Dating Business Cycle Turning Points: The Greek Economy During 1970-2010 and the Recent Recession

Ekaterini Tsouma
This paper was presented at the

6th Eurostat Colloquium on Modern Tools for Business Cycle Analysis: the lessons from global economic crisis,

held in Luxembourg, 26th - 29th September 2010.

Click here for accessing the collection of the 6th Eurostat Colloquium papers

Click here for accessing the full collection of Euroindicators working papers

Europe Direct is a service to help you find answers to your questions about the European Union

Freephone number (*):

00 800 6 7 8 9 10 11

(*) Certain mobile telephone operators do not allow access to 00 800 numbers or these calls may be billed.


ISSN 1977-3331
EWP 2011/032

Theme: General and regional statistics

© European Union, 2012

Reproduction is authorised provided the source is acknowledged.

The views expressed in this publication are those of the authors, and do not necessarily reflect the official position of Eurostat.
Dating Business Cycle Turning Points:
The Greek Economy During 1970-2010 and the Recent Recession

Ekaterini Tsouma
Research Fellow, Centre of Planning and Economic Research
September 2010

Abstract

This paper attempts to establish a reference chronology for the Greek business cycle from early 1970 to mid 2010. In light of the late 2000s global recession and the recent domestic developments, we address the question of whether there is sound evidence for the Greek economy entering and/or exiting a recessionary business cycle regime in the late 2000s. We rely on both non-parametric and parametric procedures in order to check the coherence among the obtained turning points and evaluate the establishment of a reference chronology. We use quarterly GDP data and selected monthly indicators covering important sectors of Greek economic activity. On the basis of the obtained exact turning point dates and the indications provided by several business cycle and phases characteristics, we are able to propose a reference chronology for Greece and outline stylized facts of the Greek business cycle for a time period of over 40 years. Our results clearly indicate that the Greek economy has entered a recessionary business cycle regime in 2008 and has not yet exited the contraction.

JEL classification: E32.
Keywords: Business cycle turning points, dating algorithms, recession, Greece.

Address for Correspondence:
Dr. Ekaterini Tsouma
Centre of Planning and Economic Research
Amerikis 11, 106 72 Athens, Greece
Tel.: 003210-36.27.321-5, 36.76.300-36.76.400
Fax: 003210-36.30.122-36.11.136
E-mail: etsouma@kepe.gr.
1. Introduction

The late 2000s significant downturn in cyclical economic activity worldwide enforces once again the argument that recessions, described as significant declines in the level of economic activity, remain a reality. As a result and as also witnessed in similar occasions in the past, renewed interest is addressed toward issues related to the analysis and measurement of the recurrent but not periodic fluctuations in overall economic activity, i.e. business cycles. As a part of this more general spectrum of interest, research on the derivation of the exact turning points in economic activity and, hence, the exact dating of business cycles and their phases continues to possess a central role. Such research is directly connected to the classical business cycle definition by Burns and Mitchell (1947) picturing expansions and recessions as the two distinct phases of the cycle and investigates the points in time at which the switches between phases take place. These switches, or turning points, describe the limits or boundaries of business cycle phases and their grouping in time provides the so-called business cycle reference chronology.

There are different dimensions as to the significance of the establishment of the exact timing of the switches between expansions and recessions. Intuitively, the ability to obtain knowledge concerning the state of the economy is believed to be particularly useful to individuals, institutions, enterprises and not least public authorities. On a more technical level, it is related to empirical applications such as economic series classification according to their timing or forecasting exercises. In practice, experts at the US National Bureau of Economic Research (NBER) determine with considerable historical continuity the exact timing of US business cycle turning points, on the basis of consensus. The derived reference chronology is basically considered official and constitutes the cornerstone for any individual or comparative research on the dating of the turning points in general US economic activity.

Nonetheless, the derivation of a business cycle reference chronology is not self-evident, partly due to the fact that it does not emerge out of clear-cut procedures. In most countries, in addition to difficulties related to data availability and reliability restrictions, official dating institutions are absent. This is also the case for Greece, where there exists only a very limited number of relevant investigations on issues referring to the establishment of a robust business cycle chronology for Greek economic activity. Almost the total of the related existing research is conducted
within the context of deriving individual or aggregate chronologies for the European Union and Euro-zone countries.

With the aim to fill this gap, the present work attempts to derive accurate business cycle turning points for Greek economic activity over a long historical time period. In order to control whether the results enforce the emergence of a consensus on the exact turning point dates, we apply different procedures for the dating of the Greek business cycle. To the best of our knowledge, there are no similar applications in the related empirical literature directly applying alternative procedures for dating the Greek business cycle. We apply a simplistic ‘consecutive quarters of negative GDP growth’ rule,\(^1\) the non-parametric Bry and Boschan (1971) procedure and related non-parametric algorithms introduced by Harding and Pagan (2002, 2006), as well as the parametric Markov-switching model to identify Greek business cycle turning points. This comparative exercise provides the advantage of avoiding reliance on a single procedure or algorithm and further allows facing the argument of inadequacy of the use of any single series, such as GDP\(^2\) or IP. This is achieved through the incorporation of information contained in multiple single economic time series for the Greek economy. The time period investigated starts in January 1970 (or the first quarter of 1970 for quarterly data) and ends in June 2010 (or the second quarter of 2010 for quarterly data).\(^3\)

The obtained results support the suggestion of a robust business cycle reference chronology for Greek economic activity and the total time period under investigation. The derived reference chronology appears to be consistent with widely accepted historical stylized facts of the Greek business cycle. On the basis of the identified turning points, we comment on specific business cycle characteristics, which also clearly agree with internationally well established features such as asymmetry between expansions and contractions. Finally and without an exception, the results indicate the fact that the Greek economy has entered a recessionary regime during the

\(^1\) With reference to the popular ‘two-quarters’ rule of thumb, as Harding and Pagan (2003a, p. 22) indicate, some attribute this rule of two quarters of negative growth signaling the termination of an expansion to Arthur Okun (see, for example Harding, 1997), while this actually remains unclear. Others (for example, Layton and Banerjee, 2003) attribute this rule to Shiskin.

\(^2\) For a more recent discussion on the use of GDP for business cycle dating and, more generally, the conceptualization of the cycle, see Layton and Banerji (2003).

\(^3\) The time period investigated incorporates the second quarter of 2010, since the corresponding provisional GDP data on the basis of Quarterly National Accounts was released on the 8\(^{th}\) of September by the Hellenic Statistical Authority (EL.STAT.).
year 2008 and has not yet exited the contraction, since there is no evidence on a trough in Greek economic activity up to June 2010.

The rest of the present paper is organized as follows. Section 2 provides a literature review. Section 3 outlines the methodology applied and also introduces the data used. Section 4 presents and discusses the results. Section 5 concludes.

2. Literature Review

While in most countries an official business cycle dating authority is absent and, hence, no official reference chronology is provided, there exist numerous business cycle dating empirical applications in the related literature. This is the case for most of the advanced economies; still, such applications are often distinguished in terms of various factors. These factors may pertain, for example, to the underlying concept of the business cycle itself, distinct methodologies or varying data bases. Business cycle chronologies are established either on the basis of the classical cycle or the growth cycle concept. At the same time, procedures for dating business cycles vary from simple ad hoc rules or even graphical inspection to a range of sophisticated parametric applications. The popular NBER dating methodology provides the basis for a number of procedures, even though it faces criticism on the grounds of being non-transparent or reproducible, and subject to significant delays in announcements (see for example Chauvet and Piger, 2003). To confront such criticism, a number of business cycle analysts develop and apply alternative, more transparent and consistent procedures for business cycle dating. Such procedures rely on formal algorithms, which mostly involve automated procedures, or statistical models. With reference to the data used, single or multiple series may be preferred and data frequencies may also vary. Moreover, while many applications rely on a single methodology for chronology derivation, others consider comparative exercises more preferable. In most cases, the results suggest significant coherence among the obtained turning points. In addition, established chronologies do not only refer to single countries, but are also identified for groups of countries, such as the European Union or the Eurozone groups.

