of time.
- 7.67. As described in §7.56, symmetric moving averages cannot be used at the end of a series in X-12-ARIMA, and so either asymmetric moving averages are applied or symmetric moving averages are applied to data extrapolated using an ARIMA model. In either case, there is an implicit assumption that the future will be much like the immediate past, i.e. no turning point is anticipated in the immediate future. The same is true of trend-cycle estimation in TRAMO/SEATS. Consequently, when a turning point is reached, the trend-cycle estimates take a number of quarters to properly identify it.
- 7.68. Nevertheless, there is a demand by analysts for data that reveal economic growth free of short-term irregularities, both for its own sake and also as a basis for making short-term forecasts. In particular, there is a keen interest in quickly identifying turning points in economic activity. Analysts commonly resort to using measures that reduce the influence of irregularities in the seasonally adjusted data in order to identify trend-cycle growth. Two examples of measures that are applied to seasonally and calendar adjusted data are:
- calculating the growth rate to the latest quarter from the same quarter of the previous year;
  - calculating the growth rate between the average of the latest third and fourth quarters and the average of the last two quarters.
- 7.69. Both of these methods have the effect of reducing, but not eliminating, the influence of the irregular component relative to that of the trend-cycle. The resulting estimates of growth are centred on a time point six months before the end of the latest quarter and, as a result, there is considerable delay in identifying turning points. X-12-ARIMA and TRAMO/SEATS are both capable of deriving estimates of trend-cycle growth that are superior, both in terms of smoothing and in reducing the delay in identifying turning points.
- 7.70. Trend-cycle estimates can be derived from the final seasonally and calendar adjusted data by applying a filter, such as a Henderson moving average<sup>(43)</sup> or a Wiener-Kolmogorov filter. If any outliers, abrupt changes in level or abrupt transitory changes have been identified (a, b and c in §7.47), then prior adjustments for them will be needed. In cases of abrupt changes in level (b), an equal but opposite adjustment is applied to the initial trend-cycle estimates so that the final trend-cycle estimates reflect the abrupt change in level. The same usually applies when abrupt transitory changes (c) occur spanning several quarters. But in the case of outliers affecting a single quarter (a), no such “opposite” adjustment is required to the initial trend estimates<sup>(44)</sup>. Towards the end of the series either asymmetric filters can be used, or a symmetric filter can be applied to data that have been extrapolated with an ARIMA model. All this processing takes time and may imply a later release date for QNA.
- 7.71. There is clearly some benefit for users in making available both seasonally adjusted and trend-cycle data, but the latest observations of the trend-cycle need to be treated with caution or better not published. It is therefore recommended that:
- prominence should be given to the seasonally adjusted data in press releases; and either
    - users should be given access to trend-cycle estimates either on request, by reference or by internet download. When presenting trend-cycle estimates, the most recent values should not be shown because of the end-point problem, or

<sup>(43)</sup> The trend-cycle estimates derived in the process of estimating the seasonally adjusted data will be unsuitable if any prior adjustments need to be reversed after application of the trend-cycle filter, or if the seasonally adjusted data have been adjusted in the balancing process. Whilst it is possible to derive balanced trend-cycle estimates in the same way as balanced unadjusted and seasonally adjusted data it is not proposed here.

<sup>(44)</sup> In practice it is sometimes difficult to distinguish between outliers affecting a single quarter (i.e. additive outliers) and an abrupt change in the level (i.e. level shift or transitory change outliers), especially if the abrupt change in the level happens at the current end of a time series.



- the seasonally adjusted and trend-cycle should be shown together in a graphical way. If trend-cycle estimates for the latest quarter are included, the end-point problem should be made very clear.

- 7.72. In order to decide whether to publish trend-cycle data, NSIs need to assess the strength of user demand and the practicality of deriving satisfactory trend-cycle estimates. Are users prepared to accept a few days' delay in QNA release in order to have access to trend-cycle estimates as recommended above?
- 7.73. The estimation of trend-cycle is described in Chapter 8 of the *Handbook on Seasonal Adjustment* and the issue of publishing trend-cycle estimates is discussed in Chapter 14. The estimation and publication of trend-cycle estimates is also addressed in *Information Paper: A Guide to Interpreting Time Series - Monitoring Trends, 2003* (ABS Cat. No.1349.0) <sup>(45)</sup>.

### Relationship between quarterly seasonally adjusted data and annual data

- 7.74. Temporal consistency with raw annual data or calendar-adjusted annual data is not an intrinsic characteristic of seasonally adjusted data when the seasonal pattern is changing over time, which it commonly does. For if temporal consistency were required for each possible span of four quarters (i.e. years ending in the first quarter, second quarter, third quarter and fourth quarter), then it would be impossible to accommodate an evolving seasonal pattern.
- 7.75. A major recommendation of this handbook is that the quarterly unadjusted current price and chain-linked volume estimates should be temporally consistent with the corresponding annual estimates. The question then is: should the same apply to their seasonally adjusted counterparts?

#### Reasons for not having temporal consistency

- Imposing temporal consistency on seasonally adjusted data changes their quarter-on-quarter growth rates, although the changes are usually small if an optimal benchmarking method is used and the seasonal component changes only gradually.
- When an optimal benchmarking procedure is used, revisions to the quarterly figures in the latest years, or so, occur when new annual benchmarks are introduced. Such revisions to the benchmarked seasonally adjusted data are in addition to those arising from other causes, such as revised unadjusted quarterly data or a seasonal re-estimate involving additional data.

#### Reasons for having temporal consistency

- When there is strong and rapidly changing seasonality in a time series, the annual sums of the unadjusted and seasonally adjusted data can persistently differ by plus or minus one per cent or more for a number of consecutive years. While this can be rationalised from a statistical point of view, it may cause concern amongst users that is difficult to assuage. Nevertheless, this is not a good enough reason in itself for forcing temporal consistency.
- There are some situations where forcing temporal consistency is the most practical option:
  - Unadjusted quarterly chain Laspeyres volume estimates should always be additively consistent with their annual counterparts. This is assured when the annual overlap method

<sup>(45)</sup> Available from the Australian Bureau of Statistics' website <http://www.abs.gov.au>.

is used <sup>(46)</sup> (providing the quarterly estimates in the prices of the previous year are temporally consistent) but when the one-quarter overlap method is used it is necessary to follow the linking with a benchmarking procedure. If all QNA variables are directly seasonally adjusted then the benchmarked unadjusted data can be seasonally adjusted in the usual way. However, if major aggregates, such as GDP, are seasonally adjusted by summing their seasonally adjusted components, then there is a problem. In such cases each seasonally adjusted component must be expressed in the average prices of the previous year prior to aggregation, and then aggregation is followed by linking. Hence if the one-quarter overlap method is used, the seasonally adjusted chain-linked volumes have to be benchmarked to the annual chain-linked volume estimates.

- ii. It is recommended in Chapter 8 that QNA in current prices and in the average prices of the previous year, unadjusted and seasonally adjusted, should all be balanced using supply and use tables. It is also recommended that all variables, including deflators and seasonal factors, should be eligible for adjustment. After the linking of the estimates in the average prices of the previous year, whether by the annual or one-quarter overlap method, the most practical way of ensuring temporal and contemporaneous (other than additivity of chain-linked volume estimates) consistency among the four sets of time series for each QNA variable is by benchmarking them all to the annual balanced data in a coordinated way.

- 7.76. In general, calendar adjustments should not net out over a year. This is quite obvious when one considers the nature of leap years and trading-day variation. Therefore data that have been both seasonally and calendar adjusted should not be benchmarked to raw annual data if the annual net effect of the calendar adjustments is significant. When this is the case, only seasonally adjusted data should be benchmarked to raw annual data and seasonally and calendar adjusted data should be benchmarked to calendar adjusted annual data.

#### ***Benchmarking seasonally adjusted data to the annualized quarterly unadjusted data***

- 7.77. As noted above, benchmarking QNA data to annual data is addressed elsewhere in this handbook: the univariate case in Chapter 5 and the multivariate case in Chapter 8. In both cases it is assumed that the quarterly unadjusted and seasonally adjusted data are benchmarked to independent (calendar adjusted, if significant) annual data. When applying a benchmarking procedure in such circumstances, it is assumed that the expected benchmark-to-preliminary estimate or indicator (BI) ratio (see Chapter 5) in the latest incomplete year will be the same for the unadjusted and seasonally adjusted data.
- 7.78. For the latest year or two there may be no independent annual estimates and the only annual data are annualized quarterly data. This means that the BI ratio in the latest incomplete year is expected to be 1 <sup>(47)</sup>, because when the year is complete the first annual benchmarks will be the sum of the quarterly unadjusted data. Hence, whatever benchmarking procedure is used, in order to minimize revisions to the benchmarked seasonally adjusted data there should be an expected BI ratio of 1 for the latest incomplete year. In particular, the standard Denton proportional method is less than optimal for benchmarking seasonally adjusted data in such circumstances because the BI ratio observed in the latest complete year is implicitly used in the following incomplete year, and so it is better to use the enhanced Denton proportional method and set the BI ratio to 1 (refer to the discussion on benchmarking methods in Chapter 5).

<sup>(46)</sup> This is true for chain Laspeyres volume indices, but not necessarily for other index formulae.

<sup>(47)</sup> For further details, see Quenneville, Cholette, Huot, Chiu and Di Fonzo, 2003.

## Seasonal adjustment and revisions

- 7.79. Apart from revisions due to balancing and benchmarking, revisions to seasonally adjusted data take place for three main reasons:
- The unadjusted data are revised.
  - More observations become available. The estimated seasonal pattern at the end of a series is necessarily based on past and current observations. When later data become available better estimates can be made.
  - Changes are made to the specification of the seasonal adjustment method, including changes to the specification of any ARIMA models being used.
- 7.80. When available computing power was much less than it is today, it was standard practice to seasonally reanalyse time series once a year. Besides providing new seasonal factors for the latest four quarters (or twelve months) and revising the seasonal factors for earlier periods, the seasonal adjustment program produced forward seasonal factors for the coming year. Now it is possible to do a seasonal reanalysis every quarter or month (i.e. concurrent seasonal adjustment) if desired. There are advantages and disadvantages of undertaking comprehensive seasonal reanalyses annually or more frequently (see ESS Guidelines, section 3.2), and the decision on which strategy to adopt requires careful consideration.
- 7.81. There is a range of possible strategies, the extremes of which are as follows:
- Current adjustment: the model, filters, outliers and regression parameters are re-identified and the respective parameters and factors re-estimated at appropriately set review periods. The seasonal and calendar factors to be used to adjust for seasonal and calendar effects in the unadjusted data between the review periods are estimated in the previous review period and forecasted up to the next review period.
  - Concurrent adjustment: the model, filters, outliers, regression parameters are re-identified and the respective parameters and factors re-estimated every time new or revised data become available.
- 7.82. The current adjustment strategy minimizes the frequency of revisions, but the revisions can be quite large. The concurrent adjustment strategy generates the most accurate seasonally adjusted data by making use of the most recent information at any given time point but leads to more revisions, many of which may be small and perhaps in opposing directions.
- 7.83. Both of these extreme strategies have drawbacks: for example, the current adjustment strategy can lead to a lack of precision in the estimation of the latest adjusted figures and the concurrent adjustment strategy can lead to high instability of the estimated seasonal pattern. Therefore, in practice, other balanced alternatives between these two extremes are followed:
- Partial concurrent adjustment: the model, filters, historical outliers and calendar regressors are re-identified once a year and the respective parameters and factors re-estimated every time new or revised data become available. Additionally, for each new data point of the time series an outlier analysis is carried out.
  - Controlled current adjustment: forecasted seasonal and calendar factors derived from a current adjustment are used to seasonally adjust the new or revised unadjusted data. However, an internal check is performed against the results of the “partial concurrent adjustment”, which is preferred if a perceptible difference exists. This means that each series needs to be seasonally adjusted twice. The approach is only practicable for a limited number of important series. A full review of all seasonal adjustment parameters should be undertaken at least once a year and whenever significant revisions occur (e.g. annual benchmark).

- 7.84. The recommended approach for QNA is as follows:
- When past data are revised for less than two years and/or new observations are available, partial concurrent adjustment is preferred to take into account the new information and to minimize the size of revisions due to the seasonal adjustment process.
  - However, if the seasonal component is stable enough, controlled current adjustment could be considered to minimize the frequency of revisions. In this case, a full review of all seasonal adjustment parameters should be undertaken at least once a year.
  - When revisions covering two or more years occur (as observed in national accounts) model, filters, outliers and regression parameters have to be re-identified and re-estimated.
- 7.85. Revisions to historical seasonally adjusted data with no accompanying revision of the unadjusted data may cause confusion to users. Furthermore, if QNA are balanced, each revision implies a new balancing to ensure contemporaneous consistency and adjustments to other quarters to maintain temporal consistency with the raw annual data. Hence there is a strong incentive to restrict revisions to seasonally adjusted data. The challenge is to find a balance between the need for the best possible seasonally adjusted data and the need to avoid unimportant revisions, which (a) can have major repercussions in a balanced national accounting framework, and (b) may later be reversed.
- 7.86. Prior to developing a revision policy, consideration needs to be given to the needs of users and the resources available to implement the policy. The policy should address at least the following:
- the frequency and relative size of revisions due to seasonal adjustment;
  - the precision of the seasonally adjusted data (i.e. selected diagnostic results provided by seasonal adjustment program);
  - the time period over which the unadjusted data have been revised;
  - the relationship between the timing of publication of revisions to the seasonally adjusted data and publication of the revisions to the unadjusted data<sup>(48)</sup>.
- 7.87. It is important that the revision policy is as coherent and transparent as possible and that it does not lead to the publication of sub-optimal seasonally adjusted data that could mislead users interpreting the economic picture.

### Direct versus indirect seasonal adjustment

- 7.88. In the national accounts there are many possible hierarchical relationships: regional, industrial, commodity, accounting, etc. This raises the issue as to how aggregates should be seasonally adjusted:
- directly, by seasonally adjusting every QNA variable independently, or
  - indirectly, by seasonally adjusting an aggregate as the sum of its seasonally adjusted components.
- 7.89. Both the direct and indirect approaches to seasonal adjustment can be applied in different ways, depending on the methods used to derive the unadjusted estimates. The direct approach can be applied to either the benchmarked or unbenchmarking unadjusted estimates of QNA variable, or an indicator, prior to benchmarking/modelling (see Chapter 5). Whichever variant is used, the advantages and disadvantages of direct versus indirect adjustment are the same.

<sup>(48)</sup> See: Section 3 of ESS guidelines on seasonal adjustment at <http://www.cros-portal.eu/content/guidelines-sa>.

- 7.90. The strength of the advantages and disadvantages of each approach varies from series to series. As a consequence, each case should be considered on its costs and merits. The following are factors to consider:
- If the components have different seasonal patterns and their trend-cycles are growing at different rates, then the seasonal pattern of the aggregate will change even if the seasonal pattern of each component stays the same. This problem can be severe if major components have substantially different seasonal patterns and the rates of growth of their trend-cycles vary a great deal. In this case, an indirect approach is preferred.
  - In general, the irregular component of an aggregate is smaller relative to its trend-cycle than is the case for most of its components. This means that providing the problem described in (a) is not serious, then it is usually possible to make a better and more reliable estimate of the seasonal and trend-cycle components of the aggregate by a direct adjustment, rather than an indirect adjustment, particularly for the latest observations.
  - Even if QNA are left unbalanced, additivity of both the seasonally adjusted current price data and the estimates in the average prices of the previous year is required within each account. This implies that if the direct approach is used then the discrepancy between each directly adjusted aggregate and its seasonally adjusted components needs to be distributed to one or more of the components. Pro rata adjustment is probably the best of the simple options, but if the discrepancies are large then the multivariate Denton benchmarking method (described in Chapter 8) may be needed. However, when using automatic multivariate benchmarking techniques, the final results have to be validated in order to ensure coherent results.
- 7.91. If regional QNA are compiled, then there are several possibilities:
- indirect adjustment: seasonally adjust regional components and aggregate to get both regional and national aggregates;
  - direct adjustment: direct adjustment of all aggregates, with distribution of discrepancies between regions and national components;
  - direct and indirect combination: mixture of direct and indirect seasonal adjustment of aggregates.
- As for other cases of aggregation, it is a matter of empirical and practical considerations.

### Deriving seasonally adjusted chain-linked volume measures

- 7.92. The compilation of seasonally (and calendar) adjusted QNA chain-linked volume estimates is the result of a sequence of operations, including seasonal and calendar adjustment, balancing, chain-linking<sup>(49)</sup> and benchmarking. It is somewhat more complicated than deriving chain-linked unadjusted estimates because some of these steps need to be undertaken on unlinked data (such as balancing) and some need to be undertaken on chain-linked data (such as benchmarking, seasonal and calendar factor estimation). The objective is to achieve the following for the seasonally adjusted chain linked data:
- they should be of sufficiently high quality, with no residual seasonality and no over-adjustment (the seasonal component should not contain irregular influences);
  - when expressed in the average prices of the previous year they should be additively consistent, preferably with no statistical discrepancies;
  - they should be temporally consistent with annual, calendar-adjusted benchmarks. However, if the calendar-adjustment has a negligible effect on the annual benchmarks, the unadjusted benchmarks may be used for both the unadjusted and seasonally adjusted quarterly data.
- 7.93. The following two paragraphs describe the steps to be taken in deriving seasonally adjusted, balanced and benchmarked, chain-linked QNA data when direct and indirect seasonal adjustment is used. It is assumed

<sup>(49)</sup> Chain linking is addressed in Chapter 6; univariate benchmarking quarterly data to annual benchmarks is addressed in Chapters 5; multivariate benchmarking and balancing are addressed in Chapter 8.

that the actual QNA variables are seasonally adjusted, but if the seasonally adjusted estimates of QNA variables are derived from seasonally adjusted indicators benchmarked to annual data it makes little difference to the processes described.

### **Case 1: all series are directly seasonally adjusted**

- a. Seasonally analyse each chain-linked QNA series to derive seasonal and calendar adjustment factors.
- b. Derive seasonally adjusted estimates in the average prices of the previous year. If the multiplicative model is used then the seasonal and calendar adjustment factors can be applied directly to unadjusted data in the prices of the previous year. If any other model is used the seasonally adjusted, chain-linked series needs to be unlinked.
- c. Calculate the discrepancies between each aggregate and the sum of its components and allocate them to the components so as to achieve additivity.
- d. Balance the accounts, either completely in a supply and use framework or partially by some other means.
- e. Chain link the estimates.
- f. Benchmark the chain-linked, seasonally adjusted volume estimates to calendar-adjusted annual data, if needed (see §7.76).
- g. Run all the benchmarked series through the seasonal adjustment diagnostics to check for residual seasonality or any other problems. If there are any, go back to step 1 and recalculate the seasonal and calendar adjustment factors using the balanced and benchmarked unadjusted data.

### **Case 2: all aggregates are indirectly adjusted<sup>(50)</sup>**

- a. Seasonally analyse each chain-linked QNA series at the lowest level of aggregation to derive seasonal and calendar adjustment factors.
- b. Derive seasonally adjusted estimates in the average prices of the previous year. If the multiplicative model is used then the factors can be applied directly to unadjusted data in the prices of the previous year. If any other model is used the seasonally adjusted chain-linked series needs to be unlinked.
- c. Aggregate the data to derive seasonally adjusted estimates in the average prices of the previous year for all aggregates.
- d. Steps (d) to (f) are the same as Case 1.

### **Case 3: some aggregates are directly adjusted and others are indirectly adjusted**

If some aggregates are directly adjusted and others are indirectly adjusted, then the two above approve procedures need to be blended together.

### **Non-strictly positive series**

- 7.94. Some QNA variables can take positive, negative or zero values, and it is not possible to derive chain-linked volume estimates for them: the best known example is changes in inventories. Chapter 6 describes how it is possible to derive pseudo, chain-linked volume estimates. Briefly,

<sup>(50)</sup> Benchmarking seasonally adjusted components to annual data and subsequent aggregation could also be envisaged.

- a. identify two strictly positive series that when differenced yield the target series;
- b. derive chain-linked volume estimates of these two series;
- c. difference the two chain-linked series.

Exactly the same approach can be used to derive seasonally adjusted, pseudo chain-linked volume estimates, except that after step (b) the two series are seasonally adjusted before proceeding to step (c). In the case of changes in inventories, the obvious candidates for the two strictly positive series are the opening and closing inventory levels.

- 7.95. Seasonally adjusted current price estimates of changes in inventories can be obtained by inflating the pseudo chain-linked volume estimates by a suitable price index centred on the middle of each quarter and with the same reference year as the volume estimates.

### Editing

- 7.96. Given the large number of transformations commonly made to QNA seasonally adjusted data, including the indirect seasonal adjustment of aggregates or their direct adjustment followed by adjustments to their components, and the fact that adjustments may be made external to the national accounts branch, it is recommended that a complete seasonality check of current price, chain-linked volume estimates and their implicit price deflators (IPDs) be undertaken. This is best done by running all the final seasonally adjusted data that are to be published through X-12-ARIMA or TRAMO/SEATS and generating a list of the F-test statistics for residual seasonality for each series. For ease of analysis, separate lists may be compiled for the current price, chain-linked volume estimates and IPDs ordered by their F-statistic values. Other lists could rank the results by the magnitude of the current price value, thereby giving prominence to the most important aggregates. This procedure should give reasonable protection against publishing seasonally adjusted data with residual seasonality, with the major aggregates being the biggest concern.

### Transparency of procedures

- 7.97. Seasonal adjustment is a data analysis process that is heavily dependent on the particular method that is used. It is important for any NSI wishing to demonstrate its independence and integrity that analysis and the decisions made in making the adjustment are open and follow known rules. This is essential to construct a relationship of trust between data producer and data user. Transparency of currently used methods is the pre-condition for a sound seasonal adjustment policy.
- 7.98. It is very important to publish not only the final seasonal adjusted figures but also as much information on the adjustment procedure as possible. Documentation on the practices adopted at national, euro area and EU level (*metadata*) should be published according to the template on seasonal adjustment of QNA <sup>(51)</sup> and the respective arrangements on implementing, publishing and updating the metadata should be followed. The template should be updated annually or whenever major changes occur.

### Reference paper

- 7.99. A reference paper should be produced as a separate publication in which the seasonal adjustment environment is described in full detail, including at least the following information:
- seasonal adjustment method in use;
  - decision rules for the choice of different options in the program;
  - special constraints for time and activity aggregation;

<sup>(51)</sup> The template can be found in the Annex to the ESS Guidelines on Seasonal Adjustment.

- other constraints in operation;
- outlier detection and correction methods;
- decision rules between different kind of data transformations;
- revision policy;
- description of the calendar adjustment;
- contact address.

### **Publication of information about seasonal adjustment**

7.100. In every relevant publication, the method in use and the reference paper should be mentioned as well as a reference contact for further details on the procedure. In addition, explanations of anything out of the ordinary that has occurred in the seasonal adjustment in recent periods should be prominently displayed.

### **Summary of main points**

7.101. The following is a summary of the recommendations made in this chapter. As indicated earlier, this chapter does not cover all aspects of seasonal adjustment. For further guidance, the reader should refer to the *ESS Guidelines on Seasonal Adjustment*, the *Final Report of the Task Force on Seasonal Adjustment of QNA* (endorsed by the CMFB in 2008) and the *Handbook on Seasonal Adjustment*. Chapter 20 of the latter provides a consolidated set of guidelines.

- Seasonally (and calendar) adjusted results should be produced for data in current prices, volumes and deflators by adjusting any two of these and deriving the third from the seasonally adjusted and benchmarked other two series. When the deflator is the derived one, care should be taken to prevent its path being affected by arbitrary differences in the separate adjustment of current price and volume data.
- While seasonality always has to be determined empirically, one should always try to understand what the causal factors may be.
- Both TRAMO/SEATS and X-12-ARIMA, together with well-documented and stable interfaces to these tools, provide a sound basis for seasonal adjustment. The choice between TRAMO/SEATS and X-12-ARIMA can be based on past experience, subjective appreciation and characteristics of the time series.
- TRAMO/SEATS and X-12-ARIMA have a number of parameters and specifications whose settings vary according to the characteristics of the series being adjusted. These should be reviewed on a regular basis and, if necessary, updated after satisfactory testing. The methods and specifications currently used in seasonal adjustment should be clearly communicated to users.
- Whichever method is used, there should not be a complete dependence on the automatic default options of the programs. Seasonal adjustment and QNA expertise should be used to verify and supplement decisions about the options used (e.g. for outlier treatment, model selection).
- As calendar effects are much stronger in monthly data than in quarterly data, it is better to use them, if available, to calculate the adjustments. For the same reason, the calendar adjustments for an aggregate should be derived from its components when the calendar effect is well defined within them (i.e. indirect approach to calendar adjustment). This applies to all decompositions, including regional, industry, etc.
- Unless suitable information is available to make a direct adjustment, it is recommended that a regression approach with ARIMA-based error modelling be used to estimate the trading/working-day and moving holiday effects. Calendar variables should be used for the trading/working days and the days affected by moving holidays. It is preferable if it is all



done in one model, rather than separately. Proportionate adjustments for working-days should not be used.

