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# An Economic Assessment of ICT Adoption and its Impact on Innovation and Performance

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European Commission, DG Enterprise & Industry

e-Mail: entr-innov-ict-ebiz@ec.europa.eu,
info@ebusiness-watch.org

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# An Economic Assessment of ICT Adoption and its Impact on Innovation and Performance

**A cross-sector e-Business Watch study by**

**DIW Berlin**

## Final Report

**Version 4.0**

**September 2008**

This report was prepared by DIW Berlin on behalf of the European Commission, Enterprise & Industry Directorate General, in the context of the "Sectoral e-Business Watch" programme. The Sectoral e-Business Watch is implemented by empirica GmbH in cooperation with Altran Group, Databank Consulting, DIW Berlin, IDC EMEA, Ipsos, GOPA-Cartermill and Rambøll Management based on a service contract with the European Commission.

## About the Sectoral e-Business Watch and this report

The European Commission, Enterprise & Industry Directorate General, launched the Sectoral e-Business Watch (SeBW) to study and assess the impact of ICT on enterprises, industries and the economy in general across different sectors of the economy in the enlarged European Union, EEA and Accession countries. SeBW continues the successful work of the *e-Business W@tch* which, since January 2002, has analysed e-business developments and impacts in manufacturing, construction, financial and service sectors. All results are available on the internet and can be accessed or ordered via the Europa server or directly at the Sectoral e-Business Watch website (www.europa.eu.int/comm/enterprise/ict/policy/watch/index.htm, www.ebusiness-watch.org).

This is a study on economic implications of ICT adoption for productivity growth, innovation and firm performance. It assesses implications for firms and for industries, based on econometric analyses of data from the EU KLEMS Productivity and Growth Accounts database, micro-data analysis of e-Business Watch survey results and case studies.

## Disclaimer



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## Contact

For further information about this Sector Study or the Sectoral e-Business Watch, please contact:

| DIW Berlin | e-Business W@tch | |
|---|---|---|
| **DIW Berlin**<br>Königin-Luise-Str. 5<br>14195 Berlin<br>Germany<br>fpavel@diw.de | **Sectoral e-Business Watch**<br>c/o empirica GmbH<br>Oxfordstr. 2, 53111 Bonn,<br>Germany<br>info@ebusiness-watch.org | **European Commission**<br>Enterprise & Industry Directorate-General<br>Unit D/4 "ICT for Competitiveness and Innovation"<br>entr-innov-ict-ebiz@ec.europa.eu |

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# Executive Summary

## Objectives and scope of the study

This study presents an economic assessment of the causes underlying the adoption and use of information and communication technologies (ICT), their impact on innovation and on the economic performance of firms in selected sectors in the EU. The assessment is based on empirical analyses at the firm and sector level, recent literature, expert interviews and case studies. The study focuses on the following sectors which had been selected as priorities for the work of the Sectoral e-Business Watch in 2007/08:

- Chemicals, rubber and plastics
- Furniture
- Steel
- Banking
- Transport and logistics services
- Retailing

## The ICT value chain – structure of the analysis

The starting point of the analysis was the premise that ICT is an enabler of innovation and productivity growth, which should ultimately translate into economic performance. Thus, conceptually, the analysis proceeds along an "ICT value chain" which structures the ICT-induced value added process into three main steps:

1. **Adoption: ICT adoption and use** and its relation with specific market and firm characteristics such as competition levels and value chain characteristics.
2. **Innovation: ICT-enabled innovation** and the relationship to employee skills, the available ICT capital stock and the use of various software applications.
3. **Impact**: The impact of ICT-enabled innovation and organisational change on **economic performance** at the firm and sector levels, including turnover, market shares, value added and productivity levels.

For each step of this ICT value chain, an initial set of hypotheses was specified, based on a literature review. The relevance of each hypothesis was then empirically tested at the firm and sector level, using different statistical methods. As complementary evidence, some case studies were conducted about the ICT usage and impact in individual companies. The results of the case studies were linked with the evidence from the statistical analysis.

## ICT adoption and use

The first step was to discuss factors that could have an impact on whether companies adopt ICT. This includes, for example, the relationships between structural characteristics of markets and ICT adoption by companies in this market. In particular, the analysis focuses on potential links between the level of competition and ICT adoption, and between value chain characteristics such as the relationship between suppliers and buyers and the diffusion of advanced ICT systems. The following hypotheses were tested:

**Hypothesis A.1:** Increasing rivalry in the market determines the adoption of ICT.

**Hypothesis A.2:** Firms maintaining long-term relationships with suppliers and customers are more likely to use technologies supporting inter-firm collaboration, in comparison with their peer-group in the same sector.

The results for the transport and logistics services sector and for retail provide some evidence that increasing competition between firms (i.e. rivalry in the market) induces companies to use more ICT. In these sectors, companies seem to use ICT in order to cut costs and look for innovative ways of conducting business (**A.1**). For the other sectors, the relation between competition levels and ICT adoption was not significant.

Regarding value chain characteristics, the empirical analysis does not provide evidence for the hypothesis that companies with a regular suppliers and customers base are more likely to adopt and use ICT applications (**A.2**). However,

this does not imply that relationships between firms per se do not have an impact on ICT adoption. In fact, the case studies provide interesting examples. For example, one company uses an ICT-based SCM to facilitate the shift from a single supplier to changing ones in order to reduce its dependency on a single firm. In another case, a company reports that firms of a certain size and with considerable market position can no longer refuse to implement modern corporate management systems in order to effectively interact with business partners.

Finally, the analysis finds strong evidence across all sectors that large firms are significantly more likely to use ICT than small and medium size enterprises.

## ICT-enabled innovation

The next step was to analyse the ability of firms to use ICT for innovating products, services and business processes. Particular emphasis was placed on the role of a firm's internal capacities such as knowledge stock and skills, and on the collaboration within and between firms. It was also analysed if ICT use affects a company's decisions to outsource non-key activities and how ICT diffusion is correlated with organisational changes. The following hypotheses were tested:

**Hypothesis I.1:** Firms characterised by a higher share of employees with a university degree are more likely to conduct ICT-enabled innovations, in comparison with their peer-group in the same sector.

**Hypothesis I.2:** Firms that use ICT applications to exchange information or collaborate with business partners are more likely to introduce ICT-enabled innovations, compared with their peer-group in the same sector.

**Hypothesis I.3:** ICT use is positively correlated with organisational changes.

**Hypothesis I.4:** ICT endowment is positively correlated with outsourcing.

For all sectors covered by the study, the empirical analysis demonstrates that once a company has started to use ICT, the intensive use of electronic information exchange systems such as SCM systems as well as employee skills increase the likelihood that a company achieves ICT-enabled innovations (**I.1**). For the steel and chemical industries, skills requirements clearly focus on IT-practitioners. In the furniture, retail and transport services sectors, the share of employees with higher education was found to be more significantly linked with innovation dynamics than the employment of IT practitioners in the company. For chemical and retail companies, results indicate that ICT-enabled product and service innovations are less likely in small firms.

Across all sectors, intensive ICT users are also more likely to change their organisational structure and to outsource non-core activities (**I.3**, **I.4**). Concerning the type of ICT used by a firm, software applications seem to have the strongest impact on ICT-enabled organisational change in all sectors (**I.2**). ICT infrastructure such as the available hardware applications and internet connection capacity is found to be of significant relevance for furniture and retailing, too. The results also suggest that employee skills are an important requirement for firms to realise ICT-enabled organisational change.

The important role which ICT plays for enabling product and service innovations as well as outsourcing of non-core activities is also demonstrated in several of the case studies.

## ICT-induced performance

At the final segment of the ICT value chain, it was analysed if ICT-enabled innovation was linked with a better performance of companies, and if such improvements induced overall productivity growth at the sector level. Therefore, the following hypotheses were tested:

**Hypothesis P.1**: ICT-enabled innovations are correlated with a firm's turnover.

**Hypothesis P.2**: ICT endowment is positively correlated with a change of market share.

**Hypothesis P.3**: ICT-capital investment has become a key element in growth of value added and labour productivity, while the importance of non-ICT-capital investments has been declining.

**Hypothesis P.4**: TFP growth has accelerated together with increased investment in ICT-capital, especially in ICT-using service industries like retailing, wholesale and banking.

**Regression analyses** based on micro-data clearly demonstrate that ICT use increases the turnover of firms in all sectors (**P.1**). For firms of the chemical sector, retailing and transport services, there is also evidence for a positive impact of ICT use on market shares (**P.2**).

At the **sector level**, however, these results are much less pronounced. In fact, there appears to be almost no evidence for a positive direct relationship between ICT capital investments and value added growth and only modest evidence for a relevant impact of ICT capital on labour productivity (**P.3**), while it was found that even aggregate labour productivity growth in the EU has slowed down since 1980.

The results from growth accounting do not allow clear statements regarding the link between the growth of TFP and the ICT capital stock. The estimation results identify a significant impact of autonomous technical change only for steel and banking. For the former, ICT capital per TWH does have a significant positive impact on labour productivity as well. Hence, the respective hypothesis (**P.4**) can be confirmed only for steel.

Nevertheless, the combination of firm- and sector-level analysis suggests that ICT capital does have an indirect impact on labour productivity and thus enables firms to improve their performance: at the firm level, there is strong evidence that a larger ICT capital stock increases the likelihood that a firm will outsource certain activities. At the sector level, the analysis identifies outsourcing as a key factor for labour productivity growth. In the context of the ICT value chain this can be seen as a channel through which ICT capital enables firms to increase labour productivity. These results are significant for all sectors, but we find the strongest evidence for retailing, chemical and steel.

Overall, the observed differences in the impact of ICT at the firm and sector level can be explained by the presence of a lag effect. At the firm level, certain firms assume a leading role in adoption and use of ICT. Those firms are technology leaders, which seek to secure the benefits of the first mover. At the sector level, the assessment is less pronounced since not all firms within a sector are ICT leaders. Hence, aggregate and representative information for all firms seems to suggest that the effect of ICT on performance is much weaker.

In fact, the degree to which firm-level and sector-level results deviate indicates to which extent ICT is used by only a small number of innovative firms rather than by most of the companies in the sector. Against this background, the observed differences in this study seem to suggest that there remains a significant degree of still unexploited economic potential from increased ICT usage.

Finally, the report finds strong evidence that large firms are significantly more likely to use ICT than small and medium size enterprises (SMEs) are. Given the other key findings, this also implies that large firms are more likely to introduce ICT-enabled innovations more often than their smaller competitors. In other words, it implies that the gap in ICT use between SMEs and large firms (the so-called digital divide) will increase rather than narrowing down.

## Policy implications

From a policy perspective, these key findings demonstrate that more targeted measures to foster ICT adoption and usage in the EU are urgently needed. Most alarmingly, the analysis confirms the well-known observation that labour productivity growth in the EU is declining. Since at the same time, SMEs are less likely to adopt ICT, and thus to benefit from ICT-enabled innovation and productivity increase, this implies that a significant part of European firms is unlikely to see ICT-induced improvements in economic performance. Thus, policy makers should foster their efforts to improve the business environment in which decisions on ICT adoption and usage are taken. This includes three main objectives:

### Fully integrated common markets

Despite significant political efforts, the EU markets for goods, services, labour and capital are still rather fragmented due to various country-specific regulations and legislation. As a consequence, companies cannot simply develop an implement uniform strategies and solutions at a European scale.

**Improvement of education, training of e-skills and life-long learning**

ICT-specific skills are found to be of key importance for utilising the potential of ICT capital investments. Obviously, supply of sufficient skills and expertise is still rare and needs to be improved by means of consolidated efforts which involve industries, governments and education institutions of all Member States.

**Stimulation of ICT adoption by SMEs**

The main barrier for ICT adoption by SMEs appears to be a lack of awareness of the possibilities and benefits that ICT could offer. A lot of information may be available, but the complexity of the issue is difficult to come by; the information cannot be adequately communicated. Again, this requires multi-national co-operations between governments, industry representatives (e.g. chambers of commerce) and the ICT-producing industry.

It is uncontested that these issues have already been identified by policy before and have been on the agenda of the European Commission for a long time. Nevertheless, the findings of this analysis clearly show that there remains a long way to go until the related objectives can be fully achieved. Hence, the study confirms the continued need to address these objectives, possibly with more consolidated efforts along the lines suggested. The evidence of this study can be used in political discussions to support and substantiate the need for stronger market integration, improvements in education and SME support, as well as to demonstrate the costs of not-acting.

# 1 Introduction

This report presents an economic assessment of the causes underlying the adoption, use and diffusion of ICT, its impact on innovations and the relating effects on economic performance of firms in selected sectors in the EU. The assessment is based on empirical analyses at the firm and sector level, recent literature, expert interviews, and case studies. It follows in part on *e-Business W@tch* (2006), a previous study on the impact of ICT on corporate performance, productivity and employment dynamics.

The starting point of the assessment is the premise that ICT is an enabler of innovation and productivity advances, which in turn impacts on economic performance. Conceptually, the analysis proceeds along an ICT value chain which structures the ICT-induced value added process into three main steps.

The first step analyses how **ICT adoption, use and diffusion** depend on certain market and firm characteristics such as competition levels and value chain characteristics. This follows an investigation on the relationship between **ICT-enabled innovations** and employee skills, the available ICT capital stock and the use of various software applications. Finally, the third step analyses the impact of ICT-enabled innovations and organisational changes on economic **performance** at the firm and sector level, including turnover, market shares, value added and productivity levels. At each step the assessment is based on hypotheses. The insights and results of the analysis are compared with the findings of several case studies which focus on the experiences, results and lessons that individual firms had learned from the use of ICT systems. The study concludes with policy recommendations how European firms could be enabled and supported to fully utilise the potential of ICT.

## 1.1 The Sectoral e-Business Watch

### Mission and objectives

The "Sectoral e-Business Watch" (SeBW) explores the adoption, implication and impact of electronic business practices in different sectors across the European economy. It represents the continued effort of the European Commission, DG Enterprise and Industry to support policy in the fields of ICT and e-business, which started with "*e-Business W@tch"* in late 2001.

In ICT-related fields, DG Enterprise and Industry has a twofold mission: "*to enhance the competitiveness of the ICT sector, and to facilitate the efficient uptake of ICT for European enterprises in general*." The services of the SeBW are expected to contribute to these goals. This mission can be broken down into the following main objectives:

- to assess the **impact of ICT** on enterprises, industries and the economy in general (especially with regard to productivity, growth, competitiveness and organisational changes);
- to highlight **barriers for ICT uptake**, i.e. issues that are hindering a faster and/or more effective use of ICT by enterprises in Europe;
- to identify and discuss **policy challenges** stemming from the observed developments, notably at the European level;
- to engage in **dialogue with stakeholders** from industry and policy institutions, providing a forum for debating relevant issues.

By delivering evidence on ICT uptake and impact, SeBW is supporting informed policy decision-making, in particular in the fields of innovation, competition and structural policy.

### Policy context

The original *e-Business W@tch* programme was rooted in the **eEurope Action Plans** of 2002 and 2005. The goal of eEurope 2005 was "*to promote take-up of e-business with the aim of increasing the competitiveness of European enterprises and raising productivity and growth through investment in information and communication technologies, human resources (notably e-skills) and new business models*".[1]

The **i2010 policy**[2], a follow-up to eEurope, also stresses the critical role of ICT for productivity and innovation, stating that "*… the adoption and skilful application of ICT is one of the largest contributors to productivity and growth throughout the economy, leading to business innovations in key sectors*" (p. 6). This Communication anticipates "*a new era of e-business solutions*", based on integrated ICT systems and tools, which will lead to an increase business use of ICT. However, it also warns that businesses "*still face a lack of interoperability, reliability and security*", which could hamper the realisation of productivity gains (p. 7).

in February 2005, the European Commission proposed a **new start for the Lisbon Strategy**. While it recommended changes in the governance structures, i.e. the way

[1] "eEurope 2005: An information society for all". Communication from the Commission, COM(2002) 263 final, 28 May 2002, Section 3.1.2.

[2] "i2010 – A European Information Society for growth and employment." Communication from the Commission, COM(2005) 229 final.

objectives are to be addressed, the overall focus on growth and jobs remained the same. Some of the policy areas of the renewed Lisbon objectives address ICT-related issues. Central Policy Area No. 6 deals with facilitating ICT uptake across the European economy. Policy-makers in this area will require thorough analysis of ICT uptake based on accurate and detailed information on the most recent developments. Such evidence-based analysis is also needed when targeting individual sectors to fully exploit the technological advantages, in alignment with Central Policy Area No. 7 “Contributing to a strong European industrial base”. Furthermore, Guideline No. 9, addressed to Member States, encouraging the widespread use of ICT,[3] can be effectively addressed only if actions are based on understanding of the potential for and probable effectiveness of interventions.

In 2005, taking globalisation and intense international competition into consideration, the European Commission launched a **new industrial policy**[4] with the aim to create better framework conditions for manufacturing industries in the coming years. Some of the policy strands described have direct links to ICT usage, recognising the importance of ICT for innovation, competitiveness and growth.

> ***"ICT are an important tool ..."***
>
> *"More efforts are needed to improve business processes in European enterprises if the Lisbon targets of competitiveness are to be realised. European companies, under the pressure of their main international competitors, need to find new opportunities to reduce costs and improve performance, internally and in relation to trading partners. ICT are an important tool to increase companies' competitiveness, but their adoption is not enough; they have to be fully integrated into business processes."*
>
> *Source: European Commission (2005): Information Society Benchmarking Report*

The SeBW is one of the policy instruments used by DG Enterprise and Industry to measure and support the implementation of the industrial policy and related programmes. Its activities are complementary to other related policy programmes in the field of ICT, such as:

- the e-Business Support Network (**eBSN**), a European network of e-business policy makers and business support organisations,
- the **eSkills Forum**, a task force established in 2003 to assess the demand and supply of ICT and e-business skills and to develop policy recommendations,
- the **ICT Task Force**, a group whose work is to draw together and integrate various activities aiming to strengthen Europe's ICT sector, and

[3] "Working Together for Growth and Jobs: a New Start for the Lisbon Strategy", Communication, COM (2005) 24, Brussels, 02.02.2005. http://europa.eu.int/growthandjobs/pdf/COM2005_024_en.pdf.

[4] "Implementing the Community Lisbon Programme: A Policy Framework to Strengthen EU Manufacturing - towards a more integrated approach for Industrial Policy." Communication from the Commission, COM(2005) 474 final, 5.10.2005.

- activities in the areas of **ICT standardisation**, as part of the general standardisation activities of the Commission.[5]

In parallel to the work of the SeBW, the "**Sectoral Innovation Watch**" (see www.europe-innova.org) analyses innovation performance and challenges across different EU sectors from an economic perspective. Studies cover, inter alia, the following sectors: chemical, automotive, aerospace, food, ICT, textiles, machinery and equipment.

## Scope of the programme

Since 2001, the SeBW and its predecessor "e-Business W@tch" have published e-business studies on about **25 sectors**[6] of the European economy, annual comprehensive synthesis reports about the state-of-play in e-business in the European Union, statistical pocketbooks and studies on specific ICT issues. All publications can be downloaded from the programme's website at www.ebusiness-watch.org. In 2007/08, the focus is on the following sectors and specific topics:

| No. | Sector / topic in focus | NACE Rev. 1.1 | Reference to earlier studies by SeBW |
|---|---|---|---|
| 1 | Chemical, rubber and plastics | 24, 25 | 2004, 2003 |
| 2 | Steel | 27.1-3, 27.51+52 | -- |
| 3 | Furniture | 36.12-14 | -- |
| 4 | Retail | 52 | 2004, 2003 |
| 5 | Transport and logistics services | 60, 63 (parts thereof) | -- |
| 6 | Banking | 65.1 | 2003 |
| 7 | RFID adoption and implications | (several sectors) | -- |
| 8 | Intellectual property rights for ICT-producing SMEs | 30.01+02, 32.1-3, 33.2+3; 64.2; 72 (parts thereof) | -- |
| 9 | Impact of ICT and e-business on energy use | | -- |
| 10 | Economic impact and drivers of ICT adoption | | -- |

This cross-sectional e-Business Watch study is an umbrella study and presents a **'wide-angle' perspective** on the economic drivers and impacts of ICT across the sectors studied. The study assesses how ICT is having an influence on business processes, notably by enabling electronic data exchanges between a company and its customers, suppliers, service providers and business partners in the sectors studied. The underlying conceptual framework is explained in more detail in the following section.

[5] The 2006 ICT Standardisation Work Programme complements the Commission's "Action Plan for European Standardisation" of 2005 by dealing more in detail with ICT matters.

[6] See overview at www.ebusiness-watch.org/studies/on_sectors.htm.

## 1.2 ICT and e-Business – key terms and concepts

### A definition of ICT

This study examines the use of information and communication technology (ICT) in European businesses. ICT is an umbrella term that encompasses a wide array of systems, devices and services used for data processing (the information side of ICT) as well as telecommunications equipment and services for data transmission and communication (the communication side). The European Information Technology Observatory (2007) structures the ICT market into four segments with an estimated total market value of about € 670 billion in 2007 (Exhibit 1.2-1).

***Exhibit 1.2-1: The EU ICT market according to EITO (2007)***

| Market segment | Products / services included (examples) | Market value for EU (2007) (EITO estimate) |
|---|---|---|
| **ICT equipment** | Computer hardware, end-user communications equipment (such as mobile phones), office equipment (such as copiers) and data communications and network equipment (such as switching and routing equipment, cellular mobile infrastructure) | €159 billion |
| **Software products** | System and application software | €76 billion |
| **IT services** | Consulting, implementation and operations management | €140 billion |
| **Carrier services** | Fixed voice telephone and data services, mobile telephone services, cable TV | €293 billion |

Source: EITO 2007

In its widest sense, 'e-business' refers to the application of these technologies in business processes, including primary functions (such as production, inbound and outbound logistics or sales), and support functions (such as administration, controlling, procurement and human resources management). Companies in all sectors use ICT, but they do so in different ways. This calls for a **sectoral approach** in studies of ICT usage and impact. The following section introduces a wider framework for the discussion of e-business developments that is applied in studies by the Sectoral e-Business Watch.

### Gaining momentum after a phase of disappointment

When the bust phase of the previous economic cycle – commonly referred to as the 'new economy' – started in 2001, the former internet hype was suddenly replaced by a widespread disappointment with e-business strategies. Companies adopted a more reserved and sceptical attitude towards investing in ICT. Nevertheless, ICT has proved to be the key technology of the past decade (OECD 2004, p. 8), and the **evolutionary development** of e-business has certainly not come to an end. The maturity of ICT-based data exchanges between businesses and their suppliers and customers, fostered by progress in the definition and acceptance of standards, has substantially increased across sectors and regions over the past five years. In parallel, **recent trends** such as "Web 2.0" and social networking are widely discussed in terms of their business implications and it is widely recognised that 'e'-elements have become an essential

component of modern business exchanges. In short, e-business has regained momentum as a topic for enterprise strategy both for large multinationals and SMEs.

> *"Measurement of e-business is of particular interest to policy makers because of the potential productivity impacts of ICT use on business functions. However, the ongoing challenges in this measurement field are significant and include problems associated with measuring a subject which is both complex and changing rapidly."*
>
> *OECD (2005): ICT use by businesses. Revised OECD model survey, p. 17*

Companies use ICT in their business processes mainly for **three purposes**: to reduce costs, to better serve the customer, and to support growth (e.g. by increasing their market reach). In essence, all e-business projects in companies explicitly or implicitly address one or several of these objectives. In almost every case, introducing e-business can be regarded as an ICT-enabled process innovation. Understanding one's business processes and having a clear vision of how they could be improved (be it to save costs or to improve service quality) are therefore critical requirements for firms to effectively use ICT.