4 In the present work the classical business cycle concept is chosen (see also Section 3). The focus in the present section is, hence, on related literature excluding references to growth cycle dating.
With reference to simple rules, examples are provided in Birchenhall et al. (2001), for the case of the UK, Harding (1997) for an application to the Australian coincident index and Mylonidis (2003), who uses several criteria to obtain a recession chronology for Greek economic activity, on the basis of quarterly IP data and the time period 1962(q1)-2001(q4).

The use of the original or modifications of the Bry and Boschan (1971) (BB) automated algorithm for business cycle dating finds a great number of applications in the related literature. Such applications can be found, for example, in Artis et al. (1997) for the G7 and most major European countries using IP data over the time period 1961-1993 and Christoffersen (2000) for Finland, Norway, Sweden and Denmark (data from 1974), also using monthly IP data from 1960 to 1998. An algorithm related to the BB procedure is applied by Artis (2002) to date the British business cycle on the basis of monthly GDP data and the time period 1974-2002. The quarterly version of the BB algorithm (BBQ), according to Harding and Pagan (2001), is applied by Bodart et al. (2003) and Bodart et al. (2005) for Belgium using quarterly real GDP data to provide a reference cycle chronology over the period 1980-2002 and 1980-2003, respectively. The same version is used also by Krolzig and Toro (2005) to detect business cycle turning points for a subset of six EMU member countries and the time period 1970-1996. Morley and Piger (2005) apply a modified version of the BBQ algorithm on US quarterly real GDP data for the sample period 1948(Q4)-2003(Q2).

Within the class of parametric procedures for business cycle dating, the basic Markov-switching (MS) model, as well as modifications and extensions are applied to identify business cycle turning points. This is done either within the context of using one single methodology, but often in comparative exercises applying a variety of procedures. Such parametric applications can be found, for example in Bodman and Crosby (2000) for the Canadian economy and the time period 1947-1997 using quarterly GDP. Using real GDP and employment data, Chauvet and Piger (2003) investigate the real-time performance of a Markov-switching model for replicating the NBER business cycle chronology over a time period of 40 years. As an extension, a dynamic Markov switching factor model is applied for Japan by Watanabe (2003) on

---

5 This is done in an attempt to establish the importance of nonlinearity in reproducing business cycle features.
6 The authors stress this timing advantage, which can be very notable, especially when it comes to dating business cycle troughs.
different data sets of macroeconomic variables for the time period 1975-2000. Within a real-time and a multivariate context, Chauvet and Piger (2007) compare the business cycle dating performance of a non-parametric algorithm and a parametric Markov-switching dynamic factor model (DFMS). Chauvet and Hamilton (2005) present and implement a univariate parametric representation and a multivariate MS approach to compare different formal quantitative algorithms for business cycle turning points identification.\(^7\)

Extensive comparative exercises can be found, for example, in the review provided by Boldin (1994) on the performance of five different dating procedures for the US business cycle on the basis of specific criteria in order to evaluate their usefulness.\(^8\) Layton (1996) and Layton (1997) compare the turning points obtained by the application of the MS model to those produced by the BB algorithm, using the monthly US and Australian Coincident index, respectively. In an application for the Netherlands and the time period 1815-1913, Bonenkamp et al. (2001) compare different dating procedures on the basis of annual real GDP data. Harding and Pagan (2002) compare the non-parametric BBQ dating algorithm with the MS approach.\(^9\) In order to provide evidence against the use of a single series, such as GDP, and against the application of the simple ‘two-quarters’ dating rule, Layton and Banerji (2003) apply different dating procedures to different US data series. In investigating the Italian business cycle, Bruno and Otranto (2004) and Bruno and Otranto (2008) apply five different methodologies to obtain business cycle chronologies, on the basis of quarterly real GDP data for the time period 1970-2003. Schirwitz (2009) reviews and applies a number of different dating procedures for dating the German business cycle, using quarterly GDP data for the years 1970-2006.

The dating of business cycles is not confined to individual countries, but instead sometimes extended to the question of cycle synchronization or, more generally, to the case of specific country groups. In investigating business cycle independency or synchronization in the G7, for example, Bodman and Crosby (2005)

\(^{7}\) In Golosnoy and Hogrefe (2009) the results form the DFMS approach are compared to the proposed novel sequential approach for providing timely signals about changes of the business cycle phase, using monthly data for the US and the time period 1967-2008. The suggested procedure is found to be useful and able to provide quick and precise warnings about business cycle peaks and troughs.

\(^{8}\) As a whole, the author concludes that none of the procedures are clearly superior and supports the view of complementarity of procedures in building a consensus.

\(^{9}\) On the basis of criteria such as transparency, robustness, simplicity and replicability, they conclude that the non-parametric method appears to be preferable. See the related debate with Hamilton, as expressed in the comment by Hamilton (2003) and the rejoinder by Harding and Pagan (2003).
use three different methods to construct business cycle chronologies and date recessions. McAdam (2007) applies three different dating algorithms in order to lend support to his analysis on the potential cycle synchronization between the US, Japan and the Euro area. Harding and Pagan (2001) apply the non-parametric BBQ dating algorithm in order to construct business cycle information for the Euro area, on the basis of both Euro area aggregate GDP data and individual country GDP data for the time period 1970-1998. Krolzig (2001) provides a chronology for the Euro-zone business cycle applying the Markov-switching approach and using aggregated and single-country Euro-zone quarterly real GDP data for the sample period 1980-2000. Biscarri (2002) applies the BB algorithm (a modified version, as operationalized by Artis et al. (1997)) in order to locate turning points for a group of fourteen European countries and the US using IP data for a period, in most cases, of over thirty years. Artis et al. (2003) use a non-parametric algorithm, on the basis of the theory of Markov chains, which is related to the BB dating rule in order to provide turning points for the Euro area and the main Euro area countries (see also Artis at al., 2004c). Their analysis is based on two alternative measures of Eurozone GDP data, covering the 1970-2001 and 1980-2001 time periods, single countries GDP data starting from 1970 and monthly IP data with differing sample periods for the individual countries under examination. Similarly, Artis et al. (2004b) use IP data in order to characterize the business cycle for EMU accession countries. Artis et al. (2004a) identify and date a European business cycle using Markov-switching autoregressions, using both IP and GDP data for the time period 1970-1996 and nine European economies. Bengoechea and Perez-Quiros (2004) use, in a comparative turning points analysis, both the BB algorithm and the MS approach in order to date the Euro area business cycle, relying on the Euro area IP index and the Euro area Industrial Confidence indicator. Mönch and Uhlig (2005) produce a monthly business cycle chronology for the time period 1970-2002 and the Euro area (12 member countries as of January 2002). They apply the BB procedure, augmented with an amplitude/phase-length criterion, on the basis of different monthly GDP series for the Euro area. Anas et al. (2007) discuss and review different dating procedures and their classifications with the aim of suggesting a turning point chronology for the Euro-

10 In a related work by Proietti (2005), a dating algorithm is developed, also on the basis of a Markov chain. Its application is illustrated by using the monthly Italian index of IP for the period 1981-2002 and a synthetic index obtained via dynamic factor analysis by the use of four US coincident indicators for the time period 1959-2002.
zone. In their application, they choose a non-parametric algorithm, on the basis of the BB dating rule, and propose dating chronologies using aggregate IP, GDP and employment Euro-zone data. With the aim of providing a monthly business cycle chronology for the EU15, Billio et al. (2007) reconstruct GDP and IP data back to 1970 and use various procedures to date turning points. In investigating issues related to the question of business cycle synchronization, Chen (2007) uses both classical and modern business cycle dating approaches to identify business cycle turning points based on multivariate coincident macroeconomic variables. Turning points are extracted both for the individual EMU countries (with the exception of Greece, Luxemburg and Ireland), and the Eurozone aggregate. The question of potential business cycle synchronization among Mediterranean countries is investigated by Medhioub (2009), who applies three-regime switching models on IP monthly indexes for France, Italy, Greece, Spain, Tunisia and Turkey and the time period 1994(01)-2007(12). Against this background, an explicit turning point chronology is given for Greece and the specific time period.