- h. The multiplicative model is most commonly used with X-12-ARIMA and the log-additive model is most commonly used with TRAMO/SEATS. Other models are used in particular circumstances, such as when the data are not strictly positive.
- i. Calendar adjustments should be made for those variables for which there is both statistical evidence and an economic explanation for calendar effects, which also includes a rationale for the order of magnitude of the estimated calendar effects. When deciding whether or not to apply a calendar adjustment, consideration has also to be given to related variables in the accounts in order to ensure accounting coherence.
- j. Calendar adjustments should be identifiable and sufficiently stable over time or, alternatively, it should be possible to model their changing impact over time appropriately. Changes in the selection of calendar effects should be based on both empirical evidence and economic explanation.
- k. Purely calendar adjusted data should be compiled in order to enable analysis of the impact of the non-seasonal calendar effect and to derive calendar adjusted annual data.
- l. When an abrupt change occurs, the effect should be estimated (by modelling the outliers) without delay. In the process of seasonal adjustment outliers should be detected and replaced before estimating the seasonal component. The adjustment should be reviewed prior to each subsequent seasonal reanalysis.
- m. The general principles for specifying ARIMA and regression models are parsimony and not to be fully data driven. A model needs to be validated by testing it under different circumstances and checking that the modelling structure has some robustness.
- n. The most important statistics in QNA are seasonally adjusted. Whatever the arrangements are within an NSI, it is imperative that there be people responsible for the seasonal adjustment of QNA with a high degree of seasonal adjustment expertise.
- o. Seasonally adjusted data should be made available to users and trend-cycle data can be made available to users. However, trend-cycle estimates for the latest quarter must be treated with a great deal of circumspection.
- p. Temporal consistency with annual raw (or calendar adjusted) data is not an intrinsic characteristic of seasonally adjusted data when the seasonal pattern is changing over time, which it commonly does. Forcing temporal consistency does incur 'damage' to the growth rates of the seasonally adjusted data, albeit the damage is usually relatively minor. However, in the wider context of deriving balanced and consistent unadjusted and seasonally adjusted, current price and volume data, benchmarking seasonally adjusted to raw (calendar-adjusted) annual data is practically unavoidable.
- q. A revision policy for seasonally adjusted data needs to be carefully considered: a balance needs to be struck between publishing the best possible seasonally adjusted figures; avoiding small, unhelpful revisions; and practical considerations.
- r. There are pros and cons for direct and indirect seasonal adjustment and their strength varies from series to series. As a consequence, each case should be considered on its merits.
- s. It is recommended that a complete seasonality check of current price, chain-linked volume estimates and their implicit price deflators be undertaken.
- t. Seasonal adjustment policies and practices should be publicly available.

## 8. The balancing of QNA

This chapter recommends that there should be a single definitive measure of GDP, that full balancing should be undertaken to ensure that no statistical discrepancies are left in the data, and that all variables should be eligible for adjustment. Current price and volume estimates, unadjusted and seasonally adjusted data should be balanced simultaneously.

The chapter discusses the process for balancing QNA. While it focuses on the use of supply and use tables to balance GDP, it also considers alternative ways of balancing GDP and addresses the process for balancing the accounts associated with GDP with the income, capital and financial accounts and also the institutional sector accounts.

The chapter describes the use of multivariate mathematical and statistical techniques to ensure that the balanced quarterly estimates are temporally consistent with their annual counterparts. It discusses how balancing using supply and use tables could be introduced, the need to explain to users and data suppliers the why and how of the balancing process, and the organizational arrangements for conducting the balancing process.

The chapter is supplemented by three annexes. The first describes a framework for the quarterly balancing process, the second is a formal presentation of balancing using mathematical and statistical methods, and the third describes the Dutch approach to balancing quarterly supply and use tables.

## Introduction

- 8.1. The process for compiling the national accounts attempts to make optimum use of the diverse range of available information. This information is invariably inconsistent due to measurement error, and it is therefore necessary to undertake a balancing process that both harmonizes the data in the national accounts and at the same time maximizes its accuracy. Therefore balancing is an integral and vital part of the compilation process. In broad terms, balancing seeks to confront and balance data using the accounting identities embedded within the national accounting framework. While the primary focus is on balancing elements from the production, expenditure and income measures of GDP, preferably using supply and use tables, the end-product of the balancing process should be a fully articulated and balanced set of accounts, with:
- a single, definitive estimate of GDP, and component series across the three measures that are fully consistent with this estimate;
  - consistent financial and capital accounts;
  - consistent institutional sector accounts.
- 8.2. This chapter looks at some general principles and procedures for balancing quarterly and ANA, but focuses on issues of particular relevance to balancing quarterly data. Some operational and related issues are also raised.
- 8.3. The way in which estimates of GDP and other national accounts components are made in practice depends very much on the range and quality of the information available. As this varies considerably between countries, it is not surprising that NSIs derive their quarterly national account estimates in different ways.
- 8.4. In general, quarterly information is less detailed and less accurate than annual data. This reflects the need to limit the statistical burden imposed on contributors, the limited resources of the NSIs responsible for collecting basic data and the fact that many administrative sources provide more and better annual data than quarterly data. Nonetheless, some countries are placing increasing emphasis, at least for some variables, on developing quarterly information as the main data source for the accounts. Provided the information is sufficiently reliable, this approach clearly reduces the problem of revisions.
- 8.5. Balancing can be undertaken in a number of ways. The preferred approach is based on the industry/product framework of supply and use tables or symmetric input-output tables<sup>(52)</sup>. Whichever type of tables are used the approach is the same. For the sake of ease of exposition and since supply and use tables are more commonly used than symmetric input-output tables, reference is generally made only to supply and use tables in the remainder of the chapter. Supply and use tables provide the means of establishing a definitive GDP figure and consistent estimates of the production, expenditure and income components. The principal alternatives are to balance at the level of GDP, either by making adjustments to components, by deriving some components as residuals, or by using automated statistical balancing techniques. Balancing using supply and use data at a detailed level has a number of advantages over such approaches:
- a. the process of confrontation between supply and use of products on the one hand and between gross value added and the incomes generated from it for each industry on the other hand generally leads to better estimates of GDP and its components. This is because it is easier to identify and remedy inconsistencies at a detailed level;
  - b. the outcome of the balancing process paints a coherent picture of the economy;

<sup>(52)</sup> For a comprehensive description of supply and use tables and symmetric input-output tables, and how the latter can be derived from the former see the *Eurostat Manual of Supply, Use and Input-Output Tables*.

- c. the balancing process makes the best use of the data available, with the most accurately measured components used to bolster weaker data;
- d. the balancing process fosters consistency in estimation in those cases where income, production and expenditure components are estimated using data from the same source, e.g. estimates relating to general government;
- e. national accounts compilers learn where the strengths and weaknesses are in their basic source data, and may take action to improve the latter;
- f. national accounts compilers, who may only be responsible for deriving preliminary estimates of a few components, have their experience and knowledge broadened and become better at their job by working in a comprehensive national accounting framework.

The balancing of production, expenditure and the income earned from production in a supply and use framework can be extended to include the institutional sector dimension and the distribution and use of income accounts, and the capital and financial accounts. Annex 8.A describes a framework which may be used for balancing and provides an example of manual balancing.

- 8.6. Partial balancing for particular products may be undertaken through the use of the *product (or commodity) flow approach*. When this approach is used to estimate demand from supply (or vice versa) consistency between production and expenditure is achieved, but the procedure is not strictly balancing.
- 8.7. A formal process of balancing the accounts is beneficial no matter how good or comprehensive the basic data are. If the data are comprehensive and of good quality, they are still unlikely to be consistent and the confrontation and balancing process can lead to both consistency and an improvement in the quality of the estimates. If the basic data are incomplete and of variable quality, then the better quality data can be used to impute missing values and improve the quality of the other estimates.
- 8.8. Balancing should be undertaken for both current price and volume data in order to provide an integrated and consistent set of accounts. Furthermore, by comparing the price indices implicit in the current price and volume estimates with external price indices, such as the CPI, the process of confrontation and balancing can lead to better current price and volume estimates of production and final expenditures, particularly if the balancing of the current price and volume data is conducted in a coordinated way (this is discussed further below and in Chapter 9).
- 8.9. EU Member States compile their volume estimates as chain Laspeyres-type indices (see Chapter 6). In effect, estimates are derived in the prices of the previous year and then linked together. While the estimates in the prices of the previous year are additive, the chain indices are non-additive, and so it is the estimates in the price of the previous year that must be used in the balancing process.
- 8.10. The processes for balancing annual data largely apply to quarterly data, but there are a number of factors that affect what might be done quarterly:
  - a. The range and quality of quarterly information is generally much less than is available annually. This increases the need for bringing together all the available data within the national accounting framework in order to make the most of what is available. At the same time, it inevitably means some simplification for the quarterly approach, such as less detailed supply and use tables compared with those used annually.
  - b. Another important difference between annual and quarterly balancing is that the latter should be undertaken for both unadjusted data and seasonally adjusted data. The need to deal with these two sets of data, as well as current price and volume estimates, and the comparatively high statistical variability of some quarterly data, adds to the operational complexity of the balancing process.

- c. Timeliness is more important for QNA than it is for the annual, and so there is less time for quarterly balancing.

8.11. The data for a particular quarter have to be balanced many times for a number of reasons:

- there are current (or routine) revisions comprising revisions to the quarterly source data, the introduction of annual benchmarks and the revision of annual benchmarks;
- there are occasional revisions resulting from such things as changes in surveys or the introduction of new methods, standards and classifications.

This has far reaching implications for staffing, timetables, revisions policy, and the computer systems used to support QNA. Semi-automated computer systems that have been developed to support these processes are briefly described in the main body of the chapter and in Annexes 8.B and 8.C. The process of revision is discussed further both in this chapter and in Chapter 10.

8.12. Some NSIs use the same compilation process, including balancing in an industry/product framework, for every edition of their QNA, including flash estimates. Other NSIs choose to use a more limited compilation process for their flash estimates and a more comprehensive process, which may include balancing supply and use tables, for subsequent editions. Whichever approach is adopted, it is nearly always the case that the balancing process for the first one or two editions of the accounts for a particular quarter (excluding flash estimates) is more wide-ranging and time-consuming than the balancing process for subsequent editions. The bulk of the discussion in this chapter concerns this comprehensive balancing. Chapter 5 addresses issues concerning univariate temporal consistency, while the issue of ensuring that balanced QNA are also temporally consistent is addressed in this chapter. The extension to retrospective balancing is also considered in this chapter.

### Key principles of balancing

8.13. There are four principles that should underlie the balancing process in the national accounts, and which apply equally to annual and quarterly data:

- a. Even though GDP may be estimated independently from production, expenditure and income sources there should be a single, definitive measure of economic activity.
- b. The sum of the components of GDP should add up to the total estimate of GDP. If an estimate for GDP is established before estimates for all components have been determined, the component information should be adjusted so that the production, expenditure and income components are consistent with the overall GDP estimate, with no statistical discrepancies or residual errors, but there are two important caveats:
  - the published production, expenditure and income components should be meaningful and be of sufficient accuracy and reliability to support economic analyses by users;
  - the balancing process may lead to the preliminary estimate of GDP being changed, albeit by not a great amount.
- c. In order to achieve a balance, all component series, and not just selected variables, should be eligible for adjustment.
- d. Current price and volume estimates, unadjusted and seasonally adjusted should be balanced.

These four principles are considered briefly in the following paragraphs.

- 8.14. On the first principle, it would clearly be very confusing for users to have more than one estimate of GDP in the public domain, and it is fair to say that there is little dispute with the idea of a single estimate of GDP. In practice, the definitive figure should be based on information from the available production, expenditure and income measures of GDP.
- 8.15. On the second principle, the need for — and the extent of — an adjustment procedure varies among countries. For some countries, although a single GDP is established and figures for certain variables are adjusted, there is caution about eliminating completely the discrepancies in the separate measures, and statistical discrepancies remain in the various estimates. This practice is commonly justified on the grounds of not wishing to make too large changes to the basic data, and of not knowing where precisely any such adjustments may be made. It is also often argued that such adjustments may be viewed as largely arbitrary and lacking transparency. Furthermore, large adjustments may be thought of as distorting the basic information, and this could have a major adverse effect on public confidence in the national accounts. Finally, there are the practical aspects of maintaining long time series of balanced QNA in an environment where quarterly source data and annual benchmarks are revised repeatedly.
- 8.16. A counter argument is that accounts that are not balanced and contain discrepancies may be seen as ‘unfinished’. Such accounts cannot be seen as providing a wholly consistent and coherent picture of what is happening in the economy. It can also be argued that the basic statistics are not being used in the optimum way and the best service is not being provided to users who expect the national accounts experts to derive estimates that accord with the framework of the accounts.
- 8.17. It should not be forgotten that the basic statistical information used in the accounts has in most cases already undergone a number of not always firmly-based adjustments prior to the balancing process. For example, where administrative sources of data are used it may be necessary to modify the figures so that the definitions accord with those required for the national accounts. Survey data are subject to adjustments to minimize non-sampling errors, such as those arising from non-response or the inadequacies of the sampling frame, and then may undergo further adjustments for scope and coverage deficiencies. The adjustments made within the balancing process may therefore be seen as the final stage in a continuum of statistical estimation, and it is logical for this to be carried through until a full balance is achieved. Thus not to balance fully involves an arbitrary decision on where to draw the line.
- 8.18. Full balancing is certainly not a subterfuge for manipulating data in support of a particular viewpoint. There is clearly more opportunity to manipulate the interpretation of the data when different GDP measures are available (although the existence of more than one measure could equally be seen as a contribution to transparency in the compilation process). Suspicions which users, data suppliers and national accounts compilers may have should be allayed by explanation and education. (Such issues of presentation and education are discussed at the end of this chapter.) However, the main argument for full balancing is that it provides the best set of national accounts data, and it does so by making the best use of all the available information.
- 8.19. Where operational problems arise, compilers should attempt to overcome them as well as possible. Amongst other things, this will include ensuring that sufficient time is available for the vital process of balancing. The need for balancing should therefore be a key feature in the determination of the overall timetable for the production of the estimates, and not fitted in as best as can. (This issue is discussed further later in the chapter- see §8.101-8.106).
- 8.20. On the third principle, concerning which variables are adjusted in the balancing process, again country practice varies. Where annual supply and use tables are compiled, NSIs tend towards unrestricted adjustment. In other NSIs, adjustment may be limited to a few of the less accurate variables; for example, changes in inventories within the expenditure measure of GDP and operating surplus within the income measure. In some cases these two components may not even be directly measured, and they are simply

derived as residuals from total GDP. It is strongly recommended that all components should be estimated directly, and all components should, in principle, be eligible for adjustment in the balancing process – although some may be judged to be so highly accurate that they are fixed. The arguments put forward for restricting the adjustments to only a few variables are very much the same as those already made in relation to the extent of the balancing process. In particular, there is a perceived uncertainty about the magnitude of any adjustments, and also with more variables being adjusted there is greater complexity and more time is needed for the whole balancing process.

- 8.21. An operational reason sometimes given for restricting variables for adjustment regards information that is compiled and published outside the main national accounts production round. A particular example concerns the existence of monthly data that are published before the overall balancing process is undertaken, and a concomitant reluctance to publish national accounts estimates that are inconsistent with the basic data. (This issue is considered further below - see §8.104-8.106).
- 8.22. These statistical and operational problems do not change the fact that restricting adjustments to a few series cannot provide the best estimates of aggregate and component series. In particular, the time series of the one or two variables that are adjusted will not be very meaningful, since all the ‘errors’ in the variables not being modified will be incorporated implicitly in the estimates of those figures that are adjusted. Therefore it is recommended that all variables should be eligible for adjustment in the balancing exercise. The practical problems of following this approach are recognized and are not underestimated, but ways must be found to overcome them.
- 8.23. The fourth key principle is that balancing should be undertaken for current price and volume data simultaneously, as noted in §8.8. In doing so, the methodology should incorporate the possibility of some adjustment to the component price information. In other words, the implied price deflators, derived as the ratio of the adjusted current price data to the volume data (i.e. estimates in the average prices of the previous year), are allowed to vary within reason from the original figures. In this way, not only are the current price data and volume data made to fit into the framework of the accounts, but proper use is made of the available price data. This is considered in more detail below in relation to the quarterly balancing process where there is the added complication of the existence of unadjusted and seasonally adjusted data.
- 8.24. In summary, it is recommended that the accounts should be completely balanced with a single measure of GDP and no statistical discrepancies. The objective is to maximize the quality of all published estimates such that they portray a coherent picture of the economy. This requires that all components should be eligible for adjustment. Only this approach can provide the most meaningful set of economic data, and the onus is on the compiling statisticians to use their expertise to see that this is done. There may be either statistical or operational obstacles in the way of pursuing this approach and they need to be overcome. Some of these issues are considered later in the chapter. Finally, it is vital to keep users informed about the balancing process and, most crucially, maintain their confidence in the estimates.

### Other important features of balancing

- 8.25. Before looking at the specific issues for quarterly balancing, it is necessary to consider a number of other features of the balancing process. These are presented largely as recommendations as to how balancing should be pursued in principle. However, as will be evident in what follows, the extent to which they can be incorporated within balancing practices in individual countries will depend very much on the availability of statistical and other information.
- 8.26. First, the balancing process for both total GDP and the component series should be based on the accuracy of the data included in the (quarterly) accounts. Unfortunately, the proper derivation of accuracy measures of national accounts data is an extremely difficult process, so complex that few countries have

even approximate estimates. The only type of error for which it is possible to readily quantify it, is sampling error, but there are likely to be very few variables in the accounts where the only source of error is the sampling error. Indeed, for most variables, non-sampling errors are likely to be more important than sampling errors.

- 8.27. A second best solution is to utilize a relative assessment of accuracy. For example, that the estimate of household consumption is, say, half as accurate as that of gross fixed capital formation. In the absence of any firm quantitative information, which represents the usual position in most countries, a judgemental assessment should be made based on the views of the source data providers, the national accounts compilers and the balancing team. By this means it should be possible to form some broad consensus view on the relative accuracy for all parts of the accounts. Having this material as a basis for balancing is certainly better than having no information at all. The accuracy of data sources should be regularly assessed because of the potential for changes in accuracy as a result of changes in the underlying generating processes.
- 8.28. Revisions are sometimes seen as a measure of accuracy, whereas in fact they just indicate how much estimates change between editions. The extent of revisions from the preliminary estimates to the final ones, the number of editions it takes until convergence is achieved and the path the revisions take are all aspects of “reliability”. Preliminary estimates that are close to the final estimates are said to be reliable. This is quite different to statistical accuracy, which is the difference between an estimate and the notional true value of the variable being estimated. Clearly, reliability is highly desirable as long as it does not come at the expense of accuracy.
- 8.29. Data accuracy is also relevant to another aspect of the balancing process. As will be explained later, part of balancing involves making use of information based on the structure of economic activity provided by the latest annual supply and use tables; for example what proportion of supply might go to household consumption. It becomes necessary, then, to make an assessment of the likely accuracy of such ‘structural’ estimates against that of the directly-measured data for the current quarter.
- 8.30. A further important feature about balancing is that, as well as achieving balance in the levels of the variables for a particular quarter or year, it is also vital to consider the related growth rates of the variables. In other words, it would not be acceptable to balance data for, say, two successive quarters if the results showed estimates of growth between the two periods which differed greatly from the original figures or were otherwise implausible. Note that the “original” figures referred to here have already undergone part of the validation process – see Chapter 9. Thus accuracy estimates are also required for growth rates. As for levels, the accuracy of growth rates can usually only be derived in a relative sense using judgement, and there should be some statistical relationship between the relative accuracy measures of the two. Likewise it is crucial that the adjusted components are plausible as time series, as such data are vital for many forms of economic and statistical analyses. In practice, the need to consider balancing as a three-dimensional, rather than a two-dimensional, process clearly adds to the complexity of the whole exercise.
- 8.31. Another point to be borne in mind is that the basic data used in the balancing process should as far as possible be free of measurement bias. Where such biases are thought to exist (for example as a result of a less than complete coverage of statistical registers, or reflecting inadequate definitions of variables) the basic data should be adjusted before being used in the balancing process. How to maximize the quality of basic data is discussed in Chapter 3, and the issue is discussed further in relation to quarterly balancing in §8.40.
- 8.32. The principles discussed above largely apply to the balancing of both annual and quarterly data. The chapter now goes on to discuss particular issues and procedures relating to quarterly balancing.



## Issues and procedures for quarterly balancing

8.33. Unlike annual data, quarterly data are subject to seasonal and other calendar-related variation and there exist both unadjusted and seasonally adjusted data <sup>(53)</sup>. This raises the question of whether both sets of data need to be balanced. On the one hand the seasonally adjusted data are much preferred by users for analyzing the performance of the economy and in particular for assessing growth, and on the other hand the unadjusted data represent the actual flows in the economy and they are also favoured for calculating ratios. Thus there is a strong case for balancing both sets of data. However, balancing unadjusted data raises a number of practical difficulties, which are addressed below.

### *Meaningfulness of the set of quarterly figures to be balanced*

8.34. The first issue is the need to have a meaningful set of quarterly figures before balancing begins. For some variables, the figures appearing in the accounts may largely reflect administrative and other arrangements that exist for making payments. Three examples are interest payments, taxes on operating surplus and recurrent taxes on land, buildings and other structures. Similar problems may arise when information is recorded on a cash, rather than an accrual, basis. Given all this, the question is what constitutes a meaningful quarterly series.

8.35. The question has been considered in Chapter 2 (see §2.29-2.32). In brief, it should be possible to establish an acceptable quarterly profile for the seasonally adjusted series of most variables. The problem of meaningfulness of the quarterly figures relates mainly to the unadjusted series. In principle, all variables in both unadjusted and seasonally adjusted form, should as far as possible appear on an accrual basis <sup>(54)</sup>. Two possible solutions might be considered:

- a. in some cases it will be possible to relate the variable of interest to an ‘explanatory’ variable. One example is to determine the quarterly unadjusted profile for taxes on operating surplus by using the corresponding series of the operating surplus itself;
- b. where the first method is not possible the quarterly unadjusted series can be determined by some form of distribution.

8.36. Partly due to time of recording problems and partly due to other measurement problems, which are discussed below, the unadjusted quarterly figures will usually be somewhat more inconsistent than their seasonally adjusted counterparts because seasonal adjustment will reduce, if not eliminate, inconsistencies that are seasonal. Unadjusted quarterly series for GDP based on the separate production, expenditure and income data are likely to be significantly different. It is, however, necessary to determine a preliminary, unadjusted quarterly GDP figure to which data are balanced.

8.37. One of the other measurement problems encountered when balancing unadjusted quarterly data, referred to above, relates to the way in which information about the structure of economic activity of a recent year is used as a basis for making estimates for the current quarter. For example, the assumptions required to allocate an industry’s output to household consumption are likely to be more tenable for the smoother seasonally adjusted quarterly estimates than for the more erratic unadjusted data. Another example arises from a lack of quarterly data for intermediate consumption. It is common practice to impute initial values by multiplying quarterly output data with the ratio of intermediate consumption to output for a recent year. However, the ratio of intermediate consumption to output may be seasonal due to such things as the greater use of energy in winter. Problems of this kind are common, and so much caution is needed when balancing unadjusted data.

<sup>(53)</sup> The term “seasonal adjustment” is used to cover both seasonal and calendar adjustment (such as for moving holidays, like Easter, see Chapter 7 for further details).