The increasing **competitive pressure** on companies, many of which operate in a global economy, has been a strong driver for ICT adoption. Firms are constantly searching for opportunities to cut costs and ICT holds great promise in this respect as it increases the **efficiency of a firm's business processes**, both internally and between trading partners in the value chain. While cutting costs continues to motivate e-business activity, innovative firms have discovered and begun to exploit the potential of ICT for delivering against key business objectives. They have integrated ICT into their production processes and **quality management** and, most recently, in **marketing** and **customer services**. These last sectors are widely considered key to improve competitiveness in the current phase of development of European economies. Competing in mature markets requires not only optimised cost structures, maximal efficiency, and products or services of excellent quality but also the ability to communicate effectively and cooperate with business partners and potential customers.

## A definition of e-business

As part of this maturing process, electronic business has progressed from a specific to a very broad topic. A central element is certainly the use of ICT to accomplish **business transactions**, i.e. exchanges between a company and its suppliers or customers. These can be other companies ('B2B' – business-to-business), consumers ('B2C' – business-to-consumers), or governments ('B2G' – business-to-government). In the broad sense, transactions include commercial as well as other exchanges such as sending tax return forms to the tax authorities.

If transactions are conducted electronically ('**e-transactions**'), they constitute e-commerce. Transactions can be broken down into **different phases** and related **business processes**, each of which can be relevant for e-commerce (see Exhibit A.V-2). The pre-sale (or pre-purchase) phase includes the presentation of (or request for) information on the offer, and negotiations over the price. The sale / purchase phase covers the ordering, invoicing, payment and delivery processes. Finally, the after sale / purchase phase covers all processes after the product or service has been delivered to the buyer, such as after sales customer services (e.g. repair, updates).

***Glossary***

***Definitions by standardisation groups (ISO, ebXML)***

*The term 'business transaction' is a key concept underlying the development of e-standards for B2B exchanges. Therefore, definitions have been developed by standards communities to underpin their practical work. Examples include:*

- ***Business**: "a series of processes, each having a clearly understood purpose, involving more than one party, realised through the exchange of information and directed towards some mutually agreed upon goal, extending over a period of time" [ISO/IEC 14662:2004]*
- ***Business transaction**: "a predefined set of activities and/or processes of parties which is initiated by a party to accomplish an explicitly shared business goal and terminated upon recognition of one of the agreed conclusions by all the involved parties even though some of the recognition may be implicit" [ISO/IEC 14662:2004]*
- ***e-Business transaction**: "a logical unit of business conducted by two or more parties that generates a computable success or failure state" [ebXML Glossary]*

***Exhibit 1.2-2: Process components of transactions***

| Pre-sale / pre-purchase phase | Sale / purchase phase | After sale / after-purchase phase |
|---|---|---|
| ■ Request for offer/proposal | ■ Placing an order | ■ Customer service |
| ■ Offer delivery | ■ Invoicing | ■ Guarantee management |
| ■ Information about offer | ■ Payment | ■ Credit administration |
| ■ Negotiations | ■ Delivery | ■ Handling returns |

Practically each step in a transaction can either be pursued electronically (online) or non-electronically (offline), and all combinations of electronic and non-electronic implementation are possible. It is therefore difficult to decide which components actually have to be conducted online in order to call a transaction (as a whole) 'electronic'.

In 2000, the OECD proposed broad and narrow definitions of electronic commerce, both of which remain valid and useful today[7]. While the narrow definition focuses on 'internet transactions' alone, the broad definition defines e-commerce as "*the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, conducted over **computer-mediated networks**. The goods and services are ordered over those networks, but the payment and the ultimate delivery of the goods or service may be conducted on- or offline"* (OECD, 2001). The addendum regarding payment and delivery illustrates the difficulty mentioned above to specify which of the processes along the transaction phases constitute e-commerce (see Exhibit 1.2-2). The OECD definition excludes the pre-sale / pre- purchase phase and focuses instead on the ordering process. The SeBW follows the OECD

[7] In 1999, the OECD Working Party on Indicators for the Information Society (WPIIS) established an Expert Group on Defining and Measuring Electronic Commerce, in order to compile definitions of electronic commerce which are policy-relevant and statistically feasible. By 2000, work of the Group had resulted in definitions for electronic commerce transactions.

position on this issue,[8] while fully recognising the importance of the internet during the pre-purchase phase for the initiation of business.

***Glossary***

***Definition of key terms for this study***

- ***e-Transactions****: commercial exchanges between a company and its suppliers or customers which are conducted electronically. Participants can be other companies ('B2B' – business-to-business), consumers ('B2C'), or governments ('B2G'). This includes processes during the pre-sale or pre-purchase phase, the sale or purchase phase, and the after-sale / purchase phase.*
- ***e-Commerce****: the sale or purchase of goods or services, whether between businesses, households, individuals, governments, and other public or private organisations, conducted over computer-mediated networks. (OECD)*
- ***e-Business****: automated business processes (both intra- and inter-firm) over computer mediated networks. (OECD)*
- ***e-Interactions****: covers the full range of e-transactions as well as collaborative business processes,. such as collaborative online design processes which are not directly transaction focused.*

Using the OECD definition, e-commerce is a key component of **e-business** but not the only one. A wider focus oriented on business processes has been widely recognised. This vision of e-commerce also covers the digitisation of **internal business processes** (the internal processing of documents related to transactions) as well as **cooperative** or **collaborative processes** between companies that are not necessarily transaction-focused (for example industrial engineers collaborating on a design in an online environment). The OECD WPIIS[9] proposes a definition of e-business as "*automated business processes (both intra-and inter-firm) over computer mediated networks*" (OECD, 2004, p. 6). In addition, the OECD proposed that e-business processes should integrate tasks and extend beyond a stand-alone or individual application. 'Automation' refers here to the substitution of formerly manual processes. This can be achieved by replacing the paper-based processing of documents by electronic exchanges (machine-to-machine) but it requires the agreement between the participants on electronic **standards** and processes for data exchange.

## e-Business and a company's value chains

In some contexts, the term c-commerce (collaborative commerce) is used. Although this concept was mostly abandoned when the 'new economy' bubble burst in 2001, it had the merit of pointing towards the role of ICT in cooperations between enterprises and the increasing digital integration of supply chains. These developments go beyond simple point-to-point exchanges between two companies.

[8] The respective survey questions ask companies whether they "place / accept online orders".

[9] Working Party on Indicators for the Information Society.

Despite dating back 20 years to the pre-e-business era, Michael Porter's framework of the company value chain and value system between companies[10] remains useful to understand the relevance of e-business in this context. A **value chain** logically presents the main functional areas ('value activities') of a company and differentiates between primary and support activities. However, these are "*not a collection of independent activities but a system of interdependent activities*", which are "*related by linkages within the value chain*".[11] These linkages can lead to competitive advantage through optimisation and coordination. This is where ICT can have a major impact, in the key role of **optimising linkages** and increasing the efficiency of processes.

The **value system** expands this concept by extending its scale beyond the single company. The firm's value chain is linked to the value chains of (upstream) suppliers and (downstream) buyers; the resulting larger set of processes is referred to as the value system. All e-commerce and therefore electronic transactions occur within this value system. Key dimensions of Porter's framework (notably inbound and outbound logistics, operations, and the value system) are reflected in the **Supply Chain Management** (SCM) concept. Here, the focus is on optimising the procurement-production-delivery processes, not only between a company and its direct suppliers and customers, but also aiming at a full vertical integration of the entire supply chain (Tier 1, Tier 2, Tier n suppliers). In this concept, each basic supply chain is a chain of sourcing, production, and delivery processes with the respective process interfaces within and between companies.[12] Analysing the digital integration of supply chains in various industries has been an important theme in most sector studies by the SeBW.

[10] Porter, Michael E. (1985). Competitive Advantage. New York: Free Press. Page references in quotations refer to the Free Press Export Edition 2004.

[11] ibid., p. 48.

[12] cf. SCOR Supply-Chain Council: Supply-Chain Operations Reference-model. SCOR Version 7.0. Available at www.supply-chain.org (accessed in March 2006).

## 1.3 Introduction to the sectors analysed

In this report, the pattern of ICT usage is analysed in three manufacturing (chemicals, steel and furniture) and three service sectors (retailing, transport and logistics and banking). In the following we present a brief introduction to each sector.[13]

### Chemical, rubber and plastics industry

For this analysis, this sector includes the manufacturing of chemicals, chemical products and man-made fibres as well as the manufacture of rubber and plastic products.[14] Chemicals are a major manufacturing sector in the EU. In 2004, the industry employed about three million people and generated a value added of close to 190 billion euros (Eurostat 2006). It produces key intermediate inputs for various other industries. Also, the chemical sector provides innovative materials and technological solutions and thus, is of crucial importance for the industrial overall competitiveness of the EU (European Commission 2007). The products and services provided by this industry are pervasive in everyday life, as they can be found in food, clothing, housing, transport, communications and consumer electronics. The industry also plays an important role in coping with key future challenges. For example, innovative products made of plastics are vital components of technologies to address climate change, to provide health-care services and to save energy. In the following, the term "chemicals" refers to the full sector as defined above, i.e. it includes the manufacture of rubber and plastics.

### Steel

The steel industry in this report covers all manufacture of basic metals, which includes the manufacture of basic, hollow, cold processed and casted iron and steel products.[15] In 2004, the iron and steel industry in the EU-27 employed almost 800,000 people and generated a total value added of 46.9 billion euros in 2004 (Eurostat 2006). According to the International Iron and Steel Institute, “steel is the most important engineering and construction material in the world. It is used in every aspect of our lives, from automotive manufacture to construction products, from steel toecaps for protective footwear to refrigerators and washing machines and from cargo ships to the finest scalpel for hospital surgery.”[16] After several decades of output stagnation, global steel production has increased sharply since 2000. At the same time, the global industry development is characterised by a strong consolidation process which leads to the creation of few large units.

[13] More detailed information on all six sectors is available in the e-Business Watch sector studies of 2008 on these industries, see www.ebusiness-watch.org.

[14] Technically, this includes the activities described by NACE Rev. 2 Divisions 20 and 21. NACE Revision 2 is a four-digit classification of business activities. It is a revision of the “General Industrial Classification of Economic Activities within the European Communities”, known by the acronym NACE and originally published by Eurostat in 1970. NACE Rev. 2 replaced the earlier used version Rev. 1.1 on 1 January 2008.

[15] This comprises of large parts of division 24 in NACE Rev. 2.

[16] See http://www.worldsteel.org/index.php?action=faqlist&id=6#12.

## Furniture

The furniture sector includes the manufacture of office and shop furniture as well as of kitchens and other furniture.[17] In 2004, the industry employed 1.4 million people in the EU-27 and generated a value added of 35.5 billion euros (Eurostat 2006). The furniture industry is an assembling industry which uses various raw materials such as wooden boards, metal, leather and glass. The supply chain is closely connected with supplying industries as well as with specialised independent retailers. Traditionally, manufacturing of furniture has been a labour-intensive industry that includes both small local craft firms and large manufacturers. Small enterprises often act as sub-contractors for larger firms, often highly specialised in specific tasks, producing components, semi-finished products or finishing and assembling furniture. The structure of this industry has deeply changed with the advent of "flat-pack" and ready-to-assemble furniture that allowed mass production. Traditional manufacturers have retained important niche market segments primarily for high-end, expensive and design-led products, which are mostly purchased locally, while mass-produced large-volume products are sold locally and for export.

## Retailing

This sector includes all retail trade except of motor vehicles and motorcycles.[18] The sector includes all firms that resell new and used goods to the general public for personal or household use and consumption. Retail firms do not further process goods, but companies that repair personal and household goods are included. Retailers act as an interface between the manufacturers and wholesalers on the one hand and consumers on the other. The retail firm is typically the last point in a supply chain, the point from which a product reaches the end-consumer. The main difference between retailers and wholesalers is that retailers direct their sales efforts towards end-consumers where wholesalers primarily sell to retailers and other businesses. In 2004, the industry employed more than 16.9 million people in the EU and generated a value added of more than 380 billion euros. Traditionally, the sector has been characterised by a rather large share of small companies. In recent years, weakening private consumption has stimulated both, strong competition as well as increasing concentration.

## Transport & logistics services

This sector covers rail transport (both passengers and freight) as well as land/road transport (passengers and freight). It also includes the logistics sectors of warehousing and storage, cargo handling and other transportation support activities.[19] Transport and logistics are key components of a successful economy, and governments worldwide seek to increase competitiveness through new or replacement infrastructure. The transport and logistics sector plays a major role in nationals' economy and is a significant contributor at both the national and local level. It underpins the economy, enabling the movement of goods, services and people as efficiently as possible. The transport sector in Europe plays a significant role in its economic development. It currently generates 7% of European Union gross domestic product (GDP) and for around 5 % of employment in the EU.

[17] Division 31.01, 31.02 and 31.09 of NACE Rev. 2.

[18] Division 47 of NACE Rev. 2.

[19] Divisions 49.1, 49.2, 49.3, and 49.4 as well as 52.10, 52.24, and 52.29 of NACE Rev. 2.

## Banking

This sector includes all financial intermediation, except insurance and pension funding.[20] The services offered by this sector can be divided into products (accounts, mortgages, deposits, etc.), services (credit cards, cheques, receipts, transfers, etc.) and channels through which banks reach their clients (branches, telephone banking service, Internet/e-banking, agents, commission agents). In 2004, the banking sector generated 489.4 billion euros in value added and employed about 3 million people (ECB 2006).

Europe remains a highly financial intermediation-based economy with the majority of savings and investment in the economy being channelled through banks. The restructuring of the banking sector has gained momentum after the introduction of the Euro and the European Single Market. When it comes to the size of the industry, worldwide assets of the largest 1,000 banks grew by 15.5% in 2005, reaching about 83 trillion Euros (60.5 trillion Dollars). Of these, the EU banks held the largest share, 50% at the end of 2005 rising from 38% a decade earlier[21]. Large European banks now generate a large share of their revenues abroad. In 2004, the aggregate foreign earnings share for large European banks was 40%. In comparison, the three biggest banks in the United States averaged a foreign earnings share of 27%.

Exhibit 1.3-3 summarises the main facts on the six sectors:

***Exhibit 1.3-3: Summary of employment and value added of the six sectors***

| | Chemical, rubber, plastics[a] | Steel[b] | Furniture[b] | Retailing[b] | Transp. & logistics services[a,c] | Banking[a] |
|---|---|---|---|---|---|---|
| Value added (billion euros) | 188 | 47 | 35 | 382 | 169 | 489 |
| Employment (million people) | 3.2 | 0.8 | 1.4 | 16.9 | 5.5 | 3.0 |
| % of employees working in SMEs[d] | 37% | 34% | 51% | 64% | no data[e] | no data |

[a] – data for EU-25 / [b] – data for EU-27 / [c] – data for road and railway transportation /

[d] – firms with less than 250 employees

[e] – in rail transport, more than 90% of employment is in large companies; in road transport, by contrast, SMEs account for a more significant share of employment.

[20] Division 64.1, 64.19 and 64.92 of NACE Rev. 2.

[21] International Financial Cervices, London, March 2006, www.ifsl.org.uk, 10.04.07.

# 2 The ICT Value Chain

## 2.1 Conceptual Framework

The ongoing diffusion of ICT and e-business technologies and services among firms is a striking example of the possible dynamics of technological change and economic development (Koellinger, 2006). Economic theory (Breshnahan and Trajtenberg, 1995, Helpman, 1998) suggests that the adoption and diffusion of new technologies can be spurred by many factors and can have far reaching consequences. Virtually all economic spheres can be affected by technologically induced changes, including innovation dynamics, productivity and growth, the development of market structures, and the composition of labour demand.

While it is generally accepted that ICT affects firm performance and characteristics as well as the environment in which firms operate, different firms in different sectors exhibit varying payoffs despite similar investments in ICT (Dhar and Sundararajan, 2004). Therefore, the starting point of our analysis is to develop a better understanding of why firms adopt ICT, what they do with it and how this affects their performance. Our fundamental proposition is that ICT impacts on a firm's performance by triggering innovative processes, which in turn depend on the firm's internal and external characteristics. These characteristics, including available and required skills, distribution channels, and corporate culture, vary from sector to sector and from firm to firm. They are also influenced by the price elasticity of demand, the type of innovation that ICT can enable, and the timing of the innovation in relation to other innovations in the market.

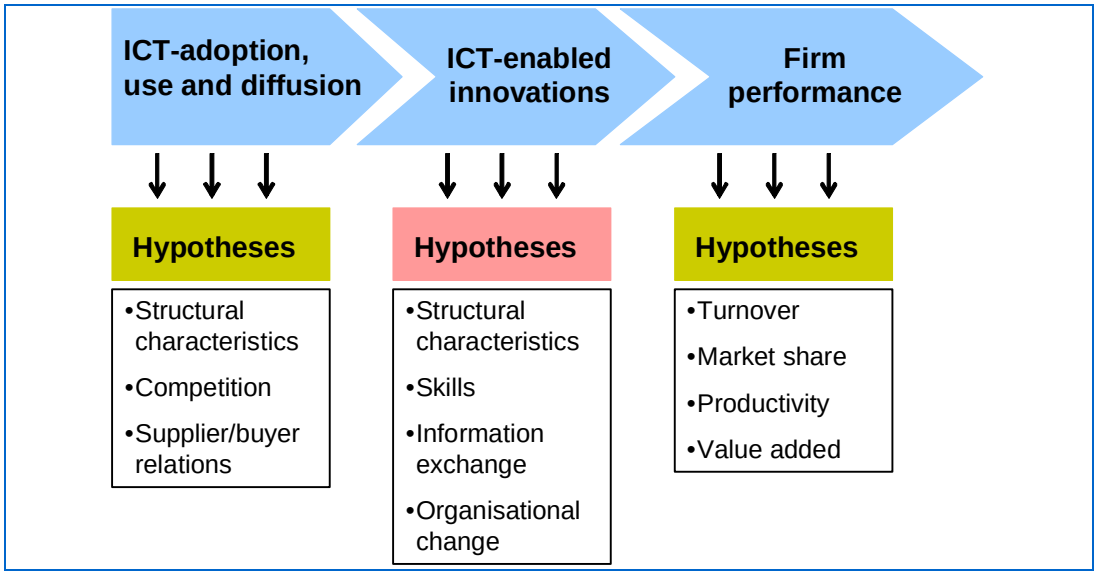
In this report, we discuss the implications of several of such internal and external characteristics on ICT adoption and the resulting innovation processes. The starting point of this analysis is the premise that ICT is an enabler of innovation (Koellinger, 2005). In other words, the adoption and use of ICT per se does not automatically induce innovations. However, ICT can contribute indirectly to firm performance by enabling them to improve labour productivity, rethink processes and develop new products.

A standard conceptual framework in economic literature which illustrates how structural characteristics of firms and markets determine a firm's conduct and performance is the Structure-Conduct-Performance (SCP) paradigm (Bain, 1951; 1956, Mason, 1939). Originally, it was designed as an illustration of how industry structure determines a firm's conduct (including production, pricing and innovative strategies) and how this in turn affects the performance of firms.

In the context of the present study, the SCP paradigm could be used as basic framework for explaining the impact of structural characteristics on the process of ICT adoption, the conduct of firms that use ICT and the performance results which they achieve. However, the SCP paradigm has been subject to severe criticism, in particular with respect to the uni-directional flow of causalities and relationships (Scherer, 1980). Critics such as Fauchart et al (2002) or Delorme et al. (2002) suggest that instead of uni-directional relationships there are various interactions between structural elements and market outcomes such as feedback effects from changes in performance on both, structure and conduct parameters.

To relax the strict causality assumptions of the SCP paradigm we define a less restrictive framework. In particular, rather than focussing on causalities and directions of impact we look at the evolution of ICT throughout its value chain.

*Exhibit 2.1-1: The ICT value chain*




The main elements of the ICT value chain are illustrated in Exhibit 2.1-1. It describes the process from ICT adoption and diffusion through ICT-enabled innovations to ICT-induced changes in firm performance. At each process step we analyse the relations with specific firm and market characteristics based on a number of hypotheses.

**ICT adoption, use and diffusion** are expected to be correlated with structural market characteristics such as the degree of competition that a firm faces, or the nature of contractual relations of a firm with its suppliers and buyers. Finally, individual firm characteristics such as size, age or national specificities might also affect its decision on ICT adoption.

Once a firm uses ICT, it can start designing new products and processes or implementing new organisational forms in order to utilise the full potential of this new technology. In the analysis with respect to **ICT-enabled innovations** we intend to demonstrate whether and to what extent firms are able to convert their ICT investments into ICT enabled innovations. We expect that this depends inter alia on the availability of specific labour skills, the use of information exchange systems such as Supply Chain Management (SCM) systems, possibilities to outsource non-core activities, structural characteristics of the firm etc.

Finally, ICT-induced changes on **firm performance** are assumed to be the combined outcome of various innovations as well as of increased productivity levels. At the firm level, we expect it to increase turnover and market shares. At the sector level, this should be reflected by value added and productivity growth.

In the rest of this chapter we discuss in detail the factors that impact on ICT adoption, innovation and firm performance and define relevant hypotheses (Section 2.2). Afterwards, all hypotheses are tested empirically (Section 2.3).

## 2.2 Background and hypothesis

Based on an *ICT value chain* as described above we have analysed the existing literature on ICT adoption, use and diffusion, ICT-enabled innovations and ICT-induced impacts on economic performance at the firm and sector level. The following three sections discuss propositions and findings of the relevant literature for each elements of the value chain. Against this background, we derive relevant hypotheses which can be tested by means of empirical analysis.

### 2.2.1 ICT adoption, use and diffusion

This section discusses factors that possibly impact on ICT adoption by firms and investigates the relationships between structural developments and ICT use and diffusion in firms or markets. In particular, we explore if the level of competition between firms affects ICT adoption, or the degree to which value chain characteristics such as the relationship between suppliers and buyers affect the diffusion of advanced ICT systems.

#### Competition and rivalry

Increasing rivalry in the market might be an important factor that drives the adoption of new technologies and innovation, as companies search for new opportunities to cut costs by improving process efficiency or develop new products. As Schumpeter already argued at the beginning of the 20th century, firms seek to escape from intensive competition through product differentiation and innovation of new products and services. In this way, innovative firms can establish unchallenged positions due to specific know how.[22] To the extend that it enables firms to innovate and improve productivity levels, the use of ICT might be of high strategic value for all firms which seek to escape from competition through innovation and specific know how.

Therefore, our first hypothesis is:

**Hypothesis A.1**: Increasing rivalry in the market determines the adoption of ICT.

#### Relationships with business partners

Supplier-buyer relations are important value chain characteristics which are likely to influence the diffusion of ICT applications. For example, because a number of applications require involvement of both transaction sides, there arise hold-up problems, where the uncertainty about who invests first and how rents are split can postpone transactions (Williamson 1985). Furthermore, in many cases firms can take advantage from incurred investments only if cooperation is maintained over a longer period of time and sufficiently many transactions per relationship are carried out (Clemons et al., 1994). Similar, the benefits of inter-firm cooperation are subject to learning effects. In order to fully benefit from integration, both parties need time to comprehend and adapt to the new organisation of activities. In other words, when relationship investments are indispensable or specific assets are procured firms will create networks in which suppliers and buyers form closed business relationships. This helps to overcome hold-up problems and allows firms to create relations, which are additionally strengthened by ICT (Thompson 2004).