It should be finally noted, that while the applications on business cycle dating referring to the US and other advanced economies are numerous, similar references to developing economies are limited. For a sample of fifteen developing economies (Côte d’Ivoire, Malawi, Nigeria, South Africa, Zimbabwe, Chile, Colombia, Mexico, Peru, Uruguay, India, South Korea, Malaysia, Morocco and Pakistan), Rand and Tarp (2002), for example, apply the BB procedure on IP data in order to identify business cycle turning points and refer to business cycle stylized facts. Du Plessis (2006) applies the BB algorithm in order to identify business cycle turning points for a group of selected developing economies (Hong Kong, Israel, Korea, Mexico, Peru, the Philippines and South Africa). He uses quarterly real GDP data but also other selected data series to date business cycle chronologies and comment on various business cycle stylized facts for the countries under examination. In an application for Colombia, Arango et al. (2008) use the BB algorithm to establish a business cycle chronology on the basis of IP data and for the time period 1980-2007.
3. Methodology and Data

The aim of this work is to date the Greek business cycle for a time period of over forty years through the application of various procedures using both aggregated quarterly and constructed monthly GDP data as well as monthly individual economic series. Consistency in the obtained dates will indicate independency of the results from the procedure applied. Retaining the basic elements inherent in the Burns and Mitchell (1947) business cycle definition and the procedures followed by the NBER business cycle Dating Committee, we focus on recessions rather than on growth retardations. In other words, and against the background of the recent developments, we choose the concept of the classical business cycle. We apply a number of different procedures in order to deal with issues relating to the alleged arguments of simplicity, non-formality or subjectivity of methodologies. At the same time, we avoid relying solely on GDP data, in order to face criticism on ignoring information contained in other important economic series.

More specifically, the chronology obtained in a first step from a simple ‘quarters of GDP growth’ rule of thumb is compared with the ones resulting from the application of three formal algorithms translating the essence of the definition of business cycles according to Burns and Mitchell (1947). These algorithms are based on automated procedures with the advantage of rendering the included steps replicable and transparent, even though they still involve a certain degree of judgment, since they underlie a number of subjective choices. First, the BB procedure is applied using a constructed monthly GDP series. Second, the algorithm for a BBQ quarterly application is used on the basis of quarterly GDP data. Third, on the basis of individually determined specific turning points in single economic series by the use of the BB procedure, an aggregate reference business cycle chronology is provided by applying the algorithm according to Harding and Pagan (2006b). Finally, in order to avoid any ad hoc subjective choices, the Markov switching model for business cycles is applied, which has the advantage that it can capture asymmetry in business cycle fluctuations. In this model, turning points are directly inferred through the obtained recession probabilities, since they are treated as structural events inherent

---

11 There remains, for example, the question of deciding on the dating criteria to be applied. In this work we largely follow the rules included in the original procedures (see also Sections 3.2, 3.3 and 3.4).
in the data generating process (see Kim and Nelson (1999)). In a last step, the derived results are used to make reference to specific business cycle characteristics.

With regard to the issue of series and data selection, the question emerges on the aggregate measure of economic activity to be used. The use of GDP or other single economic variables, such as IP, assumed to summarize economic activity appears to be intuitively appealing. In addition, the use of GDP data is in accordance with the argument by Burns and Mitchell that GDP measures would be appropriate for reflecting and measuring aggregate economic activity (Burns and Mitchell, 1947, p. 72). Still, data availability considerations restrict the use of GDP, for the simple reason that in most countries GDP is not provided on a monthly basis. More generally, the case for the exclusive use of single series is weakened by the argument of the disadvantages of relying solely on the signals given by a single series, instead of a variety of variables, which reflect broad economic conditions. Against this background and in order both to gain from the advantage of using GDP data and to confront criticism on relying on a single series, in this work we resort to different applications on the basis of either quarterly or derived monthly GDP but also multiple economic series.\footnote{There is still the issue of judgmental choice of the underlying individual economic series. Note, however, that in the case of Greece and for a time period back to 1970 this choice is considerably constrained by data availability restrictions (see also Section 3.7).}

3.1 Simple GDP growth rule

In a first step, a simple ad hoc rule imposed on GDP growth is used in order to identify turning points in the Greek business cycle. The applied rule, which is asymmetric, is based on the popular notion of ‘consecutive quarters of negative growth’ for recession identification (and ‘consecutive quarters of positive growth’ for expansion identification, correspondingly). More specifically, for the location of a peak, we require that three or three-out-of-four of the quarters that follow are characterized by negative GDP growth; for the identification of a trough we require that two or two-out-of-three of the quarters that follow are characterized by positive GDP growth.\footnote{We believe that the specific rule applies better to Greek GDP data than the ‘two-quarters’ rule (which identifies too many recessions) and is also preferred over a cutoff or threshold rule.}
3.2 Bry-Boschan procedure with monthly GDP series

A widely applied business cycle dating algorithm on the basis of monthly economic series is the non-parametric automated procedure introduced by Bry and Boschan (1971) for classical cycle turning points detection. This specific algorithm basically replicates the expert system for turning points detection developed at the NBER and codifies the procedures applied by B&M. The key element of this approach is that the chronology of the phases of the business cycle is determined by locating the exact switch points from an expansion to a contraction and vice versa. This is achieved through the procedure of identification of local minima and maxima in the path of the underlying economic series, using a general rule, so that a peak and a trough, respectively, are given if

\[
\{ y_t > y_{t-k}, y_t > y_{t+k}, k = 1,...,M \} ,
\]

\[
\{ y_t < y_{t-k}, y_t < y_{t+k}, k = 1,...,M \} .
\]

With the purpose to match the basic features of the Burns and Mitchell dating procedures, \( M \) is set to 5 for monthly data (2 for quarterly), while specific censoring rules\(^{14}\) are also imposed. These rules concern the elimination of local turns and the constraints on phase and cycle durations. Watson (1994) provides a program implementation of the BB business cycle dating algorithm.\(^{15}\) With regard to the exact process and as BB formulate it, “the programmed approach operates through a preliminary determination of cycles and a gradual narrowing down of neighborhoods within which turning points are selected. The process involves several weighted and unweighted moving averages of varying flexibility”.\(^{16}\) Table 1 offers an outline of the essential steps of the procedure.

---

\(^{14}\) As indicated by Harding (2003, p. 3-4), the most important reason for censoring turning points is to enhance the effect of nonlinearities. In the case, namely, of nonlinearities large changes are expected to differ significantly from small changes and nonlinearity is expected to show up in the path taken between successive turning points. In that sense, censoring is implemented in order to ensure that phases are sufficiently long so as to make any nonlinearity evident.

\(^{15}\) The basic GAUSS code for the implementation of the BB business cycle dating algorithm is taken from [www.princeton.edu/~mwatson/publi.html](http://www.princeton.edu/~mwatson/publi.html).

\(^{16}\) See Bry and Boschan (1971), p. 2-3.
Table 1
Procedure for Programmed Determination of Turning Points

1. Determination of extremes and substitution of values.
2. Determination of cycles in 12-month moving average (extremes replaced).
   A. Identification of points higher (or lower) than 5 months on either side.
   B. Enforcement of alternation of turns by selecting highest of multiple peaks (or lowest of multiple troughs).
3. Determination of corresponding turns in Spencer curve (extremes replaced).
   A. Identification of highest (or lowest) value within ±5 months of selected turn in 12-month moving average.
   B. Enforcement of minimum cycle duration of 15 months by eliminating lower peaks and higher troughs of shorter cycles.
4. Determination of corresponding turns in short-term moving average of 3 to 6 months, depending on MCD (months of cyclical dominance).
   A. Identification of highest (or lowest) value within ±5 months of selected turn in Spencer curve.
5. Determination of turning points in unsmoothed series.
   A. Identification of highest (or lowest) value within ±4 months, or MCD term, whichever is larger, of selected turn in short-term moving average.
   B. Elimination of turns within 6 months of beginning and end of series.
   C. Elimination of peaks (or troughs) at both ends of series which are lower (or higher) than values closer to end.
   D. Elimination of cycles whose duration is less than 15 months.
   E. Elimination of phases whose duration is less than 5 months.
6. Statement of final turning points.