<sup>(54)</sup> There are some variables, notably dividend payments, compensation of employees and taxes, that are not recorded on a completely accrual basis for practical reasons.

- 8.38. This type of problem is most relevant in the first year in which quarterly balancing is undertaken. Afterwards it should be possible to establish firmer quarterly supply and use tables that can provide the framework for the ‘structural’ estimates that enter the balancing process. In other words, the estimates of unadjusted data for a particular quarter made within the balancing process can, where appropriate, be based on the supply/use framework of the same quarter of the previous year.
- 8.39. It is highly likely that implicit seasonal factors of the balanced seasonally adjusted and unadjusted data will differ from the seasonal factors derived before balancing. This is an acceptable outcome as long as the implicit seasonal factors approximately cancel each other out over a year, i.e. the average of multiplicative seasonal factors is close to 1. However, if the unadjusted and seasonally adjusted data are balanced independently, then there is a high risk that the implicit seasonal factors will not have this property, which would imply that the balanced data are inconsistent. Therefore, the two sets of data need to be balanced together in a consistent way. Given that the current price and volume data should be balanced simultaneously, for much the same reason, then it follows that all four sets of data should be balanced simultaneously. How this should be done in practice is discussed below.
- 8.40. As mentioned earlier, the data going into the balancing process should be as far as possible free from measurement bias. Unless this is achieved, the estimate of GDP will not be a central estimate, and the estimation and balancing of the component series will be less than optimal. Furthermore, quarterly estimates serve as early estimates for ANA, and so any bias evident in the quarterly figures will affect the initial annual estimates.
- 8.41. It always best to identify and eliminate bias in the basic data, and the processes for doing this are discussed at length in Chapter 3. If this is not possible, then it is the job of the national accounts compilers to do their best to eliminate any known bias when deriving the initial national accounts estimates. Sometimes biases become evident in the balancing process, such as when a particular component is persistently out of balance. Such instances should be followed up by an investigation by the responsible compiler and a long-term remedy sought. Otherwise, biases may only be identified during a revisions analysis (see Chapter 10). Hence the need to conduct revisions analyses frequently.

### The quarterly balancing process

- 8.42. This section looks at how the key statistical and operational aspects discussed above can be implemented in practice. It also discusses the framework to be used for balancing and the steps to be followed in the balancing process. The discussion will be presented essentially in terms of balancing for the current period. Retrospective balancing is considered in §8.99-8.101.
- 8.43. The most appropriate framework for the balancing process is provided by the industry/product framework of supply and use tables or symmetric input-output tables. A supply table shows the supply of goods and services by product and by type of supplier, distinguishing supply by domestic industries and imports from other countries. The use table is a product by industry table with products and components of value added in the rows, and industries, categories of final uses and imports in the columns. A use table shows the use of goods and services by product and by type of use, i.e. as intermediate consumption by industry, final consumption, gross capital formation or exports. Furthermore, the table shows the components of value added by industry, i.e. compensation of employees, other taxes less subsidies on production, consumption of fixed capital and net operating surplus.
- 8.44. Input-output tables are symmetric matrices, either product by product or industry by industry. They are derived from supply and use tables after certain transformations have been made, which are dependent on

certain assumptions <sup>(55)</sup>. In practice, and partly for this reason, it is suggested that quarterly balancing is undertaken through the supply and use tables, rather than the symmetric input-output table.

- 8.45. Given the short space of time in which QNA are compiled, one might think that there would be insufficient time to balance detailed supply and use tables. On the contrary, experience has shown that it takes no longer to balance detailed supply and use tables than it does to balance highly aggregated ones once suitable computer systems have been constructed, and a better outcome is achieved. Therefore, while it is generally the case that the available basic quarterly data are less detailed than the annual data and cannot support supply and use tables as detailed as the annual ones, it is recommended that the quarterly supply and use tables should be as detailed as practicable.

Member States that compile their QNA within a supply and use framework invariably already have a well-established annual system for balancing supply and use tables.

### Automated and manual balancing

- 8.46. It is a commonly held view that annual supply and use tables are best balanced manually<sup>3</sup>, albeit being well supported with computerized tools. However, quarterly supply and use tables need to be balanced in a very short space of time, and many of those EU Member States that do balance their quarterly supply and use tables have found that they achieve a better outcome in these circumstances using automated procedures. Their general approach is to address major discrepancies manually and balance the remainder automatically, although where the borderline is drawn between the two may vary between countries. Member States that use this approach cite a number of advantages, namely:
- a. defining a set of statistical discrepancies to be dealt with manually results in far more organisational control of what gets investigated, the quality of those investigations and the subsequent documentation;
  - b. automated balancing of the smaller discrepancies leads to more consistent balancing over time and allows more time to focus on the more problematic data.

The Dutch approach is described in Annex 8.C and briefly referred to in §8.89. A key feature of the Dutch approach is that explicit assessments are made of the relative accuracy of the preliminary estimates of each component and these are used as weights in the balancing process. It is claimed that this is a major contributor to consistent balancing over time.

### Key features of the balancing process

- 8.47. Chapter 8 of the *Eurostat Manual of Supply, Use and Input-Output Tables* is devoted to balancing annual supply and use tables, and it provides a useful guide as to how to proceed with the balancing of quarterly supply and use tables. Of course, there two very important caveats: the quarterly balancing must be completed in a few days, rather than weeks or months, and there are much less data available quarterly. Hence there is a need to assess the appropriateness of the annual guidelines for use in a quarterly context. Key features of the recommended annual guidelines are:
- a. the balancing process should be systematic;
  - b. the following four matrices should be compiled before the balancing begins:
    - production matrix at basic prices
    - use table at purchasers' prices
    - use table of imports at basic prices
    - valuation matrices;

<sup>(55)</sup> See Chapter 11 of the Eurostat Manual of Supply, Use and Input-Output Tables.

- c. the supply and use tables should be derived in both basic prices and purchasers' prices, and balanced simultaneously;
  - d. balancing the supply and use of each product category and the value added of each industry category should be done manually;
  - e. software tools should be used as much as possible: from creating the preliminary tables to editing the results.
- 8.48. In the supply table, flows of goods and services are valued at basic prices, while in the use table the flows of goods and services are valued at purchasers' prices. In order to attain identities between supply and use they need to be valued at the same prices, such that either:
- supply at purchasers' prices is equal to use at purchasers' prices; or
  - supply at basic prices is equal to use at basic prices.
  - The transition from supply at basic prices to purchasers' prices involves using the valuation matrices:
    - reallocating and adding trade margins;
    - reallocating and adding transport margins;
    - adding taxes on products (except deductible VAT);
    - deducting subsidies on products.
- 8.49. The transition from use at purchasers' prices to basic prices requires doing the reverse.
- 8.50. Both the 2010 ESA and the *Eurostat Manual of Supply, Use and Input-Output Tables* propose valuing the supply and use tables at both basic prices and purchasers' prices. Given the need for speed and the assumptions required to derive the quarterly valuation matrices, the case for doing both in a quarterly context is somewhat weak. The use of automated balancing for the quarterly supply and use tables has already been addressed. Hence there are two of features of the recommended annual approach that may best to ignore in the quarterly context:
- the supply and use tables should be derived in both basic prices and purchasers' prices, and balanced simultaneously;
  - the supply and use of each product category and the value added of each industry category should all be done manually.
- 8.51. Annex 8.A provides an illustration of the kind of supply and use framework which can be used for quarterly balancing and explains how the component variables may be estimated. In order to achieve consistency in valuation between supply and use, supply is valued at purchasers' prices. The 'structural' information presented in Annex 8.A may be regarded as applying to both current price and volume estimates (i.e. values in the prices of the previous year), except for the income components, and also unadjusted or seasonally adjusted figures. As mentioned earlier, care needs to be taken in using the annual structure of the supply and use tables for balancing unadjusted quarterly data, especially for the first year. The format adopted for balancing can be readily modified to meet any specific individual country's requirements and data availability.

**Steps in the balancing process**

- 8.52. How a system of supply and use could, or should, be balanced crucially depends on the available information. One approach is to mimic the annual balancing process as much as possible by estimating all the components of the supply and use tables, and then use a bottom up approach to balance the supply and use of each product and the production and income estimates of value added for each industry, separately and iteratively, until a complete balance and a unique measure of GDP are achieved. Provided enough data are available, this approach is likely to lead to a good GDP estimate. With less information available, as is generally the case, a more top down approach may be more appropriate.
- 8.53. The first step in such a top down approach in the quarterly balancing process is to establish some indication of the likely level and growth of GDP. The available, bias-free estimates of GDP using the three approaches (production, expenditure and income) should be ‘weighted’ together to form a provisional, first estimate of GDP. The weights for this purpose should reflect the compilers’ judgement of the relative accuracy of the various measures. This process can be undertaken in both current price and volume terms in both seasonally adjusted and unadjusted terms and in relation to both levels and growth rates. The plausibility and consistency of the derived figures should be ensured as far as possible by following the relevant validation procedures described in Chapter 9. Given that the growth rate of the seasonally adjusted volume estimate is the headline figure, it should be the primary focus of attention.
- 8.54. At this stage, the GDP estimate is to be regarded as a ‘target’ in the balancing process rather than a definitive figure. However, in the absence of any new data, the final estimates for total GDP made after the balancing process should not be too different from this provisional estimate.
- 8.55. Full balancing requires four sets of SUTs, as well as three supporting data sets of information, comprising the current price and chain-linked volume seasonal factors, and price indices. The seven data sets are:
1. current prices not seasonally adjusted;
  2. estimates in the prices of the previous year not seasonally adjusted;
  3. current prices seasonally adjusted;
  4. estimates in the prices of the previous year seasonally adjusted;
  5. current price seasonal factors;
  6. seasonal factors for estimates in the prices of the year;
  7. prices not seasonally adjusted.

Of these, the first four are to be balanced, with the information on seasonal factors and prices providing the ‘link’ between the various tables. Data for the four sets of SUTs can be assembled along the general lines outlined in the Annex 8.A, using largely independent sources and particular estimation methodologies.

- 8.56. The only prices data listed above are unadjusted. This rests on the assumption that most prices are non-seasonal, and only a few like agricultural products are likely to be strongly seasonal, and even in this case at least some of the seasonality can be explained by the production of storage services. (The rise from the seasonal low to the seasonal high in the prices of agricultural products held in storage reflects a change in quality due to the products being transported through time, and thus a change in volume. This issue is discussed further in the section devoted to storage in Chapter 2.) Nevertheless, it is for the national accounts compilers to determine whether a table of seasonally adjusted price information should be

established for evaluating the relationship between the seasonally adjusted current price estimates and estimates in the prices of the previous year.

- 8.57. In most cases volume estimates are derived by deflating a current price value with an appropriate price index, but in some cases quantity data may be used. In either case the prices used in the balancing will be the implicit price deflators (IPDs). (Volume estimation is discussed in Chapter 6).

### *Creating the data sets*

- 8.58. It is rarely the case that all the data required to populate the supply, use and valuation tables are available quarterly, and assumptions have to be made in order to impute values for the missing data. The absolute minimum data requirements are output by industry category and the totals of final use for each major aggregate, but obviously more source data is highly desirable. In the absence of any other information or evidence to the contrary, the structures of production, intermediate consumption and final expenditures of the latest year can be used as a starting point for each quarter in the current year. Specifically:
- output by industry by product can be imputed by using the output product composition for each industry category from the latest annual supply table or the table of the same quarter of the previous year;
  - if data for intermediate consumption by industry are available, then the product composition of each industry category can be imputed using data from the latest annual use table or the table of the same quarter of the previous year;
  - if data for intermediate consumption by industry are unavailable, then they can be imputed by using the ratio of intermediate consumption to output from the latest annual supply table or the table of the same quarter of the previous year;
  - final uses by category by product can be imputed by using the uses composition for each industry category from the latest annual use table or the table of the same quarter of the previous year;
  - initial estimates of trade and transport margins, and taxes and subsidies on products can all be imputed by assuming that the same rates per product apply as per the latest annual supply table or the table of the same quarter of the previous year and then making pro rata adjustments to ensure the values sum to known totals.
- 8.59. Since changes in the product composition of supply and use generally occur relatively slowly, the assumption that latest year's product composition applies this year is likely to be a broadly acceptable assumption. However, as argued earlier, using the product composition of the latest year will be much less pertinent for unadjusted data than for seasonally adjusted figures. The reason for this is that seasonality in production and consumption will mean that the quarterly structure of the unadjusted figures will be different from the annual structure. For the unadjusted data it is necessary to consider the supply/use table for the same quarter of the previous year.
- 8.60. If some price relativities have changed substantially from the latest year, or the same quarter of the previous year, then one needs to consider if the supply and use of the products concerned are price inelastic (volumes change relatively little in response to price change) or elastic. If they are price inelastic, then the assumptions will hold better in volume terms.
- 8.61. There may be certain industries where the industrial mix of outputs and inputs may vary over quarters in a way which, ideally, should not be ignored, even for the seasonally adjusted data. For example, if the output product mix varies in seasonally adjusted terms and if the inputs required to produce a product vary from product to product within an industry, then, ideally, this should be taken account of in estimating the product composition of the intermediate inputs. Thus in deriving the various product-based

estimates it may be necessary in some quarters to modify the proportion shown by the previous year's tables.

- 8.62. There is one further complication in the case of seasonally adjusted data where the aggregates have been directly adjusted, rather than by summing their seasonally adjusted components. In this case, the seasonally adjusted figures need to be made additive before populating the supply and use tables. There are several ways of doing this, but the generally preferred way is to calculate the residual between the sum of the components and the aggregate and then to distribute it to each component on a pro rata basis.

### *The balancing steps in practice*

- 8.63. Although mention has been made earlier of the need to balance the current price and volume estimates in unadjusted and seasonally adjusted terms simultaneously, in practice some order to the process must be followed. Countries that undertake balancing adopt a variety of different approaches. For some the starting point is the SUT of current price seasonally adjusted figures. For others the emphasis is on the unadjusted volume data. It is therefore inappropriate to recommend that balancing should be undertaken in any particular sequence. This decision should be left to individual countries in the light of the way they compile the accounts and depending on other issues at the national level. The key point is that, whatever sequence of adjustment is adopted, all four SUTs (1 to 4 in § 8.55) should be balanced in a coordinated way. The description of a possible balancing process given here is based on the use of the current price seasonally adjusted estimates (that is SUT 3) as the starting point for balancing.
- 8.64. On the basis of the suggested framework and approach to data estimation set out in Annex 8.A, the first steps in the balancing process should be the comparison of:
- a. the first initial estimate of GDP with the estimates implied by the data in the tables;
  - b. the estimates of supply and use for each product;
  - c. the outputs and inputs of each industry;
  - d. gross value added with income-based estimates, if available.
- 8.65. A further set of relevant 'structural' information is provided by making estimates of the components of use for each product. This is to be done by breaking down the total use according to the pattern of demand shown by the supply/use framework for both the latest year and also the same quarter of a year earlier. These data can then be compared with the more directly estimated use data.
- 8.66. The quarterly balancing process commonly begins by balancing supply and use for each product, that is item (b) above. This involves a close assessment of the levels and growth rates of the individual series and their relative accuracy. The comparison can also include the completely imputed use data described in the previous paragraph. Note that for the quarterly figures, estimates of growth are likely to be more accurate than that of levels. Consideration also needs to be given to the deflators and seasonal factors.
- 8.67. The resulting estimates of value added for each industry are then assessed (growth rates, deflators, seasonal factors, etc.) and compared with income-based estimates, if available. A second round of balancing supply and use is then undertaken, and so on until a satisfactory set of balanced supply and use tables has been achieved. At each stage, ancillary information is used, principally from recent annual tables and the same quarter of the previous year; for example, ratios of output to value added and of taxes and margins to supply, but also data external to the supply/use framework, such as employment data. Steps in data validation are described in Chapter 9.

- 8.68. In the previous two paragraphs reference was made to assessing the deflators and seasonal factors at each stage. This reflects the fact that although the focus is primarily on the seasonally adjusted current price data at this step in this example, the other three sets of supply and use tables are being balanced in parallel, round by round, if not product/industry by product/industry. While deflators are subject to adjustment, any adjustments should be made after considering any comparable price indices, taking account of differences in scope, index construction and margin of error. Adjustments to seasonally adjusted and/or unadjusted data resulting in changes to implicit seasonal factors should ensure that the latter roughly balance over the latest four quarters (i.e. the average of multiplicative seasonal factors should approximate 1).
- 8.69. Once the quarterly current price seasonally adjusted figures have been balanced, the resulting data should be deflated to yield seasonally adjusted estimates in the average prices of the previous year. These can be compared with the unbalanced seasonally adjusted estimates in the average prices of the previous year (SUT 4 in § 8.55), from which a ‘best’ matrix of balanced seasonally adjusted estimates in the average prices of the previous year is derived, based largely on the compilers’ judgement.
- 8.70. The next step is to repeat the same procedures for the unadjusted data. The whole process will yield four balanced and consistent sets of national accounts data. These can be further examined for overall plausibility and further, expectedly small, adjustments made as needs be.
- 8.71. Although growth in the seasonally adjusted volume measure of GDP is the most important statistic in QNA, it is vitally important that the accounts portray a coherent and consistent picture of what has happened in the economy during the quarter. This means that every published statistic has to be meaningful in its own right and able to withstand scrutiny by users. National accounts compilers must avoid using certain aggregates as convenient places to hide discrepancies without regard to the resulting estimates. For example, estimates of changes in inventories obtained from business surveys are commonly subject to large standard errors of movement from one quarter to the next, and therefore often display large erratic movements that can have a major impact on GDP growth. Knowing this, national accountants commonly make adjustments to changes in inventories in achieving product balances. But at the end of the balancing process, the national accountants should be confident that the resulting estimates of changes in inventories are meaningful and make sense in the picture being portrayed of the quarter’s economic activity. Estimating and adjusting changes in inventories is discussed in detail in Chapter 2 (see §2.136-2.162).
- 8.72. The balancing exercise, particularly if it extends over a number of days, should be an iterative process, moving in stages to a level of GDP and a fully reconciled set of data. Data suppliers need to be consulted and validation checks need to be undertaken at each stage. The process should also take into account the various constraints and criteria that need to be satisfied. Balancing at a detailed level may lead to adjustments that will revise the first initial estimates of the level and growth rate of GDP established at the outset. This is a legitimate part of the balancing procedure.

### Alternatives to balanced supply and use tables

- 8.73. The procedures described above rely on the availability of annual supply and use tables to provide the basis for, and the framework within which, quarterly balancing can be undertaken. If such annual tables do not exist, or if they do but resources or time are insufficient to permit the balancing of quarterly supply and use tables, then there are other possible courses of action.



***Compiling unbalanced detailed supply and use tables***

- 8.74. One option is to prepare supply and use tables as detailed as the available data permit, but not proceed to a complete balance. The supply and use tables can be created as described above, and major discrepancies can be resolved. The thrust of the approach may be built on the following three key steps:
1. a figure for GDP is derived by weighting together estimates from the production, expenditure and income approaches, as available;
  2. resolve major discrepancies;
  3. component data at the aggregate level are adjusted so that each of the (three) measures accords with the definitive GDP.
- 8.75. The adjustments in step 3 are made by allocating the discrepancies to components according to their estimated relative accuracy and/or any other relevant information. The approach can be undertaken for both current price data and estimates in the average prices of the previous year, and also unadjusted and seasonally adjusted data, again taking into account prices and implicit seasonal factors. This approach could also be undertaken as an intermediate stage on the road to full balancing. Another alternative is to stop at step 2 and publish the data with the remaining discrepancies.

***Compiling highly aggregate supply and use tables***

- 8.76. Another option is to prepare very small SUTs at the A10 industry level, say, with a corresponding small number of product categories, and undertake either a complete or partial balancing. This is essentially a half-way house between balancing detailed SUTs and balancing at the level of GDP.

***Partial supply and use tables***

- 8.77. Yet another option is to undertake product balancing for a limited number of products from where it is suspected that major discrepancies arise, e.g. petroleum and motor vehicles. Product balancing could also be undertaken for major products that are easy to balance, such as the services predominantly produced by the non-market sector.

***Balancing GDP***

- 8.78. A less sophisticated and less satisfactory approach to balancing, albeit one which is used by some Member States, is to confront the estimates of GDP derived by the three different approaches. Adjustments can be made on the basis of the perceived relative accuracy of the components of each approach, the plausibility of the growth rates of each measure of GDP and its components, the adjustments made in previous quarters and the initial statistical discrepancies between the three measures of GDP and their average. Application of adjustments should be preceded by a process of validation as described in Chapter 9. Whilst this approach is regarded as inferior to supply and use balancing, the estimates of GDP derived can nevertheless be of good quality if the estimates of the components used in each of the three approaches are soundly based. Benchmarking the components to annual data from balanced annual supply and use tables minimizes short-term drift and usually ensures that the initial statistical discrepancies are relatively modest.

***The net lending/borrowing procedure***

- 8.79. The balancing item in both the capital account and the financial account is net lending/borrowing. The balance in the capital account is the culmination of income and expenditure flows arising from the

production account (GDP(P)), the generation of income account (GDP(I)), the distribution and use of income accounts and the rest of the world account. The balance in the financial account reflects changes in the holdings of financial assets and liabilities of institutional units arising from these flows. The values should be the same, but in practice they are not. Balancing seeks to resolve this.

- 8.80. One way of proceeding is to first establish initial estimates for GDP and net lending/borrowing in the light of the perceived accuracy of the two overall sets of financial and non-financial data. The various component series can then be adjusted to yield the net lending/borrowing figure (or something close to it). However, it is important that the adjustments lead to a derived measure of GDP which is not too far removed from the estimate established from the basic data because the margins of error for financial data are likely to be considerable. Note that this approach can be used only for current price data, since the financial information cannot be expressed in volume terms.
- 8.81. Three particular points should be made about this approach:
- a. it is difficult to balance data on a measure such as net lending/borrowing because it is the difference between various large numbers, and the errors in such data will feed through to the net balance, although this concern will be largely mitigated by adherence to the constraint on GDP, as proposed above;
  - b. unlike balancing in a supply and use framework, the data confrontation is at a highly aggregate level, and any adjustments are certain to be quite arbitrary;
  - c. the accuracy of financial accounts is generally considered to be substantially less than that of the non-financial accounts.

As a consequence, this approach is used in addition to, rather than instead of, the use of the supply and use approach.

### The integration of supply and use tables with institutional sector accounts

- 8.82. Thus far only the accounts for the total economy have been considered, and the institutional sector dimension has been ignored. Chapter 10 of the *Eurostat Manual of Supply, Use and Input-Output Tables* describes how the supply and use tables for the total economy and the institutional sector accounts can be integrated to achieve a consistent set of accounts.
- 8.83. The supply and use tables are based on three accounts: the production account, the goods and services account and the generation of income account. These accounts are elaborated and integrated by adding industry and product dimensions. In the supply and use approach, the emphasis is on the production process, the use of the products produced and the primary inputs (labour and capital) into production. Accordingly, the industry categories are based on statistical units that have similar production functions, i.e. local kind of activity units or units of homogeneous production. Although comprises often have to be made for practical reasons.
- 8.84. In the institutional sector approach, analysis focuses on the generation and distribution of income, the investment and financing of capital and the change in wealth over a period by institutional sectors. It is based on institutional units in the form of households and legal or social entities. Chapter 10 of the *Eurostat Manual* describes how a cross table can be derived that links supply and use tables with institutional sector accounts. The cross table records the following data for sectors and industries:
- transactions of production accounts: production and intermediate consumption;
  - transactions of the generation of income accounts: compensation of employees, mixed income;
  - transactions of the accumulation accounts: gross fixed capital formation.

- 8.85. If supply and use tables for the total economy and the institutional accounts are compiled independently, then there are likely to be inconsistencies in the cross table. Four methods for obtaining a balanced cross table are:
- compile the supply and use tables and institutional sector accounts independently and then do an ex-post reconciliation of both approaches;
  - use the supply and use tables as the starting point for compiling the institutional sector accounts;
  - use data from the institutional sector accounts as a starting point for compiling the supply and use tables;
  - compile the supply and use tables and the institutional sector accounts simultaneously, using the cross table as a means of ensuring consistency.

Time is of the essence when compiling QNA, and so option (b) is usually favoured.