[22] See e.g. Schumpeter (1983) for an English version of his theory on competition and innovation.

According to Helper and MacDuffie (2003), ICT facilitating B2B interactions continues to be used in a way that enhances, not replaces individual companies' business strategies. Companies develop e-business tools that reinforce old paradigms for purchasing and supplier relations. This happens because there are patterns of social interaction that are deeply imbedded in systems of procurement.

Against this background we formulate the following hypothesis:

**Hypothesis A.2**: Firms maintaining long-term relationships with suppliers and customers are more likely to use technologies supporting inter-firm collaboration, in comparison with their peer-group in the same sector.

### 2.2.2 Innovation

The next section analyses the firms' ability to use ICT for innovating products, services and business processes. Particular emphasise is given on the role of a firm's internal capacities such as knowledge stock and skills, as well as on the collaboration within and between firms. We also analyse if ICT use affects a company's decisions to outsource non-key activities and how ICT diffusion is correlated with organisational changes.

#### Internal capacity

As empirical studies have shown ICT is most productive when combined with complementary investments in working practices, human capital, and firm restructuring (Brynjolfsson and Hitt, 2000). In fact, knowledge stock and skills found a firm's absorptive capacity to adopt new technologies (Cohen and Levinthal, 1989). This, in turn, has positive impact on a firm's innovation performance. Thus, in order to develop marketable products or feasible production processes based on ICT, a firm needs to build up the relevant complementary assets such as knowledge stock and expertise.

The most obvious example of investments in complementary assets includes investments in training and organisational transformations to accompany ICT investments. Consequently, firms that combine high levels of ICT capital with a high-skilled workforce should be better positioned to develop ICT-enabled innovations.

Thus, we formulate the following hypothesis:

**Hypothesis I.1**: Firms characterised by a higher share of employees with a university degree are more likely to conduct ICT-enabled innovations, in comparison with their peer-group in the same sector.

#### Intra and inter-firm collaboration

ICT has a direct impact on process innovation in an organisational setting by facilitating inter-organisational links (Lee, 2000). ICT-enabled inter-organisational integration and collaboration enhances the innovation capabilities of companies by providing opportunities for shared learning, transfer of technical knowledge and resource exchange.

The most obvious benefit of information integration with the help of ICT is the optimisation of the value chain in order to eliminate the so-called bullwhip effect[23], a key challenge in supply chain management. Other, less obvious consequences for firms' innovativeness include creating communication infrastructures which facilitate production networks or enable partners to align the incentives of multiple players by creating joint business units or teams managing the same tasks (McAfee, 2006).

Rather than e-commerce, it is the use of electronic networks that leads to a higher probability of firms collaborating in innovative activities and increases the amount of collaborative relations they have (European Commission, 2004). This leads to the following hypothesis:

**Hypothesis I.2**: Firms that use ICT applications to exchange information or collaborate with business partners are more likely to introduce ICT-enabled innovations, compared with their peer-group in the same sector.

## Organisational changes

ICT diffusion may also impact on a company's internal organisation, i.e. the structure of and the relationships between departments within an enterprise. Organisational changes may relate to a rearrangement of functions, workflows and importance of departments and employees working in them.

ICT transforms the process of replicating business innovations across organisations (Brynjolfsson et al., 2006). Traditionally, deploying business innovation on a larger scale took time and required considerable involvement of resources and employees. Today, ICT allows companies to embed business innovations and then implement them across the organisation at a much smaller cost than before without compromising on quality. Every location or unit implements and follows all steps of the new process in a way specified in the software design.

The copy-exactly strategy is particularly beneficial if the initial understanding of the process is low, the lifecycle is short and the process is difficult to improve (Terwiesch and Xu, 2004). This is true for manufacturing industries with rapidly changing production technologies and intensive technological competition. In such industries the speed of adoption of new production processes plays a decisive role for remaining at the cutting edge. On the other hand, tools, such as email, knowledge management systems, wikis or instant messaging, considerably improve the process of innovation in knowledge-intensive and service-oriented sectors with informal, unstructured and spontaneous type of work, such as banking (McAfee, 2006). ICT facilitates firms' innovativeness by propagating innovations that are less structured than business processes.

This leads to the following hypothesis:

**Hypothesis I.3**: ICT use is positively correlated with organisational changes.

[23] The bullwhip effect describes how small variations in intermediate and final demand levels along a supply chain can add up to significant disturbances and disruptions.

### Outsourcing

The most obvious type of organisational change is outsourcing. In light of the transaction cost theory, decreasing costs of search, evaluation and monitoring of suppliers should lead to a shift away from firms and toward markets as a form of organizing economic activity (Coase 1937, and Williamson, 1985). It is therefore widely expected that ICT will introduce innovative ways of doing business, re-shaping firm boundaries and changing the constellations of value chains (see, for example, Johnston et al., 1988, Johnston et al., 1988a, Milgrom et al., 1990, Fulk et al., 1995). The availability of powerful ICT at reasonable costs also increases the attractiveness of markets for intermediate goods and services (Malone et al., 1987 and Lucking-Reiley et al., 2001). Therefore, we formulate the following hypothesis:

**Hypothesis I.4**: ICT endowment is positively correlated with outsourcing.

## 2.2.3 Performance

At the final stage of the ICT value chain, this section analyses if ICT-enabled innovations are linked to better performance of a firm, and if such improvements induce overall productivity growth.

### Turnover

The effects of ICT on corporate performance are not clear because not all studies have demonstrated clear payoffs from ICT investments (Chan, 2000, Kohli and Devaraj, 2003). In addition, the results vary depending on how performance and ICT payoffs are measured and analysed. For example, an empirical study by Brynjolfsson and Hitt (1996) finds positive impacts of ICT investments on productivity, but not on profits. Another study did not find positive effects of ICT capital on productivity, while ICT labour positively contributed to output and profitability (Prasad and Harker, 1997).

To understand these somewhat ambiguous results, recent work by Koellinger (2006) suggests that changes in corporate performance are not directly caused by changes in ICT capital but by ICT-enabled innovations. In other words, rather than having a direct impact on the various value-added processes within a firm, ICT capital enables the firm's management to introduce various innovations which in turn should increase corporate performance. Indeed, Clayton and Waldron (2003) find in a study on e-commerce adoption and business impact that firms with a relatively high share of new and improved products in overall product sales also observe higher average sales growths than other firms.

Against this background, our next hypothesis is:

**Hypothesis P.1**: ICT-enabled innovations are correlated with a firm's turnover.

### Market shares

Historically, distance to market and transportation cost have limited the number of customers a firm could reach. At the beginning of the internet era, a common believe was that ICT and e-commerce were to eliminate the limitations of location and enable firms to

expand regardless of geographical locations (Cairncross 1997). One example of how ICT allows firms to expand their operations and change market structure of existing markets, or create new ones, are entries of internet start-ups. Amazon or eBay are already icons of e-commerce that changed the landscape of the retailing industry. Though of a smaller magnitude, these effects hold for traditional shops as well.

ICT offers existing firms possibilities to expand their market reach, which consequently leads to market structure changes as well. This can be illustrated by the way ICT enables companies to cross boundaries of their markets and industries. An example for blurring lines between sectors and a possible thread for retailing comes from manufacturing firms like Dell. These firms use ICT to surpass the whole retailing sector and to sell their goods directly to customers instead of depending on a network of retailers.

Against this background, we formulate the following hypothesis:

**Hypothesis P.2**: ICT endowment is positively correlated with a change of market share.

## Productivity growth

Following the productivity growth resurgence in the US and a simultaneous diffusion of ICT products in the 1990s, it was suggested that a significant part of the increased productivity growth in the US was attributable to increased ICT investments. However, on closer inspection, more recent studies have revealed that only a few countries and specific industry sectors have clearly seen an upsurge in productivity growth resulting from ICT investment (Nordhaus, 2002, van Ark, 2002). To provide a clearer understanding, industries can be divided in to ICT-producing industries and ICT-using industries. The United States saw an increase in productivity growth because it is both a producer and user of ICT and successfully extends it to other sectors (Mahoney and van Ark, 2003). ICT using sectors that exhibited productivity growth in the US were banking, retailing, and various business services. In comparison, European industries are said to have experienced much slower productivity growth although they too invested large amounts in ICT in similar sectors (see e.g. O'Mahony and van Ark, eds. 2003; van Ark, Inklaar and McGuckin 2003). Nevertheless, ICT investment has also increased productivity levels in the EU, in particular in service industries like banking, retailing and business services (Hempell, 2002, Hempell et al. 2004).[24]

Despite the different impacts that ICT had in the US and in Europe, it is widely accepted that it generally has positive effects on total factor productivity (TFP)[25] as well as on labour productivity (Pilat, 2005). Productivity gains accrue from both, the ICT-producing and ICT-using sectors (Oliner and Sichel, 2000). In particular, ICT was found to have the largest productivity growth effects in the ICT-producing sectors themselves, and in selected service industry sectors like retailing, wholesale, financial and telecommunication services (Jorgenson, Ho, Samuels, Stiroh, 2007, Jorgenson, Ho, Stiroh, 2008, Inklaar, Timmer, van Ark, 2007). According to the OECD Information

[24] Several factors are put forward to explain the differences in productivity growth between the US and Europe. The most important ones seem to be structural impediments like rigid labour markets, institutional impediments and distorted market integration in the EU (McGuckin and van Ark, 2003), as well as time lags and different phasing of innovation cycles (Erber, 2005).

[25] TFP is a measure for all changes in total output that are not caused by changes in inputs. Such changes may be due to a variety of factors, including organisational changes (that increase productivity) or factor market distortions on e.g. labour markets (that decrease productivity).

Technology Outlook, the share of ICT capital has increased over the period from 1995 to 2003 for the OECD 25. Finland and Korea in particular exhibit high rates of ICT capital investment.

Against this background, we formulate the following hypothesis:

**Hypothesis P.3**: ICT-capital investment has become a key element in growth of value added and labour productivity, while the importance of non-ICT-capital investments has been declining.

In general, we expect the growth-stimulating impact of ICT to be more pronounced in service sectors than in industries like chemicals or steel, where non-ICT-capital and other types of innovations are likely to play more important roles.

## Capital input

In principle, we expect strong complementarities between the traditional input factors labour and (non-ICT) capital and specific ICT capital investments. This implies that with higher investment in ICT-capital also total factor productivity growth accelerates. This will be tested by the next hypothesis:

**Hypothesis P.4**: TFP growth has accelerated together with increased investment in ICT-capital, especially in ICT-using service industries like retailing, wholesale and banking.

## Labour input

Another important factor that may influence on the extent to which ICT enables productivity growth is the complementarity between ICT capital and skills. A large body of literature on skill-bias in technical change supports the finding that technical change is biased towards skilled workers, reducing demand for unskilled labour and increasing wage inequality and polarisation (Acemoglu, 2002). The impact is clearly visible in today's advanced economies; unskilled jobs have long been declining in absolute terms in Europe and growing only slowly in the US, while skilled jobs for educated workers are being created at a faster pace in most countries (Pianta, 2004). ICT tends to be a skill-biased technology and, thus, the application of ICT may increase the demand and wages for skilled labour and decrease the same for unskilled labour. The analysis will therefore focus on the interdependence of ICT investments with skills requirements.

The final hypothesis is therefore.

**Hypothesis P.5**: ICT and high- and medium-skilled labour have a positive direct impact on labour productivity growth.

## 2.3 Empirical analysis

### 2.3.1 Data sources and methodologies

#### Data sources

The empirical analysis to confirm or reject those hypotheses is based on two different data sets:

- At the firm level, we use information from the e-Business Survey 2007, where decision-makers from five industry sectors in nine EU countries and the USA were interviewed in order to collect data relating to the use of ICT and e-business in European enterprises[26].
- At the sector level, we use the EU KLEMS Growth and Productivity Accounts, a new and detailed database which reports data on measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for all European Union member states from 1970 onwards.[27]

Through the combined use of both data sets, we are able to test our hypothesis at the firm or sector level, depending on the specific issue. In particular, the hypotheses on ICT adoption, use and diffusion (A.1 and A.2) as well as on innovation (I.1 – I.4), which aim at understanding the constellation under which firm-level decisions are taken, are tested at the firm level by using the information from the e-Business Survey 2007. In contrast, the hypotheses on the impact of ICT on performance (P.1 – P.5) are tested based on both, firm-level and sector-level data. In this way we analyse not only the impact that ICT has on the performance of particular firms, but also on sector-wide developments.

Using a sector-level data base requires us to map the six sectors studied in this report into the sector-specific classification scheme used in the EU KLEMS database.[28] This is done in the following way:

- The analysis of the *banking* sector is based on data of the financial intermediation sector, which apart from banking services also includes insurance and pension funding as well as activities related to financial intermediation (NACE Rev. 1.1 classification code J).
- The analysis of *retailing* is based on retail trade data (NACE Rev. 1.1 classification code 52, except of motor vehicles and motorcycles; repair of household goods).
- The analysis of *chemicals* is based on data for chemicals, pharmaceuticals, rubber and plastics (NACE Rev. 1.1 classification code 24 and 25).
- The analysis of *transport and logistics* is based on data for transport and storage (NACE Rev. 1.1 classification code 60-63).

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[26] See annex I for details on the e-Business Survey 2007.

[27] For more information see www.euklems.net or Timmer et al. (2007).

[28] The sectoral classification in the EU KLEMS data follows the statistical classification of economic activities in the European Community (in French: Nomenclature statistique des activités économiques dans la Communauté européenne (NACE), see http://ec.europa.eu/comm/competition/mergers/cases/index/nace_all.html). NACE was originally published by Eurostat in 1970 and has been subsequently revised since then. The latest NACE revision 2 replaced revision 1.1 on 1st January 2008. The data used in this study is still based on revision 1.1.

- The analysis of the *steel industry* is based on data for basic metals and fabricated metal products (NACE Rev. 1.1 classification code 27-28).

The sector-level analysis for *furniture* has been omitted since the EU KLEMS database does not report sufficiently differentiated information on this activity.

## Methodology

Depending on the specific issue we use different econometric approaches to test the eleven hypotheses. For the analyses based on firm-level data we use the standard approaches ordinary least-squares (OLS), logit, probit and ordered probit regressions.[29]

The sector level analysis is based on two different methodologies. The first, growth accounting, is a standard technique to identify the different contributions of various factors in the growth of income levels such as GDP or value added. The methodology assumes a specific functional relationship between an output or income variable and all necessary inputs, typically labour and capital. Then, the extent to which changes in income levels can be explained by related changes in one of the inputs is estimated. The remaining income changes, which are not explained by changes in the level of inputs, are defined as change in total factor productivity (TFP).[30]

The second methodology used for the analysis of sector-level data is the estimation of a Stochastic Production Possibility Frontier (SPF). As with growth accounting, this approach is based on a specific production function that attributes all input factors to the output or – here – the income variable. The difference to growth accounting is that it considers that individual units can operate at different levels of technical efficiency[31], and that it controls for the impact of stochastic deviations in the reported variables. Thus, by estimating an SPF we expect to obtain more precise results.[32]

[29] Probit and lobit regressions are used to estimate the effect of a set of explanatory variables on a dependent variable that only takes on values of 0 or 1 (binary indicator variable). Ordered probit and logit regressions are used if the dimension of the dependent variable is greater than two.

[30] See footnote 25.

[31] In the context of our analysis, technical efficiency is defined as the amount of inputs used by an observed unit – e.g. specific sector in a given country – to produce a unit of output. The estimation process considers that each observed unit either operates efficiently or inefficiently, that is, its production is either located on the production frontier or below. Hence, the frontier is defined as the outward bound of production possibilities.

[32] See Appendix I for more information on the estimation of an SPF.

### 2.3.2 ICT adoption, use and diffusion

In the following we discuss the results of these analyses, structured according to the ICT value chain. This section tests the following hypotheses:

**Hypothesis A.1**: Increasing rivalry in the market determines the adoption of ICT.

**Hypothesis A.2**: Firms maintaining long-term relationships with suppliers and customers are more likely to use technologies supporting inter-firm collaboration, in comparison with their peer-group in the same sector.

#### Competition and rivalry

The relationship between market rivalry and ICT adoption intensity was analysed using OLS regressions over the following variables:

- The *dependent variable* accounting for the *intensity of the ICT usage* is the sum of answers to the questions regarding the internet connection type (score between 1 and 4), the use of LAN, WLAN, WWW, Intranet, Extranet, ERM, SCM, CRM, the use of the internet to sell and buy goods and employing IT practitioners (one score for each positive answer). Thus, the variable can take values between "0" and "14".
- The *independent variable* indicates whether the perceived *rivalry* in a firm's market *increased* in the last 12 months or not and takes a value "1" or "0" respectively.
- Finally, *dummy variables* control in the regression for firm size, age and country of origin.

The results of this regression are reported in Exhibit 2.3-1:

***Exhibit 2.3-1: Market rivalry and the intensity of ICT use***

| **Independent variable** [a] | **Sector** | | | | |
|---|---|---|---|---|---|
| | Chemical | Steel | Furniture | Retailing | Transport |
| Increasing rivalry (G8a) | 0.202 (0.246) | 0.311 (0.322) | 0.276 (0.284) | 0.502* (0.260) | 0.633** (0.257) |
| Less than 249 employees (G2) | -2.233*** (0.436) | -2.406*** (0.593) | -2.046*** (0.708) | -2.428*** (0.437) | -3.637*** (0.471) |
| Firm founded before 1998 (Z2b) | -0.388 (0.267) | 0.080 (0.366) | -0.451 (0.319) | 0.290 (0.224) | -0.148 (0.239) |
| **Model diagnostics** | | | | | |
| Number of observations | 910 | 449 | 697 | 1144 | 932 |
| R-squared | 0.08 | 0.07 | 0.06 | 0.08 | 0.10 |

Note: OLS regression. Table does not report country coefficients. Standard errors in parentheses
Base: Firms with >250 employees, founded after 1998 and based in the USA
[a] Questionnaire reference in parentheses. Dependent variable: A2, A3, A4, A6, A7, B1 and B3
* Significance 90%, ** Significance 95%, *** Significance 99%

Glossary:

- A *dependent variable* is the one observed to change in response to the independent variable(s), which are deliberately manipulated to invoke a change in the dependent variables;
- The *coefficient* is a constant multiplicative factor of a certain object;
- A *standard error* is the estimated standard deviation or error of a series of measurements;
- *R-squared* refers to the coefficient for determination and is the proportion of variability in a data set that is accounted for by a statistical model.

Source: Sectoral e-Business Watch, DIW Berlin (2008)

The main conclusions from this analysis are:

- Only for transport and logistics and – to a lesser extent – for retailing firms, we find statistically significant evidence that increasing perceptions of market rivalry are positively related with the intensity of ICT-usage.
- For chemical, steel and furniture-producing firms we do not find significant evidence for this hypothesis.
- For firms in all industries, the impact of firm size is strongly significant and indicates that small firms are less intensive ICT-users. For more details see Sectoral e-Business Watch reports.

The results thus suggest that service providers in retailing or transport and logistics forces which perceive an increased rivalry across firms are more likely to use innovative technologies in order to cut costs and to look for more innovative ways of conducting business. For manufacturing and industrial firms in chemical, steel and furniture this correlation cannot be observed.

The results should not be understood as evidence for a unidirectional relationship between competition and ICT adoption. While it seems to be obvious that increasing levels of competition can push firms to adopt and use ICT, also the opposite might well be the case. In fact, ICT and the usage of the Internet have drastically impacted on certain sectors such as banking and reshaped the competitive scenario, as e.g. the case study on a financial service provider (Section 3.3) illustrates.

For all firms we find strong evidence that firm size is significantly and negatively correlated with ICT-usage. This evidence clearly underlines that large-scale firms are more likely than small ones to adopt ICT-technology. The case study on two medium-size Polish furniture producers in Section 3.5 provides further insights. In fact, the most substantial barriers seem to be the financing of ICT projects, which often compete with non-ICT investments, uncertainty with respect to the future impact of ICT on firm performance, a strong managing focus on operational business that leaves little room for strategic planning and the need to recruit new personnel with ICT-specific skills which imposes new risks to the company.

## Relationships with business partners

The relationship between a firm's long-term relationship with suppliers and customers on the one hand and its use of technologies that support inter-firm collaboration on the other hand was analysed by means of descriptive statistics. In the e-Business Survey 2007, firms were asked about the use of collaborative applications and practices such as SCM, software to collaborate with business partners in the design of new products or services and sharing information on inventory levels or production plans electronically with business partners. Furthermore, they were asked to define whether they interact with a regular or changing supplier and customer base. Based on companies' answers to the questions regarding the type of supplier and customer base, we build four clusters[33] and compute the share of companies using a particular technology in each cluster (

[33] Firms with regular supplier and customer base, with regular supplier and changing customer base, with changing supplier and regular customer base, and with changing supplier and customer base.

Exhibit 2.3-2).

*Exhibit 2.3-2: Relations with business partners and the use of collaboration technologies*

| | | Regular supplier and customer base[a] | Regular supplier and changing customer base[a] | Changing supplier and regular customer base[a] | Changing supplier and customer base[a] |
|---|---|---|---|---|---|
| **Do firms use SCM applications?** | | | | | |
| **Chemical** | yes | 23% | 26% | 24% | 60% |
| | no | 77% | 74% | 76% | 40% |
| **Steel** | yes | 16% | 10% | 26% | 0% |
| | no | 84% | 90% | 74% | 100% |
| **Furniture** | yes | 13% | 11% | 14% | 10% |
| | no | 87% | 89% | 86% | 90% |
| **Retailing** | yes | 15% | 12% | 19% | 19% |
| | no | 85% | 88% | 81% | 81% |
| **Transport** | yes | 12% | 8% | 10% | 12% |
| | no | 88% | 92% | 90% | 88% |
| **Do firms share information electronically?** | | | | | |
| **Chemical** | yes | 14% | 17% | 21% | 15% |
| | no | 86% | 83% | 79% | 85% |
| **Steel** | yes | 8% | 14% | 10% | 0% |
| | no | 92% | 86% | 90% | 100% |
| **Furniture** | yes | 9% | 7% | 19% | 11% |
| | no | 91% | 93% | 81% | 89% |
| **Retailing** | yes | 18% | 17% | 13% | 25% |
| | no | 82% | 83% | 87% | 75% |
| **Transport** | yes | 17% | 15% | 18% | 14% |
| | no | 83% | 85% | 82% | 86% |
| **Do firms use e-Collaboration for product design?** | | | | | |
| **Chemical** | yes | 16% | 16% | 21% | 20% |
| | no | 84% | 84% | 79% | 80% |
| **Steel** | yes | 1% | 7% | 15% | 0% |
| | no | 99% | 93% | 85% | 100% |
| **Furniture** | yes | 14% | 7% | 24% | 25% |
| | no | 86% | 93% | 76% | 75% |
| **Retailing** | yes | - | - | - | - |
| | no | - | - | - | - |
| **Transport** | yes | - | - | - | - |
| | no | - | - | - | - |

[a] Questionnaire reference: G16 and G19 n.a.