The applied procedure for turning points location as implemented by Watson consists of different steps, in accordance with the description provided in the above table. The first step consists in identifying and replacing the detected outliers by an average of neighboring observations. The second step involves the determination of turning points in 12-month moving averages, on the basis of the series with adjusted extremes, as the highest or lowest values within ±5 months. Thereby, as also in all the following steps, the condition of alternating turns is enforced by choosing the highest peak and the lowest trough in cases of no alternation. In a third step, the identified turns are refined by using the determined turns in a Spencer curve. The new dates are derived as the highest or lowest within ±5 months of the old ones, while the condition of minimum cycle (P-to-P and T-to-T) duration of 15 months is enforced. Turning point dates are again refined in a fourth step, by the use of a short-term moving average dependent on MCD (months of cyclical dominance), with turns identification as the highest or lowest within ±5 months of the selected turns in the Spencer curve. In the fifth and final step of the procedure, the turns are refined by using the original series. The new dates are derived as the highest or lowest within ±4, or MCD term.
(depending on whichever is larger), of the selected turns in the chosen short-term moving average. The determination of the final turning points requires the elimination of specific turning points which is undertaken in order to apply several censoring rules. More specifically, the elimination concerns any turns within six months of beginning and end of the series, any peaks (and troughs) at both ends of the series which are lower (higher) than values closer to the end, any cycles with duration less than 15 months and, finally, any phases with duration less than 5 months.

In the absence of monthly Greek GDP data which are required for the application of the monthly BB procedure, we resort to the method of interpolation. The method proposed by Chow and Lin (1971)\textsuperscript{17} presents a prominent and often applied procedure for interpolation. The main underlying idea is to use the information contained in related higher frequency series to derive a monthly measure for GDP. In other words, on the basis of quarterly GDP data and monthly data on related series, a monthly GDP series is estimated by regression on the related series to obtain the best linear unbiased estimates of the monthly GDP series.\textsuperscript{18}

3.3 Quarterly Bry-Boschan procedure with quarterly GDP data

Based on the BB dating algorithm which focuses on monthly data, Harding and Pagan (2002, 2003a) develop and apply the version known as BBQ to be used with quarterly economic series. This procedure, which relies on a quarterly version of the programmed implementation of the BB censoring code by Watson (1994), can be seen as a simplification of the BB procedure (see Harding and Pagan, 2003a, p. 3).\textsuperscript{19}


\textsuperscript{18} See Appendix A for the exact derivation procedure.

\textsuperscript{19} In investigating the econometric effects of censoring of turning points, Harding (2003) argues that a clear and transparent mathematical representation of what censoring does is needed, since the BBQ algorithm still embodies the “black box” approach to censoring.
An algorithm for the implementation of the BBQ algorithm is provided by James Engel.  

In equivalence to the basic idea behind the BB algorithm, the BBQ variant looks for the local minima and maxima in the sample path of an economic time series $y_t$. The definition remains unaltered, as a local peak (trough) occurs at time $t$ whenever $\{y_t > (<) y_{t+k}\}$, with $k = 1, ..., K$. For quarterly data, $k$ is set equal to 2, ensuring that a local maximum or minimum is found at $t$ relative to the two quarters on either side, so that

$$peak \ at \ t = \{(y_{t-2}, y_{t-1}) < y_t > (y_{t+1}, y_{t+2})\} \quad (3)$$

$$trough \ at \ t = \{(y_{t-2}, y_{t-1}) > y_t < (y_{t+1}, y_{t+2})\}. \quad (4)$$

The censoring procedures are maintained and, in addition, rules are found adapting to the ones in BB by the decision on the minimal length of cycles and phases in terms of quarters. The censoring of turning points ensures that peaks and troughs alternate, that each business cycle phase lasts a minimum of two quarters and each complete business cycle a minimum of five quarters.  

### 3.4 Aggregation of turning points in individual series

In following Harding and Pagan (2006b) (H&P), a non-parametric automated algorithm is applied in order to obtain the reference cycle chronology by identifying in a first step the specific turns in selected individual series and, in a second step, by a process of ‘aggregation’ of the individually derived switch points.  

More specifically, the BB algorithm for monthly series is used at first to determine the specific turning points and cycles in the individual economic series.

---

20 A GAUSS version of James Engel’s business cycle dating programs is provided at [www.ncer.edu.au/data](http://www.ncer.edu.au/data).

21 For the Greek case, these censoring rules are adjusted to eliminate phases and cycles with duration less than 3 and 6 quarters, respectively.

22 This methodology is sometimes termed ‘indirect’, as opposed to direct ones, where business cycle turning points are established on the basis of a constructed coincident indicator (see Bruno and Otranto, 2004). I thank Professor Don Harding for kindly providing the corresponding GAUSS code for the implementation of the specific algorithm.
Given that $t_i^p$ and $t_i^T$ are vectors containing the dates to peaks and troughs, respectively, in the $i$th specific cycle, functions $\tau_i^p(t)$ and $\tau_i^T(t)$, respectively, are defined, which measure the distance in months from data $t$ to the nearest peaks and troughs, respectively, in the $i$th specific cycle. Second, functions $\tau^p(t)$ and $\tau^T(t)$ are defined, which measure the median distance from $t$ to the set of nearest peaks and troughs, respectively. Then, the central dates of clusters of peaks are given by local minima in these functions and comprise dates at which the distance in months to the sets of nearest peaks and troughs are minimized. Vectors $M^p$ and $M^T$ are defined as the vectors of dates of local minima in $\tau^p(t)$ and $\tau^T(t)$, respectively. In other words these are the vectors containing the dates of the clusters of peaks and troughs. Finally, it is controlled whether or not the peak (trough) nearest to the centre of that cluster is in that cluster, which is provided by the conditions that it is not nearer to the centre of another cluster and it is less than a distance $\bar{d}$ from the centre of the cluster. With $m_j^p$ and $m_j^T$ being the $j$th elements of $M^p$ and $M^T$, $C(m_j^p)$ and $C(m_j^T)$ represent the clusters of peaks and troughs centered on $m_j^p$ and $m_j^T$, respectively.

As indicated by Harding and Pagan (2006b), if local minima are not unique, it may be necessary to break ties, in order to decide on the turning point, which is done by the algorithm by looking at higher percentiles than the median until a unique local minimum is found. Moreover, several censoring rules may be implemented in order to ensure that peaks and troughs alternate and restrictions on the minimum phase and cycle durations may be imposed to maintain the NBER criteria.

### 3.5 Markov switching model

In a specification according to Hamilton (1989), we model the business cycle as a two-state Markov switching process. The growth rate of the selected measure of economic activity, $\Delta y_t$, is represented by

---

23 We take log differences.
\[
\Delta y_t = \mu(S_t) + \sum_{i=1}^{q} \phi_i(\Delta y_{i-1} - \mu(S_{i-1})) + \epsilon_t, \quad (5)
\]
\[
\epsilon_t \sim i.i.d. N(0, \sigma^2), \quad (6)
\]

where the mean growth rate of economic activity \( \mu \) depends on the state variable \( S_t = \{0,1\} \) and switches between two regimes with

\[
\mu(S_t) = \mu_0(1 - S_t) + \mu_1 S_t \quad (7)
\]

depending on economic activity switching between expansions and contractions; the disturbance term is assumed to be state-independent and \( \phi_i \) describe the autoregressive parameters. Since we are dealing with the classical concept of business cycles, the imposition of two states is intuitively appealing. The transition probabilities for the potential switches from the one business cycle regime to the other are given by

\[
\Pr(S_t = i \mid S_{t-1} = j) = P_{ij}, \quad (8)
\]

and hence, the probability process driving the state variable is captured by four transition probabilities such as

\[
\begin{align*}
p &= \Pr[S_t = 1 \mid S_{t-1} = 1], \\
1 - p &= \Pr[S_t = 0 \mid S_{t-1} = 1], \\
q &= \Pr[S_t = 0 \mid S_{t-1} = 0] \quad \text{and} \quad 1 - q = \Pr[S_t = 1 \mid S_{t-1} = 0].
\end{align*}
\]

In order to derive the business cycle reference chronology on the basis of the results from the Markov switching model, we need to convert the transition probabilities into turning point dates. For that reason we adopt the simple rule that a period of recession is defined as a period in time where the inferred probability of recession is greater than 0.5.\(^{25}\)

\(^{24}\) We select four autoregressive terms.