- 8.86. There is almost always a discrepancy for each institutional sector between the figures for net lending/borrowing from the capital account and the corresponding figures from the financial account. In principle, of course, there should be no discrepancies. If the discrepancy at the total economy level is relatively small for most quarters then a balance may be able to be achieved by making adjustments to the capital and/or financial accounts based on their perceived relative accuracy and external information. In practice, it would usually be the financial accounts data that were adjusted on the grounds that they are considered the least accurate and also for practical reasons – there are fewer consequential adjustments. The financial account for the household sector is largely derived residually by using counterparty data. So once a balance for the total economy has been struck, adjustments can be made between the financial accounts of the institutional sectors to achieve balanced capital and financial accounts for each sector.
- 8.87. If the discrepancies for the total economy and its sectors are generally large, then the best solution is probably to tolerate them in the short term, but instigate investigations into the causes of the discrepancies by focusing on particular types of institutional units, with a view to finding a lasting remedy. The alternative is to force a balance by making large and somewhat arbitrary adjustments over successive quarters with little assurance that the resulting data will be meaningful.

### **Use of mathematical and statistical methods to balance quarterly SUTs and achieve temporal consistency with balanced annual data**

- 8.88. Mathematical and statistical methods may be used to balance single quarterly SUTs or to create a time series of balanced quarterly SUTs that are consistent with balanced annual SUTs. Chapters 4 and 5 describe various methods for using mathematical and statistical methods to derive quarterly estimates of national accounts variables that are consistent with their annual counterparts, given different circumstances. The circumstances vary from having no quarterly data to having quarterly data that accurately measure the particular national accounting concept concerned, and various cases in between these two extremes. Two of these methods have been extended to deal with many variables at once:
- the optimal method developed by Chow and Lin, which is used when indicators are available of the short-term growth of a national accounts variable;
  - the proportional and difference methods developed by Denton, which are used for benchmarking a QNA variable to its annual counterpart.

The multivariate versions of these methods ensure that accounting identities hold while achieving the same temporal objectives as their univariate counterparts. A brief description of the two methods follows, but full details are presented in Annex 8.B.

8.89. The Dutch CBS has recently developed two sophisticated, semi-automated methods for benchmarking and balancing supply and use tables and other tables. The first method, used for benchmarking and extrapolation of quarterly data, is an extension of the multivariate Denton methods and has been coined the ‘Quarterly Machine’. This extension of the Denton methods is somewhat more sophisticated than the one described elsewhere in this section and in Annex 8.B. First, it allows the specification of “soft” constraints in addition to the “hard” constraints that are required to satisfy accounting identities; and second, it allows new partial and unbalanced annual data to be included as benchmarks for the out years in order to improve the quality of the initial quarterly estimates. The second CBS method is used for balancing data for a particular period (quarterly or annual) for the first time. It is an extension of Stone’s method and has been coined the ‘Balancing Machine’. Both methods are used to automatically eliminate the smaller statistical discrepancies in SUT systems, whereas the larger discrepancies are handled ‘manually’ by national accounts experts. Both methods are briefly described in Annex 8.C and are not discussed further in this section.

### *Multivariate optimal methods*

8.90. Time series of related quarterly variables are used in a multivariate regression model to derive quarterly estimates that satisfy accounting constraints (e.g. the constraint may correspond to the quarterly series of GDP) and at the same time achieve temporal consistency. The method derives from the univariate Chow and Lin method, and two different versions have been developed, each using different specifications for the error term in the regression model. The two forms of the stochastic error process considered are:

- multivariate white noise;
- multivariate random walk.

8.91. The estimation is carried out according to the same principles as the univariate case: the relationship between the annualized indicators (or preliminary estimates) and the annual benchmarks is estimated and used to impute quarterly values for QNA variables from the quarterly indicators both for periods for which there are annual benchmarks and for quarters beyond the latest annual benchmarks.

### *Multivariate benchmarking method*

8.92. The starting point is a set of initial estimates of QNA variables that satisfy the temporal constraints (when annual figures are available), but do not satisfy the accounting constraints. The multivariate benchmarking method ensures that the resulting estimates satisfy the specified accounting identity as well as temporal consistency with their annual counterparts. Obviously, an essential requirement is that the annual data must satisfy the accounting constraint.

8.93. The problem consists then in distributing, according to a suitable criterion, the discrepancy between the initial values and the specified quarterly accounting constraint (often represented by a quarterly series). As in the univariate case, the distribution is made by minimizing a quadratic loss function according to the same approach proposed by Denton.

### *Applying the multivariate methods*

8.94. Both of these methods should only be used to resolve relatively minor breaches of the accounting constraints. For example, if the quarterly components of GDP satisfy both the temporal and accounting constraints and the annual (benchmark) data undergo minor revision, then it is reasonable to apply these methods to maintain consistency. If, however, the revisions are substantial, then manual adjustments will probably be needed before they are applied. The same applies to revisions to quarterly indicators.

- 8.95. Chain-linked volume estimates are usually constrained to be temporally additive, i.e. quarterly chain-linked volume estimates sum to their annual counterparts, but they are non-additive contemporaneously, i.e. the quarterly chain-linked volume estimates of a major aggregate are not equal to the sum of the chain-linked volume estimates of its components. Hence neither the multivariate optimal method nor the multivariate (Denton) benchmarking method, as described in Annex 8.B, can be applied to quarterly chain-linked volume estimates. Neither can they be applied to estimates in the prices of the previous year because although such estimates are contemporaneously additive, they do not form continuous time series. (The Dutch “Quarterly Machine” – described in Annex 8.C - has been designed to overcome this problem).
- 8.96. After these multivariate methods have been applied to the current price data, one way of deriving consistent chain-linked volume estimates is to:
- a. derive implicit price deflators (IPDs) from both the seasonally adjusted and unadjusted initial data;
  - b. apply these deflators to the benchmarked current price seasonally adjusted and unadjusted data, respectively;
  - c. benchmark the resulting estimates to their annual counterparts using one of the univariate Denton methods.

This approach rests on the assumption that the adjustments made to the component current price data in order to satisfy accounting constraints apply only to their volume elements, which seems a reasonable assumption to make.

- 8.97. If the major aggregates of current price data are seasonally adjusted indirectly (i.e. by summing the seasonally adjusted components – see Chapter 7), then the approach used for unadjusted may be used. If major aggregates are directly seasonally adjusted, then the benchmarking process has to be broken down into several stages in a top-down process, where each stage is determined by an aggregate that is seasonally adjusted directly. For example, suppose the multivariate (Denton) benchmarking method is being applied to the expenditure side of GDP. Further suppose household final consumption expenditure, government final consumption expenditure and gross fixed capital formation are all seasonally adjusted directly, but all the other major aggregates, such as exports and imports, are seasonally adjusted by summing seasonally adjusted components at the most detailed level. The first stage would be to apply the multivariate benchmarking method to the seasonally adjusted estimates of household final consumption expenditure, government final consumption expenditure and gross fixed capital formation and to the seasonally adjusted components of the other major aggregates. The second stage would be to apply the multivariate benchmarking method separately to the components of each of household final consumption expenditure, government final consumption expenditure and gross fixed capital formation.

### Some organizational issues for the balancing process

- 8.98. The final part of this chapter looks at a number of non-statistical features of the balancing process. Some solutions are proposed to the problems raised, although the exact nature of what is done will depend very much on the circumstances pertaining in individual NSIs. The main issues are:
- a. the general organizational arrangements for carrying out balancing;
  - b. the need to accommodate the process in the general timetable for preparing QNA;
  - c. the education of users and others about the balancing process, including whether information on the adjustments should be made available outside the NSI. Some other issues are also covered.

**Organizational arrangements**

- 8.99. It is recommended that a dedicated team be appointed to undertake the balancing work. The precise nature of the responsibilities of the team should be made clear at the outset, in particular in relation to decisions about the way in which the adjustments are made. The team may undertake its work through a series of bilateral or wider discussions with compilers, in which issues related to their particular data and any possible adjustments can be considered. On the basis of these discussions, the team can assemble a further matrix of data, not necessarily fully balanced, but certainly exhibiting greater reconciliation than was evident in the initial estimates. This can then be discussed at a meeting of all interested parties with the objective of reaching agreement on a final, balanced set of figures. Responsibility for final decisions on balancing, for example when there is disagreement about the size and location of adjustments, needs to be vested in one individual. As mentioned before, the whole process is essentially an iterative one, utilizing at each stage the information available to try to form the optimum view of the overall economic picture provided by the figures. In some cases balancing will be undertaken with a given set of data, in others new data may come to hand during balancing.
- 8.100. It is considered vital to use to the full the expertise of compilers in the balancing process. Their knowledge of particular data is crucial to the whole exercise. Their involvement in the balancing process serves to broaden their knowledge and is likely to enable them to make better estimates in the future. Compilers should investigate particular problems that emerge at the various stages of the balancing process and seek to achieve some resolution; they may need to consult data suppliers for explanations of the behaviour of their data. This ‘consultative’ approach attempts to avoid simply taking information and adjusting it in a way in which compilers and suppliers would not necessarily agree and indeed may even wish to disown. However, it is best if the national accountants set quality standards for the information supplied to them, thereby reducing the occurrence of data problems being identified in the balancing process. This is discussed in detail in Chapter 3.

**The quarterly timetable**

- 8.101. One of the main practical issues is that the balancing process can be seen as a potentially extremely time-consuming exercise that is difficult to fit into an already tight quarterly timetable. Where balancing is not at present undertaken, or where it is present but can be improved, there will be a natural reluctance to delay publication of the national accounts to accommodate the extra work. Thus the introduction or enhancement of the balancing process, with the associated improvement to the accounts, should involve a re-appraisal of the whole QNA timetable. This will almost inevitably raise a conflict between timeliness and accuracy of the national accounts statistics. In addressing this conflict, one needs to consider the time/benefit of each stage in the process. For instance, does the benefit of spending two more days balancing outweigh the “cost” of bringing forward the respondent cut-off date for quarterly surveys, and can this earlier cut-off be ameliorated by more intensive and/or earlier telephoning of tardy respondents?
- 8.102. Collecting, compiling and preparing QNA is a very costly exercise, but balancing is a relatively small, low cost part of the whole statistical process, and together with validation it is arguably the most important and cost effective part. Therefore it makes sense to make time for balancing. If existing deadlines cannot be changed, then the time required for balancing should be found from some other stage in the compilation process.
- 8.103. Balancing and the final phases of validation should be the final actions in the quarterly timetable. However, there is much merit in undertaking a preliminary balancing exercise earlier in the timetable to allow time for the investigation of particular problems, rather than leaving everything to the final stages. The appropriate place in the timetable for this first, exploratory assessment will depend on the flow of data, including the timing of the availability of certain monthly data (see below). It will also be essential to ensure that an adequate set of data can be assembled to make the balancing process worthwhile,

although a preliminary look at figures will seldom go unrewarded. Thus the stage at which preliminary balancing may be undertaken will be a compromise between, on the one hand, providing sufficient time to investigate and resolve any problems and, on the other hand, the availability of data and extent to what balancing may be done.

- 8.104. A common problem faced by NSIs arises when source data for two months or even complete quarters are published before the balancing process for QNA is undertaken. The inclusion of such series in the balancing exercise could well lead to the series being revised in QNA fairly soon after they have been published in their own right. In many cases there are sufficient differences between the source data and the national accounts estimates derived from them, in terms of scope, definition, etc., that this does not present a problem, but in those cases where there is little difference there is an issue. Three possible examples of the latter are monthly statistics of international trade and industrial production, and data from a quarterly economy-wide business survey.
- 8.105. There are several things to consider in addressing this issue:
- a. How close in definition, scope, etc. are the source data to the corresponding national accounts data? For example, in the case of international trade, time of recording problems for products of high value, such as ships and aircraft, commonly require some adjustment to the source data that can be explained to users.
  - b. How accurate are the source data? If they are judged to be highly accurate then they may be regarded as definitive and not subject to adjustment in the balancing process. If they are judged to be of moderate accuracy, then it could be explained to users that they are imperfect and are subject to adjustment in deriving the national accounts – see below. If they are of low accuracy, should they be published at all?
  - c. There is another option for quarterly data that are close to national accounts data in terms of definition, scope, etc., and that is to ensure the data are consistent with the to-be published national accounts. For example, changes in inventories are commonly adjusted in the balancing process because the estimates are subject to large standard errors of movement (see §8.71-8.72). It is therefore statistically legitimate to make adjustments within the range of sampling error in the balancing process and to publish these adjusted data in a survey-based publication. It can be explained to users that in cases like this it is better to sacrifice some timeliness for greater accuracy. Given that the primary use of quarterly business survey data is to enable economists and other users to second guess what QNA are going to show, what is the point in publishing data that will mislead them?
- 8.106. Before deciding on a particular course of action, an assessment should be made of the whole quarterly timetable and all the important source data. The chosen strategy will depend on the circumstances prevailing in each Member State, and the only recommendations made here are that NSIs should endeavour to publish the best national accounts they can and to be frank and open with their users.

### Education of users and presentational issues

- 8.107. Although balancing is only one part of whole estimation process, it is difficult to avoid it being regarded as a procedure of some special importance and one with a special focus. This is likely to raise certain questions concerning the need for the adjustment process, how it is undertaken and the magnitude of the adjustments made.
- 8.108. The balancing process may be seen by some as a means of manipulating the data, possibly at worst for political purposes. Such perceptions should be actively countered because they clearly put the whole statistical system into question. It is fundamental to the integrity of the national accounts statistics, indeed statistics generally, that users have confidence in the estimates and are adequately informed about the

statistical processes. It is therefore important to explain clearly why a balancing process is needed and how it is conducted. It should be documented and explained through seminars and other formal and informal meetings to both users and data suppliers. But most of all it is vitally important that the major users and opinion makers (business economists and economic journalists) understand why balancing is needed and are supportive. One of the great advantages of using supply and use tables to do the balancing is that the intrinsic virtues of the process can be easily explained and readily understood by major users.

- 8.109. Having understood the balancing process, users may wish to know the magnitude of the adjustments made. As was mentioned earlier in this chapter, balancing is essentially the final stage in what can be regarded as a continuum of adjustment needed to compile the national accounts. Requiring an indication of the adjustments being made to data raises the question of where to draw the line in the whole estimation process. Limiting the indication to the adjustments made during balancing is a convenient, though still arbitrary, decision. In reality, the provision of information of this kind does little more than indicate the quality of the data underlying the national accounts. It might be inferred that the smaller the balancing adjustments the better the overall quality of the data. However, this will not be the case if, for example, the estimates contain larger adjustments made before the balancing process. Furthermore, providing details of adjustments is tantamount to having the equivalent of two sets of national accounts data in circulation at the same time. Although the basis and other relevant features of the two tables could be explained, it is inevitable that there would be misinterpretation or misuse of the information.
- 8.110. Given all these considerations, it does not appear that there would be much to be gained from making information on the balancing adjustments generally and widely available. However, it should be recognized that there is likely to be some value in restricted dissemination of the information. For example, compilers may benefit from discussions of the details of the balancing process with experts outside the NSI. There is also the important consideration that if information on the adjustments was denied totally it is likely that suspicions would be aroused on the probity of the estimation process. It is suggested, therefore, that in addition to giving such information to outside experts it is also provided to meet strong and bona fide requests made by others. However, as far as possible and to limit potential misunderstanding, the material should be provided for personal rather than general use. All releases of such material should be accompanied by a short description on any key points related to the particular quarter, together with some indication of the accuracy of the data being adjusted.

### Other issues

- 8.111. Finally and briefly, there are a few other issues worth addressing. To begin with, the balancing process has a number of important implications for the statistical system:
- a. One particular consequence is that regular balancing, with all series being reviewed, may lead to more revisions to data than hitherto. The revisions policy adopted will need to determine how this is to be dealt with.
  - b. It is vital to learn lessons from the balancing exercise about the general quality of the estimates. The process should include investigation into the main problem areas in the accounts, and the reasons for inconsistencies should be found and remedied.
  - c. Attempts should be made to improve the quality of basic information that is identified as being weak, either by making changes to collection or estimation practices or by seeking alternative sources.
  - d. When balancing is being introduced for the first time or major improvements are being made to existing practices it is advisable to have a trial run of procedures before using the process to generate the published statistics. If possible, changes to timetables might also be tested before being actually implemented.



## Summary of main points

8.112. It is useful to bring together the main principles and issues related to balancing that have been discussed in this chapter.

8.113. First, the four key general principles are:

- a. there should be a single, definitive estimate of GDP;
- b. full balancing should be undertaken, that is no statistical discrepancies should remain in the estimates;
- c. in principle, all variables should be eligible for adjustment;
- d. quarterly balancing should be undertaken for current price and volume estimates in both unadjusted and seasonally adjusted terms, and they should be balanced simultaneously.

8.114. Second, there are a number of general statistical issues:

- a. The balancing of production, expenditure and the income generated from production data should be undertaken through the framework of supply and use tables (or possibly symmetric input-output tables). Four sets of tables should be balanced for each quarter:
  - current prices not seasonally adjusted;
  - estimates in the prices of the previous year not seasonally adjusted;
  - current prices seasonally adjusted;
  - estimates in the prices of the previous year seasonally adjusted.

Each set of tables is balanced in sequence in an iterative process.

- b. It may also be possible to confront and balance these data (using a cross table) with the institutional sector accounts if separate basic data have been used to compile them, but it is more likely that the data from the balanced supply and use tables will be used to derive the institutional sector accounts. If possible, the distribution of income and use of income accounts, and the capital and financial accounts for each institutional sector should also be balanced.
- c. The supply and use tables should be as detailed as practicable.
- d. The experience of Member States that balance their quarterly supply and use tables suggests that a combination of manual and automated balancing is most effective.
- e. Balancing for a given period also needs to take account of growth rates and the time series nature of the variables.
- f. Not only the basic national accounts variables should be open to adjustment, but price indices and seasonal factors should be included, too.
- g. Adjustments should be based on the estimated accuracy of the component data and any other available information.
- h. The appropriateness of the information included in the balancing process that is based on the previous year's framework needs to be carefully assessed. Structural data from the same quarter of the previous year is generally preferred to annual data for imputing unadjusted data.
- i. Quarterly balanced matrices should be made consistent with the firmer annual data. Multivariate mathematical and statistical models provide powerful tools for doing this, but where there are substantial revisions manual adjustments will be needed.
- j. The introduction of balancing may necessitate some modification of the policy on revisions.

8.115. Third, the main operational issues are:

- a. Arrangements and responsibilities for the balancing work should be clearly established, with the compilers having a key role.
- b. The balancing process is a complex operation, and sufficient time must be allowed for it in the quarterly timetable. Moreover, major changes to procedures should be trialled before being formally introduced.
- c. The why and how of the balancing process must be clearly communicated to users.

## 8. Annex A — A framework for quarterly balancing

### Introduction

- 8.A1 The aim of the balancing process outlined here is to confront and balance the available data contributing to the production, expenditure and income measures of GDP in a supply and use framework. The annex outlines a framework which could be used for the balancing exercise and briefly describes how the initial estimates might be made prior to balancing, but more detailed descriptions can be found in §8.58-8.62 and Chapter 2.
- 8.A2 An illustration of the kind of supply and use table which might be used for balancing is shown at the end of this annex. It is the standard presentation, but the actual industry and product categories used will be determined according to data availability and the classification framework set out in ESA 2010. The way in which the preliminary estimates might be derived is outlined below. The letters relate to the matrices or vectors of data, as identified in the framework. The brief description in this annex can, in principle, be applied to any one of the following four data: current price estimates and estimates in the average prices of the previous year in both unadjusted and seasonally adjusted terms, except for the absence of volume measures of income. As mentioned in the main text of Chapter 8, it is necessary to ensure the meaningfulness of the unadjusted data. Finally, all values should be measured in accordance with the ESA 2010 recommendations (i.e. basic prices for outputs, purchasers' prices for inputs, free-on-board for internationally traded goods) to ensure that they are consistent.
- A. *Matrix of estimates of domestic production*  
The column vector of estimates for output for each individual industry can be based on quarterly data of output or sales, or other sources. The product composition for each industry can then be estimated using the structure of the annual domestic production matrix and summed across all industries to yield the row of product totals. Note that there may be problems in using the annual matrix for estimation for unadjusted data; if possible, the matrix for the same quarter a year earlier should be used.
- B. *Matrix of estimates of intermediate consumption*  
The column vector of estimates of purchases by individual industries can be made by applying an estimate of the ratio of intermediate consumption to output to the figures of output estimated for matrix A. The product composition for each industry can then be estimated using the structure of the annual intermediate consumption matrix and summed across all industries to yield the column of product totals. Again, there may be problems in using the annual matrix for estimation for unadjusted data, and use should be made of the quarterly matrix of a year earlier.
- C. *Vector of estimates of final consumption of households and NPISHs*
- D. *Vector of estimates of final consumption of general government*
- E. *Vector of estimates of gross fixed capital formation*
- F. *Vector of estimates of changes in inventories*
- G. *Vector of estimates of exports of goods and services*
- H. *Vector of estimates of imports of goods and services*
- I. *Vector of estimates of trade and transport margins*

*J. Vector of estimates of taxes less subsidies on products*

Estimates by product for all the above variables should be derived by a mixture of actual quarterly data and estimation, preferably using the latest annual supply and use table. The meaningfulness of some of the unadjusted information may need to be examined.

*K. Vector of estimates of value added*

These estimates by industry should ideally be available from the income measure of GDP so that they can be confronted with the imputed estimates from the supply and use table. If they are not, then the confrontation and balancing process is limited to the production and expenditure measures of GDP. If estimates of compensation of employees and taxes less subsidies on production and imports are available, then the aggregate of gross operating surplus and gross mixed income can be derived as a residual.

8.A3 The framework requires that the estimates satisfy two identities. These are:

- for each product:  
Total supply (A+H+I+J) = Total use (B+C+D+E+F+G);
- for each industry:  
Total inputs (B+K) = Total outputs (A).

Also note that, in aggregate, GDP at market prices is derived from the matrix or vector total as follows:

- Production: A-B+J;
- Expenditure: C+D+E+F+G-H;
- Income: K+J.

Table 8.A.1: Supply and Use table

|                       | PRODUCTS    | INDUSTRIES  | H/H +<br>NPISH<br>FCE | GFCE | GFCF | ΔINV | Exports | Σ              |
|-----------------------|-------------|-------------|-----------------------|------|------|------|---------|----------------|
| PRODS                 |             | B           | C                     | D    | E    | F    | G       | $U_1$<br>$U_N$ |
| INDS                  | A           |             |                       |      |      |      |         | $O_1$<br>$O_M$ |
| Value Added           |             | K           |                       |      |      |      |         |                |
| Imports               | H           |             |                       |      |      |      |         |                |
| Margins               | I           |             |                       |      |      |      |         |                |
| Net taxes on products | J           |             |                       |      |      |      |         |                |
| Σ                     | $S_1$ $S_N$ | $I_1$ $I_M$ |                       |      |      |      |         |                |

- For each product – at purchasers’ prices  
Supply (S=A+H+I+J) = Use (U=B+C+D+E+F+G)
- For each industry – at basic prices  
Inputs (I=B+K) = Outputs (O=A)

GDP(Production) = A-B+J  
 GDP(Expenditure) = C+D+E+F+G-H  
 GDP(Income) = K+J

### An example of a balancing exercise

8.A4 The following example demonstrates a simple application of balancing principles in the context of an input-output table.

8.A5 The hypotheses are as follows:

- a. The following figures have not to be adjusted (they are considered to be accurate and fixed and they are put in bold in Table 8.A.2):
  - industry output (total);
  - net taxes on products;
  - imports;
  - other net taxes on production;
  - exports;
  - government final consumption expenditure.
- b. In this example, the adjustment of the single items should be made according to the following rules:
  - Income components: the total adjustment is made roughly in proportion to the size of item (i.e. compensation of employees and GOS/GMI).
  - Final expenditure components: total adjustment is made in the following proportions: households and NPISH final consumption expenditure 2, GFCF 1, changes in inventories 2.
  - Output component proportions: P1: 38%, P2: 62%.
- c. The final estimates of GDP according to the three approaches must be the same.
- d. The adjustment has to be made with whole numbers.