Source: Sectoral e-Business Watch, DIW Berlin (2008)

The results allow only for some conclusions. First, in each supplier-customer cluster the share of users of either SCM applications, e-sharing of information or e-collaboration for product design is rather small when compared to the share of non-users. Second, in each supplier-customer cluster and for each industry, the ratio between users and non-users is rather constant (i.e., the figures in each row do not change significantly). Third, there is no evidence that the share of users for firms with a regular customers and supplier structure is significantly larger than the share of firms with less regular structures. Finally, we observe that we observe the most significant deviations from these patterns for firms with changing suppliers and customers (the very right column). However, the number of observations in this cluster is very small relative to all others, which is the most likely reason for this observation.

Hence, based on the evidence presented above we cannot confirm that firms that maintain long-term relationships with suppliers and customers are more likely to use technologies that support inter-firm collaboration than other firms in the same sector. However, these results do not imply that relations with business partners are per se not important for this decision to use such technologies. Instead, the need to harmonise and standardise supply chain and quality management as well as information exchange across firms are key reasons for using ICT-based systems. The case study on DanSteel (Section 3.2) provides an example where a company intended to reduce its dependency on a single supplier and adopted a SCM system to manage the workflows with changing suppliers. Possibly, a more meaningful indicator for the use of inter-firm information exchange and collaborate systems would have been the size of a company. For example, the case study on the Polish furniture producer FORTE (Section 3.4) demonstrates that companies of a certain size and with considerable market position can no longer refuse to implement modern corporate management systems.

### 2.3.3 Innovation

In this section, the following hypotheses are tested:

**Hypothesis I.1**: Firms characterised by a higher share of employees with a university degree are more likely to conduct ICT-enabled innovations, in comparison with their peer-group in the same sector.

**Hypothesis I.2**: Firms that use ICT applications to exchange information or collaborate with business partners are more likely to introduce ICT enabled innovations, compared with their peer-group in the same sector.

**Hypothesis I.3**: ICT endowment is positively correlated with outsourcing.

**Hypothesis I.4**: ICT use is positively correlated with organisational changes.

#### Internal capacity

The relationship between the share of employees with a higher university degree and ICT-enabled innovations was analysed through probit regressions over the following variables:

- The dependent variable is an index which indicates if the product or service innovations of a given firm during the last 12 months were ICT related (index equals 1) or not (index equals 0).
- Independent variables are the share of employees with a higher university degree and a variable controlling for the presence of ICT practitioners (equals 1 if yes).
- Dummy variables control for firm size, age and country of origin.

The results of these regressions are given below:

***Exhibit 2.3-3: Effect of employee skills on ICT-enabled innovation activity***

| **Independent variable** [a] | **Sector** | | | | |
|---|---|---|---|---|---|
| | Chemical | Steel | Furniture | Retail | Transport |
| % of employees with higher university degree (G11) | 0.002<br>(0.003) | 0.009<br>(0.006) | 0.014***<br>(0.004) | 0.004**<br>(0.002) | 0.005**<br>(0.002) |
| IT practitioners (E1) | 0.678***<br>(0.109) | 0.681***<br>(0.182) | 1.075***<br>(0.143) | 0.864***<br>(0.106) | 0.920***<br>(0.117) |
| Less than 249 employees (Z2b) | -0.347*<br>(0.195) | -0.083<br>(0.266) | -0.256<br>(0.320) | -0.343*<br>(0.198) | -0.014<br>(0.230) |
| Firm founded before 1998 (G2) | 0.059<br>(0.118) | 0.031<br>(0.171) | -0.195<br>(0.136) | 0.060<br>(0.092) | -0.046<br>(0.103) |
| **Model diagnostics** | | | | | |
| Number of observations | 797 | 406 | 637 | 973 | 845 |
| R-squared | 0.07 | 0.07 | 0.12 | 0.09 | 0.09 |

Note: Probit estimates. Table does not report country coefficients. Standard errors in parentheses

Base: Firms with >250 employees, founded after 1998 and based in the USA

[a] Questionnaire reference in parentheses. Dependent variable: D2 and D4

* Significance 90%, ** Significance 95%, *** Significance 99%

Glossary:

- A *dependent variable* is the one observed to change in response to the independent variable(s), which are deliberately manipulated to invoke a change in the dependent variables;
- The *coefficient* is a constant multiplicative factor of a certain object;
- A *standard error* is the estimated standard deviation or error of a series of measurements;
- *R-squared* refers to the coefficient for determination and is the proportion of variability in a data set that is accounted for by a statistical model.

Source: Sectoral e-Business Watch, DIW Berlin (2008)

The main findings from

Exhibit 2.3-3 are as follows:

- Furniture, retailing and transport firms with large shares of employees with higher university degrees or with specific IT- practitioners are more likely to realise ICT-related product- and service innovations.
- For chemical and steel firms we observe such a significantly positive relationship only for the presence of IT- practitioners.
- For chemical and retail firms the likelihood of ICT-related product- and service innovations is negatively related to firm size, albeit at a relatively low significance level of 90%.

Overall, our results indicate that high-skilled employees are relevant for ICT-related product- and service innovations. More than for higher university education we find this to be relevant for IT- practitioners with very specific skills that seem to be of crucial importance. This is consistent with the observation that the success of the ICT-driven innovation processes relies on the availability and quality of complementary assets such as labour. Evidence for the importance of relevant skills for the success of ICT-based projects is also provided in the case studies in section 3, in particular the case of the financial service provider (section 3.3) or the small polish furniture producer (Section 3.5). In the latter case, the need to recruit ICT specialists as key requirement for the successful ICT adoption forms one of the most severe barriers of ICT uptake to SMEs.

## Intra and inter-firm collaboration

The relation between electronic data and information exchange between business partners and ICT-enabled innovations was analysed using probit regressions over the following variables:

- As above, the *dependent variable* is an index which indicates if the product or service innovations of a given firm during the last 12 months were *ICT related* (index equals 1) or not (index equals 0).
- The *independent variables* control for the use of *SCM systems*, *applications to collaborate with business partners* in the design of new products or services and *sharing information* on inventory levels or production plans *electronically* with business partners.
- *Dummy variables* control for firm *size, age and country* of origin.

All independent variables are dummy variables, taking a value of 1 if a specific characteristic is identified and 0 otherwise. The results of these regressions are given in Exhibit 2.3-4.

***Exhibit 2.3-4: Effect of electronic collaboration with business partners on ICT-enabled innovation activity***

| **Independent variable** [a] | **Sector** | | | | |
|---|---|---|---|---|---|
| | Chemical | Steel | Furniture | Retailing | Transport |
| Use of SCM (A7) | 0.345*** (0.108) | 0.718*** (0.187) | 0.635*** (0.146) | 0.410*** (0.112) | 0.704*** (0.139) |
| Share information electronically (B9) | 0.291** (0.122) | 0.561*** (0.190) | 0.494*** (0.189) | 0.489*** (0.101) | 0.599*** (0.122) |
| Applications to collaborate (b10) | 0.481*** (0.119) | 0.600*** (0.205) | 0.580*** (0.150) | - [b] | - [b] |

| | | | | | |
|---|---|---|---|---|---|
| Less than 249 employees (Z2b) | -0.400** (0.168) | 0.018 (0.259) | -0.331 (0.274) | -0.453*** (0.160) | -0.183 (0.185) |
| Firm founded before 1998 (G2) | 0.132 (0.107) | -0.024 (0.164) | -0.223* (0.125) | 0.063 (0.083) | -0.016 (0.098) |
| **Model diagnostics** | | | | | |
| Number of observations | 910 | 449 | 697 | 1144 | 932 |
| R-squared | 0.06 | 0.12 | 0.09 | 0.06 | 0.09 |

Note: Probit estimates. Table does not report country coefficients. Standard errors in parentheses

Base: Firms with >250 employees, founded after 1998 and based in the USA

[a] Questionnaire reference in parentheses. Dependent variable: D2 and D4

[b] n.a.

* Significance 90%, ** Significance 95%, *** Significance 99%

Glossary:

- A *dependent variable* is the one observed to change in response to the independent variable(s), which are deliberately manipulated to invoke a change in the dependent variables;
- The *coefficient* is a constant multiplicative factor of a certain object;
- A *standard error* is the estimated standard deviation or error of a series of measurements;
- R-squared refers to the coefficient for determination and is the proportion of variability in a data set that is accounted for by a statistical model.

Source: Sectoral e-Business Watch, DIW Berlin (2008)

The main findings are as follows:

- Across all sectors, firms that use applications and practices to support the electronic exchange of information between companies are significantly more likely to realise ICT-enabled product and service innovations.
- For chemical and retail firms we also find that ICT-enabled product and service innovations are less likely in small firms.

Obviously, these results indicate towards a close link between ICT-enabled innovations and the extent to which firms exchange information electronically. While the coefficients for all analysed means of information exchange are all positive and highly significant, there respective levels are quite different. This clearly indicates that the different means (use of SCM systems, applications to collaborate with business partners in the design of new products or services, or the electronic exchange of information on inventory levels or production plans with business partners) are of different importance for the six analysed sectors.

In fact, several of the case studies in section 3 demonstrate the key role that electronic information exchange plays for product and service innovations. For example, a deep restructuring process as well as several merger waves has confronted many European banks with the challenge to manage various decentralised systems, data redundancies and non-standard applications across non-integrated platforms. Here, the case study on a large financial service provider in Switzerland (section 3.3) is an interesting example of how the integration of diverse applications within one platform enables the firm to increase service quality as well as the productivity of its employees. Similarly, the case study on the polish company Zabka (section 3.1), which entered the retailing market with a new business model that combines the proximity of 'neighbourhood' stores with economies of scale that large retail chains enjoy, provides an interesting example of an

ICT-enabled innovation where in fact the use of an electronic resource planning system is key to the success of the company.

## Organisational changes

The relationship between ICT-usage and organisational changes was analysed by running ordered logit regressions over the following variables:

- The *dependent variable* indicates if a company has carried out certain types of *organisational changes* during the past 12 months. We therefore constructed an index which controls for four possible types of changes, namely changes in i) corporate strategy; ii) management techniques; iii) organisational structure; or iv) marketing concepts. For each possible change, that a firm might have undertaken, the index increases by one. Hence, it can take values between 0 (indicating that a company has not carried out any of the listed changes) and 4 (indicating that a company has carried out all four types of changes).
- The *independent variables* control for the following types of *ICT components*:
  - An *ICT-infrastructure index* controls for the hardware applications used by a firm. It comprises of the share of company employees with an internet access at their workplace, the available internet connection capacity, and the use of LAN, Intranet and Extranet.
  - A software index summarises the main software applications used by a firm. It comprises of software applications to manage the placing or receipt of orders, ERM, SCM, CRM and the use of the internet to buy and sell goods.
  - ICT-related human capital is controlled for by a variable that reports the share of employees with higher university degree, and by a variable that controls for the presence of *ICT practitioners* (equals 1 if yes and 0 otherwhise).
- *Dummy variables* control for the percentage of employees with a higher university degree, firm size, age and country of origin.

The results of our analysis are as follows:

***Exhibit 2.3-5: Effect of ICT use on organizational changes***

| **Independent variable** [a] | **Sector** | | | | |
|---|---|---|---|---|---|
| | Chemical | Steel | Furniture | Retailing | Transport |
| ICT-Infrastructure index (A2, A3, A4) | 0.001 (0.003) | 0.004* (0.002) | 0.012*** (0.004) | 0.005** (0.002) | 0.000 (0.002) |
| Software index (A6, A7, B1, B3) | 0.389*** (0.059) | 0.136*** (0.045) | 0.221*** (0.069) | 0.275*** (0.059) | 0.362*** (0.060) |
| IT practitioners (E1) | 0.093 (0.176) | - [b] | 0.191 (0.233) | 0.843*** (0.177) | 0.571*** (0.195) |
| % of employees with higher university degree (G11) | 0.006 (0.005) | - [b] | 0.018*** (0.007) | 0.002 (0.003) | 0.003 (0.004) |
| Less than 249 employees (G2) | 0.361 (0.313) | -0.183 (0.207) | -0.467 (0.495) | 0.021 (0.328) | -0.312 (0.338) |
| Firm founded before 1998 (Z2b) | -0.047 (0.178) | 0.011 (0.142) | -0.326 (0.221) | -0.212 (0.156) | -0.071 (0.174) |
| **Model diagnostics** | | | | | |
| Number of observations | 673 | 366 | 485 | 706 | 651 |

| | | | | | |
|---|---|---|---|---|---|
| R-squared | 0.04 | 0.02 | 0.06 | 0.04 | 0.05 |

Note: Ordered logit estimates. Table does not report country coefficients. Standard errors in parentheses

Base: Firms with >250 employees, founded after 1998 and based in the USA

[a] Questionnaire reference in parentheses. Dependent variable: D5 n.a.

[b] n.a.

* Significance 90%, ** Significance 95%, *** Significance 99%

Glossary:

- A *dependent variable* is the one observed to change in response to the independent variable(s), which are deliberately manipulated to invoke a change in the dependent variables;
- The *coefficient* is a constant multiplicative factor of a certain object;
- A *standard error* is the estimated standard deviation or error of a series of measurements;
- R-squared refers to the coefficient for determination and is the proportion of variability in a data set that is accounted for by a statistical model.

Source: Sectoral e-Business Watch, DIW Berlin (2008)

The main conclusions from Exhibit 2.3-5 are:

- For all five sectors there is a significant positive relationship between the software index and the extent of organisational changes.
- For two sectors (furniture and retailing) we found a significant positive relationship between ICT infrastructure and the extent of organisational changes.
- For two sectors (retailing and transport), there is a significant positive relationship between the presence of ICT practitioners and the extent of organisational changes.
- For furniture, the share of employees with higher university degree is significantly and positive related with organisational changes.
- For firm size and age we did not find significant connections with organisational changes.

Hence, the intensity of ICT usage increases the probability for organisational changes in all analysed sectors. In particular, we found strong links in chemical and transportation and the lowest link in the steel sector. On the contrary, ICT infrastructure appears to be of lesser importance, since we found significant relationships for only two sectors and in both cases, the impact on probabilities for organisational change (the estimated coefficient) are much lower.

As our estimates also reveal, the quality of human capital is of lesser importance for organisational changes than for ICT-enabled innovations (see

Exhibit 2.3-3).

Overall, these findings indicate that ICT infrastructure and software have different implications for organisational changes of companies. Whereas infrastructure is a necessary condition for efficient ICT use, it does not appear to be sufficient for business transformation. Rather, it is the availability and use of innovative software which enables firms to rearrange their operations, functions and workflows, i.e. find innovative ways of doing business.

The link between ICT use and organisational change is also demonstrated in the case studies in Section 3. For example, ICT use was of key importance for the restructuring process of the Danish steel company DanSteel after is was acquired by a foreign steel concern (section 3.2). Likewise, the adoption of an electronic data exchange system by the Polish furniture producer FORTE enabled the company to replace the work of specific departments that were responsible for all communications with business partners, thereby reducing process time and costs while increasing quality through a lower error rate (section 3.4).

## Outsourcing

The relationship between ICT endowments and outsourcing was analysed using probit regressions over the following variables:

- The *dependent variable* takes a value 1 if a company *outsourced* any of its business activities in the last 12 months, or 0 if it did not.
- The *independent variable* is an index that controls for a company's *ICT endowment*. It is an index based on answers to the questions regarding the type of internet connection (score between 1 and 4), the use of LAN, WLAN, WWW, Intranet, Extranet, ERM, SCM, CRM, the use of the internet to sell and buy goods and employing IT practitioners (one score for each positive answer). The variable can take values between 0 and 14, where 14 indicates a large ICT-endowment.
- *Dummy variables* control for firm size, age and country of origin.

Exhibit 2.3-6 shows the results of our regressions.

*Exhibit 2.3-6: The intensity of ICT use and outsourcing*

| Independent variable [a] | Sector | | | | |
|---|---|---|---|---|---|
| | Chemical | Steel | Furniture | Retailing | Transport |
| ICT endowment (A2, A3, A4, A6, A7, B1, B3) | 0.060*** (0.016) | 0.063*** (0.024) | 0.048*** (0.018) | 0.052*** (0.015) | 0.059*** (0.017) |
| Less than 249 employees (G2) | -0.146 (0.188) | 0.755* (0.402) | -0.086 (0.346) | -0.332* (0.192) | 0.050 (0.237) |
| Firm founded before 1998 (Z2b) | 0.125 (0.126) | 0.190 (0.192) | 0.052 (0.152) | -0.239** (0.109) | 0.211* (0.125) |
| **Model diagnostics** | | | | | |
| Number of observations | 910 | 405 | 651 | 1144 | 932 |
| R-squared | 0.06 | 0.09 | 0.05 | 0.04 | 0.05 |

Note: Probit estimates. Table does not report country coefficients. Standard errors in parentheses

Base: Firms with >250 employees, founded after 1998 and based in the USA

[a] Questionnaire reference in parentheses. Dependent variable: G22

* Significance 90%, ** Significance 95%, *** Significance 99%

Glossary:

- A *dependent variable* is the one observed to change in response to the independent variable(s), which are deliberately manipulated to invoke a change in the dependent variables;
- The *coefficient* is a constant multiplicative factor of a certain object;
- A *standard error* is the estimated standard deviation or error of a series of measurements;
- R-squared refers to the coefficient for determination and is the proportion of variability in a data set that is accounted for by a statistical model.

Source: Sectoral e-Business Watch, DIW Berlin (2008)

The conclusions of this analysis are as follows:

- For all sectors, the propensity to outsource business activities increases with the size of a company's ICT-endowment.
- Except of for steel and retailing companies, firm size is not significantly correlated with outsourcing activities (for steel firms, we find that smaller firms are more likely to outsource activities while the opposite is the case for retailing – however, both results are not strongly significant.
- Only for transport and retailing firms we find significant impact of firm age on outsourcing activities. As the contrary signs indicate, those effects appear to be very sector-specific.

As these results indicate, companies' ICT endowments are strongly correlated with outsourcing activities. In fact, the more advanced a company uses ICT, the more likely it is to outsource some of its business activities. The case study on DanSteel (section 3.2) provides a practical illustration of how ICT usage enables firms to outsource of non-core activities within a complex supply chain. In this case, the use of a specific supply chain management system enabled the firm to better coordinate all processes and helped to collect and manage the necessary information dispersed by different actors along the supply chain to facilitate the decision-making process.

### 2.3.4 Performance

In this section, the following hypotheses are tested:

**Hypothesis P.1**: ICT-enabled innovations are correlated with a firm's turnover.

**Hypothesis P.2**: ICT endowment is positively correlated with a change of market share.

**Hypothesis P.3**: ICT-capital investment has become a key element in growth of value added and labour productivity, while the importance of non-ICT-capital investments has been declining..

**Hypothesis P.4**: TFP growth has accelerated together with increased investment in ICT-capital, especially in ICT-using service industries like retailing, wholesale and banking.

**Hypothesis P.5**: ICT and high- and medium-skilled labour have a positive direct impact on labour productivity growth.

#### Turnover

To analyse the impact of ICT-enabled innovations and changes in firms' turnover we ran probit regressions over the following variables:

- The *dependent variable* is an index which indicates increases in a firm's *turnover* during the last 12 months (the index equals 1 if a firm reported a turnover increase, otherwise 0).
- The *independent variable* controls for the introduction of any *ICT-enabled innovations* in the same time period.
- *Dummy variables* control for firm size, age and country of origin.

All independent variables are indices which equal 1 if a specific characteristic is identified, and 0 otherwise. The results of these regressions are as shown in Exhibit 2.3-7. The main findings are:

- Firms that report ICT-enabled innovations are significantly more likely to report turnover increases as well.
- There is no significant relationship between firm age or size on the one hand and turnover increases on the other hand.

Overall, firm's which realise ICT-enabled innovations are more likely to observe turnover increases than other firms. This evidence is also supported by several case studies in Section 3. For example, the Polish retailing firm Zabka (Section 3.1) or furniture producer FORTE (Section 3.4) both report that ICT-usage has been key to the successful developments of their businesses, which both have seen strong increases in turnover during recent years.

The results of the regression (see Exhibit 2.3-8) can be interpreted as follows:

- For firms in the chemical, retailing and transport sector the ICT endowment has a significantly positive impact on changes in the respective company's market share.
- For steel and furniture firms results are unclear: although the estimated coefficients indicate towards the expected relationship, the estimates are not statistically significant.

- Firm size and – with the exception of retailing and transportation – age appear to be uncorrelated with changes in market shares.
- The significant negative relationship between age of retailing and transportation firms and changes in their market share indicate towards significant structural changes in the respective industries.

***Exhibit 2.3-7: Effect of ICT-enabled innovation activity on turnover increase***

| **Independent variable** [a] | **Sector** | | | | |
|---|---|---|---|---|---|
| | Chemical | Steel | Furniture | Retailing | Transport |
| ICT enabled innovation (D2, D4) | 0.252*** (0.094) | 0.315** (0.157) | 0.303*** (0.110) | 0.245*** (0.081) | 0.300*** (0.095) |
| Less than 249 employees (Z2b) | 0.063 (0.171) | -0.368 (0.258) | 0.003 (0.279) | -0.149 (0.156) | -0.128 (0.184) |
| Firm founded before 1998 (G2) | 0.130 (0.102) | -0.026 (0.150) | -0.117 (0.120) | -0.031 (0.081) | 0.007 (0.093) |
| **Model diagnostics** | | | | | |
| Number of observations | 910 | 449 | 697 | 1144 | 932 |
| R-squared | 0.10 | 0.16 | 0.09 | 0.06 | 0.07 |

Note: Probit estimates. Table does not report country coefficients. Standard errors in parentheses

Base: Firms with >250 employees, founded after 1998 and based in the USA

[a] Questionnaire reference in parentheses. Dependent variable: G9

* Significance 90%, ** Significance 95%, *** Significance 99%

Glossary:

- A *dependent variable* is the one observed to change in response to the independent variable(s), which are deliberately manipulated to invoke a change in the dependent variables;
- The *coefficient* is a constant multiplicative factor of a certain object;
- A *standard error* is the estimated standard deviation or error of a series of measurements;
- *R-squared* refers to the coefficient for determination and is the proportion of variability in a data set that is accounted for by a statistical model.

Source: Sectoral e-Business Watch, DIW Berlin (2008)

## Market shares

The relationship between ICT endowments and changes in market shares was analysed by ordered logit regressions over the following variables:

- The *dependent variable* is an index which equals 0 if a firm's *market share* has decreased, 1 if it has remained constant and 2 if it has increased during the last 12 months.
- The *independent variable* is the index for companies' *ICT endowments* as explained above (Section 2.3.3).
- As above, we use *dummy variables* to control for firm size, age and country of origin.

*Exhibit 2.3-8: The intensity of ICT use and change in the market share*

| Independent variable [a] | Sector | | | | |
|---|---|---|---|---|---|
| | Chemical | Steel | Furniture | Retailing | Transport |
| ICT endowment (A2, A3, A4, A6, A7, B1, B3) | 0.063*** (0.021) | 0.042 (0.031) | 0.023 (0.023) | 0.044*** (0.017) | 0.070*** (0.020) |
| Firm founded before 1998 (Z2b) | -0.270 (0.174) | 0.044 (0.231) | -0.237 (0.190) | -0.371*** (0.131) | -0.306** (0.149) |
| Less than 249 employees (G2) | 0.286 (0.288) | -0.204 (0.388) | -0.010 (0.430) | 0.002 (0.263) | -0.073 (0.315) |
| **Model diagnostics** | | | | | |
| Number of observations | 822 | 411 | 659 | 1054 | 872 |
| R-squared | 0.03 | 0.04 | 0.02 | 0.02 | 0.02 |

Note: Ordered logit estimates. Table does not report country coefficients. Standard errors in parentheses

Base: Firms with >250 employees, founded after 1998 and based in the USA

[a] Questionnaire reference in parentheses. Dependent variable: G7

* Significance 90%, ** Significance 95%, *** Significance 99%

Glossary:

- A *dependent variable* is the one observed to change in response to the independent variable(s), which are deliberately manipulated to invoke a change in the dependent variables;
- The *coefficient* is a constant multiplicative factor of a certain object;
- A *standard error* is the estimated standard deviation or error of a series of measurements;
- *R-squared* refers to the coefficient for determination and is the proportion of variability in a data set that is accounted for by a statistical model.