\(^{25}\) The basic GAUSS code for the implementation of the Markov switching model is taken from [weber.ucsd.edu/%7Ejhamilto/software.htm#Markov](http://weber.ucsd.edu/%7Ejhamilto/software.htm#Markov) and is part of the data and software from James D. Hamilton. On the basis of the MS model, we calculate both filtered and smoothed recession probabilities.
3.6 Measuring Business Cycle Features

Provided a business cycle reference chronology has been derived, the located dates can be used independently or in conjunction with the underlying series to provide information on specific business cycle features. Such features may refer to complete cycles or cycle phases. Complete cycles run from a trough point to the next or from a peak point to the next and cycle phases run from a trough point to the next peak point (expansion), and from a peak point to the next trough point (contraction). In this application to the Greek business cycle we focus on cycle and phase durations as well as amplitudes, but also on cumulative movements and excess cumulative movements within phases. These measures are calculated since they provide useful and important information on the features of the length, depth and shape of business cycles and/or business cycle phases.

Beside the reference chronology, all applied procedures can be in practice used to provide comparative duration measures, and, hence cycle and phase lengths and their corresponding averages, since cycle and phase durations are measured on the basis of the obtained chronologies. $D_i$ can be denoted to be the duration of the $i$th phase, whether expansion or recession, which is defined by two consecutive turning points (trough-to-peak or peak-to-trough) that fall in periods $t$ and $t+d$, returning $D_i = d$. It follows that the duration of a complete cycle can be easily calculated by the addition of the durations of two consecutive phases. In contrast to the case of durations, the underlying data series are needed for the measurement of phase amplitudes, but also cumulative movements and excess cumulative movements. We take the quarterly GDP series, denoted $Y_t$, since the derived reference chronology is on a quarterly basis. We denote by $A_i$ the amplitude and, hence, depth of the $i$th phase which is measured as $A_i = y_{i+d} - y_i = \Delta_d y_{i+d}$, where $y_i = \ln(Y_t)$.\(^\text{26}\) In this case, the log has a natural interpretation as the approximate percentage change between trough (peak) and peak (trough) (see Harding and Pagan, 2006b, p. 6).

Following Harding and Pagan (2002, 2006), Krolzig and Toro (2005) and Camacho et al. (2008), we combine phase duration and amplitude in a useful way and

\(^{26}\) In assuming that $Y_t$ is positive for all $t$, we can work with $y_i = \ln(Y_t)$. This transformation, being monotonic, will not impact on the determination of turning points (see Harding and Pagan, 2003, p. 2).
consider a cycle phase as a triangle. The base of the triangle stands for the duration of the business cycle phase, the height is considered to be the amplitude, and the hypotenuse gives the path of the series for the hypothetical case of a linear transition between two successive turning points. As a result, the triangle area offers an intuitive approximation to the cumulated gain (loss) in output from one turning point to the next, while this approximation allows, at the same time, the examination of the concavity or convexity, and, hence, shape of the cycle phase. Then, the ‘triangle approximation’ to the cumulated movements is given by the product 

\[ C_T = 0.5(D_i * A_i) \]

Nonetheless, the actual cumulative movements, \( C_T \), may in practice differ from \( C_T \); the measure of the ‘excess cumulated movements’, \( E_i \), is used to calculate this difference and is given by 

\[ E_i = (C_T - C_T + 0.5 * A_i) \]

In interpreting the resulting difference, negative (positive) excess measures indicate that the actual cumulative movements, gains or losses, are larger (smaller) than the triangular approximation for expansions and contractions, respectively. At the same time, the above excess measure possesses an additional interesting dimension, since it offers insights as to the abruptness with which the series enters in and exits from a phase. Within this context, great positive (negative) divergences from a triangle in the expansion phase reflect rapid (slow) recovery in the early part of an expansion; accordingly, great negative (positive) divergences from a triangle in the contraction phase indicate rapid (slow) decline in the early part of the contraction. \(^{27}\)

3.7 Data

The present application for dating the Greek business cycle applies both monthly and quarterly data, which are in all cases seasonally adjusted. \(^{28}\) The time period investigated starts in January 1970 (or 1970Q1) and ends in June 2010 (or 2010Q2). Since monthly GDP data are not provided, we take quarterly GDP data

\(^{27}\) Note that ‘positive’ and ‘negative’ divergences in this context indicate greater gains and greater losses, which according to the above definition of \( E_i \) are signaled by a negative sign for expansions and contractions, respectively.

\(^{28}\) In cases of seasonally non-adjusted series, seasonal adjustment is conducted in EViews by the US Census Bureau X12 procedure. Note that one would expect a certain degree of sensitivity of the business cycle dating outcome depending on the seasonal procedure method employed on monthly data. However, it is beyond the scope of this paper to analyze the exact impact of alternative seasonal adjustment procedures on business cycle dating.
(constant prices) from the Quarterly National Accounts. For both the derivation of a monthly GDP series through interpolation and the determination of specific cycles chronologies to be used in turning point aggregation, several monthly data series are selected. The underlying series are chosen as being related to GDP and expected to adequately cover significant sectors of Greek economic activity and, hence, reflect the corresponding cyclical movements. The series incorporated are (a) the Industrial Production Index, taken from the OECD Main Economic Indicators Database, (b) the Turnover Index in Retail Trade which is deflated, and (c) the value of Imports (arrivals) which is deflated and indexed.

4. Results

4.1 Greek Business Cycle Chronology

The five dating procedures as outlined in Section 3 are applied to Greek data for the time period January 1970 (Q1 1970)-June 2010 (Q2 2010). They lead to five chronologies for the Greek business cycle and the corresponding exact peak and trough dates are presented in Table 2. Figure A2 in Appendix B pictures the smoothed recession probabilities resulting from the application of the MS model.

A first and very significant indication is the basic consistency between the obtained turning point dates. In other words, the application of the five different algorithms suggests in most cases very similar and in many cases even identical dates for business cycle peaks and troughs. As a result, there appears to be, with some exceptions, a considerable general agreement on the approximate timing of economic recessions and expansions for Greek economic activity and the time period starting in January 1970 (or Q1 1970) and ending in June 2010 (or Q2 2010). At the same time, since the applied methodologies differ in several aspects, some deviations between the obtained chronologies are seen to be justified.