Table 8.A.2: Original data

|                                      | Products                   |           |            | INDS      | H/H +<br>NPISH<br>FCE | GFCF      | GFCF<br>+<br>$\Delta$ INV | Exports   | $\Sigma$   |
|--------------------------------------|----------------------------|-----------|------------|-----------|-----------------------|-----------|---------------------------|-----------|------------|
|                                      | P1                         | P2        | $\Sigma$   |           |                       |           |                           |           |            |
| <b>Products</b>                      | <b>P1</b>                  |           |            | 120       | 50                    | <b>10</b> | 10                        | <b>40</b> | 230        |
|                                      | <b>P2</b>                  |           |            | 180       | 70                    | <b>10</b> | 25                        | <b>40</b> | 325        |
|                                      | <b><math>\Sigma</math></b> |           |            | 300       | 120                   | <b>20</b> | 35                        | <b>80</b> | 555        |
| <b>INDS</b>                          | 200                        | 300       | <b>500</b> |           |                       |           |                           |           | <b>500</b> |
| <b>Net taxes on products</b>         | <b>10</b>                  | <b>5</b>  | <b>15</b>  |           |                       |           |                           |           |            |
| <b>Compensation of employees</b>     |                            |           |            | 110       |                       |           |                           |           |            |
| <b>Gross operating surplus</b>       |                            |           |            | 60        |                       |           |                           |           |            |
| <b>Gross mixed income</b>            |                            |           |            |           |                       |           |                           |           |            |
| <b>Other net taxes on production</b> |                            |           |            | <b>10</b> |                       |           |                           |           |            |
| <b>Imports</b>                       | <b>40</b>                  | <b>25</b> | <b>65</b>  |           |                       |           |                           |           |            |
| <b><math>\Sigma</math></b>           | 250                        | 330       | 580        | 480       |                       |           |                           |           |            |

### The balancing procedure

8.A6 According to the figures displayed in table 8.A.2 and 8.A.3, the three approaches to the GDP give the following results:

- production approach: GDP = 215
- expenditure approach: GDP = 190
- income approach: GDP = 195

8.A7 According to §8.53, the first step in a top-down approach is to establish a target estimate of GDP. It is obtained here by taking a simple average of the initial estimates of GDP derived from the three approaches, that is  $(215+190+195) = 200$ .

In order to achieve a balance consistent with this estimate, the following discrepancies need to be distributed:

- production approach: -15
- expenditure approach: +10
- income approach: +5

Table 8.A.3: Balanced data

|                               | Products   |            |            | INDS       | H/H +<br>NPISH<br>FCE | GFCE.     | GFCF<br>+ΔINV | Exports   | Σ          |
|-------------------------------|------------|------------|------------|------------|-----------------------|-----------|---------------|-----------|------------|
|                               | P1         | P2         | Σ          |            |                       |           |               |           |            |
| Products                      | P1         |            |            | <u>126</u> | <u>52</u>             | <b>10</b> | <u>12</u>     | <b>40</b> | <u>240</u> |
|                               | P2         |            |            | <u>189</u> | <u>72</u>             | <b>10</b> | <u>29</u>     | <b>40</b> | <u>340</u> |
|                               | Σ          |            |            | <u>315</u> | <u>124</u>            | <b>20</b> | <u>41</u>     | <b>80</b> | <u>580</u> |
| INDS                          | <u>190</u> | <u>310</u> | <b>500</b> |            |                       |           |               |           | <b>500</b> |
| Net taxes on products         | <b>10</b>  | <b>5</b>   | <b>15</b>  |            |                       |           |               |           |            |
| Compensation of employees     |            |            |            | <u>113</u> |                       |           |               |           |            |
| Gross operating surplus       |            |            |            | <u>62</u>  |                       |           |               |           |            |
| Gross mixed income            |            |            |            |            |                       |           |               |           |            |
| Other net taxes on production |            |            |            | <b>10</b>  |                       |           |               |           |            |
| Imports                       | <b>40</b>  | <b>25</b>  | <b>65</b>  |            |                       |           |               |           |            |
| Σ                             | <u>240</u> | <u>340</u> | <b>580</b> | <b>500</b> |                       |           |               |           |            |

## 8. Annex B — Balancing by using mathematical and statistical models

### A formal presentation

8.B1 Following the notation of Annex 5.A, detailed consideration is given here to the mathematical approach to the disaggregation and extrapolation problems in the multivariate context of the balancing problem.

To be estimated are  $M$  unknown ( $N \times 1$ ) vectors of quarterly data,  $\mathbf{y}_j$ ,  $j=1, \dots, M$ , each pertaining to one of  $M$  basic (i.e. disaggregated) time series which have to satisfy both contemporaneous and temporal aggregation constraints.

8.B2 The solution of this problem entails consideration of a number of procedures that, as in the single variable case, can be characterized as either *pure adjustment* or *least-squares optimal*. The information set common to both cases is given by the following  $M+1$  aggregated vectors:

- $\mathbf{z}$ , ( $N \times 1$ ) vector of quarterly contemporaneously aggregated data;
- $\mathbf{y}_{ja}$ ,  $j=1, \dots, M$ , ( $n \times 1$ ) vectors of annual data.

8.B3 Consider the two distinct situations:

- a.  $M$  preliminary quarterly time series,  $\mathbf{p}_j$ ,  $j=1, \dots, M$ , are available,

where  $\sum_{j=1}^M \mathbf{p}_j \neq \mathbf{z}$  and/or  $\mathbf{B}\mathbf{p}_j \neq \mathbf{y}_{ja}$ ;

- b. a set of quarterly related indicators is used to obtain indirect estimates of the  $M$  unknown time series.

The distinction is not necessarily as strict as it seems, in that initial quarterly series could have been individually obtained by using related indicators.

8.B4 Assuming that each basic series satisfies a multiple regression relationship with a number of known related indicators, a least-squares optimal solution, consistent with the aggregation constraints, can be obtained. This approach will be developed by discussing some specific error covariance pattern.

Consider the  $[(N + nM) \times 1]$  vector

$$\mathbf{y}_0 = \begin{bmatrix} \mathbf{z} \\ \mathbf{y}_a \end{bmatrix}$$

$$\text{where } \mathbf{y}_a = \begin{bmatrix} \mathbf{y}_{1a} \\ \mathbf{y}_{2a} \\ \vdots \\ \mathbf{y}_{Ma} \end{bmatrix}$$

The following accounting constraints hold:

$$\sum_{j=1}^M \mathbf{y}_j = \mathbf{z}$$

$$\mathbf{B} \mathbf{y}_j = \mathbf{y}_{ja}, j=1, \dots, M.$$

The complete set of constraints between the series to be estimated and the available aggregated information can be expressed in matrix form as

$$\mathbf{H} \mathbf{y} = \mathbf{y}_0$$

where 
$$\mathbf{H} = \begin{bmatrix} \mathbf{1}_M & \otimes \mathbf{I}_N \\ \mathbf{I}_M & \otimes \mathbf{B} \end{bmatrix} = \begin{bmatrix} \mathbf{H}_1 \\ \mathbf{H}_2 \end{bmatrix},$$

$\mathbf{1}_M$  is a (M x 1) vector, all the elements of which are equal to unity and

$$\mathbf{y} = \begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \vdots \\ \mathbf{y}_M \end{bmatrix}$$

8.B5 Note that the contemporaneous aggregation of temporally aggregated series implies

$$\sum_{j=1}^M \mathbf{y}_{aj,t} = \sum_{i=1}^4 \mathbf{z}_{4(t-1)+i} = \mathbf{z}_{a,t}, t=1, \dots, n,$$

and then, given this relationship between the  $M+1$  aggregated vectors, matrix  $\mathbf{H}$  has rank

$r = N + n(M - 1)$ ,  $n$  aggregated observations being redundant.

### Multivariate adjustment

8.B6 Suppose there are  $M$  preliminary series,  $\mathbf{p}_j, j = 1$  to  $M$ , that need to be adjusted in order to satisfy the accounting constraints. This has to be accomplished by distributing the discrepancies

$$\mathbf{z} - \mathbf{H}_1 \mathbf{p}$$

and

$$\mathbf{y}_0 - \mathbf{H}_2 \mathbf{p}$$



$$\text{where } \mathbf{p} = \begin{bmatrix} \mathbf{p}_1 \\ \mathbf{p}_j \\ \mathbf{p}_M \end{bmatrix}$$

according to some reasonable criterion. In the following two multivariate adjustment procedures are dealt with: (i) proportional adjustment; (ii) Denton's multivariate adjustment.

8.B7 The proportional adjustment procedure is very simple and widely used, although less generally applicable than the Denton method because it assumes only contemporaneous constraints have to be fulfilled (that is,

$$\mathbf{B}\mathbf{p}_j = \mathbf{y}_{aj}, j=1, \dots, M).$$

8.B8 A simple and fairly reasonable way to eliminate the discrepancy between a contemporaneously aggregated value and the corresponding sum of disaggregated preliminary quarterly estimates consists in distributing such a discrepancy according to the weight of each single temporally aggregated series with respect to the contemporaneously aggregated one.

8.B9 Denton's multivariate adjustment generalizes the univariate procedure shown in §5.A24 by taking into account some technical devices about (i) the treatment of starting values (Cholette, 1984, 1988) and (ii) the nature of the accounting constraints.

### Multivariate optimal estimation

8.B10 If there exists a set of quarterly indicators related to the unknown disaggregated series, it is possible to specify  $M$  regression models

$$\mathbf{y}_j = \mathbf{X}_j \boldsymbol{\beta}_j + \mathbf{u}_j, j=1, \dots, M$$

with

$$E(\mathbf{u}_j) = \mathbf{0}, \quad E(\mathbf{u}_i \mathbf{u}_j') = \mathbf{V}_{ij}, i, j=1, \dots, M,$$

where,  $\mathbf{X}_j$ ,  $j=1, \dots, M$ , are  $(N \times \kappa_j)$  matrices of related series. The  $M$  models can be grouped as follows:

$$\begin{bmatrix} \mathbf{y}_1 \\ \mathbf{y}_2 \\ \mathbf{y}_M \end{bmatrix} = \begin{bmatrix} \mathbf{X}_1 & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{X}_2 & & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & & \mathbf{X}_M \end{bmatrix} \begin{bmatrix} \boldsymbol{\beta}_1 \\ \boldsymbol{\beta}_2 \\ \boldsymbol{\beta}_M \end{bmatrix} + \begin{bmatrix} \mathbf{u}_1 \\ \mathbf{u}_2 \\ \mathbf{u}_M \end{bmatrix},$$

or, extending the notation used in §8.B5,

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{u}$$

where  $E(\mathbf{u}) = 0$  and,  $E(\mathbf{u}\mathbf{u}') = \mathbf{V} = \{V_{ij}\}$ ,  $i, j = 1, \dots, M$ .

8.B11 The observed, aggregated regression model is given by:

$$\mathbf{y}_0 = \mathbf{X}_0\boldsymbol{\beta} + \mathbf{u}_0$$

where  $\mathbf{X}_0 = \mathbf{H}\mathbf{X}$ . The aggregated disturbance vector,  $\mathbf{u}_0 = \mathbf{H}\mathbf{u}$ , has zero mean and singular covariance matrix  $E(\mathbf{u}_0\mathbf{u}_0') = \mathbf{V}_0 = \mathbf{H}\mathbf{V}\mathbf{H}'$ .

8.B12 The quarterly estimates can be obtained as a solution of a linear prediction problem in a generalized regression model with singular covariance matrix (Di Fonzo, 1990):

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{L}(\mathbf{y}_0 - \mathbf{X}\boldsymbol{\beta}),$$

$$\hat{\boldsymbol{\beta}} = (\mathbf{X}'_0\mathbf{V}_0^-\mathbf{X}_0)^{-1}\mathbf{X}'_0\mathbf{V}_0^-\mathbf{y}_0.$$

$$E[(\mathbf{y} - \bar{\mathbf{y}})(\mathbf{y} - \bar{\mathbf{y}})'] = (\mathbf{I}_N - \mathbf{L}\mathbf{H})\mathbf{V} + (\mathbf{X} - \mathbf{L}\mathbf{X}_0)(\mathbf{X}'_0\mathbf{V}_0^-\mathbf{X}_0)^{-1}(\mathbf{X} - \mathbf{L}\mathbf{X}_0)',$$

with  $\mathbf{L} = \mathbf{V}\mathbf{H}'\mathbf{V}_0^-$ , where  $\mathbf{V}_0^-$  is the Moore-Penrose generalised inverse of the singular matrix  $\mathbf{V}_0$ . The above relationships are natural extensions of the optimal univariate counterparts worked out by Chow and Lin (1971).

8.B13 In practice, matrices  $\mathbf{V}_{ij}$  are unknown and must be estimated according to proper assumptions on the  $\mathbf{u}_j$

Two cases seem to be interesting from both a theoretical and a practical point of view:

- a. multivariate white noise;
- b. multivariate random walk.

8.B14 In the multivariate white noise case it is assumed

$$E(\mathbf{u}_i\mathbf{u}_j') = \sigma_{ij}\mathbf{I}_N, \quad i, j = 1, \dots, M,$$

$$E(\mathbf{u}\mathbf{u}') = \sum \otimes \mathbf{I}_N, \quad \sum = \{\sigma_{ij}\}$$

The elements of  $\Sigma$  can be estimated using the ordinary least squares residuals of the temporally aggregated regressions  $\mathbf{y}_{aj} = \mathbf{X}_{aj}\boldsymbol{\beta}_j + \mathbf{u}_j$ . Furthermore, in this case the inversion of  $\mathbf{V}_0 = \mathbf{H}\mathbf{V}\mathbf{H}'$  can be notably simplified: by a suitable partition of  $\mathbf{V}_0$ , only a  $[(M - 1)(M - 1)]$  matrix needs to be inverted (Di Fonzo, 1990).

8.B15 The multivariate random walk case is a straightforward generalization of the univariate approach of Fernández (1981). This model is based on the following assumptions:

$$\mathbf{u}_t = \mathbf{u}_{t-1} + \boldsymbol{\varepsilon}_t, t = 1, \dots, N,$$

$$\mathbf{u}_0 = 0, E(\boldsymbol{\varepsilon}_t) = 0,$$

$$E(\boldsymbol{\varepsilon}_r \boldsymbol{\varepsilon}_s') = \begin{cases} 0 & \text{if } r \neq s \\ \Sigma & \text{if } r = s \end{cases}, r, s = 1, \dots, N,$$

where  $\mathbf{u}_t$  and  $\boldsymbol{\varepsilon}_t$  are  $(M \times 1)$  contemporaneous disturbance vectors. These assumptions imply  $E(\mathbf{u}_t) = 0$  and  $E(\mathbf{u}_r \mathbf{u}_s') = \Sigma \bullet \min(r, s)$ , that is  $E(\mathbf{u}\mathbf{u}')$ , where  $\Sigma$  can be estimated as in the multivariate white noise approach.

### Extrapolation

8.B16 When  $N > 4n$  it is necessary to estimate data for which the relevant temporally aggregated values are not available. In this case it has to distinguish whether the contemporaneously aggregated information is or is not available. In the former case there is *constrained extrapolation* while in the latter there is a *pure extrapolation* problem. In both cases the best linear unbiased estimator is needed

$$\mathbf{y}_{j,4n+i} = \mathbf{X}_{j,4n+i} \boldsymbol{\beta}_j + \mathbf{u}_{j,4n+i}, j=1, \dots, M, \text{ and } i=1, \dots, r,$$

where  $\mathbf{X}_{j,4n+i}$  is a  $(\kappa_j \times 1)$  vector of the  $\kappa_j$  related indicators for the  $j^{\text{th}}$  series at time  $4n+i$  and  $\mathbf{u}_{j,4n+i}$  is a zero mean unobservable random error.

8.B17 In the pure extrapolation case the parameter vector need not be re-estimated, the extrapolation being given by a straightforward multivariate generalization of the univariate solution shown in §5A.39.

8.B18 If a contemporaneously aggregated series is available, the complete set of estimates must instead be re-calculated (Di Fonzo, 1990).

## 8. Annex C — Benchmarking and balancing methods in the Dutch national accounts

### Introduction

- 8.C1 Chapter 8 describes the advantages of balancing the supply and use tables (SUT) as a means of improving the accuracy and overall quality of QNA; for maximum benefit the SUTs should be compiled at the most detailed level practicable.
- 8.C2 Given the time constraints for compiling QNA, balancing a large SUT with appropriate care can be difficult, particularly in a time series context. In recent years Statistics Netherlands has developed semi-automatic benchmarking and balancing methods that help the Dutch national accountants achieve the objective of balanced and temporally consistent accounts whilst giving them time to resolve any significant problems with the data. This last point needs to be emphasized: these mathematical methods are used only to eliminate small statistical discrepancies in the SUTs, whereas large discrepancies are handled ‘manually’ by national accounts experts.
- 8.C3 Both the balancing and benchmarking methods have been fully implemented for annual and quarterly SUTs. They also have a more general application, and they are applied to the institutional sector accounts (both annual and quarterly) as well as various national accounts satellite accounts (e.g. regional accounts) and in other national accounts subsystems (e.g. investment statistics).
- 8.C4 Statistics Netherlands only compiles SUTs for unadjusted data. Seasonal adjustment – using an indirect approach – is undertaken after the balancing process has concluded.
- 8.C5 The “core” of the Dutch balancing and benchmarking methods are called the Balancing Machine and the Quarterly Machine. Both “machines” are implementations of general quadratic optimization models. The mathematical aspects of these “machines” as well as their implementation, i.e. the software tools and the way these tools are used to define and solve the mathematical models, are described here. However, within the scope of this annex, many details are ignored. A reference for further details is provided below.
- 8.C6 The Balancing Machine can be used to balance a SUT for a single period (quarterly or annual). Given a certain reference period, the dataset for a single period is balanced whilst minimizing the adjustment needed to the growth rates (from an earlier period) of the preliminary estimates. It is used to balance the SUT for a period for the first time. The Balancing Machine is essentially a special application of the technology of the Quarterly Machine. The Quarterly Machine can balance the SUTs of twelve consecutive quarters in a single calculation. It is used to maintain balanced SUTs when data are revised and when new annual estimates become available. When a new final annual estimate has been compiled, the Quarterly Machine allows for a complete benchmarking of three years of quarterly data to the new annual totals. Not only are the twelve quarters benchmarked, but new balanced preliminary estimates for the quarters beyond the latest annual benchmark are derived. Furthermore, the Quarterly Machine allows new partial and unbalanced annual data to be included as benchmarks for the out years in order to improve the quality of the preliminary quarterly estimates.
- 8.C7 The “machines” are part of a redesign of the production system for the Dutch National Accounts. This redesign covers the complete production sequence of economic statistics: from data collection via surveys and registers (input), through statistical data validation and processing (throughput) to the compilation and dissemination of the statistical products (output), of which national accounts statistics are prominent examples.

## Setting the scene

- 8.C8 While all NSIs try to use their available data to best effect, the availability of data and country traditions mean that compilation processes can be quite different. A brief description of the starting point in the Netherlands is therefore useful.
- 8.C9 Statistics Netherlands has a long tradition of compiling annual and quarterly SUTs. The quarterly SUTs consist of 120 industry groups, 200 product categories and 17 final expenditure categories. The preliminary table is not seasonally adjusted. Although the level of detail would seem to suggest the availability of extensive quarterly data sources, much of it is estimated using fairly crude assumptions, in particular the product composition of output and intermediate consumption.
- 8.C10 Balancing the quarterly estimates used to be done manually. In order to increase efficiency, gain more organizational control over the balancing process and make balancing adjustments more transparent, it was decided that more automation was needed. In addition, there was the aim of making better use of quarterly estimates to compile preliminary annual estimates and to eliminate the step problem between the first quarter of one year and the fourth quarter of the previous year that commonly occurred when benchmarking to new annual totals.
- 8.C11 What has emerged is a new compilation process for balancing and benchmarking. From an organizational point of view, the most notable feature of the new national accounts process is a separation between, on the one hand, the identification, investigation, elimination and documentation of a relatively small number of large discrepancies by national accounts specialists (i.e. manually) and, on the other hand, the elimination of a large number of remaining small discrepancies by automated methods, i.e. by use of the “machines”. First, the Quarterly Machine will be discussed at some length, followed by a brief discussion of the Balancing Machine.

## The Quarterly Machine

### *The model*

- 8.C12 The Quarterly Machine uses a benchmarking method which is a multivariate extension of the univariate first order Denton method (see §5.48-5.55, §8.88-8.97 and Annex 8.A). The key feature of the first order Denton method is minimizing the sum of the quadratic adjustments in (either additive or proportional) first differences of the quarterly series, also known as the “movement preservation principle”. The minimization is subject to the constraint that the adjusted quarterly series has to be consistent with the annual series. Denton’s method is therefore an example of a constrained quadratic minimization problem. Selected formulae are provided at the end of this annex.
- 8.C13 Statistics Netherlands began its investigation of using semi-automatic methods by considering a multivariate version of the Denton method in which the various quarterly series are subject to (i.e. connected through) exogenous (or “hard”) linear, contemporaneous constraints. Hard constraints need to be satisfied exactly. This type of constraint is necessary for national accounts applications so that all the accounting identities in the framework are satisfied and temporal consistency is achieved.
- 8.C14 After some preliminary investigations and numerical experiments with actual national accounts data, a few necessary extensions to the accounting identity and temporal constraints were identified. First, it was recognized that there was a need to assign weights to the individual time series in order to reflect the relative accuracy of the underlying source data and any assumptions. For example, in the Dutch QNA output estimates are regarded as more accurate than estimates of intermediate consumption because the former are based on actual data whereas the latter are estimated by assuming a proportional relationship to output in volume terms. These relative degrees of accuracy of the different time series need to be taken into account in the benchmarking process. Second, it was recognized that there was a

need for “soft” linear constraints and “soft” ratio constraints. Soft constraints are those that need to be satisfied approximately by the adjusted series.

- 8.C15 An example of soft ratio constraints applies to price indices, which can be formulated as the ratio of values in current prices to values in average prices of the previous year and as the ratio of values in average prices of the previous year to values in the average prices of the reference year. Preserving both types of price indices of the unadjusted series as well as possible has proved to be necessary in the benchmarking process to achieve satisfactory results. Soft ratio constraints can also be used to keep the volume change of intermediate consumption in line with the volume change of output during balancing and to maintain the links in volume between the supply and demand of goods and related trade margins. The soft ratio constraints can be assigned a weight label to reflect the relative accuracy of the preliminary estimates.
- 8.C16 Soft linear constraints are useful for other purposes. For instance, in situations where a limited number of unbalanced annual estimates are available for benchmarking the quarterly series and the annual estimates are not considered to be “exact”. In this case a weight can be assigned to the annual estimate such that the adjusted quarterly series has to add up approximately, but not exactly, to the annual estimate. In this situation the annual “soft” estimate helps to guide the benchmarking process of the quarterly series, so as to make the best of the available quarterly and annual estimates.
- 8.C17 The upshot is that the original multivariate Denton method (including only linear exogenous constraints and no weights) has been extended at Statistics Netherlands to include weights for the individual quarterly series and weighted soft linear and weighted soft ratio constraints. An essential feature of the extended method is that the weights of the quarterly series as well as the weights of the soft constraints have been parameterized in a careful way, such that in practice weight labels are assigned to reflect the relative accuracy of the different series and constraints. These weight labels (letters A to G) subsequently appear as numerical weights in the quadratic terms of the objective function to be minimized.
- 8.C18 In formulating the benchmarking problem, numerical values of the weights do not need to be specified because they are calculated from the assigned weight labels according to the parameterization formulae. The parameterization of weights is a key feature of the extended method because it makes it feasible to apply the method in practical situations where all that is known, at best, are the relative accuracies of the quarterly and annual estimates that are fed into the model.
- 8.C19 The approach, as discussed above, was tested with complete SUT data sets. During these experiments, the benchmarking setup, i.e. all the necessary relations among the variables, was developed and tested and the set of weight labels was optimized in order to obtain plausible results. The experiments eventually showed that satisfactory results could be obtained. These positive test results served as a “proof of concept” and, subsequently, work was started to create an implementation of the extended method in the national accounts.

### *The tools*

- 8.C20 Apart from the obvious tools needed to read and write data from the national accounts databases, which are not discussed here, it was decided that two specific modules (or tools) had to be developed in order to implement the methodology. The first module was needed to enable national accounts statisticians to formulate the problem to be solved, i.e. to specify all necessary hard and soft constraints (the benchmarking set-up) and to assign the appropriate weight labels to the series and constraints. A second module was needed to translate the specification of the problem into an objective function to be minimized, to subsequently carry out the numerical optimization, and finally to return the “optimal solution” as rounded values that need to be consistent with all the hard linear constraints in the system.