Source: Sectoral e-Business Watch, DIW Berlin (2008)

Overall, we find evidence in sectors like chemical, retailing and transport that firms which have significant ICT endowments are likely to have increased their market share. The case study on Polish retailer Zabka further supports this result. On the contrary, for steel and furniture firms none of the analysed variables appears to be correlated with structural changes.

We also find evidence pointing towards significant structural changes in retailing and transport, where younger firms seem to gain market share at the expense of elder ones. However, it is important to note that firm age in these sectors is not significantly correlated with ICT usage, as our analysis on the causes for ICT usage indicate (Exhibit 2.3-1). Hence, there is no evidence that the strong performance of young firms in retailing and transport is due to ICT usage.

## Value added and productivity growth

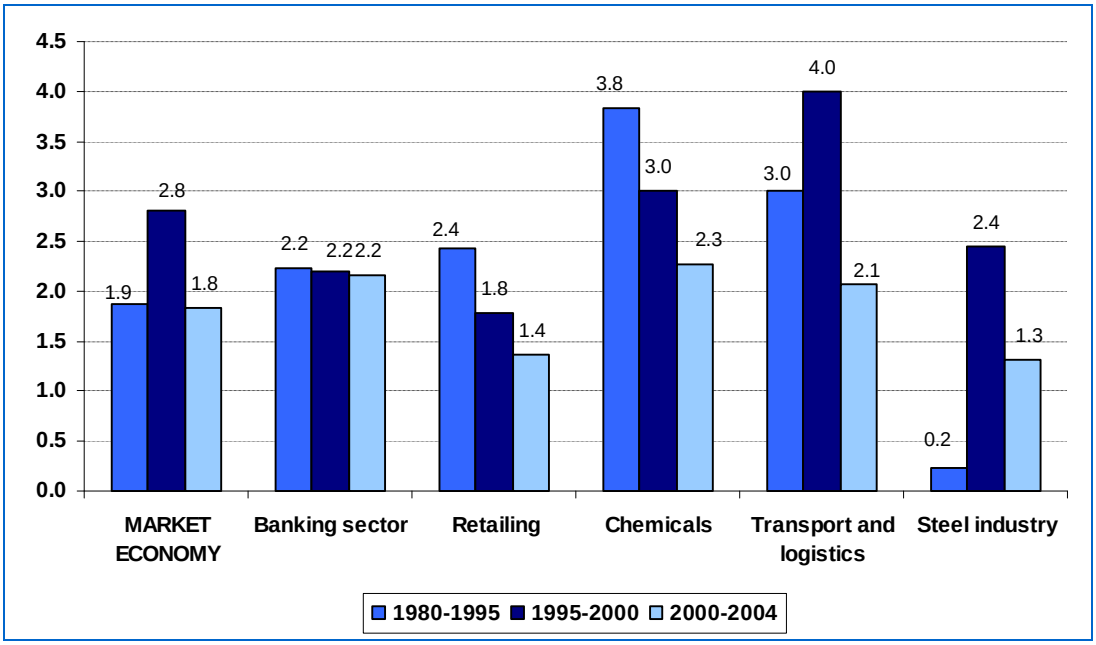
In contrast to the preceding analysis, the last three hypotheses focus on sector-level rather than firm-specific developments. Consequently, our empirical verification was also based on sector-level data.

Exhibit 2.3-9 gives a first overview of the pattern of value added growth since 1980 for aggregate industry and service sectors[34] (henceforth MARKET ECONOMY) of ten EU

[34] Service sectors do not include non-marketable services such as public administration, education and health, defence; compulsory social security, education, health and social work as well as real estate activities.

member states[35] as well as for five out of the six sectors that we have analysed.[36] Annual average growth rates are reported for three different periods, 1980-1995, 1995-2000 and 2000-2004, to reflect the overall economic trends within this time period. In particular, the period from 1980-1995 includes developments prior to the new economy boom, while 1995-2000 and 2000-2004 report the boom period and its aftermath.

***Exhibit 2.3-9: Gross value added growth in the EU-15***
***(annual average volume growth rates for different time periods, in %)***




Source: EUKLEMS data base, GGDC; own calculation

As can be seen, the economy-wide growth of value added during the new economy boom has been at around 2.8% per year, up from 1.9% in the period before. However, with the end of this boom period, also average value added growth slowed back to 1.8% per year.

For the different sectors, developments have been rather heterogeneous. Overall, we find the larges growth rates for the chemical sector as well as for transport and logistics. These two sectors are also the only ones for which we observe annual growth rates above the respective economy-wide levels in all three periods. Interestingly, value added growth in the banking sector has been above the economy-wide levels in the periods before and after the new economy boom, while falling short of it during the boom time. Finally, the growth pattern in the steel sector indicates towards a significant increase in recent growth rates, relative to the levels in the period from 1980-1995.

While annual growth rates in the banking sector have been almost constant throughout the entire period, we observe a continuous slowdown of annual value added growth for retailing and the chemical sector. On the contrary, growth rates in transport and logistics as well as in the steel industry replicate the growth pattern of the overall economy.

[35] The database consists of all EU member states for which growth rates and the respective contributions of different factors can be accounted for. These are Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Spain and the United Kingdom.

[36] The sector-level analysis for furniture has been omited since the sectoral classification of the EU-KLEMS database does not provide the necessary information (see Section 2.3.1).

## Growth accounting for gross value added

Based on the standard growth accounting approach we can identify the various contributions of different input factors to gross value added growth (On the sector-specific level, we observe that there is neither a single factor that accounts for the most significant contributions to growth in value added over the analysed periods, nor is there a uniform tendency with respect to the changes in importance of a given factor. In fact, whether changes in ICT or non-ICT capital, labour composition, the number of hours worked or changes in TFP are key determinants for economic growth appears to be highly sector-specific.

Consequently, we find the role of ICT capital to be rather heterogeneous. Clearly the sector in which it plays the most-dominant role is banking. While ICT capital has been the largest contributor to value added growth in all three periods, its specific contribution has increased from about 35% until 1995 to more than 60% during the new economy boom. With the burst of the dotcom bubble also the growth contributions of ICT capital have somewhat slowed down (e.g. 44% on average from 2000-2004), but it has remained the most important contributor for value growth in the European banking sector. At the same time, the role of non-ICT capital has declined considerably, from being the second largest contributor till 1995 to almost no further contributions to growth since 2000.

For all other sectors, ICT capital does not account for the largest or second largest contributions to economic growth. Nevertheless, we observe that its importance has slightly increased for all sectors during the three periods. For example, until 1995 ICT capital accounted for only about 6% of average annual growth rates in retailing while this share increased to about 15% in the two latter periods. For transport and logistics we identify a similar tendency, where contributions increased from 10% before 1995 to 15% thereafter. For chemicals and the steel industry there is a slightly different development. Like all other sectors, they both saw an increase in ICT capital contributions to growth rates from 5% and 3% to 13% and 9%, respectively. However, with the end of the new economy boom, the contributions of ICT capital to value added growth in both sectors went back again to 5% and 6%, respectively. This equals about the role that ICT capital has played prior to 1995 in the two sectors.

Exhibit 2.3-10). The specific structure of the EU KLEMS database allows for a detailed presentation of different contributions, including ICT and non-ICT capital, total working hours and the composition of the labour force by different skill levels.

Most importantly, the comparison of different contributions to economy-wide growth during the three periods shows a modestly increasing role of ICT capital. Having been only the third-biggest contributor to growth until 1995, ICT capital became the second-largest one in the two later periods. In percent of net value added growth, the contribution of ICT capital has increased from 17% until 1995 to slightly more than 25% thereafter.

As On the sector-specific level, we observe that there is neither a single factor that accounts for the most significant contributions to growth in value added over the analysed periods, nor is there a uniform tendency with respect to the changes in importance of a given factor. In fact, whether changes in ICT or non-ICT capital, labour composition, the number of hours worked or changes in TFP are key determinants for economic growth appears to be highly sector-specific.

Consequently, we find the role of ICT capital to be rather heterogeneous. Clearly the sector in which it plays the most-dominant role is banking. While ICT capital has been the largest contributor to value added growth in all three periods, its specific contribution has increased from about 35% until 1995 to more than 60% during the new economy boom. With the burst of the dotcom bubble also the growth contributions of ICT capital have somewhat slowed down (e.g. 44% on average from 2000-2004), but it has remained the most important contributor for value growth in the European banking sector. At the same time, the role of non-ICT capital has declined considerably, from being the second largest contributor till 1995 to almost no further contributions to growth since 2000.

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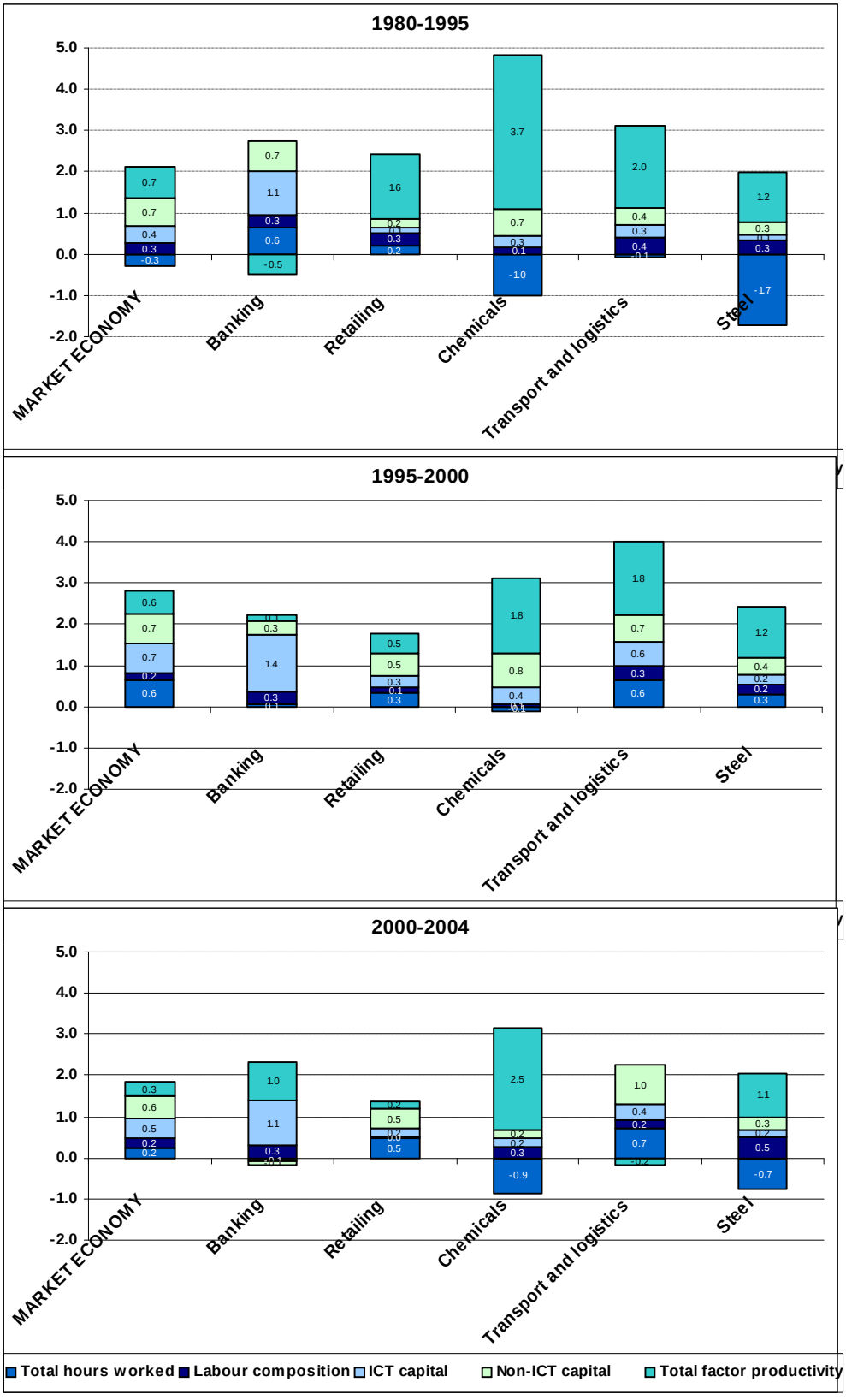
Exhibit 2.3-10 shows, the most significant single contributor to value added growth throughout the analysed periods has been non-ICT capital, with contributions of 62% between 1995 and 2000 and 44% from 2000 to 2004, respectively, to net value added growth. Hence, on an economy wide level the importance of ICT capital for value added growth has been slightly increasing, while we do not find evidence for a diminishing role of non-ICT capital.

On the sector-specific level, we observe that there is neither a single factor that accounts for the most significant contributions to growth in value added over the analysed periods, nor is there a uniform tendency with respect to the changes in importance of a given factor. In fact, whether changes in ICT or non-ICT capital, labour composition, the number of hours worked or changes in TFP are key determinants for economic growth appears to be highly sector-specific.

Consequently, we find the role of ICT capital to be rather heterogeneous. Clearly the sector in which it plays the most-dominant role is banking. While ICT capital has been the largest contributor to value added growth in all three periods, its specific contribution has increased from about 35% until 1995 to more than 60% during the new economy boom. With the burst of the dotcom bubble also the growth contributions of ICT capital have somewhat slowed down (e.g. 44% on average from 2000-2004), but it has remained the most important contributor for value growth in the European banking sector. At the same time, the role of non-ICT capital has declined considerably, from being the second largest contributor till 1995 to almost no further contributions to growth since 2000.

For all other sectors, ICT capital does not account for the largest or second largest contributions to economic growth. Nevertheless, we observe that its importance has slightly increased for all sectors during the three periods. For example, until 1995 ICT capital accounted for only about 6% of average annual growth rates in retailing while this share increased to about 15% in the two latter periods. For transport and logistics we identify a similar tendency, where contributions increased from 10% before 1995 to 15% thereafter. For chemicals and the steel industry there is a slightly different development. Like all other sectors, they both saw an increase in ICT capital contributions to growth rates from 5% and 3% to 13% and 9%, respectively. However, with the end of the new economy boom, the contributions of ICT capital to value added growth in both sectors went back again to 5% and 6%, respectively. This equals about the role that ICT capital has played prior to 1995 in the two sectors.

***Exhibit 2.3-10: Contributions of different input factors to value added growth in the EU-15 (contributions to annual average volume growth rates for different time periods, in %)***




Source: EUKLEMS data base, GGDC; own calculation

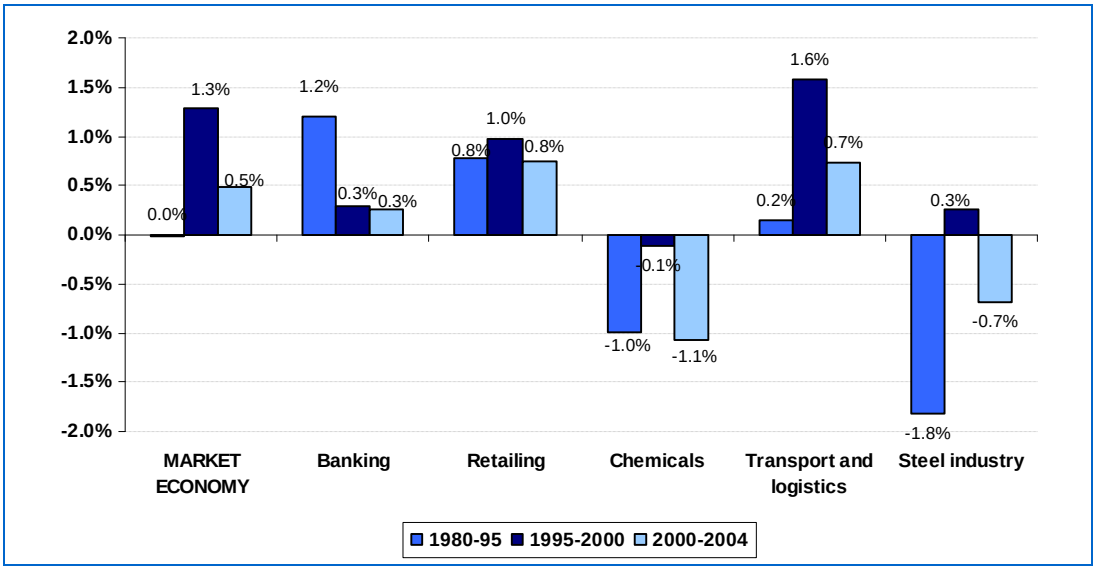
Similar to capital, also the contributions of TFP to value added growth follow a heterogeneous, sector-specific pattern. The two sectors in which TFP has accounted for the largest contributions to growth during all three periods are steel and chemicals. In retailing and transport and logistics, TFP changes have been of crucial importance since 2000 while their respective contributions have been rather small in later years. In banking, TFP has accounted for significant contributions to growth only since 2000. However, the contributions of TFP have to be interpreted carefully. In fact, the growth accounting approach attributes all variations in value added which cannot be explained by changes in labour and capital to TFP. Hence, it not only includes "true" productivity advances, but also a number of other effects such as business cycles. Hence, a more specific methodology is used for analysing specific contributions to productivity changes in the next paragraph.

Overall, our analysis shows slightly increasing contributions of ICT capital to value added growth, but also a very heterogeneous as well as sector-specific pattern. With respect to the Hypothesis P.3 the results from growth accounting show that with the exception of banking ICT capital does not appear to be a key element in the growth of value added in the five sectors that we analyse in this report. Likewise, with the exception of banking (and chemicals to some extent) no sector shows evidence for a diminishing role of non-ICT capital.

## Employment developments

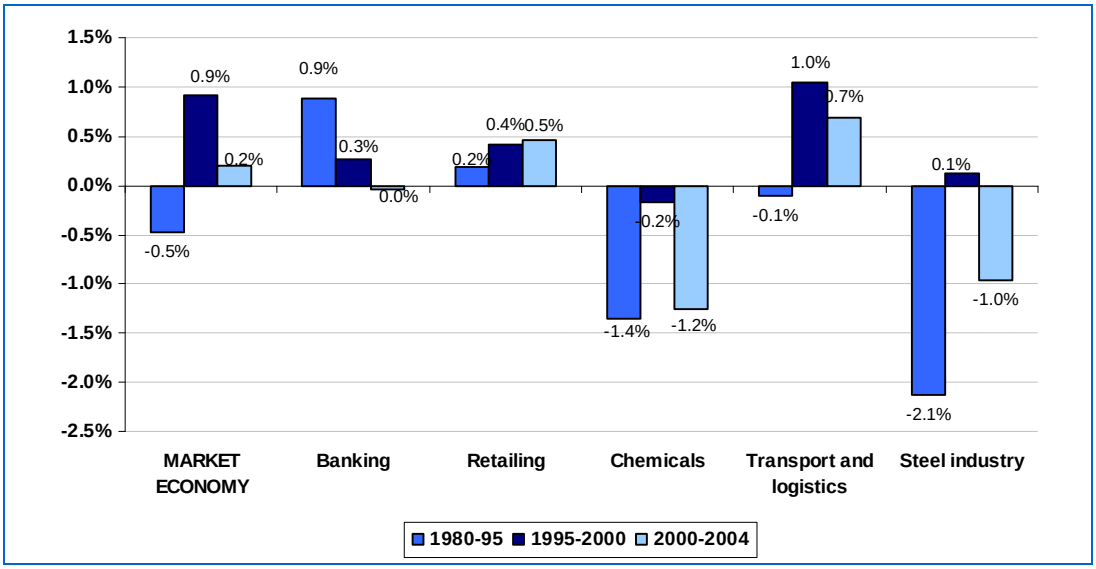
Exhibit 2.3-11 and Exhibit 2.3-12 give an overview on employment developments in the EU 15 (*market economy*) as well as for the five different sectors. In principle, we observe that employment per capita and in total working hours have followed the same pattern, both at the aggregate as well as at the various sector levels. In the entire market economy, employment has increased since 1995 with stronger average growth rates until 2000. At the sector-level, the picture is quite different. In banking, retail and transport and logistics employment levels have been growing during all periods (with the slight exemptions of total working hours in banking since 2000 and in transport and logistics from 1085-95). In contrast, the steel and chemical industries have observed substantial employment reductions, mainly from 1985 till 95 and since 2000.

***Exhibit 2.3-11: Changes in employment levels in the EU-15 (annual average growth rates of total persons engaged, in %)***




Source: EUKLEMS data base, GGDC; own calculation

***Exhibit 2.3-12: Changes in employment levels in the EU-15 (annual average growth rates of total hours worked, in %)***




Source: EUKLEMS data base, GGDC; own calculation

## Labour productivity

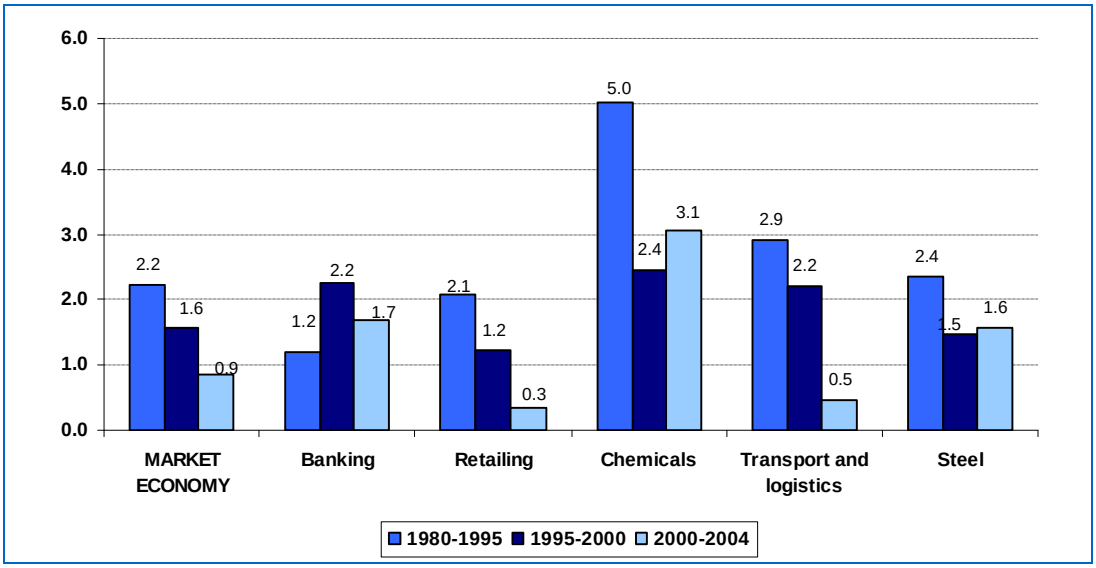
Exhibit 2.3-13 shows the development of labour productivity (defined as gross value added per working hour) for all industrial sectors and service sectors except non-market services[37] (henceforth MARKET ECONOMY) of the EU-15 as well as for five of the six

[37] Public administration, education and health, public administration and defence; compulsory social security, education, health and social work, and real estate activities.

sectors analysed in this report. As above, annual average growth rates are given for the three periods 1980-1995, 1995-2000 and 2000-2004.