---

29 Due to the latest and significant 2007 upward revision of GDP, official quarterly GDP data are provided by the Hellenic Statistical Authority (EL.STAT.) and Eurostat only back to 2000. For the construction of a continuous GDP series, we adjust the data backwards on the basis of the q-o-q percentage changes of the non-revised earlier quarterly data provided by Eurostat back to 1970.
30 Series selection was to a significant degree dictated also by data availability considerations. Against this background, employment/unemployment and personal income data are not included. The alternative of a shorter time period including such time series was discarded on the basis of the intention to try to establish the validity and robustness of a business cycle chronology by focusing on long historical stylized facts of the Greek business cycle.
Table 2
Derived Business Cycle Chronologies for Greek Economic Activity
January 1970 (Q1 1970)-June 2010 (Q2 2010)

<table>
<thead>
<tr>
<th>GDP growth Rule</th>
<th>BB Interpolated Quarterly GDP</th>
<th>BBQ Quarterly GDP</th>
<th>H&amp;P Algorithm Monthly Series</th>
<th>MS Model Quarterly GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak</td>
<td>Trough</td>
<td>Peak</td>
<td>Trough</td>
</tr>
</tbody>
</table>

More specifically, four out of the five procedures applied identify six full, even though not identical, business cycles, while the BBQ algorithm suggests five full business cycles. Moreover, the beginning of a period of recession for the Greek economy during the year 2008 is confirmed in all cases, whereas disagreement abounds on the exact peak date and, hence, the exact point in time of entering the recessionary regime. The BB algorithm with monthly GDP data and the H&P algorithm both identify April 2008 as the peak month, hence implying that Greek economic activity entered the recessionary regime in May 2008. This is in agreement with the corresponding date provided by the MS model, which specifies the second quarter of 2008 as the peak quarter. At the same time, the BBQ algorithm and the GDP growth rule suggest the third quarter of 2008 as the peak quarter, implying that the fourth quarter of 2008 was the first quarter of the latest recession. Also very importantly, the obtained results indicate, independently of the procedure applied, that until June 2010 there have been no signs of the Greek economy exciting the recession. In other words, since no trough date is identified after the peak in 2008, the last full cycle and phase remain incomplete implying that Greek economic activity has not yet entered an expansionary regime.

As to the individual business cycles which the Greek economy is suggested to have experienced during the past four decades according to the procedures applied,
we are able to outline stylized facts which also agree with the international and European experience.\textsuperscript{31} First of all, all procedures without exception locate the mid-1970s recession, which is associated with the first oil price shock. There is moreover significant agreement among four of the five methodologies on the exact timing, with a slight deviation signaled by the MS model: The peak date is placed within the fourth quarter of 1973 in two cases (whereas the MS model selects the third quarter of 1973), with October or November suggested as the exact months for the turning point in the other two. The third quarter of 1974 is identified in three cases as the quarter of exiting the contraction, and July or September are the proposed trough months in the other two cases. As to the apparent short duration of the specific recession for Greece, there is agreement with other findings in the respective literature. The same is outlined, for example, by Biscarri (2002), who claims that the Greek economy was the first to recover from the crisis, compared to the other European countries under investigation.\textsuperscript{32}

The exact dating of the recession of the early 1980s is not characterized by full agreement among the applied dating methods. Still, the degree of correspondence between dates provided by four of the five procedures applied allows a consensus on the respective peak and trough dates. The most important point of disagreement concerns the fact that, while four methodologies distinguish between an approximate 1980-1981 and an approximate 1982-1983 recession, the BBQ algorithm identifies one lasting recession from early 1980 to mid-1983. This fact, however, may be related to the short duration of the otherwise identified expansion beginning in 1981 and may emerge as a result of the involved censoring rules.\textsuperscript{33} The case for a double early 1980s recession does not seem implausible and is further enforced by the fact that it can be connected to the second oil price shock. It also agrees with the so called ‘double-dip’ recession identified for other European countries (see for example Biscarri, 2002\textsuperscript{34}).

\textsuperscript{31} Note that there is also approximate agreement with recessionary regimes as identified in the literature for the EU and the Euro-zone countries. See for example, Billio et al. (2007), Anas et al. (2007) and Chen (2007).

\textsuperscript{32} The mid-70s recession is established in the literature for a number of countries worldwide and is always related to the 1974 oil price rises, even though in some countries the peaks predated these increases, as indicated by Artis et al. (1997).

\textsuperscript{33} With the imposed restriction of a minimum phase length of 3 quarters, an expansion phase with a duration of 2 quarters is eliminated. Relaxation of the respective rule to 2 quarters leads to the location of an expansion lasting through the second and third quarters of 1981.

\textsuperscript{34} Note that according to the findings in Biscarri (2002), which are not in agreement with the ones presented here, Greece escaped the early 1980s recession and regained the synchronicity with the other European countries during the recovery from the recession of the 1990s.
Very similar results are presented, for example, by Bruno and Otranto (2004) for Italy, who, depending on the procedure applied, find indications both for a single long early 1980s recession and two distinct recessions separated by a short recovery in the second half of 1981.

The second point of differentiation as to the identified ‘double’ early 1980s recession is related to the exact months/quarters of the obtained turning points, which do not totally coincide. There seems to exist a general consensus on the first quarter of 1980 (or March 1980 as to the BB algorithm) as the peak date of the ‘first’ early 1980s recession, which disagrees only with the result from the H&P algorithm, identifying December 1979 as the peak month. However, there is no similar agreement as to the located dates of the corresponding trough. According to the MS model and the H&P algorithm, the first quarter of 1981 and February 1981, respectively, present the respective trough dates, whereas the GDP growth rule and the BB algorithm identify the second quarter of 1981 and June 1981, respectively as the corresponding trough dates. Three procedures agree on the fourth quarter of 1981 (or November 1981 according to the BB algorithm) being the peak date signaling the begin of the second early 1980s recession, whereas the H&P algorithm identifies March 1982 as the corresponding peak date. General consensus exists as to the date of the trough signaling the end of the second early 1980s recession in Greece, with the dates obtained being the second quarter of 1983 or the months of April and May 1983. Only the MS model determines an earlier point in time, giving the first quarter of 1983 as the corresponding trough date.  

The 1986-1987 contraction is consistently identified by all five applications and in almost all cases (except the GDP growth rule giving the second quarter of 1986 as the peak point) the peak date is determined within the fourth quarter of 1985 or October 1985 by the BB and November 1985 by the H&P algorithm. Three methodologies locate the trough date signaling the end of the 1986-1987 recession during the second quarter of 1987, whereas the BB algorithm and the H&P algorithm identify January 1987 and March 1987, respectively, as the corresponding trough dates.

Similarly to the case of the early 1980s double recession, there is evidence on a double early 1990s recession. Such a double recession is not confirmed by the GDP  

---

35 Note, however, that, according to the MS model, the second quarter of 1983 is characterized by a high recession probability lying marginally below the 0.5 threshold.
growth rule\textsuperscript{36} and the H&P algorithm. One single early 1990s recession is also identified by Biscarri (2002) for Greece, lasting three and a half years. At the same time, there is no significant disagreement as to the date of the peak signaling the beginning of the early 1990s recession (whether single or double), since the first quarter of 1990 and January 1990 are the identified dates, except for the MS model giving the fourth quarter of 1989. Furthermore, the BB algorithm and the MS model identify the third quarter of 1990 and September 1990, respectively, as the corresponding trough dates of the first and short early 1990s recession, while according to the BBQ procedure the trough date is given by the second quarter of 1991. This appears to be a significant point of differentiation, since in the first case the procedures locate a very short 1990 recession, whereas the BBQ algorithm indicates a longer 1990-1991 recession. However, once again, this fact may be related to the short duration of the otherwise identified contraction beginning in 1990 and may emerge as a result of the involved censoring rules.\textsuperscript{37} Three methodologies (the GDP growth rule, the BBQ algorithm and the MS model) provide identical dates for the second potential early 1990s recession, with the respective peak and trough dates being the first quarter of 1992 and the first quarter of 1993, respectively. In disagreement with that, the BB algorithm identifies November 1991 as the corresponding peak and November 1992 as the corresponding trough, with the latter agreeing with December 1992 being identified as the trough date by the H&P algorithm. Once again, similar findings are provided by Bruno and Otranto (2004) for Italy as to the early 1990s recession. Their results are also distinguished, since there are both indications for a single longer period recession from 1990 to 1993 and for a short recession in 1990 followed by another one over the period 1992-1993.

Perhaps the most important points of deviation among the identified switch points refer to two distinct recessions identified only by one methodology in each case. They concern the 1994-1995 recession located by the GDP growth rule and the early 2000s recessionary period which, according to the H&P algorithm, began in June 2000 and ended in October 2001. There are, however, no such findings on the basis of the BB, BBQ algorithms or the MS model. With reference to a potential early

\textsuperscript{36} Note, however, that according to the GDP growth rule the second and the third quarters of 1990 are characterized by significant negative growth, but the ‘three negative quarters of GDP growth’ imposed rule does not allow the identification of such a short recession period.