- 8.C21 The first module was implemented as an object library which can be accessed using the Visual Basic for Applications (VBA) programming language (or in principle, any other scripting language) that is included in the Microsoft Office package. Using the object library, a statistician is able to program the benchmarking set-up, i.e. to specify the set of all hard and soft constraints in the system and to assign the appropriate weight labels.
- 8.C22 The second module was implemented as a “shell” around a commercial optimization software package XPress-MP, which is designed specifically to solve large scale optimization problems. This module takes care of the necessary translation of input and output files and the communication with the XPress solver.

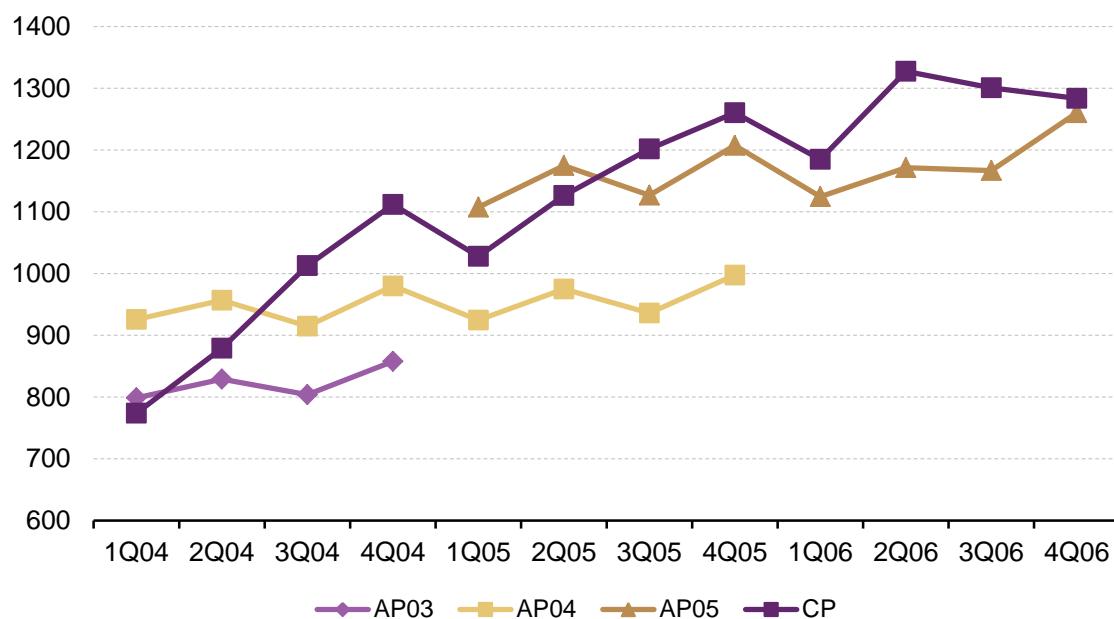
### *The benchmarking process in practice*

- 8.C23 In a typical QNA benchmarking setup at Statistics Netherlands, there are quarterly series consisting of twelve quarters (i.e. three complete years). For each supply and use variable there are current price estimates and estimates in the average prices of the previous year. Figure 8.C.1 depicts the case (of use of diesel fuel) when the twelve quarters coincide with three calendar years (2004, 2005 and 2006):
- current price values - CP;
  - estimates for the four quarters of 2004 at average 2003 prices – AP03;
  - estimates for the eight quarters of 2004 and 2005 at average year 2004 prices – AP04;
  - estimates for the eight quarters of 2005 and 2006 at average year 2005 prices – AP05.

The corresponding price indexes are calculated implicitly by the Quarterly Machine.

Figure 8.C.1: Quarterly supply and use data in the Quarterly Machine

Total use of diesel fuel in the Netherlands (€millions)



- 8.C24 In addition, there is at least one (the final annual estimate for the first year) and at most three SUT annual estimates. For each quarter, a QNA dataset consists of about 42,000 variables (estimates). For the complete set of 12 quarters there are, therefore, roughly half a million (500,000) estimates that are subject to adjustment in the benchmarking process. This involves satisfying, simultaneously, temporal constraints with the annual totals and (typically) 1,000 hard linear constraints and 15,000 soft ratio constraints for each quarter, which for the entire dataset corresponds to a total of at least 300,000 constraints. The numbers mentioned here are not exact but are meant to give an indication of the magnitude of the problem of benchmarking large QNA datasets.
- 8.C25 One iteration of QNA benchmarking process involves the following steps:
- a. reading data from QNA and SUT databases;
  - b. running the VBA script for defining the rules (constraints and weights);
  - c. solving the optimization problem;
  - d. writing the results back into the databases.
- 8.C26 After each iteration of the benchmarking process the results are examined by national accounts experts. If problems in the results are detected (i.e. adjustments to the original quarterly series that do not meet plausibility checks), they are discussed in a small group of national accounts specialists and possible ways of solving them are considered. There are essentially two approaches available to solving unsatisfactory results:
- modifying the original quarterly series so as to eliminate large discrepancies between quarterly and annual estimates, or
  - modifying the model setup, i.e. adding or modifying constraints or adjusting weights.

Normally, the first option is preferred since the model setup is thought of as more or less a fixed specification for the benchmarking problem at hand, and so it should not be subject to frequent changes. This is especially the case for the set of weight labels, which represent the relative accuracy of the source data underlying the quarterly estimates, and which require very good reasons to be changed. Occasionally, however, adjustments to the model setup (constraints or weights) are allowed when these are expected to be an effective solution for specific problems identified in the benchmarking process.

- 8.C27 Currently, for each year, about 5 to 7 iterations are needed to arrive at satisfactory benchmarked QNA series. For the complete quarterly benchmarking cycle in the annual production cycle (three consecutive years) this implies up to 20 iterations to finalize QNA benchmark process. However, for each iteration the workload and capacity (in terms of the amount of hours spent by national accounts statisticians to review the results) is rather limited.
- 8.C28 As was described earlier, the Quarterly Machine and the Balancing Machine are designed to effectively, efficiently and transparently eliminate the (large number of) small discrepancies in national accounts systems. Even though the machines are able to eliminate large discrepancies, they are not used for that purpose. In order to ensure results of good quality, the (relatively small number of) *large discrepancies* need to be examined and resolved by national accounts specialists, as they point to clear problems in the source data or assumptions underlying the preliminary estimates. In other words, large discrepancies are an indication of (large) inconsistencies in the preliminary estimates that cannot be dismissed as statistical “noise”, and they need to be examined and resolved with the expertise of national accounts specialists and those responsible for the source data, if required.



## The Balancing Machine

- 8.C29 The *Balancing Machine* is an extension of the method proposed by Richard Stone (first formulated in 1942) for balancing an accounting system while taking into account the differences in accuracy of the *preliminary* estimates of the variables in the system. In Stone's method, the discrepancies (or residuals) are distributed among the variables in such a way that the more accurate estimates are adjusted less than the less accurate estimates, and the known (i.e. precise estimates) values are not adjusted at all.
- 8.C30 As formulated here, Stone's method is a constrained quadratic minimization problem in which the sum of the weighted quadratic adjustments to the preliminary estimates is minimized subject to the condition that the adjusted estimates need to exactly satisfy all relations among the variables, such as the accounting identities.
- 8.C31 As discussed above in the context of the Quarterly Machine, the need for additional soft linear and soft ratio constraints is needed in order to make the method suitable for application to national accounts systems. Accordingly, at Statistics Netherlands research was carried out to extend Stone's method to include these types of soft constraints.
- 8.C32 A set of parameterization formulae was developed in order to calculate the appropriate numerical weights for the variables and soft constraints in the objective function to be minimized, such that weight labels can be assigned to the variables and constraints that reflect the relative accuracy of the preliminary estimates. As explained earlier, this parameterization is an essential aspect of the approach because it makes it feasible to apply the method in practical situations.
- 8.C33 Several experiments were carried out with actual QNA data sets and they demonstrated that satisfactory results could be obtained. During the experiments, the balancing "set-up", i.e. all the necessary relations among the variables, were developed and tested. The weight labels of the variables were optimized using the manual balancing process. Subsequently, work was started to implement the method and it was applied for the first time to balance QNA estimates of third quarter 2010 in December 2010.
- 8.C34 The tools and the organization of the balancing process using the Balancing Machine are very similar to the tools and the organization of the benchmarking process using the Quarterly Machine. In particular, the clear distinction which is made in the process between large discrepancies, which need to be investigated and resolved by national accounts experts, and the (large number of) remaining small discrepancies which can be reconciled automatically, is identical in both approaches.

## Selected formulae

- 8.C35 This section presents the main formulae on which the benchmarking and balancing methods are based. The objective function of the extended multivariate Denton method is as follows:

$$\begin{aligned} \text{Min}_{\hat{x}} \quad & \sum_{i=1}^N \sum_{t=2}^T A_{it} \left( \frac{\Delta x_{it} - \Delta \hat{x}_{it}}{w_{it-1}^A} \right)^2 + \sum_{i=1}^N \sum_{t=2}^T (1 - A_{it}) \left( \frac{\left( \frac{\hat{x}_{it} - \hat{x}_{it-1}}{x_{it} - x_{it-1}} \right) / w_{it-1}^P}{w_{it-1}^P} \right)^2 + \\ & \sum_{r=1}^{C^S} \left( \frac{\left( b_r^S - \sum_{t=1}^T \sum_{i=1}^N c_{rit}^S \hat{x}_{it} \right) / w_r^C}{w_r^C} \right)^2 + \sum_{r=1}^{R^S} \left( \frac{\hat{x}_{i,t_r} - d_r^S \hat{x}_{j,t_r}}{w_r^R} \right)^2 + \\ & \sum_{i=1}^N \sum_{t=2}^T B_{it} \left( \frac{x_{it} - \hat{x}_{it}}{w_{it-1}^L} \right)^2 \end{aligned}$$

with the conditions that:

$$b_r^H - \sum_{t=1}^T \sum_{i=1}^N c_{rit}^H \hat{x}_{it} = 0 \quad r = 1, \dots, C^H$$

$$l_{it} \leq \hat{x}_{it} \leq u_{it} \quad i = 1, \dots, N; t = 1, \dots, T.$$

The optimal solution has to meet the linear (hard) constraints and upper and lower bounds which are imposed on the adjusted estimates.

8.C36 In the formulae  $x_{it}$  are the preliminary estimates,  $\hat{x}_{it}$  are the adjusted estimates, and there are  $N$  variables and  $T$  time periods (e.g. quarters).

The objective function to be minimized is quadratic and consists of five types of quadratic terms:

1. additive Denton adjustments;
2. proportional Denton adjustments;
3. soft linear constraints;
4. soft ratio constraints (linearized);
5. soft level constraints.

Features of these adjustments and constraints are as follows:

- In the first and second terms there is an indicator function  $A_{it}$ , which equals 1 if additive Denton adjustments apply and zero if proportional Denton adjustments apply.
- In the third term, there are  $r = 1$  to  $C^S$  soft linear constraints,  $b_r^S$  is a target value for the  $r^{\text{th}}$  soft linear constraint and  $c_{rit}^S$  are coefficients for the soft linear constraints.
- In the fourth term, there are  $r = 1$  to  $R^S$  soft ratio constraints, and  $d_r^S$  is a target value for the  $r^{\text{th}}$  soft ratio constraint.
- In the fifth term, there is an indicator function  $B_{it}$  which equals 1 if a soft level constraint applies and zero if it does not.
- There are  $r = 1$  to  $C^H$  hard constraints and  $b_r^H$  is a target value for the  $r^{\text{th}}$  hard constraint.

8.C37 Each of the five terms in the objective function has its own set of parameterized weights  $w_{it}^A$ ,  $w_{it}^P$ ,  $w_r^C$ ,  $w_r^R$ , which are used as substitutes for variances of the estimates of each variable.

The parameterization formulae for the weights are:

$$(w_{it}^A)^2 = \beta^{-2J_{it}} |\overline{x_i}|^2,$$

$$(w_{it}^P)^2 = \beta^{-2J_{it}},$$

$$(w_r^C)^2 = (\alpha^C)^2 \beta^{-2K_r} \left( \sum_{t=1}^T \sum_{i=1}^N (c_{rit}^S)^2 \beta^{-2J_{it}} |\overline{x_i}|^2 \right) / (c_r^S)^2$$

$$(w_r^R)^2 = (\alpha^R)^2 \beta^{-2L_r} \beta^{-J_{i'r'}} \beta^{-J_{j'r'}} (d_r^S)^2 \tilde{x}_{j'r'}^2$$

$$(w_{it}^L)^2 = (\alpha^L)^2 \beta^{-2M_{it}} \beta^{-2J_{it}} |\overline{x_i}|^2.$$

where

$|\overline{x_i}| = \frac{1}{T} \sum_{t=1}^T |x_{it}|$ ,  $(c_r^S)^2 = \sum_{t=1}^T \sum_{i=1}^N (c_{rit}^S)^2$ , and  $\tilde{x}_{j'r'}$  is an imputed value for  $x_{j'r'}$  (see reference below for details).

$\beta$ ,  $\alpha^R$ ,  $\alpha^C$ ,  $\alpha^L$  are numerical constants which control the relative importance of the various quadratic terms in the objective function.

The numerical parameters  $J_{it}$ ,  $K_r$ ,  $L_r$  and  $M_{it}$  can be assigned integer values (for instance, in the range:  $-3$ ,  $-2$ ,  $1$ ,  $0$ ,  $1$ ,  $2$ ,  $3$ ), and they correspond to the weight labels (for instance, G, F, E, D, C, B, A), which can be assigned to the different terms in the objective functions, as discussed above.

8.C38 It is beyond the scope of this annex to discuss the derivation of the parameterization formulae and their properties. These and other details can be found in a methodological paper (Bikker, Daalman and Mushkudiani (2012)) available on the website of Statistics Netherlands<sup>(56)</sup>. Formulae for the Balancing Machine are very similar and are not shown here.

<sup>(56)</sup> <http://www.cbs.nl/NR/rdonlyres/6CEAAB46-AE7D-4F6D-92CA-CF2DD49157A9/0/2012Macrointegrationmultivariategedontart.pdf>

## 9. The validation of QNA

Good quality QNA are needed to enable business and government economists, journalists and others to understand what has been happening in the economy and to support well-founded economic decisions. To ensure that the accounts are fit for purpose, it is essential that the estimates are subjected to a thorough validation process.

Validation of QNA has three distinct dimensions: statistical, accounting and economic. Statistical validation consists of ensuring the source data are as accurate possible, assessing whether methodological assumptions continue to be valid, ensuring methods are consistently and appropriately applied, and, most importantly, ensuring there are no compilation errors. Accounting validation consists of ensuring that accounting rules are obeyed. Economic validation consists of bringing to bear knowledge of what has been happening in the economy and looking at the national accounts estimates in conjunction with non-national accounts data through the eyes of a trained economist. All three dimensions of validation are applied through the compilation process, but it is necessary to distinguish between them, both for the sake of exposition and the role each has to play.

## Introduction

- 9.1. Previous chapters have discussed data sources, deriving estimates of QNA variables, benchmarking quarterly data to annual estimates, seasonal adjustment and balancing. This chapter is concerned with checking, evaluating and verifying the estimates at each stage of the compilation process and making corrections and amendments as required. At the end of validation:
- the figures should be well-grounded, i.e. all the elemental estimates should have been carefully scrutinised and considered to be satisfactory;
  - there should be no compilation errors;
  - the national accounts as a whole should paint a coherent picture;
  - the figures should be able to withstand close scrutiny by users, so that any query or criticism of the estimates can be answered.
- 9.2. Validation of QNA has three distinct dimensions: statistical, accounting and economic. Statistical validation consists of ensuring the source data are as accurate as possible, assessing whether methodological assumptions continue to be valid, ensuring methods are consistently and appropriately applied, and, most importantly, ensuring there are no compilation errors. Accounting validation consists of ensuring that accounting rules are obeyed. Economic validation consists of bringing to bear knowledge of what has been happening in the economy and looking at the national accounts estimates in conjunction with non-national accounts data through the eyes of a trained economist. It needs to be stressed that the latter is only for the purposes of validation and anticipating user enquiries; it does not mean fashioning the figures to fit a particular economic theory or to meet the expectations of users.
- 9.3. Statistical validation is undertaken intensively at the beginning of the compilation process in order to identify any errors or other deficiencies in the source data and any errors made in compiling the preliminary national accounts estimates. It is also undertaken at the end of the compilation process, but with regard to the data to be published. It may also be undertaken at various intermediate stages. Accounting validation is undertaken once the major aggregates have been derived and then again right at the end of the compilation the process to ensure the published data satisfy the accounting constraints. Economic validation is usually undertaken after the first round of accounting validation has been completed.
- 9.4. One element of validation is to check the revisions made to the estimates published in the previous release. The revisions analysis discussed in this chapter is restricted to identifying erroneous revisions and assessing the validity of the revised economic depiction of previous quarters. Chapter 10 discusses how revisions may be analyzed in order to improve preliminary estimates and thereby reduce subsequent revisions. An important goal of revision analysis is the elimination of bias in preliminary estimates.

## Why validation is so important in QNA

- 9.5. Validation aims to ensure that QNA are good enough to support public debate and economic analysis. While many data validation issues apply to both ANA and QNA, they tend to be of greater significance in QNA for several reasons:
- Quarterly source data tend to be scantier and more partial, are generally subject to greater measurement error, are often preliminary and hence subject to revision, and may not have been as thoroughly edited as annual source data.
  - Quarterly source data are less likely to satisfy national accounting definitions than the annual source data, and there is more reliance on models and assumptions. As a result, the processes for deriving QNA are generally less reliable than their annual counterparts.

- c. QNA compilers are faced with dealing with all these issues in a very short space of time, and they make mistakes.
- 9.6. QNA validation aims partly at ensuring credible data. Credibility is a twofold concept:
- a. It corresponds to an ability to describe in an understandable or explainable way from a global point of view what various economic agents can observe in their different and restricted economic sectors of activity.
  - b. It also corresponds to the accuracy, reliability and stability of the estimates (see §10.5 - §10.10). While reliability should never be achieved at the expense of accuracy, the size of revisions should be small enough to make the first estimates relevant and sufficiently reliable for use in decision making. This is achieved by sound estimation practices, informed by revisions analysis, and a thorough validation process.
- 9.7. Validation also aims at ensuring that the national accounts properly describe an ever-changing economic world in which new products are created and new relationships between economic actors are established. Therefore it is essential that QNA compilers be aware of any assumptions and models used to derive their estimates, and be alert to any developments that may invalidate them.
- 9.8. It is standard business accounting practice that the accounts of a business are audited to ensure that they give a true and fair statement of the business's performance and financial position. Likewise, QNA should be subject to an audit to ensure that they give a true and fair statement of a territory's economic activity and financial position. Validation of QNA is the equivalent of an audit of a business's accounts. It is critically important that national accountants have confidence in their estimates and are able to defend them. A thorough validation process is an essential ingredient.

### Statistical validation

- 9.9. It is imperative that a thorough statistical validation be undertaken of the source data and preliminary QNA estimates (see Chapter 3). This preliminary statistical validation is not necessarily done by national accountants as it may be done by those supplying the source data if they are part of the same organization. Whoever is responsible, if this initial validation is not done effectively, then errors and other deficiencies will either go through the entire compilation process unnoticed and unaddressed, or they will be identified later in the compilation process and precious time will be wasted re-working the estimates. It is equally important that the final data be subject to a thorough statistical validation in order to ensure that there are no compilation errors in the published data. Statistical validation is most efficiently done with the aid of computer-generated tables and graphs. Generally, tables are best for analyzing short time spans in detail, while graphs are best suited for analyzing long time spans.

#### *Validating the source data*

- 9.10. Source data for the national accounts generally fall into one of five categories:
- a. data from official business and labour force surveys (e.g. output, sales, compensation of employees, new capital expenditure, inventories and employment);
  - b. administrative data from government organisations (e.g. government finance, international trade (customs), new motor vehicle registrations, health and education output, financial assets and liabilities of financial institutions, and insurance data);
  - c. publicly available data from research institutes, news agencies, etc. (e.g. opinion surveys and other qualitative data);

- d. data from professional unions and industry bodies (e.g. information relating to doctors, dentists, lawyers and pharmacists);
  - e. specially tailored surveys of a few very large private and public corporations (e.g. utility and transport services).
- 9.11. In all cases, national accounts compilers should collect information about the data such that they understand what the data are measuring and are aware of their strengths and weaknesses for the purpose of compiling QNA. In the case of sample surveys, national accounts compilers should be aware of the scope and coverage of the survey, the suitability of the questions used, the size of the sampling errors, and they should have some notion of the nature and importance of non-sampling errors. In the case of other data sources, national accounts compilers should understand what exactly is being measured and how well it is being measured. As discussed in Chapter 3, national accounts compilers should work as closely as possible with their data providers to maximize the quality of the estimates they receive and to obtain explanations for any unusual movements.
- 9.12. In those countries with centralized statistical systems, most of the statistical surveys collecting economic data are conducted by the same agency that compiles the national accounts. In such cases, the national accountants should be able to work very closely with the survey statisticians to obtain good quality survey estimates and eliminate any systematic biases at source. When such a good data service is unavailable, it falls to the national accountants to do the best they can to overcome any shortcomings of survey data. This requires them to keep abreast of developments by regularly reading the economic and business press to learn about mergers, new plants, etc., and determine whether they are being adequately reflected in the source data. They also need to keep abreast of government decisions that may have an impact on the economy.
- 9.13. Where a chronic bias exists in the source data, national accountants should alert the survey statisticians to the problem and seek to have it remedied, irrespective of whether the survey statisticians belong to the same organization. Presented with biased data, national accountants should adjust them as best as they can, warn the users (both intermediate and final users) of possible mismeasurement and stipulate the cause of the bias.
- 9.14. A common cause of biased survey data is an inadequate business register. It may be poorly maintained, such that the sample population is seriously out of date, or the new business provisions may be either non-existent or inadequate in some way (e.g. they do not take account of the fact that the number of businesses increases at a greater rate in a business cycle upswing than during a downswing). When problems of this kind occur, national accountants have to try to assess the impact of the deficiencies on levels and, in particular, short-term growth. When they have exogenous information at their disposal, such as the number of births and deaths of firms, then in the absence of new business provisions they should adjust the survey data as well as possible and inform users of the problem and what they are doing about it in their methodological documentation. When they know that a new large plant has begun production and it is not being adequately accounted for in the survey estimates, they should collect information to estimate the impact of the new plant on national output and make an adjustment. Knowledge of such weaknesses in the source data and the steps taken to overcome them may play a role in the reconciliation and balancing process conducted later. But it needs to be stressed, that such attempts by national accountants to fix problems with survey data are very much a last resort. It is far better if the problems are resolved by the survey statisticians.

***Validating the initial national accounts estimates***

- 9.15. Once the initial national accounts estimates have been derived, it is necessary to assess them. The primary objective is to identify any errors or deficiencies in the source data and any errors made by the national accounts compilers. This commonly involves comparing the initial estimates with something else; there are several possibilities:
- a. comparing an observation with previous observations, i.e. analysing growth rates;
  - b. checking that there is no residual seasonality in the seasonally adjusted figures by comparing the quarterly growth rate pattern over the latest year with those of previous years;
  - c. analysing the consistency of the current price and volume estimates by analysing the growth rate of the implicit price deflator (IPD) and comparing it with the growth rate of related price indices;
  - d. analysing the ratio of output to gross value added for each industry; in seasonally adjusted volume terms this ratio is not normally expected to change very much from quarter to quarter;
  - e. undertaking a revision analysis by comparing the newly-made estimates for past quarters with those made previously. For example, in the preparation of QNA for the fourth quarter, estimates made for the third and previous quarters should be compared with the estimates prepared for the final third quarter release;
  - f. comparing the growth rate of a national accounts variable with closely related indicators.