As we see, the overall increase in employment as depicted above has slowed down the growth of economy-wide labour productivity in the EU-15 since 1980 from an average of 2.2% per year between 1980 and 1995 down to an average annual growth of only 0.9% since 2000. Generally, this observation is well known (see e.g. van Ark, O'Mahony and Timmer, 2008). Together with strong increases of labour productivity growth as they have been observed in the US since 1995 (Jorgenson et al., 2007) it implies that the gap in labour productivity between the U.S. and the EU is widening.[38]

***Exhibit 2.3-13: Labour productivity growth in the EU-15 (in %, different periods)***




Source: EUKLEMS data base, GGDC; own calculation

Exhibit 2.3-13 also shows that the pattern of labour productivity growth at the sector level has been quite heterogeneous. Specifically, while growth rates for retailing and transport and logistics have slowed down since 1980 in line with economy-wide developments, banking, chemicals and steel show different developments. In particular, productivity levels have even been increasing since 1995 for steel and – in particular – for chemicals. This development has been mirrored by substantial employment reductions that these two sectors have experienced since 1985 (see

[38] The productivity gap between the U.S. and the EU has been observed since the 1960. E.g. van Ark, O'Mahony and Timmer (2008) estimate that in 1960, GDP per working hour in the EU-15 accounted for less than 60% of the respective level in the U.S. Due to stronger productivity growth in the EU, this gap has been almost closing until 1995. Since then, however, labour productivity growth in the U.S. has been accelerating while the opposite has happened in the EU. Consequently, the productivity gap has been widening again. In 2006, van Ark, O'Mahony and Timmer (2008) estimate that GDP per working hour in the EU-15 has fallen back to about 90% of the U.S. level.

Exhibit 2.3-11 and Exhibit 2.3-12).

## Labour productivity change

To analyse the causes for labour productivity change in the five sectors we estimated a stochastic production possibility frontier. As for the growth accounting, the analysis is based on data from the EU KLEMS database, in particular on secondary intermediate inputs as well as on the two primary input factors capital (broken down into ICT and non-ICT capital stock) and labour (measured by working hours, separately reported for high-, medium-, and low-skill categories) for the five different sectors. In this way we were able to estimate sector-specific stochastic production possibility frontiers by using panel data from 1995 until 2004 for different countries.[39]

As a particular specification we employed the error component model (Battese and Coelli, 1992), in which the parameters of a specified production function are estimated while parts of the observed deviations are also explained by systematic differences in technical efficiency across different countries. To ensure constant returns to scale of the production technology output and input variables were normalised by total working hours (TWHs).[40] Thus, the estimated coefficients report the impact that different factor intensities (e.g. intermediate inputs per TWH) have on labour productivity, measured as gross output per TWH. To consider the potential impact of autonomous technical change a time dummy was included as additional variable. The estimation results based on a Cobb-Douglas production function are summarised in Exhibit 2.3-14.[41]

Most importantly, intermediate inputs seem to have a crucial impact on labour productivity. In fact, intermediate inputs are the only factor intensity for which we find high significant coefficients in all five sectors. Moreover, in four out of five sectors (except of banking) the coefficients are also the largest ones, indicating that changes in the use of intermediate inputs per TWH do have the by far strongest impact on the observed variations in labour productivity. To a certain extend, this might simply be due to low degree of substitutability between primary and secondary input factors. Additionally, the high coefficient values can also be interpreted as evidence for a positive relationship between the outsourcing of non-core activities and productivity growth. This finding is clearly supported by the seminal work of Coase (1937) who already argued that outsourcing contributes to productivity growth. As far as the economic potential from the use of ICT is concerned, the important role of outsourcing – reflected by the strong impact of intermediates on labour productivity – is likely to provide a starting point for the beneficial use of ICT systems as they can enable firms to increase labour productivity. This is particularly likely for chemical and steel, where productivity increases have been mirrored by substantial employment reductions, it was discussed above.

In contrast to intermediate inputs, neither the intensity of ICT nor of non-ICT capital per TWH seems to have a consistent and significant impact on labour productivity across the five sectors. Instead, we find sector-specific evidence that ICT capital does matter in some sectors (retailing, chemical, steel) while it does not in others (banking, transport

[39] Due to differences in data availability by country, the different industy samples consist of different countries (see Exhibit 2.3-14).

[40] This leads to an accordingly restricted stochastic production possibility frontier where the real gross production value per working hour is explained by six factor intensities using total working hours as the denominator.

[41] See appendix II for more details on technical specifications. For the econometric estimations we used the Frontiers 4.1 software package (Coelli, 1996).

and logistics). In the light of empirical evidence on the causes of productivity growth in the U.S. such as Jorgenson et al. (2000), who identified rather strong impacts of ICT and non-ICT capital on labour productivity growth, this finding is somewhat surprising. For the case of banking, it also appears to be inconsistent with our findings from growth accounting where we identified ICT capital as the largest contributor to value added growth. At first glance, these results are surprising when compared to most of the discussed literature. However, in contrast to standard growth accounting exercises the SPF estimation is based on much more detailed information. In particular, the analysis uses gross production values including intermediate inputs, rather than gross value added, which only accounts for primary input factors. Furthermore, labour input has been explicitly broken down by skill classes.[42] Hence, the results indicate that probably the direct positive link between ICT-capital investments and labour productivity growth is much weaker than typically suggested in the literature.

***Exhibit 2.3-14: Parameter Estimates of a Stochastic Production Possibility Frontier by Industries (Error Component Models)***

| Explanatory variables | Banking | Retailing | Chemical | Transport and logistics | Steel |
|---|---|---|---|---|---|
| Constant | 0.55 (+)[1] | 0.16 (+) | 0.22 (+) | 0.03 (+) | 0.03 (+) |
| Intermediate Input per TWH[2] | 0.27 (+) | 0.87 (+) | 0.84 (+) | 0.22 (+) | 0.51 (+) |
| ICT-Capital Stock per TWH[2] | 0.06 (n.s.) | 0.04 (+) | 0.02 (+) | 0.03 (n.s.) | 0.07 (+) |
| Non-ICT-Capital Stock per TWH[2] | 0.17 (+) | -0.03 (n.s.) | - | - | 0.17 (+) |
| High-Skilled-WH per TWH[2] | 0.15 (+) | - | - | 0.21 (+) | - |
| Medium-Skilled-WH per TWH[2] | 0.32 (+) | 0.04 (+) | 0.16 (n.s.) | -0.05 (n.s.) | -0.10 (n.s.) |
| Low-Skilled-WH per TWH[2] | 0.03 (+) | - | 0.04 (+) | - | - |
| Time | 0.02 (+) | - | - | - | 0.01 (+) |
| sigma square | 0.04 (+) | 0.16 (+) | 0.15 (+) | 0.02 (+) | 0.02 (+) |
| gamma | 0.93 (+) | 0.98 (+) | 0.98 (+) | 0.96 (+) | 0.98 (+) |
| eta | -0.08 (n.s.) | -0.02 (+) | -0.01 (+) | -0.14 (+) | -0.09 (+) |
| Countries included | EU-12 - Austria, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Spain, Sweden, UK | EU-16 - Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Poland, Slovenia, Spain, Sweden, UK | EU-16 - Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Poland, Slovenia, Spain, Sweden, UK | EU-14 - Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Slovenia, Spain, Sweden, UK | EU-14 - Austria, Belgium, Czechia, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Slovenia, Spain, Sweden, UK |

[1] brackets: + = significant at 95%-level, n.s. = insignificant at 95%-level

[2] TWH - total working hours

Glossary:

- A dependent variable is the one observed to change in response to the independent variable(s), which are deliberately manipulated to invoke a change in the dependent variables;
- The coefficient is a constant multiplicative factor of a certain object;
- A standard error is the estimated standard deviation or error of a series of measurements;
- R-squared refers to the coefficient for determination and is the proportion of variability in a data set that is accounted for by a statistical model.

Source: own calculation

[42] On the contrary, in the growth accounting exercise we only relied on an indicator for compositional changes in the skill-structure of the labour force.

Exhibit 2.3-14 also indicates that only in some sectors labour productivity has changed significantly due to structural shifts in labour composition. In particular, productivity in the banking sector has increased due to larger shares of high-skilled and especially medium-skilled workers. Similarly, the share of high-skilled labour in TWH has significantly increased productivity in the transport and logistics sector.

Finally, we note that we obtained significant estimates for the impact of Harrod-neutral technical change for only two sectors, banking and steel. Since also for these two sectors the estimated coefficient values are relatively small we can conclude that autonomous technical change does apparently not play a substantial role in explaining the observed changes in labour productivity. Again, this observation is somewhat in contradiction to the classical findings of growth accounting, where TFP typically accounts for important contributions in economic growth for at least some sectors (see e.g. Exhibit 2.3-10).

## Summary of sector-level results

In summary, the comparison of results from growth accounting and SPF estimation reveals some surprising insights. Overall, there is a modest direct impact of ICT capital on labour productivity in chemical, steel and retailing, while there seems to be no evidence for transport and logistics as well as for banking. For non-ICT capital, both approaches find significant contributions in the steel sector and a diminishing role in the chemical industry. For all other sectors, the evidence from growth accounting contradicts the findings from SPF estimations. In particular, the former suggests that non-ICT capital plays an important role in retail, and transport, but not in banking. On the contrary, the estimated coefficients of the SPF identify a significant impact of non-ICT capital per TWH on labour productivity in banking, but not in retail and transport. Hence, the results only partially support the hypothesis that ICT capital has become a key element in growth of value added and labour productivity while the importance of non-ICT capital has diminished (Hypothesis P.3).

However, in combination with the previous results at the firm level there appears to be evidence for an indirect impact of ICT capital on labour productivity. At the firm level, regression results for all sectors suggest that firms which use ICT more intensively are also significantly more likely to outsource activities (see Section 2.3.3). At the sector level, the SPF estimation results suggest that only intermediate inputs have a significant positive impact on changes in labour productivity across all sectors (see also Exhibit 2.3-14). As argued above, this can – at least in part – be taken as evidence for that outsourcing contributes to productivity growth. Hence, both findings together suggest that the use of ICT enables firms to outsource activities, which in turn has a positive impact on labour productivity growth at the sector level.

The results from growth accounting do also not allow for clear statements regarding the link between the growth of TFP and the ICT capital stock. The estimation results in Exhibit 2.3-14 identify a significant impact of autonomous technical change only for steel and banking. For the former, ICT capital per TWH does have a significant positive impact on labour productivity as well. Hence, the respective hypothesis (P.4) is confirmed for steel. For banking, growth accounting finds important contributions of ICT capital although our frontier estimations fail to find a significant impact between ICT capital per TWH and labour productivity. Nevertheless, the hypothesis of a strong link in the growth of TFP and the ICT capital stock (Hypothesis P.4) is also confirmed for banking. For the remaining three sectors, the hypothesis is rejected.

Finally, we find evidence for the expected complementarily between ICT capital and medium-skilled labour (hypotheses P.5) only in the chemical sectors and – to a lesser extent – in retailing.

## 2.4 Summary

Exhibit 2.3-15 gives an overview on the results for all tested hypotheses. As the analysis indicates, the nature of relationships between buyers and suppliers does not seem to play an important role in the diffusion of ICT applications. Rather, we find some evidence that increasing competition levels (rivalry) induces companies to use ICT in order to cut costs and look for more innovative ways of conducting business.

***Exhibit 2.3-15: Hypotheses summary***

| | Chemical | Steel | Furniture | Retailing | Transport & logistics | Banking |
|---|---|---|---|---|---|---|
| **ICT adoption, use and diffusion** | | | | | | |
| **A.1**: Rivalry **ó** ICT adoption | no | no | no | (yes) | yes | n.a. |
| **A.2**: Relationships **ó** ICT usage | no | no | no | no | no | n.a. |
| | | | | | | |
| **Innovation** | | | | | | |
| **I.1**: Employee skills **ó** ICT-enabled innovation | yes | yes | yes | yes | yes | n.a. |
| **I.2**: e-collaboration **ó** ICT-enabled innovation | yes | yes | yes | yes | yes | n.a. |
| **I.3**: ICT endowment **ó** outsourcing | yes | yes | yes | yes | yes | n.a. |
| **I.4**: ICT use (infrastr.) **ó** organisational change | no | (yes) | yes | yes | no | n.a. |
| ICT use (software) **ó** organisational change | yes | yes | yes | yes | yes | n.a. |
| | | | | | | |
| **Firm performance** | | | | | | |
| **P.1**: ICT- innovation **ó** turnover | yes | yes | yes | yes | yes | n.a. |
| **P.2**: ICT endowment **ó** market share | yes | no | no | yes | yes | n.a. |
| **P.3**: ICT capital investment **ó** value added growth | no | no | n.a. | no | no | yes |
| ICT capital investment **ó** labour prod. growth | (yes) | (yes) | n.a. | (yes) | no | no |
| Diminishing importance of non-ICT capital | yes | no | n.a. | (no) | (no) | (no) |
| **P.4**: TFP growth accelerated with ICT capital | no | (yes) | n.a. | no | no | (yes) |
| **P.5**: ICT & medium-skilled labour **ó** labour product. | yes | no | n.a. | (yes) | no | no |

Note: the grey shaded cells highlight the hypotheses that have been tested on a sector–wide level.

Once a firm has started to use ICT, employee skills and the intensive use of electronic information exchange systems such as SCM systems increase the likelihood for ICT-enabled innovations. Intensive ICT users are also more likely to change their organisational structure and to outsource non-core activities.

With respect to the impact of ICT use on performance we find strong evidence at the firm level that ICT use is associated with increases in turnover, and some evidence for a similar impact on market shares. At the sector level, these results are much less pronounced. In fact, we find almost no evidence for a direct relationship between ICT capital investment and value added growth, and only modest evidence for a relevant impact of ICT capital on labour productivity (while we find that aggregate labour productivity growth in the EU has even been declining since 1980).

A possible explanation for that the impact of ICT on performance appears to be less significant at the sector-wide than at the firm level could be a lag effect along the ICT

value chain. At the micro level, certain firms assume a leading role in adoption and use of ICT. Those firms are leaders, which seek to secure the benefits of the first mover. Both, the firm-level analysis as well as the case studies (Section 3) demonstrates that ICT use has indeed a positive impact on performance. At the sector level, the assessment is less pronounced. In fact, not all firms within a sector are ICT leaders. Hence, aggregate sector-level information is obviously less pronounced to reveal the full potential of ICT usage. Moreover, the degree to which ICT-induced performance effects, which we observe at the firm level, are also visible at the sector-wide level reveals important information about structural developments in the economy. The more firm-level observations match the results of sector-level analysis, the more we can expect that a majority of firms has already followed up upon the example of their best-performing peers. Against this background, the gap that we observe between firm- and sector-level results seems to suggest that the lack between best performers at the firm level and average performance at the sector level is still rather large. In other words, there appears to be a significant degree of still unexploited economic potential from increased ICT usage.

Finally, we need to stress the observation that we found larger firms to be significantly more likely to intensively use ICT. Given our general results, this also implies that large firms are likely to introduce ICT-enabled innovations more often than small and medium-seized enterprises (SMEs). In other words, this suggests that the gap in ICT use between small and large firms (the so-called digital divide) is widening rather than narrowing down.

# 3 Case studies

The following section provides illustrations of several of the issues discussed above. The case studies have been so selected that individual cases of drivers and impacts of ICT can be observed across countries and sectors. They will be used to further substantiate the results of our analysis. The aim was to get a perspective from both the manufacturing and service sectors and for varying firm size.

The case study on the polish retailer Zabka highlights how a start-up, through the use of ICT, was able to realise its new business model and impact market structure through extended market reach. This supports our finding that intensive use of ICT can help a firm to gain market share (see the analysis on Hypothesis P.2 in Section 2.3.4).

The case study on the steel sector, DanSteel, examines the role of restructuring as a driver of ICT adoption in facilitating value-chain changes. DanSteel made use of an off-the-shelf supply chain management system in order to realise their new business model. It is therefore an example of how ICT enables firms to change their organisational structure and to outsource activities (see the analysis on hypotheses I.3 and I.4 in Section 2.3.3).

The case study on a financial service provider in Switzerland focuses on the link between ICT and innovations. In 2002, the company implemented the Java Application Platform (JAP) which standardised and integrated enterprise applications, resulting in the automation of business processes and the rapid diffusion of product and service innovations. The case study thus illustrates our finding that ICT enables firms to improve corporate performance through product and service innovations (see the analysis on Hypothesis I.2) in Section 2.3.3).

The case study on FORTE Furniture Factories demonstrates how intensive use of ITC enables a firm to develop a leading role in a rapidly growing market. The case study lays out how the use of Electronic Data Interchange has enabled the firm to cut the costs of internal processes and develop relationships with new large business partners. The final case study reports about the experience of two medium-size furniture producers in Poland that intended to introduce ICT systems to better control their workflows and improve communication with business partners. However, due to several structural obstacles none of the two companies eventually went forward with their respective ICT project.

***Exhibit 3-1: Case studies and business examples evaluated in this report***

| Case | Company / project | Sector | Country | Topic(s) |
|---|---|---|---|---|
| 1 | Zabka | Retail | Poland | example of ICT enabling a new business model |
| 2 | DanSteel | Steel | Denmark | example of restructuring as driver of ICT adoption |
| 3 | Financial services provider | Banking | Switzerland | example of ICT-enabled innovation |
| 4 | FORTE Furniture Factories | Furniture | Poland | role of ICT in strengthening competitiveness. |
| 5 | Small furniture producer | Furniture | Poland | internal information exchange |

Source: Sectoral e-Business Watch (2007/08)

## 3.1 Zabka (Poland)

### Abstract

*Founded in 1999 as a start-up, Żabka S.A. is a Polish retail chain. Its business model aims at developing a network of convenience shops located close to customers. The main challenge of the start-up was to efficiently manage a large number of dispersed stores and not to lose the benefits of proximity to customers at the same time. To facilitate this, Żabka implemented a supply chain management tool that allows it to gather information from all outlets and automatically manage the process of inventory replenishment.*

*The case study shows how innovative use of an ICT system facilitated the implementation of a business model organised around the information flow within the network of many small outlets and the distribution centre. By optimal use of ICT, the company was able to enter a competitive market and maintain continuous growth and steadily increase it customer base. This case study provides credibility to the hypothesis that increased ICT use is positively correlated to an increasing customer base.*

### Case study fact sheet

| | |
|---|---|
| *Full name of the company:* | *Żabka S.A.* |
| *Location (HQ / main branches):* | *Poznań, Poland (Headquarters)* |
| *Main business activity:* | *Retail chain, 1800 outlets* |
| *Year of foundation:* | *1999* |
| *Number of employees:* | *250 (Headquarters), 5300 (Outlets)* |
| *Turnover in last financial year:* | *~ 330 million €* |
| *Primary customers:* | *Private consumers* |
| *Most significant geographic market:* | *Poland* |
| *Main e-business applications studied:* | *Corporate management system, market structure, firm entry* |

### 3.1.1 Background and objectives

Founded in 1999 as a start-up, Żabka S.A. is a Polish distribution and retail chain. The firm was established by a team which, in the mid-nineties, also founded and developed Biedronka, a very successful chain of discount supermarkets. As of today, the firm has 1,800 outlets operating in Poland.

When the company was initially established, the retail industry was dominated by two types of retailing models. The first one, the 'neighbourhood' store model, dominated the Polish retailing industry. 'Neighbourhood' stores were independent and managed directly by their owners. Due to their small scale of operations, they served only local customers but their main advantage was convenience and proximity of shopping. The second one, the 'all-in-one' model, was adopted by large retailing chains created by foreign companies such as Auchan or Tesco. These supermarket chains had built a network of stores in major cities and created centralised systems of operations, procurement and logistics. This resulted in large economies of scale and low operating costs. Furthermore, by centralising procurement, large retailing chains gained significant bargaining power,

which enabled them to negotiate low prices and favourable delivery conditions from suppliers. As a result, they gained considerable price advantage over local stores and were able to successfully lure price sensitive consumers away from local shops.

Żabka's business model aimed at combining the proximity to customers of 'neighbourhood' stores and economies of scale of large retailing chains. The company intended to create a chain of convenience stores that would be located close to busy city areas and offer a range of basic products at low prices. The goal was to open 7,500 outlets. In order to achieve this in a short time and without incurring significant up-front costs, the firm adopted the franchising model. Thus, the novelty of Zabka's approach was to merge the elements of both retailing models. The firm aimed at benefiting from the 'neighbourhood' focus and centralisation. The former would give it the flexibility to adapt to local demand. The latter would help it to reduce the cost of operations and procurement. Consequently, the start-up could offer an optimal basket of products in each store at competitive prices.

However, implementing this business model involved some challenges. First, it required the creation of a large network of small shops that would act independently of each other based on local demand information. Second, in order to generate economies of scale, the start-up needed to design and implement a distribution centre that could serve the entire network of outlets all over the country. Consequently, the main challenge was to efficiently manage a large number of geographically dispersed stores and the information flow between them and the distribution centre. This was necessary in order to cater to as many customers as possible. The rest of the case study illustrates how Zabka aligned their overall strategy with their ICT strategy.

### 3.1.2 e-Business activity

The company's founders were aware that the solution to the problems described above was a combination of an innovative organisational structure and the use of an ICT based management tool. The company adopted the vendor managed inventory (VII) to deal with issues of organisational structure. According to the principle of this model, all outlets submit information on individual product sales i.e. demand, inventory levels and order volumes from a central database. The company's management then use this information for both short and long-term order and logistics planning. This includes the selection suppliers, product and volume ordering and distribution. As the company's IT manager, Maciej Kląskała states *'ICT systems and especially ERP/SAP retail, were vital to the company business model and without those the business would have been unable to grow'*. Consequently, aligning IT strategy with the overall strategy was one of the main priorities of the company right from the beginning so as to be as close to customer needs as possible. The rest of the section describes the e-business activities in detail.

#### Solution selection

After analysing the solutions available for the company's line of business, Żabka decided to choose a solution designed for the requirements of the retail industry. As an IT partner, the retail chain selected a local subsidiary of IMG, an international firm specialised in business engineering. The reason behind selecting a large system provider was its experience and know-how in the implementation of corporate management systems in the retail sector. This expertise was particularly important, as Żabka was the first Polish retailer to implement such a solution.

### Implementation phases

System implementation began in mid-2000 and lasted until March 2001. The implementation plan included initialisation, development of business and technical concepts of the system, realisation and the system launch. The project covered the following three areas:

- Logistics
- Sales
- Accounting

The initialisation phase started in July 2000 and a month later, employees who participated in the implementation project began training in system functionalities. The objective of the employee training was to provide the technical know-how necessary to develop a link between the system and the business concept. The business concept consisted of designing business processes and defining tasks and the resulting structure of information flow within the supply and retail chain.

The main problem that Żabka had to overcome was the short implementation time. Due to a tight schedule, the firm had to conduct employee training and the development of business and technical concepts of the system at the same time. Furthermore, since the entire firm was still in the formation phase, there were other projects in progress, which demanded a lot of effort and attention from both the management and employees. Thus, the main challenge was to integrate the various activities, without losing sight of the overall goal.