\textsuperscript{37} With the imposed restriction of a minimum phase length of 3 quarters, a contraction phase with a duration of 2 quarters is eliminated. Relaxation of the respective rule to 2 quarters leads to the location of a contraction lasting through the second and third quarters of 1990.
2000s, Biscarri (2002) argues that there is evidence on a deceleration of economic activity in Greece in the early 2000s, something that is also the case for other European countries, too. However, he stresses the fact that there is ambiguity on whether this incident qualifies as an ‘official’ recession.

Finally and very importantly, as already indicated in the beginning of this section, there is important agreement among three of the five procedures on the peak date signaling the beginning of the late 2000s recession, which is found to be April 2008 by the BB and the H&P algorithm and the second quarter of 2008 by the MS model. At the same time, the GDP growth rule and the BBQ method identify the third quarter of 2008 as the peak quarter and, hence, the fourth quarter of 2008 as the outset of the latest recessionary period for the Greek economy.\(^{38}\)

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Suggested Business Cycle Reference Chronology for the Greek Economy, Q1 1970-Q2 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Cycle Reference Chronology Quarterly</td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>Trough</td>
</tr>
<tr>
<td>Q4 1973</td>
<td>Q3 1974</td>
</tr>
<tr>
<td>Q1 1980</td>
<td>Q1 1981</td>
</tr>
<tr>
<td>Q4 1981</td>
<td>Q2 1983</td>
</tr>
<tr>
<td>Q4 1985</td>
<td>Q2 1987</td>
</tr>
<tr>
<td>Q1 1990</td>
<td>Q3 1990</td>
</tr>
<tr>
<td>Q1 1992</td>
<td>Q1 1993</td>
</tr>
<tr>
<td>Q2 2008</td>
<td></td>
</tr>
</tbody>
</table>

Having established basically consistent results on the basis of the five different applied procedures, we now proceed to the suggestion of a quarterly reference chronology for the Greek business cycle over a time period from the first quarter of 1970 to the second quarter of 2010. To do that, we mainly rely on the dates provided by the methodologies which mostly agree on the inferred peak and trough points. Moreover, we take into account additional information such as the impact of specific censoring rules and the detailed information on the recession probabilities provided

\(^{38}\) Note that according to the announcement of the Euro Area business cycle Dating Committee on the determination of the 2008Q1 peak in economic activity, Greece belongs to the countries that reached their highest GDP values at the end of the, by that time available, sample. As a result, it is argued that it cannot be said to have peaked based on GDP data alone. See [http://cepr.org/press/Dating-Committee-Findings-31-March-2009.pdf](http://cepr.org/press/Dating-Committee-Findings-31-March-2009.pdf).
by the MS model. The resulting reference chronology offering the exact turning points can be said to accurately present a robust chronology for the Greek business cycle over the time period Q1 1970 to Q2 2010. The suggested reference chronology is presented in Table 3. The quarterly GDP data series together with the identified recessions, which are represented by shaded areas, are pictured in Figure A1 in Appendix B.

4.2 Greek Business Cycle Features

The derivation of a robust reference cycle chronology for Greek economic activity allows elaborating on important information concerning specific characteristics of the detected full business cycles as well as their phases. These are offered in Table 4.\textsuperscript{39} which first presents the calculated evidence on the durations, or the length, of the detected full cycles and the related phases. We refer to full cycles both as cycles from one peak to the next (P to P) and from one trough to the next (T to T) and to phases by distinguishing between expansions and contractions. We also provide the corresponding mean durations and standard deviations.

Not surprisingly, the most striking characteristic pertains to the difference in duration between expansions and contractions. The mean duration of expansions amounts to 18.8 quarters, while contractionary regimes in Greece last 4.2 quarters on average. This is in accordance with the internationally well established business cycle characteristic of asymmetry between expansions and contractions, reflected in expansionary regimes being significantly longer than contractionary regimes. The calculated durations of expansions and contractions are also well distinguished in terms of standard deviations, with a value of 21.6 for expansions and 1.6 for contractions. The evidence further indicates that the longest expansion lasted 61 quarters and is the one that was interrupted by the beginning of the most recent contraction of the year 2008. With reference to the recorded recessions, the longest recessions lasted 6 quarters. At the same time, the last recorded full cycle is identified

\textsuperscript{39} For reasons of comparison, Table A1 in Appendix B provides similar information on the durations of full cycles and phases for all the derived chronologies on the basis of the different methodologies applied. In all cases the provided evidence confirms the information extracted on the basis of the reference chronology.
as the longest full cycle measured from peak-to-peak, with a duration of 65 quarters. The duration of the corresponding last trough-to-trough full cycle cannot yet be calculated, since the turning point announcing the end of the current recession has not yet occurred.

Table 4
Durations, Amplitudes, Cumulated Movements and Excess Cumulated Movements of the Identified Cycles and/or Phases
Q1 1970 – Q2 2010

<table>
<thead>
<tr>
<th>Durations</th>
<th>Amplitudes (%)</th>
<th>Cumulated Movements (%)</th>
<th>Excess Cumulated Movements (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full BC Durations</td>
<td>Phase Durations</td>
<td>Phase Amplitudes</td>
<td>Within phases</td>
</tr>
<tr>
<td>25</td>
<td>26</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>17</td>
<td>13</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>65</td>
<td>61</td>
<td>4</td>
<td>52.3</td>
</tr>
</tbody>
</table>

\[ M \]
23 14.8 18.8 4.2 21.7 -8.7 366 -22.5 6.6 -3.1

\[ SD \]
21.6 6.8 21.6 1.6

Notes: Phase information is provided only for completed phases. Average values and standard deviations are given in the last rows. The excess cumulated movements are presented here in relation to the triangle.

Further information on Greek business cycle characteristics is provided by the summarized evidence on phase amplitudes, cumulated movements and excess cumulated movements within business cycle phases. In terms of phase amplitudes, or the depth of the recorded cycle phases, the highest expansion amplitude is recorded during the last and longest expansion and reaches a level of 52.3%. At the same time, the highest contraction amplitude amounts to -14.2% and refers to the 1973-1974 recessionary period. On average, expansion amplitude is significantly higher with 21.7% than contraction amplitude with -8.7%, signaling an asymmetry feature between expansions and contractions. Cumulated movements and excess cumulated movements offer some indications on the shape of the identified business cycle phases. The evidence provided by the measures of cumulated movements implies that during expansions there have been considerable cumulated gains of output when
compared to the level before the turning point. The cumulated losses recorded for contractions are considerably lower, even though still not negligible. These indications are reflected in the values for the average cumulated movements, which amount to 366% and -22.5% for expansions and contractions, respectively. Finally, the calculated excess cumulated movements provide some additional information on the shape of expansions and contractions, which, however, appears to be mixed. More specifically, in three out of the six cases of expansions, the significant positive (negative) excess measures suggest that the actual cumulative movements, and hence the actual gain, are lower (larger) than measured by the triangular approximation. As for contractions, in three out of the six cases the negative excess measures suggest that there is a much larger loss in output during recessions than measured by the triangular representation, indicating more rapid decline in growth when coming out of expansion.

5. Conclusions

In the present work we apply five different business cycle dating procedures for the purpose of providing a robust reference chronology which locates the exact turning points in general Greek economic activity for the time period beginning in early 1970 and ending in mid 2010. In order to incorporate additional information, we do not rely solely on GDP data, but also take into account information included in individual economic series. The results indicate a considerable degree of coherence among the located peak and trough dates as determined by the GDP growth rule, the BB, the BBQ and the H&P automated dating algorithms and the MS model applied. Combination of the provided evidence leads to the suggestion of a reference business cycle chronology, which can be safely considered to describe the exact switch dates for the Greek business cycle and the time period Q1 1970 to Q2 2010. The located turning points clearly identify the mid-1970s recession, the early 1980s ‘double’ recession, the mid-1980s recession and the early 1990s ‘double’ recession. More importantly and with reference to the more recent economic developments, the derived chronology confirms the beginning of a recessionary period for Greek overall economic activity in the late 2000s. The second quarter of 2008 is dated as the peak quarter and, hence, the third quarter of 2008 presents the first quarter of the latest
recessionary regime ending an expansion phase that lasted 61 quarters. The absence of any indication of a trough point until June 2010 suggests that the Greek economy has not yet exited the contraction. The robustness of the derived reference chronology is enhanced by the confirmation of widely accepted business cycle stylized facts, such as the significant asymmetry characteristic between expansions and recessions. Durations as well as amplitudes indicate different behavior during expansions than during contractions.