***Plausibility of the quarterly growth rates***

- 9.16. One of the most basic edits is to simply examine the growth rates of a variable, with particular attention being paid to the latest quarter. If there are original and seasonally adjusted current price and volume estimates available, then it is usually best to examine the growth rates of the seasonally adjusted volume estimates first. Do the growth rates appear to be implausible? Do they appear too high or too low, or has there been no change at all? Checking for plausibility requires judgement based on past experience and a perception of the current economic situation. For example, growth from the previous quarter in seasonally adjusted volume terms of gross value added for total manufacturing of 10% or final household consumption expenditure of -3% would in normal circumstances provoke suspicions that an error has been made. One would then examine the original volume data and the original and seasonally adjusted current price data to see where the “implausibility” originated.
- 9.17. If there are compilation errors in the national accounts system one fixes them, but if the original source data appear to be questionable, then an investigation is required. If the source data are very likely in error, then one should contact the data provider for an explanation immediately. If the explanation is unsatisfactory, then the national accounts compiler needs to be persistent until he gets to the bottom of the matter. If this fails, then he needs to alert his supervisor of the problem. It is not unknown for data suppliers to give assurances that anomalous data are correct when in fact they are not. Even if the growth rates of the source data are within the bounds of credibility, then it is generally worthwhile contacting the data supplier for confirmation and to get any insights they can provide.

***Adequacy of the seasonal and calendar adjustment***

- 9.18. The seasonal adjustment of QNA is addressed in Chapter 7, and procedures for updating seasonal and calendar factors are discussed in §7.79-7.87. It is recommended that all QNA variables subject to seasonal adjustment should be re-analyzed every quarter either for the purpose of concurrent seasonal adjustment or to ascertain whether the forward factors being used are adequate. Even if these recommendations have been implemented, it cannot be assumed in the validation phase that all is well



with the seasonal and calendar adjustments. One still needs to check that there are no obvious problems with the seasonal adjustment:

- a. do the implicit seasonal and calendar factors appear to be legitimate; do the seasonal factors almost cancel out over a year?
- b. are there any signs of residual seasonality in the seasonally adjusted data?
- c. do those series that are indirectly seasonally adjusted equal the sum of their seasonally adjusted components (for volume estimates they should be additive in the average prices of the previous year)?

#### *Consistency of the current price and volume estimates*

- 9.19. For expenditure and production estimates there are both current price and volume estimates, and in most cases the volume estimates are derived by deflating the current price data with a suitable price index at a detailed level. The easiest way to check that current price and volume estimates are consistent is to examine the implicit price deflators (IPDs). First, check that the IPDs have an average close to 1 in the reference year and then examine the growth rates. The prices of most products are non-seasonal, and for such products the IPDs derived from unadjusted data and those derived from seasonally adjusted data should be similar, with only small differences between their quarter-on-quarter growth rates that offset each other over a year. Significant differences would suggest that there is an inconsistency in the seasonal adjustment of the current price and volume estimates that needs to be investigated. Products that have seasonality in their prices, such as some agricultural products and products sold at lower prices during seasonal sales, can be expected to have seasonality in the IPDs derived from the unadjusted current price and volume data, but no more than slight, transient seasonality in the IPDs derived from the seasonally adjusted data. Significant differences between the annual averages of the two IPDs could mean there are inconsistencies in the seasonal adjustment.

#### *Unexpected revisions*

- 9.20. An assessment should be made of the revisions to the levels and growth rates since the previous quarter's release. Are the revisions plausible? If they are not, check that no compilation errors have been made and then query the data supplier. Even if the revisions are plausible but substantial, then contact the data supplier for an explanation. If they are so substantial that they materially change the picture painted in the previous quarter's release, then an investigation may be needed to determine if there is a way that such large revisions can be avoided in future. Are the revisions to original and seasonally adjusted current price and volume data consistent? Revisions can be expected to be different if there has been a seasonal reanalysis, but a large difference warrants an investigation. If the same source data are used to derive estimates of different variables (e.g. related expenditure and production variables), then check that the revisions have been made consistently. Check that no revisions have been made prior to the period liable for revision set by the revisions policy. Graphs are useful for this purpose.

#### *Coherence with national accounts indicators*

- 9.21. Comparisons between the indicators used in the compilation of QNA, plus any quantitative data that have been identified as auxiliary indicators, and the corresponding national accounts variables should be built into the editing process – see Box 9.1. The primary objective is to identify any anomalies that could be due to compilation errors, but anomalies between the indicators could indicate a deficiency in one of them that needs to be investigated. In most cases, the differences between the growth rates of QNA estimates and the indicators will be legitimate and be due to differences in definition, scope and weighting, but one should avoid falling into the trap of assuming that this is always the case. If national accounts compilers do not make these comparisons, then they can rest assured that some users will. Thus such comparisons offer two benefits:

- a. they can reveal deficiencies with national accounts variables;
- b. they enable the national accountant to be prepared to answer any queries from users as to why there are differences between the national accounts and non-national accounts variables.

**Box 9.1: Identifying and using auxiliary indicators – an example**

The usual data used to measure the output of aluminium manufacturing may be obtained from a monthly or quarterly business survey. If available, sales of electricity to aluminium manufacturers could be used to cross-check the output (or intermediate consumption, if it is collected quarterly) reported by the aluminium manufacturers in the knowledge that the cost of electricity accounts for much of the value of aluminium. But first, the national accountant would need to satisfy himself that the electricity data accurately measures the usage by the aluminium producers and, second, he would need to check on the stability of the relationship between aluminium output and electricity usage either by referring to supply and use tables or examining the data collected in annual censuses or surveys. Given that the output of aluminium manufacturing is measured in euros and electricity usage is measured in kilowatt hours, the cross-check would be done by comparing the growth rate of the volume measure of output with that of electricity usage.

- 9.22. Comparisons are usually more informative if they are made with seasonally adjusted data, when available, because there can be vagaries of a seasonal nature between the measures being compared. Furthermore, it is desirable that the series to be compared have been seasonally adjusted in a consistent way. Also, it is generally better to make comparisons in volume terms, rather than at current prices, because the prices of the variables being compared may grow at different rates. The following are some common comparisons and evaluations made between national accounts variables and the corresponding indicators:
- a. indicators of production or output versus the corresponding national accounts measure of gross value added;
  - b. retail sales versus retail gross value added versus household final consumption of goods;
  - c. exports and imports of goods versus customs data;
  - d. health expenditures versus health insurance statistics;
  - e. price indices versus the corresponding national accounts IPDs, e.g. the CPI versus the IPD of household final consumption expenditure, export price indices versus the corresponding export IPDs, and import price indices versus the corresponding import IPDs;
  - f. employment underlying the estimates of compensation of employees versus employment data from the labour force survey;
  - g. a wage cost index versus compensation of employees per employee.
- 9.23. The recommended approach is to develop tables that present all the required information in a user-friendly way that supports a thorough, but rapid investigation. Things to consider when making the last three of these comparisons (e, f and g) are discussed in the annex to this chapter.
- 9.24. The principal reason for cross-checking with auxiliary indicators is to check the plausibility of the national accounts data, but it may be possible to go one step further and use the secondary data source directly to improve the quality of the national accounts estimate by using optimal methods, such as that of Chow and Lin, which is described in Chapter 5. Also, if data from the primary source are unavailable in time for a particular quarterly release, or for the flash estimates every quarter, then data from the

secondary source may be used solely to produce the national accounts estimates. Dealing with missing information is discussed in Chapter 4.

### **Validating estimates from later compilation steps**

- 9.25. At the end of each subsequent compilation step, further statistical validation may be undertaken, but it is essential that the final estimates undergo statistical validation. The primary objective is to find any compilation errors and revisions prior to the revision cut-off (as defined by the revisions policy), but it may be that there are some deficiencies in the source data yet to be uncovered. As the compilation process proceeds, the focus moves to the data to be published, and in particular to the major aggregates. In most other respects, the validation edits are much the same as those used for the initial estimates. An examination of the contributions to the growth of GDP in unadjusted and seasonally adjusted, current prices and volumes should be made once estimates of GDP are available. Are the contributions consistent on the production, expenditure, and income sides of GDP? Do the contributions to growth of the component chain-linked volume estimates sum to the growth rates of their aggregates?

### **Accounting validation**

- 9.26. Accounting validation entails ensuring that all the accounting relationships embedded in the national accounts are satisfied. Ideally, QNA should be fully balanced. It is recommended in Chapter 8 that the balancing of production, final expenditures and the income generated from production should be undertaken through the framework of supply and use tables (or possibly symmetric input-output tables). There should be complete consistency between the production, expenditure and income approaches to measuring GDP in unadjusted and seasonally adjusted current prices and also between the production and expenditure approaches to measuring GDP in unadjusted and seasonally adjusted volume terms. It may also be possible to confront and balance these data (using a cross table) with the institutional sector accounts if separate basic data have been used to compile them, but it is more likely that the data from the balanced supply and use tables are used to derive the institutional sector accounts. If possible, the capital and financial accounts for each institutional sector should also be balanced.
- 9.27. Those NSIs that balance their accounts using supply and use tables will automatically ensure that the goods and services account, production account and generation of income account are in balance and validated in an accounting sense. Those NSIs that do not balance their different measures of GDP in a supply and use framework must undertake some form of balancing at a high level of aggregation (see §8.73–8.78). They can then undertake a partial accounting validation by comparing the growth rates of related variables on the production and expenditures sides of GDP. For example:
- a. household final consumption expenditure on food and beverages versus the corresponding net imports *plus* manufacturing of processed food and beverages *plus* agricultural output of food that is not processed (e.g. fruit and vegetables) *less* changes in inventories;
  - b. the sum of private and government final consumption on education versus the output or gross value added of education, and the same for health;
  - c. gross fixed capital formation of building and construction versus the output of the construction industry;
  - d. gross fixed capital formation of machinery and equipment versus the corresponding net imports and manufacturing output data.
- 9.28. Such comparisons can reveal both inconsistencies in the source data and deficiencies in any models and assumptions being used to generate QNA estimates. It is therefore crucial to be aware of what models are being used.

- 9.29. The possibilities for validating the incomes earned from production in an accounting sense are more limited. Two examples are:
- a. Comparing production-based and income-based estimates of gross value added by industry. If there are no independent estimates of gross operating surplus and gross mixed income, then the aggregate of the two can be derived residually for each industry and assessed by comparing its growth rate with those of gross value added and compensation of employees.
  - b. At a global level, an assessment of the changes in the factor income shares of GDP can be made, i.e. the ratios of the following to GDP: compensation of employees, gross operating surplus of financial and non-financial corporations, gross mixed income, and taxes *less* subsidies on production and imports.
- 9.30. Balancing items comprise some of the most interesting statistics in the national accounts. GDP, gross value added by industry and gross operating surplus/gross mixed income are invariably closely scrutinized by national accounts compilers, whether supply and use tables are used or not. All the other balancing items should be closely assessed, too, in order to ensure that they are meaningful in their own right, and also because they can be indicators of inconsistencies in the accounts.
- 9.31. One balancing item of particular interest is household saving; in particular, its ratio to household disposable income. Household saving is derived as household disposable income *less* household final consumption<sup>(57)</sup>. Household disposable income comprises compensation of employees *plus* net property income receivable *plus* net current transfers receivable. Hence the estimated value of household saving includes all the non-offsetting errors in these components and household final consumption. Unless compensation of employees, the major component of household disposable income, is well balanced with household final consumption expenditure in a supply and use table, their measurement errors are likely to be poorly correlated. Consequently, erratic growth in the household saving ratio is often indicative of inconsistencies in the accounts.
- 9.32. Another balancing item is net lending/borrowing. This item is separately derived in the capital and financial accounts, and initial estimates can be wildly different. Ideally, the figures for net lending/borrowing should be the same in each of the two accounts and they should be meaningful in their own right. The balancing of this item is addressed in §8.79-8.81.

### Economic validation

- 9.33. As for the other two types of validation, economic validation is primarily about finding any deficiencies in QNA estimates and fixing them. It does this by testing how well QNA estimates fit with data that are not statistically linked to the national accounts, but that are linked in an economic sense. When the fit is poor, an investigation is undertaken. If this leads to finding a deficiency in QNA, it is fixed, otherwise no action is taken. But in this case, at least the national accountants are prepared for any queries from users.
- 9.34. With a few exceptions, such as comparing QNA and labour force survey employment data (see §9.A7-9.A11), statistical and accounting validation are unlikely to reveal deficiencies in the national accounts arising from problems with the business register. By comparing QNA estimates with data derived independently of the business register, economic validation provides a valuable tool for addressing this shortfall. Furthermore, if QNA are not fully balanced using supply and use tables, there may be deficiencies in the estimates arising from source data inconsistencies and model deficiencies that have not been detected by accounting validation, but economic validation may identify them.

<sup>(57)</sup> *Plus* an adjustment for the change in equity of households on pension funds if this has been excluded from disposable household income.

- 9.35. Economic validation has two aspects: (i) it refers to cross-checking different kinds of economic information, and (ii) it involves the detailed study of the economic change described by the figures and its concordance with the empirical knowledge of the economic mechanisms observed in the past.

### **“Economic” cross-checks**

- 9.36. Economic cross checks are made by comparing the growth rate of a national accounts variable with that of another variable that may be expected to be closely correlated with it. Economic cross checks differ from statistical cross checks in that the variables being compared are not statistically related. An example of an economic cross-check is to compare the growth rate of the volume measure of household final consumption expenditure on food with population growth. This cross-check is based on the assumption that food consumption per head should not change very much in the short term. But first, the national accountant needs to check the veracity of the quarterly population estimates and satisfy himself that they provide an adequate indicator.
- 9.37. Other examples are data from qualitative surveys (for example, business attitudinal surveys), which are a source of statistical information, are rapidly available, usually only slightly revised, and summarise qualitative appraisal of the economic situation. From a general point of view, they provide interesting qualitative information about the short-term development of economic activity. However, there are some caveats that should be borne in mind when using them:
- a. they are qualitative, not quantitative, and so they can only measure tendencies;
  - b. opinions about the future can be influenced by data, including the national accounts, that are already in the public domain, and therefore they can be backward-looking. Therefore qualitative data of this kind should be avoided.
- 9.38. Qualitative data should only be used when they refer specifically to the topic of interest (prices, investment, etc.) and the questions should be fact-based (e.g. “were sales higher this quarter than last quarter?”), and not opinion-based (“do you think sales will be higher next quarter?”). This does not mean all questions with regard to the future are not useful. For instance, forward-looking questions with regard to new capital expenditures from the previous quarter can be useful for validating this quarter’s estimates.
- 9.39. Suppose a graph is produced by plotting a balance of assessments from a “state of trade” survey and another is produced by plotting the quarterly growth rate of an economic variable directly related to the object in question. If the curves produced bear a close relationship to each other, then qualitative assessments survey information can be used to validate the short-term change described by QNA figures. Sometimes a calibration procedure can be used to estimate a quantitative relationship between the balance of assessments for various questions and the quarterly growth rate of the economic variables that measure various activities (production, say, of manufactured goods or services,...). For instance, stable quantitative relationships may sometimes be estimated between the output of a given product and the assessments of entrepreneurs on their past demand for the product.
- 9.40. Estimation of the price change of output may be able to be built up with a calibration procedure from the balance of assessments on the past movements of output prices. However, such procedures need to be undertaken with a great deal of care. The quantitative relationship that can be estimated from the balance of assessments sometimes shows that the nature of the information it contains is relatively elaborate: answers sometimes seem to take seasonal effects into account and the variable used for comparison must be similarly adjusted.
- 9.41. Balance of assessments data can also be used indirectly. For example, information on the growth of gross fixed capital formation may be inferred by studying the balance of assessments for wholesale trade demand for equipment from the wholesale trade survey. Used either directly or indirectly, a complete set

of qualitative data that covers households and all types of producers in the market sector can be very useful for validating the economic picture portrayed by QNA.

### *Economic analysis*

- 9.42. The second aspect of economic validation deals with the similarity of the economic mechanisms described by QNA with what has been observed in the past. For example, a statistic commonly derived from national accounts data is gross value added (or output) per hour worked (or less desirably per employee) for each industry branch and the total economy, otherwise known as a measure of “labour” productivity. It is commonly observed that there is a lag in the business cycle between gross value added and hours worked (and employment). As a result, at the beginning of a downturn labour productivity commonly declines because the growth rate of gross value added slows down earlier than hours worked. In general terms, this phenomenon can be explained by the reluctance of employers to shed labour:
- until they believe the downturn is confirmed;
  - the costs of hiring and training labour when the economy picks up;
  - humanitarian considerations.
- 9.43. Conversely, at the beginning of the rebound labour productivity typically displays strong growth as gross value added grows more strongly than hours worked because the existing work force was not being fully utilized prior to the pick-up. There are other factors that can extend or shorten the lag and widen or narrow the difference between the growth rates of production and measured labour input, such as the growth rate of real unit labour costs, changes in the terms of trade (that cause real gross domestic income to grow at a different rate than the volume measure of GDP), and business expectations. As a result, the lag between production and hours worked tends to differ from one business cycle to another and can vary from a quarter or two to a year or more <sup>(58)</sup>.
- 9.44. It may be possible to compare the latest QNA estimates with recently prepared short-term economic forecasts. Differences between forecasts and QNA estimates can then be studied to determine whether the forecasts are erroneous or whether QNA estimates are based on weak information. If the forecast is erroneous, it may be interesting to analyze the reasons for the error and maybe, in this way, focus attention on an economic phenomenon that needs to be analyzed in detail to permit a better understanding of the economic situation. If the estimate seems to be based on weak information, compilers will try to cross-check their information. If their first estimate is confirmed, they will carefully analyse its economic interpretation. Otherwise they will have to adopt a prudent attitude to avoid misleading their users.
- 9.45. If there are substantial revisions to earlier periods, then the efficacy of comparing the latest estimates with short-term forecasts made using previously released data is reduced. However, if the short-term economic forecasters are part of the NSI compiling the national accounts, then it may be possible to have them remake the short-term forecasts using revised data up to the previous quarter.
- 9.46. National accounts compilers need to have an appreciation of the relative magnitude of the macroeconomic variables, their relative quality and their variability. They also need to have a sound understanding of economy theory and current economic circumstances so that they can look at the figures in the same way that many of their most important users will. This knowledge is not only useful for validating the economic description of the current situation and its salient features, but also for writing the commentary that is dispatched on the day of release to inform the users.

<sup>(58)</sup> June quarter 2005 issue of Australian National Accounts: National Income, Expenditure and Production (5206.0).

## Flash estimates

9.47. In principle, the validation of flash estimates is no different to that of quarterly estimates made later in the cycle, but there are differences in practice arising from the fact that there are less data available and there is little time to make the estimates. While the best approach is to follow the same procedures that are used for the later estimates as far as possible, some compromises usually have to be made.

## Summary of main points

9.48. There are three types of validation: statistical, accounting and economic. Each follows its own logic and has a different, but complementary, role to play. Economic logic is subordinated to statistical and accounting internal consistency, and statistical logic is subordinated to accounting principles. Concepts of economic behavioural and related analyses are used only to test for the consistency of the economic description at the end of the process.

9.49. Economic logic and description must not be used to determine the relevance of different statistics to estimate the various components of an economic equation. In other words, QNA compilation must not rely on economic reasoning or relationships. It would be very damaging to their credibility and legitimacy if some economic theory were used to organize the use of statistical information during compilation. The basic principle is the following one: each QNA variable must be based on basic statistics of exactly the same economic nature, i.e. income from income statistics for each sector, expenditures from expenditure or turnover statistics for each product and each sector, output from output statistics for each product, etc.

9.50. In brief, validation corresponds to the processes used to:

- a. eliminate all compilation errors and minimize deficiencies in the source data;
- b. ensure internal coherence;
- c. try to capture rapidly the most important new economic phenomena;
- d. analyse the revisions (when they occur) of the last released figures and their consequences for understanding the current economic situation;
- e. be satisfied that the description of the overall economic situation adequately approximates reality and be prepared to answer any queries concerning the data, including those concerning relationships with non-national accounts data.

9.51. It must rely on a set of simple steps. Here are some of the most important:

- a. understand how the source data are derived, and have an appreciation of their strengths and weaknesses;
- b. regularly read the economic and business press to learn about mergers, new plants, etc., and determine whether they are being adequately reflected in the source data; collect information on government economic actions;
- c. critically examine the source data and obtain explanations for what is driving the figures, especially when the data are showing unusual growth rates; do not be fobbed off with inadequate explanations;
- d. analyse revisions and ensure that they are legitimate;
- e. compare the growth rates of QNA estimates with those of source data and auxiliary indicators to check for compilation errors;
- f. compute contributions to growth of GDP and check for consistency and additivity;

- g. accounting validation is particularly important if QNA are not balanced in supply and use tables , but even if they are there are other balancing items that need to be reviewed;
  - h. be aware of the models and assumptions made in deriving QNA estimates;
  - i. compare the growth rates of QNA estimates with those of independent variables that are linked via economic theory to check for deficiencies in the source data or the models used;
  - j. compare the growth rates of QNA estimates with short-term forecasts published by renowned organisations to check for deficiencies;
  - k. most importantly, check for errors at the beginning and end of the compilation process.
- 9.52. The validation process stops when all these steps have been taken and any notable developments provided by the new figures compared with those previously released can be commented on, explained or discussed.



## 9. Annex A — Statistical Validation: Comparing National Accounts Variables with Closely Related Indicators

9.A1 Comparisons between national accounts variables and closely related indicators can provide a powerful means of determining if compilation errors have been made and in some cases whether there are more deep-seated deficiencies with the national accounts data. Data collected under community legislation in the field of short-term statistics (see Annex 2.A) provide a rich source of data that can be compared with QNA variables:

- a. CPI versus HFCE IPD;
- b. other comparisons of price indices with national accounts IPDs;
- c. compensation of employees versus employment data from the LFS and a wage cost index;
- d. construction statistics versus GFCF of building and construction and gross value added of the construction industry;
- e. production and turnover indices versus gross value added of market sector-dominated industries;
- f. overseas trade statistics versus exports and imports of goods.

However, differences in definition, scope and coverage need to be taken into account if the comparisons are to be effective. This annex describes some of the issues that need to be considered when making comparisons a, b and c.

### CPI versus HFCE IPD

9.A2 Although the consumer price index (CPI) and the household final consumption expenditure (HFCE) implicit price deflator (IPD) both relate to household consumption, the definitions, scope and index formulae of the two price indices differ. The major differences are:

- a. the CPI is constructed as a Laspeyres-type index and the HFCE IPD is a Paasche-type index; in addition, the time span from the base period to the current period often differs (see section B of Chapter 15 of the 2008 SNA for an overview of index number theory, and, in particular §15.16 -15.18 and §15.34 -15.35);
- b. the CPI measures the prices of expenditures in the domestic territory, while the HFCE IPD measures the prices of consumption by residents wherever it occurs;
- c. the HFCE IPD includes the prices of goods and dwelling services produced by households for their own use, but the CPI only measures the prices of market transactions;
- d. the CPI measures the prices of actual explicit payments made for financial and insurance services (e.g. insurance premiums), while the HFCE IPD measures the prices of financial and insurance services provided, including those for financial services indirectly measured (FISIM);
- e. the CPI and HFCE have different classifications; but if detailed CPI data are available, then they can be aggregated as per COICOP.

9.A3 When a comparison is made between the CPI and HFCE IPD at the level of volume estimation, the differences due to different index formulae and weights are no longer an issue, and the national accounts compiler can focus on differences between items common to the scope of both indices. The tables to support these comparisons could show the price index levels with a common reference year and quarter-on-quarter growth rates for both original and seasonally adjusted data. Contributions to growth of each component of both the CPI and HFCE IPD enable the national accounts compiler to see what is driving the differences between the two indices.

- 9.A4 There are two ways of deriving volume estimates from the current price estimates of HFCE. One way is to simply use the most appropriate CPI available. The other way is to deflate values of HFCE at basic prices, within a use table, with deflators constructed from producer price indices (PPIs) and import price indices (IPIs), and then add volume estimates of trade and transport margins and taxes *less* subsidies on products to get volume estimates of HFCE at purchasers' prices. If the first approach is used, then one expects a very close correspondence between the change in the CPI and HFCE IPD at the HFCE volume estimation level, UNLESS an adjustment has been made to the CPI prior to deflation. Occasionally, there is a change in the CPI that is not reflected in the corresponding national accounts variable. For example, if the government increases the amount it pays pharmacists so that they can charge a lower price for prescription drugs, then this would be reflected in a fall in the CPI for pharmaceuticals. By contrast, it would be recorded in the national accounts as a reduction in HFCE and a corresponding increase in government final consumption expenditure (GFCE) (i.e. social transfers in kind), and there would be no price change recorded for either HFCE or GFCE.
- 9.A5 If the second approach is used to derive volume estimates of HFCE, then a comparison between CPIs and HFCE IPDs at a detailed level should be made as part of the balancing process of the supply and use tables. Substantial differences need to be investigated. If it is assumed that the CPI growth rate is correct, then any difference between it and the growth rate of the corresponding HFCE IPD implies that there is a problem with the volume estimation of the HFCE variable. It may be that the weights given to the IPIs and PPIs are out of date, or it may be that there is a timing problem due to the time it takes for goods to go through inventories, or it may be that the assumptions used to derive volume estimates of trade and transport margins are invalid. Whatever the reason, adjustments to the volume estimates will need to be made.