Today, the central system gathers all necessary data to manage the retail chain and executes all processes in the supply chain. The data comes from the sales points' cash desk systems. The system automatically processes and verifies incoming orders and makes them available to the accounting module. Furthermore, it takes into account inventory levels in both warehouses and outlets. Every day, based on this information, the system triggers the inventory replenishment process. Consequently, the described ERP system links all the outlets with the distribution centre. It creates a communication platform which allows for efficient information exchange which in turn makes resource planning more efficient.

## 3.1.3 Impact

As mentioned above, within a few years the company created a network of nearly 2000 outlets dispersed all over the country and two distribution centres. Furthermore, to optimise its inventory levels and product range, the firm needs to interact with a number of suppliers. Currently, it offers 2500 different products and has to deal with changing demand and customers' preferences. All of this has to be managed within the supply chain, which creates a huge organisational and logistical challenge. Without the supply management system, the firm would not be able to efficiently manage all outlets and, as a result, the entire chain. Mr Kląskała confirms that '*ERP/ SAP system has been supporting all business processes across the company, from data gathering, mining and monitoring to producing analysis vital to decision making across the whole venue'.*

The following factors enable Żabka enterprise to efficiently manage its supply chain and optimise its logistic costs:

- Automatic monitoring of all outlets,
- Up-to-date information on all business processes,
- Centralised data repository,
- Access to consistent information at all supply chain steps,
- Integration of sales operations with the logistics of the entire chain.

The most important goals that Żabka achieved by implementing the system were the automation of the information flow within the company network and the creation of a single information depository. This allowed it to monitor the level of stock in every outlet and, consequently, keep the right amount of reserve stock. This benefits the company in three ways. First, the problem of out-of-stock is very common for retailers and, unfortunately, has serious consequences. Running out of stock leads to sales losses, as the actual demand is not satisfied and customers change to a different store. Thus, efficient and up-to-date information exchange allows Żabka to avoid out-of-stock situations. This, in turn, has a positive effect on sales. Second, maintaining too high levels of inventories might be equally costly as running out of goods. Reserve stock ties up capital and requires storage capacity. Thus, accurate information on actual demand and inventory levels allows Żabka to keep the cost of inventory as low as possible. Lastly, the system helps the retailer chain cope with the complexity of supply chain management. On the whole, all these benefits sustain a business model that gives the retailer a competitive advantage and allows it to grow in a demanding industry.

### 3.1.4 Lessons learned

This case study illustrated how ICT facilitated the implementation of a business model by a start-up in the retailing industry. Based on the example of Żabka's implementation of a supply chain management application, the case study discussed opportunities of implementing an industry solution. There are two lessons that can be drawn from the Żabka case study:

- First, it showed how a company that enters a very competitive industry can secure a solid market position and growth by adopting a novel business model and modern ICT tools to facilitate it. In this respect, Żabka is similar to the case of Wal-Mart. Żabka became within a short period of time an important player in the Polish retail industry. This could have only been achieved by establishing a centralised information system and efficient supply-chain-management practice. ICT allowed Żabka to utilise the proximity to customers and centralisation of operations and procurement operations in order to increase the customer base.
- Second, due to the complexity of processes, the number of involved parties and the vast range of products, collecting, managing and utilising the necessary information in the retiling industry is a challenging task. The case study illustrates how ICT can help firms to cope with the challenges of supply-chain management. In order to optimise reserve stocks and avoid out-of-stock situations. A supply-chain-management application, such as the one deployed by Żabka, enables retailers to turn sequential and linear supply chains into a flexible and efficient supply-chain network. It links a retailer with all supply-chain parties and allows it to

jointly plan and coordinate their activities and optimize their business processes along the entire value-added chain.

### 3.1.5 References

Research for this case study was conducted by Aneta Herrenschmidt-Moller (aneta@hmoller.com), on behalf of the Sectoral e-Business Watch. Sources and references used: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- Websites:
  - Żabka, http://www.zabka.pl (last accessed on 14th of August, 2007)
  - IMG Poland, http://www.img.pl (last accessed on 14th of August, 2007).

## 3.2 DanSteel (Denmark)

### Abstract

*The following case study illustrates how restructuring within a steel company, DanSteel A/S, acted as a driver of ICT adoption. The creation of DanSteel resulted in certain production changes within the company including no in-house steel production, higher standards and requirements for products and a greater dependence on external network partners. In order to realise their new business model, DanSteel invested in an off-the-shelf supply chain management system, the Steel Planner. The system provides complex control of all the processes along the supply chain allowing increased efficiency at reduced costs.*

*This case study provides evidence for the hypothesis that a firm restructuring its operations is able to use ICT to outsource many of its operations and create a collective network of players..*

### Case study fact sheet

| | |
|---|---|
| ■ *Full name of the company:* | *DanSteel A/S* |
| ■ *Location (HQ / main branches):* | *Frederiksvaerk* |
| ■ *Main business activity:* | *Steel Rolling, steel plates production* |
| ■ *Year of foundation:* | *2002 (1940 Danish Steel Works Ltd.)* |
| ■ *Number of employees:* | *408 (2006)* |
| ■ *Turnover in last financial year:* | *~308 Mln €* |
| ■ *Primary customers:* | *International shipping industry, boiler and pressure vessel producers, transport and wind turbine sectors* |
| ■ *Most significant geographic market:* | *Northern Europe* |
| ■ *Main e-business applications studied:* | *Restructuring, supply chain management.* |

### 3.2.1 Background and objectives

DanSteel A/S is a Danish steel rolling company that produces steel plates, boilers, and pressure vessels for the international shipping industry, transport sector and for the wind turbine industry. The company is an extension of Danish Steel Works Ltd. that was founded in 1940 and went in to bankruptcy in the middle of 2002, due to changes in the European steel sector, particularly from consolidation tendencies that negatively impacted the situation of the company. This resulted in foundation of DanSteel A/S that is now 100% owned by NLMK International (The Novolipetsk Integrated Iron and Steel Works).

The foundation of DanSteel A/S was accompanied by significant changes in the profile of the company. DanSteel stopped producing steel in its facilities. Instead, the company receives its inputs from other units of the conglomerate located in Russia and Ukraine. The production of DanSteel is sold almost exclusively to countries in the European Union particularly to Northern Europe.

Generally speaking, there is a strong trend in the steel sector to modernize its processes and to introduce new technologies[43], according to some reports "In order to improve competitiveness, steel industries have no other choice but to permanently upgrade existing facilities". This situation is related to the search for more favourable cost and efficiency in production. These needs have resulted in permanent improvements in the technology of production in steel companies and the ability of companies to be innovative has a significant influence on their financial results.

DanSteel also followed this innovation trend making investments in the modernisation of its production facilities. This change was required not only because of the market situation, but principally by the new conditions after restructuring, namely by the cessation of in-house steel production. The dependence on external units within the conglomerate required high levels of coordination and networking along the whole supply chain. There was a need to have real-time information. Thus, technology was deemed necessary to create a network forming the company, its suppliers and customers. This was the first incentive to change the old technology that supported production.

### 3.2.2 e-Business activity

#### Incentive for restructuring

The old technology was based on an application mainframe provided by a third party company, which in practice meant a strong dependence on the external supplier. According to Mr. Konstantin Makogon, the Assistant Director at DanSteel, "DanSteel needed to be independent from third parties in technology issues". Soon after restructuring (in 2002), the company made investments in technology for its financial operations, stock management and transparency of information throughout the supply chain. These preliminary decisions were the first steps directed to foster the cooperation of the company with their suppliers and clients. However, the key decision took place at the beginning of 2007, when the company decided to stop using the mainframe platform provided by a third company and implement a complex system to optimize its supply chain.

DanSteel has several other reasons to implement the new technology in its operations:

- First, severe competition in the market implied that the company fulfil the requirements of its clients better and delivers products that are strictly in line with customer specifications. This was only possible when transparency and availability of information about customers' needs with regard to quality and quantity of products was assured. This could be achieved only by implementation of an integrated information system that created a link between customer's orders, company's production and the steel procured from foreign countries;
- Second, the trend in the sector to reduce costs caused some pressure to look for technologies that could enable profit from cost advantages arising from certain stages of production or other operations. According to Mr. Makogon, the automation resulting from the implementation of the supply chain management

[43] Source: Erkki Liikanen "The Competitiveness of the Steel Industry in an Enlarged Europe", http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/00/428&format=HTML&aged=0&language=EN&guiLanguage=en.

system was a chance to decrease costs. This could be achieved by limiting discrepancies between the amount of products manufactured and the amount of steel delivered by suppliers, minimizing inventory costs;

- Third, there was a need from the management to have transparency in production and ordering to ensure better planning.

The final phase of the project is planned for the middle of 2008 and its cost (hardware, software and organisation costs) is estimated by Mr. Makogon at about 1 Million Euros.

## Implementation phases

In response to the above mentioned requirements, in April 2007, DanSteel started the implementation of a SteelPlanner – a solution of a company AIS that enables the planning and controlling of production and inventories. The SteelPlanner is a set of applications that supports various functions in a company, e.g. production or inventory management and at the same time provides linking of information and processes within the supply chain achieving information transparency. Such a system is a cross-functional approach that enables data storage about all changes in raw materials, work-in-process, inventory and finished goods from their origin to point-of-consumption. The general purpose of a supply chain management system is to foster trust and collaboration among partners, improve visibility and inventory velocity.

The whole solution includes the following modules: Production Unit Scheduling, Production Control and Planning and Production Management, as it is presented at the graphic below.

***Exhibit 3-2: Steel Planner solution***


Source: www.steelplanner.com

The Steel Planner enables complex production planning beginning from detailed daily plans, through routine daily planning, orders planning, capacity planning to strategic planning. In this way the company's management can effectively track the actual production and compare it with the orders set by customers. Moreover, the modules provide the planning personnel with constant updated information making production and order management easier, more efficient and cost-effective. As a side-effect of the implemented system, quality control is ensured.

The implementation of the SteelPlanner was in response to the needs the company identified after restructuring took place namely that it was going to focus on specific activities while the rest would be outsourced. The SteelPlanner enabled better coordination of processes and provided transparency of information dispersed among the different actors throughout the supply chain to facilitate decision making.

### Steel Planner at DanSteel Today

"The Steel Planner is existent in the whole process of delivering products to our customers", states Mr. Makogon. At one end, the steel plates are delivered from Novolipetsk Steel in Lipetsk according to required quantities calculated by the SteelPlanner based on previous needs declared by customers. Then the mother slabs are checked for dimension and then cut into baby slabs that are further marked with an insert number and test number that are stored in the system and are later used for inventory control. An additional quality checking verifies if the product complies with the standards and specifications to ensure that customer's expectations are met.

The different actors in the supply chain are now provided with one source of consistent data stored in the SteelPlanner system and accessed through certain applications. Through the use of ICT, the discrepancies between all actors in the network can be avoided and some costs can be decreased i.e. inventory costs.

The process of full implementation of the SteelPlanner at DanSteel requires a few more months. As the SteelPlanner is an off-the-shelf product, it requires additional time and effort to adjust to the environment and processes of a certain company. Mr. Makogon also emphasizes the fact that while the company continues with its operations and serves its customers, the transition from one system to another must be done smoothly and carefully in order to minimize a risk of failures and profit from the positive impact that the whole system brings to the company.

## 3.2.3 Impact

The example of DanSteel shows that information and communication technologies bring significant and visible improvements to the company. According to Mr. Makogon, the most important result of the implementation of the supply management system at DanSteel is the fact that the company is capable of serving their customers better and delivering products that are in line with the characteristics that they give. "A better delivery quality at the end of the chain is the most important change that we achieved", Mr. Makogon says. One reason for the higher quality is the transparency of processes that increases the pressure to deliver better products.

The management itself has also greater transparency into the operations and production of the company. The easy flow of information weakens the effect of geographic boundaries and lets the company leaders predict the behaviour of their customers and strategically plan production for the next periods. "These better planning possibilities contribute directly to the ability to deliver products to the market more quickly than before", as Mr. Makogon adds. Thus, the availability of constant updated information allows efficient evaluation of production possibilities to respond to the needs of customers.

The supply management system has also improved the efficiency of production and decreased the level of costs. The net profit has been growing for the last 4 years and the company expects its further increase in 2007, what can be observed in the table below.

***Exhibit 3-3: Financial results of DanSteel in 2003-2006***

| Key figures | 2003 | 2004 | 2004 | 2006 |
|---|---|---|---|---|
| Gross margin (gross profit as % of revenue) | 7,6% | 9,7% | 14,7% | 23,0% |
| Profit margin (operating profit as % of revenue) | negative | 11,0% | 8,9% | 16,2% |
| Net revenue per employee in DKK '000 | 3.578 | 5.345 | 5.564 | 5.958 |
| Average number of employees | 333 | 361 | 383 | 385 |

Source: www.dansteel.com

### 3.2.4 Lessons learned

This case study illustrates how a restructuring process enabled the use of information and communication technologies and brought visible profits to a company that was on the verge of disappearing but was able to recreate itself with a new business model and an ICT solution. The creation of DanSteel resulted in certain production changes within the company including no in-house steel production, higher standards and requirements and higher dependence on external network partners. In other words, restructuring was requiring the company to focus on its core competencies and outsource other activities. In order to realise their new business model, certain supply chain changes needed to be made. DanSteel invested in an off-the-shelf supply chain management system which enabled their new business model. The availability of constantly updated information allowed efficient evaluation of production possibilities to respond to the needs of customers and manage the outsourced functions within the supply chain.

The case study further highlights how such computer networks enable an innovative system where each player is able to concentrate on one specific activity yet be connected through the use of ICT. Restructuring and better application of ICT at DanSteel enabled a stronger customer focus. Thus, the use of ICT greatly reduces transaction and coordination costs allowing the firm to outsource activities and maintain trust, interaction and coordination to meet market demands.

### 3.2.5 References

Research for this case study was conducted by Aneta Nowobilska (aneta.nowobilska@gmail.com), on behalf of the Sectoral e-Business Watch. Sources and references used:

- Interview with Mr. Konstantin Makogon, an Assistant Director at DanSteel A/S, on 18.10.2007
- Quote source: speech "The Competitiveness of the Steel Industry in an Enlarged Europe" by Erkki Liikanen, see http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/00/428&format=HTML&aged=0&language=EN&guiLanguage=en)
- Other sources: http://www.steelplanner.com/
- Websites: DanSteel A/S http://www.dansteel.de.

## 3.3 Financial services provider (Switzerland)

### Abstract

*This case study illustrates the use of ICT in company operations which in turn enabled innovation and new products and services. After the e-business boom, the company implemented an application platform for its applications in java – a technical back-end hardware and software solution to improve company operations. The application platform allows the integration and standardisation of enterprise applications and automates business processes across the company. The solution improved the ability of the company to introduce innovative projects and resulted in the development of key applications. As a result, significantly lower costs and a 20% increase in efficiency were observed allowing the company to improve the quality of its financial services throughout the organisation.*

*Specifically this case study provides evidence for the hypothesis that firms using ICT applications to exchange information are more likely to conduct ICT enabled innovation.*

### Case study fact sheet

| | |
|---|---|
| ■ *Main business activity:* | *Financial Services* |
| ■ *Year of foundation:* | *before 1998* |
| ■ *Number of employees:* | *>45,000* |
| ■ *Turnover in last financial year:* | *~80 bn €* |
| ■ *Primary customers:* | *Private and business customers* |
| ■ *Most significant geographic market:* | *Europe* |
| ■ *Main e-business applications studied:* | *ICT impact on work processes, innovation* |

### 3.3.1 Background and objectives

The company is a one of the leading players in its sector on the international and national level providing institutional as well as retail clients their solutions and services.

The financial sector to which the company belongs experienced many structural changes during the last 10 years, related to a great extent to wider adoption of ICT and the usage of the Internet that "has drastically impacted on the sector and reshaped the competitive scenario"[44]. Since information is a fundamental asset of this sector, ICT constitutes a fundamental element to develop and deliver financial services. The role of the technology has changed within the last decade and become "a major factor in the decision-making process and a principal element in delivering banking services to customers"[45].

"After the flurry of (…) mergers, many banking firms deal with the challenge of decentralised systems, data redundancies and non-standard applications across non-integrated platforms"[46] Indeed, adoption of ICT first appeared in the form of the development of independent applications responsible for a given function and managed

[44] e-Business Watch "The European eBusiness Report", 2002/2003, p. 165.

[45] European Monitoring Centre on Change "Sector future: the future of financial services – changing times", 2004, p. 4.

[46] e-Business Watch "The European eBusiness Report", 2002/2003, p.169.

by a certain person in a company. Commonly, this functional dispersion resulted in inefficiencies in the distribution of resources and redundancies in the processed data. To exemplify, hypothetically a company could have separate applications for their two functions: finance and marketing. These applications would then run on separate servers and could be developed and managed by two separate teams. However, one can deduct that these two applications may have many similar components in terms of programming code implying that these components could be developed only once.

This hidden inefficiency gained importance at the beginning of the 2000 when the so called “e-business boom” took place. At that time, companies facing fierce competition started to look for better means to achieve competitive advantages in the sector. The company also started to look for solutions at the infrastructural level.

It was necessary that the needed solution provides high security and access to multiple applications. The company decided to implement a common unified application platform to provide common services for their numerous distributed applications in the java language. This case study provides an insight into back-office infrastructure that acts as enabler of efficient delivery of innovative products services to customers.

### 3.3.2 e-Business activity

#### Initial stage of the implementation of the application platform

The implementation of the application platform at the company began just after the “e-business boom “and the company‘s IT department was responsible for it. The *integration of diverse applications within one platform* was a strategic decision that turned out to be a great challenge, particularly with respect to personnel resources that, in the initial stage of the project, were still tied to various servers and applications; as well as to difficulties in switching from individual routine functions to the usage of a common platform. According one of the representatives of the company, this choice, even if preceded by a detailed study, was related to some risk. There was namely no comparable solution on the market so it was hard to evaluate the actual results that it could have or learn from mistakes of others.

#### Technology description

The application platform is a *complete environment that serves to develop, integrate, deploy, execute and support for company’s applications*. It consists of architectural guidelines, shared hardware, an integrated tool-chain to automate key processes, as well as a number of services such as system and network management, application development and software engineering support, security services, platform operations and transaction processing[47]. Its fundamental role is to provide connectivity of data sources and complementary systems, so in other words to make the distributed applications work within one platform. This function is supported by the processing of data, storage and management possibilities and features to ensure the quality of data and secure access for all users of the system.

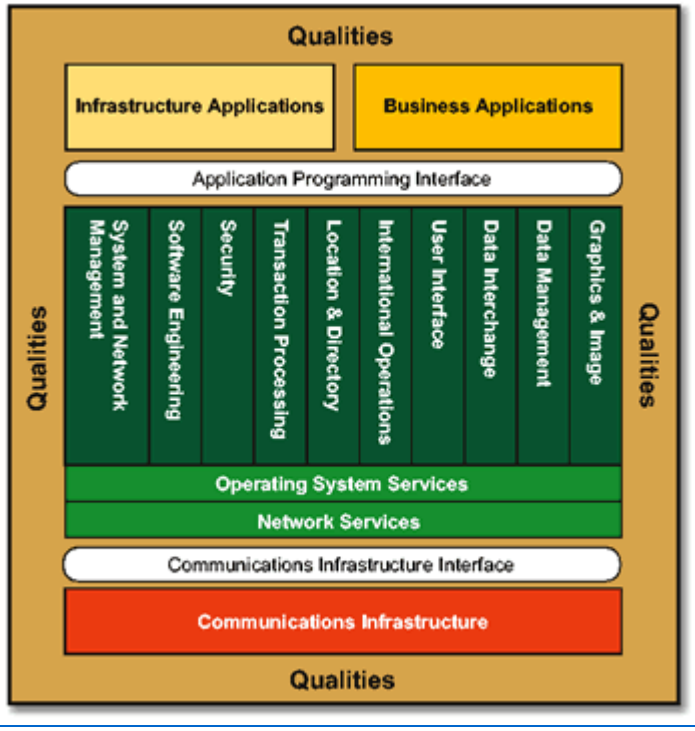
The application platform also includes software engineering and development tools that contain some built-in functions that enable diverse skill levels to productively develop

[47] Open Group “Foundation Architecture: Technical Reference model”, 1999-2006

applications benefiting from the automation of certain processes supported by these tools. This solution further provides advanced security means and models that enable usage of the system by multiple individuals without any threat from external users. The following graphic illustrates key elements of the Technical Reference Model, the most recognized representation of the model and taxonomy of generic platform services. There are three basic levels in the company infrastructure:

- the level of software applications used by employees in functional entities of the organization e.g. financial applications, as well as infrastructure applications that are responsible for the general-purpose business functionality in the company, e.g. e-mail services or presentation software;
- the level of application platform that provides common services for the company's applications, also "defined [as] set of services necessary to support the specific function"[48]; These services aim to support the optimal implementation of the company's business requirements;
- the communications infrastructure – service to provide connections between systems e.g. physical transmission media;
- these levels are connected by two interfaces: application platform interface and communications infrastructure interface that are not significant in this context.

***Exhibit 3-4: Elements of the Technical Reference Model with generic platform services***




Source: Open Group http://www.opengroup.org/architecture/togaf8-doc/arch/chap19.html

At the moment, almost all key applications at the company run on the application platform e.g. the e-business applications and solutions based on VoP (Voice over IP). Basically, about 25% of e-business solutions in java language are based on this platform, which in

[48] Open Group "Foundation Architecture: Technical Reference model", 1999-2006

total makes 150 applications. The number of new introductions doubled after the adoption of the platform and it is seen as a reason that contributes to gains resulting from the competitive advantage.

The next step was to internationalise this solution and implement it in further branch offices of the company.

### 3.3.3 Impact

The introduction of the application platform became an important reason that contributed to the ability of the company to introduce a variety of innovative solutions for its customers.

The application platform proved to bring various benefits:

1. Cost and time-to-money period reduction possibilities due to the fact that use of application platforms significantly shortens almost every phase of the development cycle of applications. As a result new solutions can be launched more quickly and are significantly less expensive than the ones developed as stand-alone;
2. Scalability of applications can be achieved because the application platform forces a standardisation of certain elements. As a result, the solutions are more scalable meaning that they have the ability to more easily adapt to changing environments;
3. Increase of productivity of employees – thanks to the possibility to reuse some elements, employees working on application development can concentrate on the specificity of a project instead of investing their time in re-development of existing components. Such functions like security or fault handling are also dealt with by the application platform;
4. User-friendliness – providing the development of application is based always on the same tools, it is easier for potential clients to use a given application.

The application platform at the company has influenced both the project side and the infrastructure side (operations, engineering). According to one of the representatives of the company, the most significant benefit of this integration of enterprise applications and resulting automation of business processes is the *quality* of operations. As emphasised before, project teams can concentrate on problem-solving issues instead of dealing with repeatable development of elements common for many applications. In-built tools of the application platform guide projects from set-up to production of applications, supporting project managers with ordering, configuration and deployment tasks. This leaves more time to concentrate on the quality of the project. Since the implementation of the application platform, numerous high qualitative e-business solutions have been implemented.

Projects can profit from well-managed, high-quality components developed at *lower cost*. Such issues as security or fault handling do not infer additional costs any more and the complexity of application development is reduced. Re-use of components resulted in shortening the application development life cycle and resulted in *accelerating* the delivery of new products to customers.