Once a robust reference chronology is established, it can form the base for further research on Greek business cycles. Such research may involve the exercises of constructing coincident and/or leading indicators, detecting turning points in real-time and forecasting turning points, but also investigating the issue of business cycle synchronization. Such research may as a whole very well contribute to the better understanding and monitoring of the current and future state of economic activity in Greece and may facilitate and provide guiding lines for economic policy conduction.
Appendix A

Chow-Lin Interpolation Method

According to Chow and Lin (1971),\(^{40}\) it is assumed that the \(3n\) monthly (with \(n\) quarters) observations of the series \(y_m\) to be estimated are related to the \(3n\) monthly observations of the \(p\) related series, \(x_1, \ldots, x_p\), via a regression of the form

\[ y_m = X_m \beta + u_m, \]  

(1)

where \(y_m\) is \(3n \times 1\), \(X\) is \(3n \times p\) and the regression residuals follow a first-order autoregression \(u_{m,t} = \alpha_m u_{m,t-1} + e_{m,t}\) for \(t = 1, \ldots, 3n\), with zero mean and covariance matrix \(V_m\). The latter has the form \(V_m = A_m[\sigma^2/(1 - \alpha_m^2)]\), where

\[
A_m = \begin{bmatrix}
1 & \alpha_m & \alpha_m^2 & \cdots & \alpha_m^{3n-1} \\
\alpha_m & 1 & \alpha_m & \cdots & \alpha_m^{3n-2} \\
\alpha_m^2 & \alpha_m & 1 & \cdots & \alpha_m^{3n-3} \\
\vdots & \ddots & \ddots & \ddots & \ddots \\
\alpha_m^{3n-1} & \cdots & 1
\end{bmatrix}.  
\]  

(2)

Letting \(C\) be the matrix that converts the \(3n\) monthly observations into \(n\) quarterly observations, such as

\[
C = 1/3 \begin{bmatrix}
1 & 1 & 1 & 0 & \cdots & 0 \\
0 & 0 & 1 & 1 & 1 & 0 & \cdots & 0 \\
\vdots & & & \ddots & & \ddots & \ddots & \ddots \\
0 & \cdots & 1 & 1 & 1
\end{bmatrix},  
\]  

(3)

the vector of \(n\) quarterly observations of the dependent variable will satisfy the regression model

\(^{40}\) See Chow and Lin (1971) and Robertson and Tallman (1999). It corresponds to case two in Chow and Lin as regards the assumption for the residuals (see p. 374-375).
\[ y_q = Cy_m = CX_m \beta + Cu_m = X_q \beta + u_q, \]  

(4)

with the covariance matrix of \( u_q \) being

\[ V_q = CV_mC'. \]  

(5)

According to Chow and Lin, the best linear unbiased estimator \( \hat{y}_m \) of \( y_m \) is given by

\[ \hat{y}_m = A y_q = X_m \hat{\beta} + \hat{A}_mC'(C\hat{A}_mC')^{-1}\hat{u}_q. \]  

(6)

To obtain a consistent estimate of \( \alpha_m \), observe that the first-order autocorrelation coefficient of the quarterly residuals, \( \alpha_q \), is the ratio of the second element to the first element on the first row of matrix \( V_q \). With the ratio being calculated as

\[ \alpha_q = \frac{\alpha_m^5 + 2\alpha_m^4 + 3\alpha_m^3 + 2\alpha_m^2 + \alpha_m}{2\alpha_m^2 + 4\alpha_m + 3}, \]  

(7)

i.e. a polynomial equation in \( \alpha_m \), \( \alpha_m \) can be obtained as a unique solution to (7).
Appendix B

Figure A1  Quarterly GDP and Suggested Reference Business Cycle Chronology for Greek Economic Activity – Q1 1970-Q2 2010

Notes: GDP, in millions of €, is plotted at constant (2000=100) prices and is seasonally adjusted. Shaded areas describe the identified recession phases, while the line at Q3 2008 presents the beginning of the latest recession.

Figure A2  Smoothed Probabilities of Recession from MS Model
### Table A1

*Durations of Identified Greek Business Cycles, January 1970 (Q1 1970)-June 2010 (Q2 2010)*

<table>
<thead>
<tr>
<th>GDP growth Rule</th>
<th>BB</th>
<th>BBQ</th>
<th>H&amp;P Algorithm</th>
<th>MS Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarterly GDP</td>
<td>Interpolated Monthly GDP</td>
<td>Quarterly GDP</td>
<td>Monthly Series</td>
<td>Quarterly GDP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>P-P</th>
<th>T-T</th>
<th>E</th>
<th>C</th>
<th>P-P</th>
<th>T-T</th>
<th>E</th>
<th>C</th>
<th>P-P</th>
<th>T-T</th>
<th>E</th>
<th>C</th>
<th>P-P</th>
<th>T-T</th>
<th>E</th>
<th>C</th>
<th>P-P</th>
<th>T-T</th>
<th>E</th>
<th>C</th>
<th>P-P</th>
<th>T-T</th>
<th>E</th>
<th>C</th>
<th>P-P</th>
<th>T-T</th>
<th>E</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full BC Durations (quarters)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Durations (quarters)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Durations (months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BB</td>
<td>25</td>
<td>27</td>
<td>22</td>
<td>3</td>
<td>77</td>
<td>83</td>
<td>68</td>
<td>9</td>
<td>25</td>
<td>35</td>
<td>22</td>
<td>3</td>
<td>73</td>
<td>77</td>
<td>63</td>
<td>10</td>
<td>26</td>
<td>26</td>
<td>22</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BBQ</td>
<td>7</td>
<td>8</td>
<td>2</td>
<td>5</td>
<td>20</td>
<td>23</td>
<td>5</td>
<td>15</td>
<td>23</td>
<td>16</td>
<td>10</td>
<td>13</td>
<td>27</td>
<td>26</td>
<td>13</td>
<td>14</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H&amp;P Algorithm</td>
<td>18</td>
<td>16</td>
<td>12</td>
<td>6</td>
<td>47</td>
<td>44</td>
<td>29</td>
<td>18</td>
<td>17</td>
<td>16</td>
<td>11</td>
<td>6</td>
<td>44</td>
<td>47</td>
<td>31</td>
<td>13</td>
<td>16</td>
<td>17</td>
<td>11</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS Model</td>
<td>23</td>
<td>23</td>
<td>19</td>
<td>4</td>
<td>51</td>
<td>44</td>
<td>36</td>
<td>15</td>
<td>8</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>50</td>
<td>69</td>
<td>34</td>
<td>16</td>
<td>16</td>
<td>13</td>
<td>10</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>9</td>
<td>6</td>
<td>4</td>
<td>22</td>
<td>26</td>
<td>14</td>
<td>8</td>
<td>66</td>
<td>62</td>
<td>4</td>
<td>124</td>
<td>106</td>
<td>89</td>
<td>35</td>
<td>9</td>
<td>10</td>
<td>6</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>53</td>
<td>3</td>
<td>197</td>
<td>185</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**M** 23.2  16.6  19  4.2  69  44  56.2  12.8  27.8  18.5  21.6  6.2  68.8  65  51.3  17.5  23.2  14.8  18.8  4.3

**SD** 17.6  8.4  18.3  1.2  66.1  23.9  66.8  3.9  22.4  11.8  23.6  4  36  30.4  29.8  8.9  21.6  7.1  21.6  1

*Notes:* Phase and cycle information is provided only for completed phases and cycles. Average values and standard deviations (in months or quarters) are given in the last row.
References