### Other comparisons of price indices with national accounts IPDs

- 9.A6 Some of the issues described above apply to other comparisons between price indices and national accounts IPDs, such as those for production, exports and imports. For example, most official price indices are compiled as Laspeyres-type price indices. Other things to look out for include:
- Determine the basis of valuation of the price indices. Are they at basic or purchasers' prices, or something else? Any differences in valuation basis with the national accounts IPDs will need to be taken into account when making comparisons.
  - Are there differences between the methods used to derive volume estimates in the national accounts and the corresponding official price indices? For example, is an hedonic price index used to derive the volume estimates of imports of computer equipment, while the corresponding official import price index is derived using some other means?

### Compensation of employees versus employment data from the LFS and a wage cost index

- 9.A7 Quarterly estimates of compensation of employees are commonly derived from several sources. For the general government sector they are usually obtained from government finance statistics, and for other sectors they are commonly derived from, at least substantially, quarterly business surveys. From whatever sources the data are obtained, it is very useful for validation purposes if a decomposition can be made between employment and compensation per employee, because this allows comparisons to be made with independent indicators of employment from the labour force survey and wages growth from a wage cost index.
- 9.A8 Employment data from general government and business surveys relate to jobs. The difference between jobs and employment is explained in Chapter 11 of the ESA 2010. Either the jobs data from the national accounts sources or the employee data from the LFS need to be adjusted so that they are on a comparable basis. The comparison can be very informative because estimates of total employees from the LFS are not

dependent on the business register, and so inadequacies in the combination of new business provisions and failures to keep the business register up-to-date can be revealed.

- 9.A9 LFS employee data are not without their problems at the industry and sector level. The industry and institutional sector to which an employed person belongs is determined by matching the name of the employer, given by the respondent, with business names on the business register. Hence the LFS estimates are matched to the same industries and sectors as compensation of employee estimates from a business survey. When the name given by the respondent cannot be matched with the business names on the register, the common practice is to allocate the employed person to an industry on the basis of occupational information given by the respondent. For some occupations, such as accountants, this can lead to a poor industry allocation. Inaccuracies can also arise with respect to the employees of businesses that provide labour to other businesses if the respondent names the latter rather than the former as the employer.
- 9.A10 Another weakness of the LFS industry data is that they can be subject to large sampling errors for those industries with small employment numbers, such as mining. This deficiency can be ameliorated to some extent by smoothing the quarterly data. If the employee shares of each industry are smoothed, there is no distortion of total employee numbers.
- 9.A11 If a wage cost index is available, then its growth can be compared with that of compensation per employee. As for most other price indices, wage cost indices are usually compiled as Laspeyres-type indices. Growth in compensation per employee is affected by changes in the composition of the work force and variations in paid hours, and so it is not a pure a measure of changes in wage costs. Nevertheless, the comparison provides a useful short-term editing tool.

## 10. Revision policy and analysis

An important characteristic of the data published by NSIs is that they usually undergo a recurrent revision process before being considered definitive.

This is particularly the case for QNA data, for which the increasing need for timely information on the state of the economy has to be balanced with the requirement for more accurate estimates.

The chapter discusses the causes of revisions and classifies them as routine, major and non-scheduled, according to their causes and timing.

The chapter also discusses the nature of the revision process of QNA and the importance of a well-founded revisions policy, how users may be informed of revisions and the quantitative analysis of revisions from both a user and a producer perspective. It stops short of prescribing a particular revisions policy or particular types of revision analysis, as these are the subject of ESS guidelines currently under development.

## Introduction

- 10.1. Revisions are a common characteristic of both quarterly and ANA releases, but revisions have a particular significance in QNA because they tend to be larger and they occur more frequently. Factors contributing to revisions of QNA include:
- preliminary source data are revised as less timely, but higher quality, source data become available;
  - seasonally adjusted data are revised when the unadjusted data are revised and when more data allow better estimates to be made of the current seasonal pattern;
  - revisions occur when quarterly figures are benchmarked to more accurate annual figures.
- 10.2. There are two major aspects to any consideration of revisions: analysis and policy. ESS guidelines on revisions policy were promulgated in 2011. These guidelines focus on Principal European Economic Indicators and Euroindicators, but are potentially applicable to all infra-annual statistics. Also in 2011, the CMFB drafted an elaboration of these guidelines in respect of the national accounts and balance of payments, and the views of Member States are currently being canvassed<sup>(59)</sup>. Furthermore, section 6.4 of the ESS guidelines on revision policy calls for the ESS to agree on a template for revisions analysis and its adoption by Member States.
- 10.3. In the light of these current and prospective developments, the handbook confines itself to a brief description of the different types of revision and how they may be analysed, and it makes some suggestions as to how users should be informed of revisions.

## Revision analysis

- 10.4. By far the main purpose of revision analysis is to reduce revisions in the future, chiefly by identifying and remedying any possible bias in the initial figures. Such biases can arise from problems with either the basic source data or the estimation methods used. In either case, steps must be taken to eliminate them in future.
- 10.5. An important secondary purpose is to quantify the characteristics of revisions so that users can take account of the quality of the data when using them. From the perspective of data users, three key aspects are important for the evaluation of the impact of revisions on the overall data quality:
- accuracy;
  - reliability;
  - stability (number of revisions within a given unit of time).

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<sup>(59)</sup> The draft relates only to unadjusted data. The ESS guidelines on seasonal adjustment provide guidance on how the consequent revisions to the seasonally and calendar adjusted data should be made (see Chapter 7).

- 10.6. *Accuracy* can be defined as the proximity of an estimate to its notional true value. The true value is considered notional because in practice most statistics cannot be measured with perfect accuracy. Also, as this true value is generally unknown, it is generally impossible to quantify exactly how far an estimate deviates from its true value and what the margin of error is. It is generally the case that the only precise measure of error for a national accounts statistic is the sampling error of an estimate obtained from a sample survey, but survey estimates are also subject to non-sampling errors that are of unknown size.
- 10.7. While it is generally not possible to measure the absolute accuracy of QNA statistics, it is possible to make an approximate assessment of how accurate the estimates are relative to each other. This can be done by undertaking detailed analyses of the data, the methods used to derive them and the information gained from data confrontation in supply and use tables and between these tables and the distribution (and use) of income, capital and financial accounts. A ranking of the accuracy of the estimates can then be made available to users.
- 10.8. It is also possible to make comparative assessments of different versions of the estimates based on the quality of the data and methods used to derive them. Thus ANA statistics are generally judged to be more accurate than their quarterly counterparts, and final QNA statistics are judged to be more accurate than preliminary quarterly figures derived from preliminary and/or less complete data.
- 10.9. *Reliability* <sup>(60)</sup> is defined to be the extent to which estimates are revised; the more estimates are revised the less reliable they are. They can be used as indicators of the uncertainty of the estimates in the most recent data release. Unlike accuracy, reliability is easily measured. But reliability is no substitute for accuracy. On the one hand, initial estimates that are revised substantially are clearly inaccurate, given that the final estimates are the most accurate. On the other hand, estimates that are highly reliable (i.e. they do not get revised very much) are not necessarily accurate; it may be that the initial estimates are highly inaccurate and remain so. If the average difference between the initial and final estimates of a QNA variable is non-zero, then the initial estimates are said to be *biased*.
- 10.10. The *stability* of the estimates is governed by the frequency of revisions, or the number of revisions within a given unit of time. On the one hand, users appreciate stability in the data, but on the other hand, they want the most accurate statistics available. This implies that the NSI has to strike a balance between making meaningful revisions when new or better data become available and avoiding making minor revisions of little consequence.

### *Different approaches to revision analysis*

- 10.11. There are two different, though inter-related, approaches to revision analysis: producer-oriented or user-oriented. Although the objective of the first approach is to reduce revisions in the future, both can contribute to a better understanding of the causes of the revisions and can suggest possible remedies for improving the data production process of NSIs.
- 10.12. The supply, or producer-oriented, approach is to consider the revision process from the viewpoint of data producers. analysis of revisions provides NSIs with a basis both for assessing the accuracy of preliminary estimates in relation to final estimates (i.e. reliability), and for improving the methods of estimation used to compile preliminary figures. For example, evidence of the presence of a systematic bias in the preliminary figures will lead the national accountant to undertake an investigation into its cause and develop a remedy. This may involve the collection of new/additional information and sources, or the improvement of the estimation procedures. Another example is a process of revision in which increases

<sup>(60)</sup> The ECB booklet *Reliability of First Estimates for GDP and Expenditure Components in the Euro Area* provides various reliability statistics for countries in the euro zone. The focus is on the quarter-on-quarter growth rates of seasonally and calendar adjusted data. The reliability statistics include measures of bias and the average size of revisions without regard to sign, calculated over different time spans. The booklet is updated annually.

and decreases to the quarter-on-quarter growth rates are repeatedly reversed. In such circumstances an investigation would need to be undertaken to find out what the cause was and then to develop a remedy.

10.13. The user-oriented approach is to analyze the effects that the revision process can have on users' perceptions of the economic conditions. This approach often concentrates on the nature of the revision in order to verify if preliminary releases satisfy certain desirable features of rational forecasts (i.e. lack of bias, low mean square error, moderate average revision without regard to sign and whether the revisions are uncorrelated with each other). The NSI may go further and work with economic forecasters to assess to what extent models using data from preliminary releases are sensitive to changes resulting from the revision of data. An important aspect for the latter is to consider the stationarity of the revisions from different releases (i.e. the invariance of their statistical properties to changes in the time origin) and their similarity from an econometric point of view.

### **Revisions database**

10.14. An essential tool for revision analysis is a vintage, or real-time, database. A vintage database is used to archive data releases so that revisions between any two releases for any common variables for any common periods can be readily determined. The metadata for a vintage database should include details of any non-routine changes (see below) that might need to be taken into account when assessing the revisions, such as changes in classification, concept and methods used. Where possible, the metadata should support any transformations required to deal with such changes.

### **Revision policy**

10.15. Revision policy is concerned with establishing an approach, preferably a standardized, coordinated and publicised approach, for introducing revisions. The basic principle is that the most accurate estimates, using the most up-to-date source data, should be published in every release. But this principle needs to be balanced by the need to avoid making minor revisions of little consequence.

10.16. It is highly desirable that revisions to related data be coordinated across statistical domains. In those cases where there is an intersection of statistics in different domains, such as between the balance of payments, national accounts and certain government finance statistics, then it is essential that revisions should be highly coordinated.

10.17. It is also highly desirable that consistent and coordinated revision policies be adopted by Member States in order to maximize the comparability of statistics within particular domains across countries. When major revisions occur due to changes in statistical standards (e.g. the ESA and related classifications) consistency and coordination are essential. But there is also a good case to be made for coordinating policies for making revisions arising from more mundane causes because having standardized and coordinated policies not only maximizes the comparability of statistics, it also makes it easier for users of the national accounts of different countries if there is a single European revision policy.

10.18. In order to develop a common revision policy for the national accounts it is necessary to consider the different types of revision. The ESS guidelines on revision policy differentiate between three types:

- routine revisions;
- major revisions;
- ad hoc revisions.

**Routine revisions**

- 10.19. Routine revisions are characterized by their high periodicity and regularity. Normally they adhere to a revision policy and are published according to a publicly available pre-announced release/revision calendar (e.g. each time when a new data point is published, the revised result for the previous month/quarter is also published).
- 10.20. Depending on their causes, routine revisions can be of a diverse nature. They can be due to the growing need for timely information, to the statistical characteristics of the estimation techniques adopted by NSIs, to revisions to the basic statistics used to compile quarterly figures or, more simply, to errors made by national accountants.
- 10.21. Essentially, the main reason for routine revisions to QNA is that it is the price to be paid for timeliness. For most countries the trade-off between timeliness and accuracy often leads to within-year revisions that occur when the annual value is not yet available and quarterly estimates are mainly based on the information provided by the available quarterly basic statistics. Quarterly basic statistics are commonly susceptible to revision, thus inducing revisions to the previously released national accounts estimates. Furthermore, some basic statistics may be unavailable for flash estimates, which leads to greater reliance on incomplete or very preliminary data for a quarter, ancillary data and models (see Chapter 4).
- 10.22. In addition to this kind of routine revision, there are revisions associated with the derivation of annual estimates from quarterly and annual basic statistics (and balanced in annual supply and use tables) for a new year. This introduces a new annual benchmark not only for the quarters within the year, but also for any subsequent quarters. Country practices differ in how they go about deriving their annual estimates. Some NSIs derive preliminary annual estimates shortly after the reference year and then make revisions as more annual basic statistics become available, while other NSIs produce less timely, but maybe more reliable, initial annual estimates. In any case, the ensuing revisions to the quarterly data differ not only conceptually from the within-year revisions, but also quantitatively as they can give rise to changes to all the quarters in recent years. The magnitude of these revisions is commonly correlated with differences in the growth rates of the quarterly basic statistics and the basic statistics used to estimate the annual figures. Means of minimizing the resulting revisions are discussed in Chapters 4 and 5.
- 10.23. Further revisions to the quarterly data occur when the annual estimates are revised. This particular kind of revision can be called an “annual benchmark” revision.
- 10.24. Seasonal and calendar adjustment represents another cause of routine revisions, both when applied to the unadjusted national accounts estimates or to quarterly indicators, as is the case for some EU Member States. Revisions to seasonally adjusted data occur both when the original data are revised and when a seasonal reanalysis is conducted. Chapter 7 provides guidance on how seasonal reanalyses should be conducted.
- 10.25. All EU Member States compile their quarterly chain-linked volume estimates as annually-based, chain Laspeyres-type indices. In effect, quarterly estimates of expenditure and production are expressed in the prices of the previous year and then linked together to form long, continuous time series in both unadjusted and seasonally adjusted terms (see Chapter 6). Each year a new base year is introduced, and the quarterly estimates in the following year(s) are expressed in the prices of the new base year before linking. The timing of the introduction of a new base year varies between Member States, and in some cases there may be a delay in the introduction of a new base year that results in the growth rates in the chain-linked volume estimates for the latest quarters being revised (see §6.84-6.85).



10.26. Chain-linked volume indices can be referenced to any year and NSIs may choose to reference them to the current price values in the reference year or to 100, as is commonly done for price indices. Most Member States re-reference their chain-linked volume estimates every five years, usually to a year ending in zero or five, but some countries re-reference every year so that the reference year coincides with the latest base year and thereby ensures additivity for the latest quarters. Re-referencing changes the levels of the entire time series of chain-linked volume estimates, but it has no effect on growth rates. Therefore it is evident that revision analyses and policies with respect to chain-linked volume estimates should be confined to their growth rates. Indeed, the reason for deriving volume estimates is to measure growth.

### *Major revisions*

10.27. Major revisions are changes in published data, often substantial, which are due to one of the following reasons:

- a. availability of a new structural source of data that is only collected at long intervals (5 to 10 years), such as the census, input-output tables, labour cost surveys, etc.;
- b. a change in the concepts, definitions and/or classifications used to produce the series. Some examples are the adoption of a new classification or changes in international statistical standards;
- c. a new legal act is brought into force.

10.28. Usually, data producers take the opportunity of a forthcoming major revision to introduce methodological improvements. This should be considered as good practice as it avoids revisions occurring too often. Therefore it is common that major revisions are not determined by one single cause but by a combination of them. Producers should identify the impact of each single change on the total revisions of the time series and inform the users. However, a change in method specific to a country of a group of countries that helps to produce significantly better results for important macroeconomic variables should be implemented rapidly in order to foster accuracy, if in line with European legal acts.

10.29. Major revisions affect a large part of the time series and sometimes even the complete time series. Therefore it is necessary to back-cast the series, otherwise major revisions will produce breaks and inconsistencies in the time series.

10.30. Major revisions are expected and planned very well in advance. Users should be informed in advance of the forthcoming major revisions and warned that considerable changes in the time series are to be expected. A policy for major revisions should specify at least the following elements:

- the pre-announcing strategy;
- how to communicate in advance, information on the causes of the revisions;
- the expected magnitude, scope and length of major revisions.

### *Ad hoc revisions*

10.31. Ad hoc revisions are non-scheduled and are not announced in advance either because they are a result of unforeseeable events such as errors or accidents, or because of the lack of a scheduling procedure. The term “non-scheduled” does not refer to the cause of the revision but to the timing. Non-scheduled revisions are not pre-announced or reflected in dissemination plans.

10.32. As non-scheduled revisions can confuse users and undermine confidence in the quality of statistics, it is important to be committed to avoiding them as much as possible and to limit them to the case of

important errors. When significant mistakes occur, the communication of the mistake should be frank and the revised data should be published at the earliest possible date.

### Informing users of revisions

10.33. Users should be made aware of an NSI's revision policy for the national accounts. This can be achieved by giving prominence to a description of the revisions policy on the NSI's website and by making references to it in national accounts publications and other releases. The description of the policy should describe the overall approach to dealing with routine, major and ad hoc revisions. It should also describe how key outputs, such as GDP, are to be revised and set out a general revisions schedule for them. This schedule should be consistent with EU regulations and take account of users' preferences; it should therefore be subject to periodic user consultation.

10.34. Any major changes to methods, concepts and classifications should be announced prior to their introduction. This might take the form of articles on the NSI's website that describe the nature of the changes and give a theoretical explanation of the expected effects on key aggregates. Key users may also be informed by means of seminars or other face-to-face means. The over-riding objective is that users should not be surprised or confused when major changes are introduced. Ideally, they should be comfortable with the changes and view them as improvements.

Table 10.1: Revisions to quarter-on-quarter growth rates of seasonally and calendar adjusted chain-linked volume estimates of GDP for the EA12

|                      | 2010Q1 | 2010Q2 | 2010Q3 | 2010Q4 | 2011Q1 | 2011Q2 | 2011Q3 | 2011Q4 |
|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>2010Q1-flash</b>  |        |        |        |        |        |        |        |        |
| <b>2010Q1-first</b>  | 0.01   |        |        |        |        |        |        |        |
| <b>2010Q1-second</b> | 0.00   |        |        |        |        |        |        |        |
| <b>2010Q2-flash</b>  | 0.00   |        |        |        |        |        |        |        |
| <b>2010Q2-first</b>  | 0.12   | -0.01  |        |        |        |        |        |        |
| <b>2010Q2-second</b> | 0.02   | 0.00   |        |        |        |        |        |        |
| <b>2010Q3-flash</b>  | 0.00   | 0.00   |        |        |        |        |        |        |
| <b>2010Q3-first</b>  | 0.02   | 0.04   | 0.00   |        |        |        |        |        |
| <b>2010Q3-second</b> | 0.00   | 0.00   | -0.02  |        |        |        |        |        |
| <b>2010Q4-flash</b>  | 0.00   | 0.00   | 0.00   |        |        |        |        |        |
| <b>2010Q4-second</b> | 0.02   | 0.00   | -0.01  | -0.01  |        |        |        |        |
| <b>2010Q4-third</b>  | 0.01   | 0.00   | 0.01   | -0.01  |        |        |        |        |
| <b>2011Q1-flash</b>  | 0.00   | 0.00   | 0.00   | 0.00   |        |        |        |        |
| <b>2011Q1-second</b> | -0.08  | -0.04  | 0.05   | -0.03  | 0.01   |        |        |        |
| <b>2011Q1-third</b>  | 0.02   | -0.01  | -0.01  | 0.01   | 0.00   |        |        |        |
| <b>2011Q2-flash</b>  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |        |        |        |
| <b>2011Q2-second</b> | 0.02   | -0.04  | 0.00   | 0.03   | -0.07  | -0.02  |        |        |
| <b>2011Q2-third</b>  | -0.02  | 0.02   | 0.02   | -0.02  | 0.01   | 0.01   |        |        |
| <b>2011Q3-flash</b>  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |        |        |
| <b>2011Q3-second</b> | 0.04   | -0.02  | 0.03   | 0.00   | 0.00   | 0.01   | 0.00   |        |
| <b>2011Q3-third</b>  | 0.01   | -0.02  | 0.00   | 0.00   | 0.00   | -0.01  | -0.02  |        |
| <b>2011Q4-flash</b>  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |        |
| <b>2011Q4-second</b> | 0.02   | 0.00   | -0.02  | 0.00   | -0.01  | -0.02  | 0.01   | 0.00   |
| <b>2011Q4-third</b>  | 0.03   | 0.01   | 0.02   | 0.05   | -0.04  | 0.01   | 0.01   | 0.01   |

For every quarter there are three releases, which are indicated in the first column of the table. Flash corresponds to the release issued 45 days after the reference quarter. Flash estimates do not incorporate revisions to previous periods. First corresponds to the release issued around 65 days after the reference quarter. Data for previous quarters are eligible for revision. Second corresponds to the release issued around 100 days after the reference quarter. Data for previous quarters are eligible for revision.

As of 15 February 2011 (data for 2010Q4 onwards) Eurostat renamed the releases such that what was previously called the first release (T+65 days) was renamed the second release and what was previously called the second release (T+100 days) was renamed the third release.

- 10.35. Major revisions should also be accompanied at the time of publication by explanations of their nature and effects. This takes the articles mentioned in the previous paragraph one step further, by replacing theoretical with actual effects, which may often be different, or may change over time.
- 10.36. When the changes are very substantial, such as the introduction of a new industry classification, a major revision to the ESA or a major methodological change affecting many variables, then a re-release of the latest quarter's data according to the new standard should be considered. For example, suppose a new standard is to be introduced with the second release for quarter  $t+1$ , then a re-release of the data up to quarter  $t$  that incorporates the new standard could be made a few weeks before. This would allow users to become acquainted with the data according to the new standard and to make any changes that may be needed to their systems and models before their formal introduction. An important feature of a re-release is that it only incorporates changes arising from the adoption of the new standard; thereby allowing users to make a direct comparison with the data previously published according to the old standard.
- 10.37. The long-term effect of revisions on key outputs should be monitored and the findings made public. This should include regularly updated revision triangles (see Table 10.1), along with explanatory material that could include estimations of systematic bias (if any) in the estimates and how revisions profiles have changed over time. For resource reasons this will probably concentrate on key indicators such as GDP, but material may be published for sub-components as necessary.
- 10.38. Major revisions arising from the introduction of changes to classifications and concepts are generally coordinated at the EU level. But in planning revisions due to methodological and other changes, NSIs should carefully consider, in consultation with users, the balance between grouping revisions as opposed to many successive revisions. Whilst users often prefer grouping to avoid multiple revisions, this leads to larger, more complex projects and difficulties in distinguishing separate effects.
- 10.39. Where sub-components of main aggregates are revised in advance of the aggregates (for example if the index of production or trade data are revised before the publication of GDP data), it is good practice to include commentary relating to the expected effect of these revisions on the national accounts aggregates to be released subsequently (either growth or level, depending on the aggregate), all other things being equal.

### Summary of main points

- 10.40. Revisions to QNA statistics are both necessary and inevitable, given the conflicting objectives of timeliness and accuracy. There are two major aspects to any consideration of revisions: analysis and policy.
- 10.41. By far the main purpose of revision analysis is to reduce revisions in the future, chiefly by identifying and remedying any possible bias in the initial figures. An important secondary purpose is to quantify the characteristics of revisions so that users can take account of the quality of the data when using them. An essential tool for revision analysis is a vintage, or real-time, database.
- 10.42. It is important that an NSI has a clear and explicit revisions policy so that revisions are made in an orderly and predictable manner. In order to avoid inconsistencies, revisions to the national accounts should be coordinated with those of related data such as the balance of payments and government finance

statistics. It is better still if revision policies across Member States are consistent and coordinated to the extent that this is practicable.

- 10.43. Users should be informed of the revisions policy and should be regularly provided with the results of revision analyses. Major revisions should be highlighted and an explanation of their cause should be provided to users.

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