These efficiency gains are also derived from the *transparent* and efficient structure of the system architecture based on the application platform. This standardisation allows better

employment of company resources, greater *flexibility* and the ability to react to the changing situation in the market.

### 3.3.4 Lessons learned

This case study illustrated how the use of ICT can result in increased quality, performance and innovation. The company invested in the application platform in order to integrate disconnected applications and platforms across the organisation that hindered the development of both, projects and infrastructure. The application platform provides a common platform and automation which enables the development and maintenance of company applications. Thus, the use of ICT enabled the introduction of more technologically advanced and highly innovative projects. The company was able to launch brand new e-business solutions. These applications are developed at lower cost due to the standardisation and re-use of components from existing applications. All these aspects contributed to a high *quality* of operations and applications that the company was able to achieve through the implementation of the application platform.

This case study provides a clear example for the hypothesis that the use of ICT applications to facilitate information exchange can positively impact company operations through innovative activity i.e. ICT enabled innovations. Innovations occur more frequently as a result of the application platform and allow speedy diffusion throughout the organisation. This is particularly relevant for the financial services sector where e-activity is becoming the norm transcending barriers of time and place.

### 3.3.5 References

Research for this case study was conducted by Aneta Nowobilska (aneta.nowobilska@gmail.com), on behalf of the Sectoral e-Business Watch. Sources and references used:

- Interview with the representative of the company
- Quote source:

  Open Group “Foundation Architecture: Technical Reference Model”, 1999-2006, http://www.opengroup.org/architecture/togaf8-doc/arch/chap19.html.
  - European Monitoring Centre on Change “Sector future: the future of financial services – changing times”, 2004.
  - e-Business Watch “The European eBusiness Report”, 2002/2003.
- Website of the company.

# 3.4 FORTE Furniture Factories (Poland)

## Abstract

*This case study illustrates the impact of ICT on the market structure and competition in the Polish furniture sector. The company studied is perceived as a leader among the Polish furniture manufacturers and furniture exporters. Its strong position in the dynamically developing furniture sector in Poland is the result of intense investment activity supported by consistent implementation of the modern communications and information systems.*

*Recent implementation of the Electronic Data Interchange (EDI) within the company's SAP system is another step in the consistently executed strategy of external and internal communication computerisation. EDI enables standardisation, digitalisation and automatisation of the communication with business partners, which gives the company a competitive edge vis-a-vis its competitors and opens possibilities for collaboration with new partners, especially outside of the domestic market.*

## Case study fact sheet

| | |
|---|---|
| *Full name of the company:* | *FORTE Furniture Factories* |
| *Location (HQ / main branches):* | *Ostrowia Mazowiecka, Poland (Headquaters) and 4 other production sites* |
| *Main business activity:* | *Furniture manufacturing and sales* |
| *Year of foundation:* | *1992* |
| *Number of employees:* | *2300 (in all 5 factories)* |
| *Turnover in last financial year:* | *~ 102 million € (2006)* |
| *Primary customers:* | *Wholesale and retail furniture shops* |
| *Most significant geographic market:* | *Poland* |
| *Main e-business applications studied:* | *Electronic Data Interchange (EDI)* |

## 3.4.1 Background and objectives

Founded in 1992, FORTE Furniture Company is one of the largest Polish furniture manufacturers and furniture exporters. In 1993 FORTE has formed the FORTE Group jointly with German kitchen furniture producer Alno. Today the Group consist of 12 furniture producing and distribution companies, who collectively aim at building a strong position on the Polish and European markets (e.g. Möbelvertieb FORTE GmbH responsible for the German, Belgian and Dutch markets; FORTE Ukraine targeting Eastern European markets, etc.).

The Polish furniture sector has experienced dynamic growth rates in recent years and has doubled its production capacity between 2000 and 2006. Moreover, the sector's contribution to the national GDP is significantly higher than on average in the EU. According to Maciej Formanowicz, the Chairman of the Polish National Chamber of Furniture Producers, the sector will continue experiencing annual growth rates of 10-12% in coming years. Such dynamic development in the sector means growing competition and usually rising prices of key production factors such as wood. That in turn forces

companies to reduce their costs and seek new ways of boosting their competitiveness as well as provides incentives for the expansion onto the new markets.

FORTE is perceived as a clear leader on the domestic market and now focuses its investments on expansion abroad. Domestically the company has an extensive distribution network, providing products to the biggest Do-It-Yourself stores chain, Praktiker, and self-service warehouses chain, Makro Cash and Carry. Exports constitute 60% of the company's overall sales and are focused primarily on Western Europe. In coming years the company's newly opened production sites in Ukraine and Russia are expected to bring increased sales returns in Eastern Europe.

Due to the FORTE's ambitious growth strategy and intensive investment activity, incremental implementation of modern methods of enterprise management is necessary for maintaining long term profitability. In comparison to its competitors the company displays particularly strong commitment to the use of ICT as the main driver of costs minimisation and quality maximisation, for which it has earned considerable level of recognition (e.g. IT Leader Award 1999 for the implementation of SAP system awarded by Computerworld, Golden Laur 2005 for use of advanced IT solutions in the wood, furniture and paper sector awarded by TELEINFO)

The company has been consistently investing in IT and advanced corporate management systems that provide uninterrupted flow of internal and external communication. Currently FORTE operates on the SAP ERP system, which supports business processes from the design stage, through production, up to sales and order control. SAP is the most popular enterprise resource planning software in Poland, particularly often used by the big companies. According to industry research, SAP holds a share of about 35% of the Polish market for IT business solutions (IDC 2004).

In previous years the company has successfully introduced additional modules, such as the OptiTrans logistics system, radio data terminals (RDT) and SAP module for the Warehouse Management (WM), which have furthered helped to reduce the operational costs and improve the quality of the client service. All the subsystems used by FORTE are integrated into the main system using the SAP Business Connector (SAP BC).

The company's IT Manager, Tomasz Krawczuk, explained that through adoption of the Electronic Data Interchange (EDI) the company was determined to reduce the costs attached to the error-occurrence in the information exchange through elimination of human intervention in the process. He further added that some companies were not willing to cooperate with FORTE if it did not have the EDI system. Thus the implementation of EDI can be judged as the result of two parallel trends: firstly, the consistently implemented internal process of the communication automatisation within the company; and secondly, the adaptation process driven by the demands of a growing furniture market and rising expectations of large business partners.

### 3.4.2 e-Business activity

#### Solution selection

The company did not have any legacy systems in place before and therefore needed an entirely new solution to connect EDI with the rest of the system. As it was the case by introduction of the new modules in the past (e.g. by implementation of OptiTrans or WM), FORTE has turned to a professional software developer in order to receive a solution

specifically tailored to the company's needs. The local subsidiary of the International Business Machines Corporation (IBM) has been selected due to its experience and know-how in EDI services. After developing an appropriate IT solution, IBM sold the program to FORTE and now the module is managed exclusively by FORTE.

## Technology description

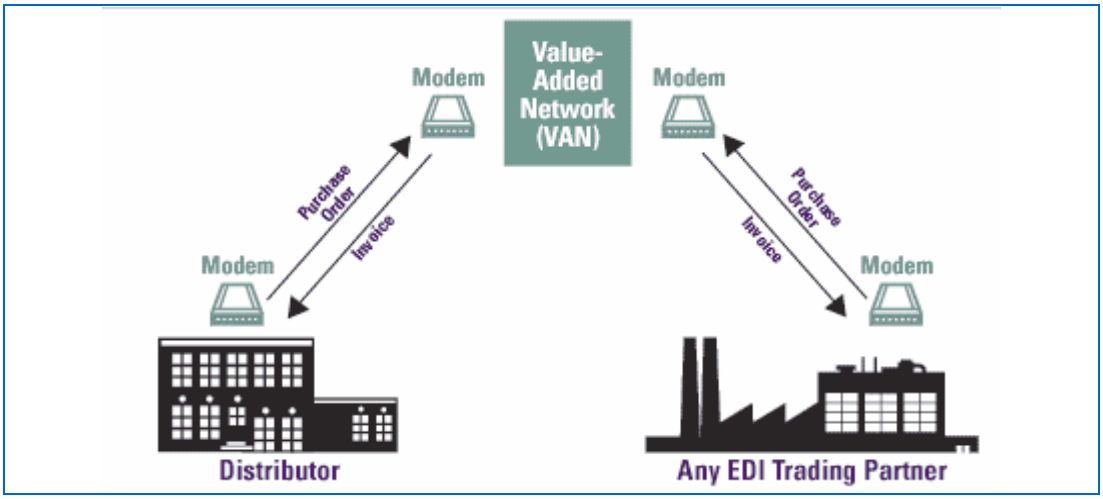
EDI can be formally defined as the transfer of structured data by agreed message standards between computer systems, by electronic means. It allows value chain partners to exchange purchase orders, invoices, advance ship notices, and other business documents directly from one business system to the other, without human intervention.

The essential elements of EDI are:

- the use of an electronic transmission medium (originally a value-added network, but increasingly the open, public Internet) rather than the dispatch of physical storage media such as magnetic tapes and disks;
- the use of structured, formatted messages based on agreed standards (such that messages can be translated, interpreted and checked for compliance with an explicit set of rules);
- relatively fast delivery of electronic documents from sender to receiver (generally implying receipt within hours, or even minutes); and
- direct communication between applications (rather than merely between computers).

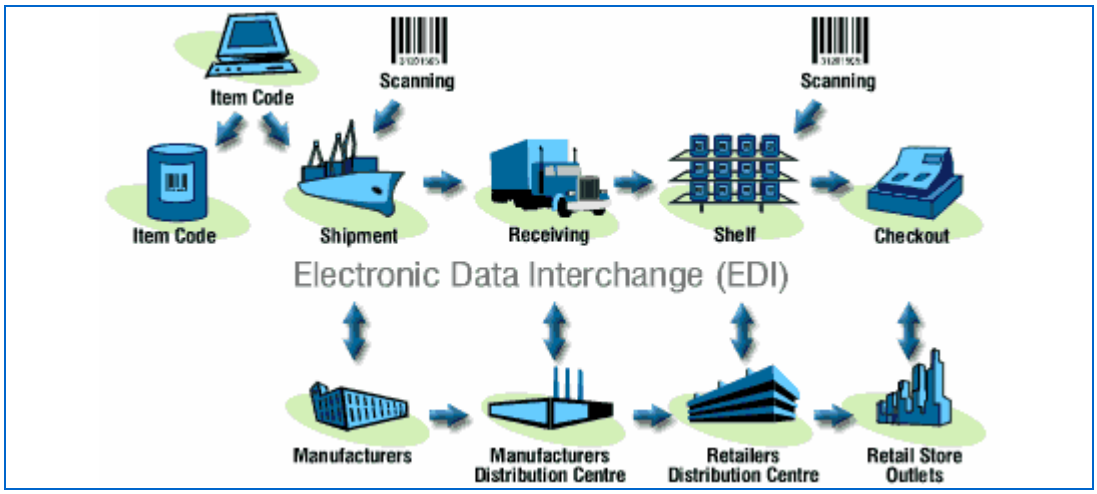
Implementation of the EDI helps the company to improve data accuracy, reduce technical complexity, lower personnel needs, and ultimately accelerate information exchange.

***Exhibit 3-5: Automatic information exchange between business partners thanks to the use of EDI***




Source: http://distribution.activant.com

*Exhibit 3-6: Range of the types of information exchange covered and standardised by EDI*




Source: http://www.globalscorecard.net

### Implementation

The company started planning introduction of EDI in 2005. It took 6 moths to implement the system and it has been fully operational for 2.5 years at the time of preparing this case study.

IBM specialists have worked closely with the FORTE's IT specialists group headed by Mr Krawczuk, while developing the program. Thanks to the involvement of the FORTE's IT specialists in the process, the implementation and operation of the system did not pose any particular challenges as the internal IT unit was aware of all the particularities of the program. The IT unit was than responsible for providing training to the employees that had to operate the system.

Although the costs of the investment were not revealed, Mr Krawczuk highlighted that the investment did not pose significant risk nor imposed excessively high costs on the company, compared to the profits. The expected returns on the other hand were judged to be considerable. Mr Krawczuk has expressed deep satisfaction with the way EDI is operating now and did not see a need for changes in the systems in the foreseeable future.

## 3.4.3 Impact

EDI has had significant impact on the speed and quality of the information exchange between FORTE and its business partners, which further contributed to the company's competitiveness and helped gain new business partners. The areas were the consequences of the introduction of EDI were most visible are:

- **Costs reduction**: due to the high sales turnover inaccuracy in data exchange can significantly raise operational costs. After the communication between business partners has been automatised, errors have been eliminated and the process speeded up. In particular the order-to-money cycle has been shortened and the execution pf payments made easier.

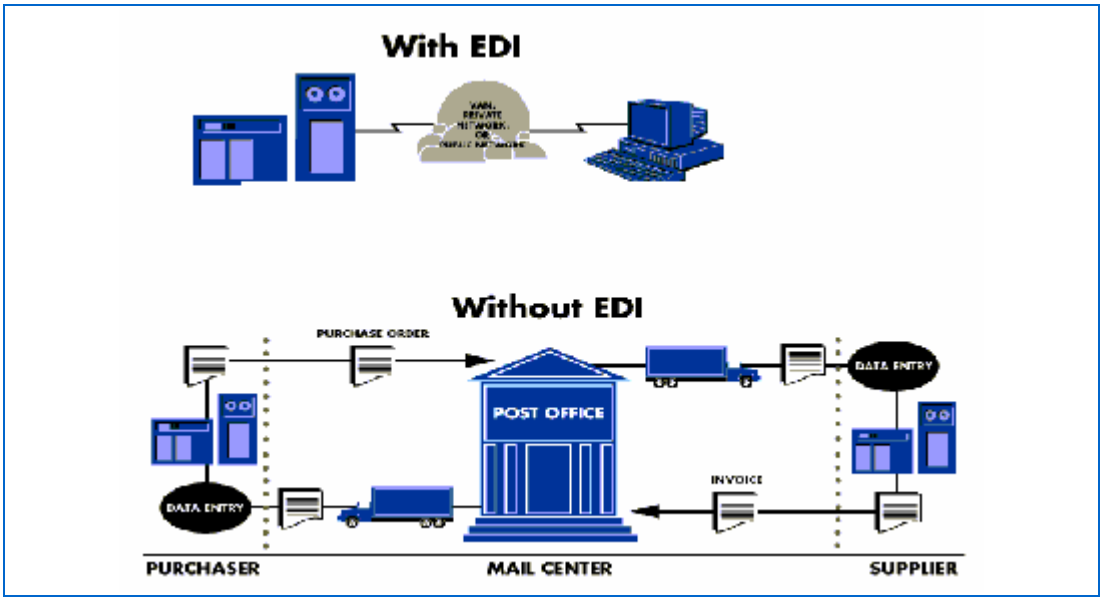
- **Relationship with business partners**: the implementation of the system has eradicated the errors in the data exchange attached to human intervention (invoicing, orders of purchase, delivery forecast, etc.) and reduced overall order-service cycle time. However, not all business partners are involved in the program. The decision whether to include a client or not depends on the purchases volume and character of the relationship with the client. The decisions are made on the case by case basis according to the results of the costs-benefits analysis. One of the most important business partners that have already profited from the EDI with FORTE is Makro Cash and Carry S.A. which might have resigned from further cooperation, if the company failed to introduce the system.

  The introduction of EDI also opened possibilities to collaborate with new business partners. On the very day of the interview with Mr Krawczuk two independent companies have contacted FORTE voicing interest in collaboration based on EDI. The sales driven revenue increased in 2006 in comparison with the year 2005 and the export sales level display an incremental tendency.

- **Work organisation**: the Departments involved in EDI are Sales, Purchases and IT. The introduction of the system required organisational changes within those departments. The employees responsible for the communication with the business partners that is now done automatically by EDI have been transferred to different departments. Although the departments involved have experienced significant labour reduction, the overall number of employees in the company has not changed much.

As EDI is one of many e-business projects that the company is currently using, in itself it did not change the requirements FORTE sets in front of its employees. As the company is undergoing constant computerisation process, a certain level of IT literacy has already been incorporated into the initial recruitment requirements or is being solved through provisional IT training.

***Exhibit 3-7: The impact of the EDI on the communication quality***




Source: www.firstsource-furniture.com

### 3.4.4 Lessons learned

This study has illustrated how a company which operates on a dynamically developing market can use ICT in order to strengthen competitiveness and expand its market share.

FORTE has displayed consistent commitment to the use of ICT as the way to assure the optimality of its operations, high quality of service and competitive position vis-a-vis its competitors. The fact that today FORTE is a market leader in the Polish furniture sector with annually increasing sales returns and optimistic outlooks on expansion abroad proves that ICT can be an important means of assuring sustainable growth in the longer term.

The case further illustrates that companies of a certain size and with considerable market position can no longer refuse to implement modern corporate management systems, if they want to expand further. The demands of the business partners seem to be a driving force for adoption of progressive IT solutions, independently of the company's strategy.

Moreover, the fact that the company did not encounter any significant obstacles during the implementation process or while using EDI proves the importance of experience accumulated through adoption of previous systems. Whereas the initial stages of computerisation of any company bear considerable risk (fixed costs, need of training, unsure results), once that stage is overcome, the risk-profit ratio changes drastically for the advantage of the company.

The company has also used the implementation of EDI as a learning experience that could provide lessons for further work with ICT. According to Tomasz Krawczuk implementation of EDI proved to be a particularly important learning experience for the company's management. Since the implementation of the project the company realised the importance of work in managerial teams and makes more frequent use if it today. Mr Krawczuk further explained that faced with the same situation in future, the company would disseminate information about the project and provide training to the staff earlier, before the actual implementation of the system. That shows the importance of the IT skills and incorporation of systematic IT training into the organisational structures.

### 3.4.5 References

Research for this case study was conducted by Monika Sztajerowska (msztajerowska@diw-econ.de), on behalf of the Sectoral e-Business Watch. Sources and references used:

- Interview with Tomasz Krawczuk, IT Manager of FORTE on 15. May 2008
- Websites:
  - FORTE Furniture Factories website, www.forte.com.pl
  - Article on the Polish furniture sector, 18.03.2008 available at http://www.wirtualnemedia.pl/article/2266359_Wartosc_produkcji_polskiego_przemyslu_meblowego_to_27_mld_zl.htm.

# 3.5 Small furniture producers (Poland)

## Abstract

*This case study illustrates the obstacles faced by SMEs when making the strategic decision about introducing advanced ICT systems. "FAT meble" and "Mebin" are both medium-size Polish furniture manufacturers, exposed to considerable competition due to their relatively small market share in the dynamically developing sector.*

*Both companies intended to implement more advanced information systems, but due to the obstacles which this study will examine, they were forced to either remain operating on the outdated legacy system or implement a different, less optimal solution. Three main obstacles identified are: the insufficient financial capacity, managerial approach towards ICT and the skill requirements on employees for the operation of a more advanced system.*

## Case study fact sheet

| | |
|---|---|
| *Full name of the company:* | *FAT meble* |
| *Location (HQ / main branches):* | *Werblinia k/Pucka, Poland* |
| *Main business activity:* | *manufacturing of upholstery and box furniture* |
| *Year of foundation:* | *1992* |
| *Number of employees:* | *~ 100* |
| *Turnover (last financial year)* | *3 mln €* |
| *Primary customers:* | *Wholesale only: small or medium size furniture shops* |
| *Most significant geographic market:* | *Poland* |
| *Main e-business applications studied:* | *Internal information exchange* |

| | |
|---|---|
| *Full name of the company:* | *MEBIN* |
| *Location (HQ / main branches):* | *Ładzice, Poland* |
| *Main business activity:* | *manufacturing of wall-units and upholstery* |
| *Year of foundation:* | *1994* |
| *Number of employees:* | *300* |
| *Turnover (last financial year)* | *5,5 mln €* |
| *Primary customers:* | *Wholesale and retail: small or medium size furniture shops* |
| *Most significant geographic market:* | *Poland* |
| *Main e-business applications studied:* | *Systematisation of the magazine turnover* |

### 3.5.1 Background and objectives

Founded in 1992, "FAT Meble" is a medium-sized company specialising in the production of upholstery and box furniture based on the high-quality laminated plate as well as semi-finished furniture. The main network of its distributors is located in Poland, although the company is also increasingly present in the Baltic States, Slovakia and Scandinavia. The biggest national partner is "ABRA", a network of 61 furniture shops in 50 different cities across Poland with the headquarters in Cracow, whereas the biggest distributor abroad is the Latvian company 'Manas'. "FAT Meble" could be located on the lower segment on the medium companies' size-scale, although according to the company's management it is still positioned within 100 biggest furniture manufacturers in Poland.[49] The company does not have a well-established market position and is exposed to fierce competition.

Since 2000 "FAT Meble" is using machines produced by the German company "Homag", market leader in the field of machines, plants and systems for the woodworking industry. Furthermore, since 2002 the company is managing the quality according to ISO standards 9001:2000. It seems to prove the company's general commitment to raising the quality of its services and purchasing high-quality equipment, which provides an important insight into understanding the reasons of non-implementation of the advanced ICT system.[50]

"MEBIN" is also a medium size company, however, in comparison to "FAT Meble" it could be positioned in the upper-segment on the medium enterprises size-scale according to the number of employees. Since its foundation in 1994 it is manufacturing wooden chest-units and upholstery and is a recognizable brand on the domestic market. Company's main distribution channel consists of an extensive network of various retail shops in Poland as well as the company's own furniture shop located in the same building as the manufacturing unit, which serves to needs of the individual clients. Mebin has also numerous business partners abroad and sells its products primarily to Central Eastern Europe: Hungary, Czech Republic, Germany as well as to Russia.

Both of the companies tend to develop long-terms relationships with their clients and suppliers. Some of the partnerships exceed 15 years and date back to the companies' start-up. Common qualities of both SME that would increase the propensity to implement an advanced ICT system:

- A relatively wide distribution network
- Business partners abroad
- Long-term relationship with the business clients
- Competitive environment within a dynamically developing sector.

[49] SME definition is understood as stated in the Commission's Recommendation 2003/361/EC from 06.05.2003.

[50] The fact that modern machinery for furniture manufacturing contains significant embedded ICT is not specifically analysed In this case study.

### 3.5.2 e-Business activity

#### Current ICT situation

**FAT Meble:** the company is currently operating on a Polish program called "Subjekt", which is a simple program keeping the record of quantitative changes in the magazine stock, number of manufactured products and the products ready for sale. The program has been implemented as a substitute for an ERP system that the company wished to implement, but did not have sufficient financial resources to do so. Four departments are currently using the system: Production, Magazine, Sales and Accounting. "Subjekt" has facilitated the internal documents circulation, reporting within the company and in particular the work of the Accounting department.

**Mebin:** Despite the use of the common telecommunications methods such as mails, faxes or coordinated phone network (with internal numbers), there is no systematic use of e-business in which clients, partners or suppliers would be involved. Usually there is one person responsible for a particular segment, such as a magazine, and is reporting about the current needs of the unit, making the orders by phone or email when necessary. Company's employees use Intranet, which enables relatively quick communication and easier documents sharing between the departments. The implementation of the internal information sharing system has speeded-up invoicing, however, as confirmed by Pawel Purola, company's IT Manager, it is a very simple program and did not lead to any significant efficiency improvements or organisational changes.

#### Plans and perceived gains

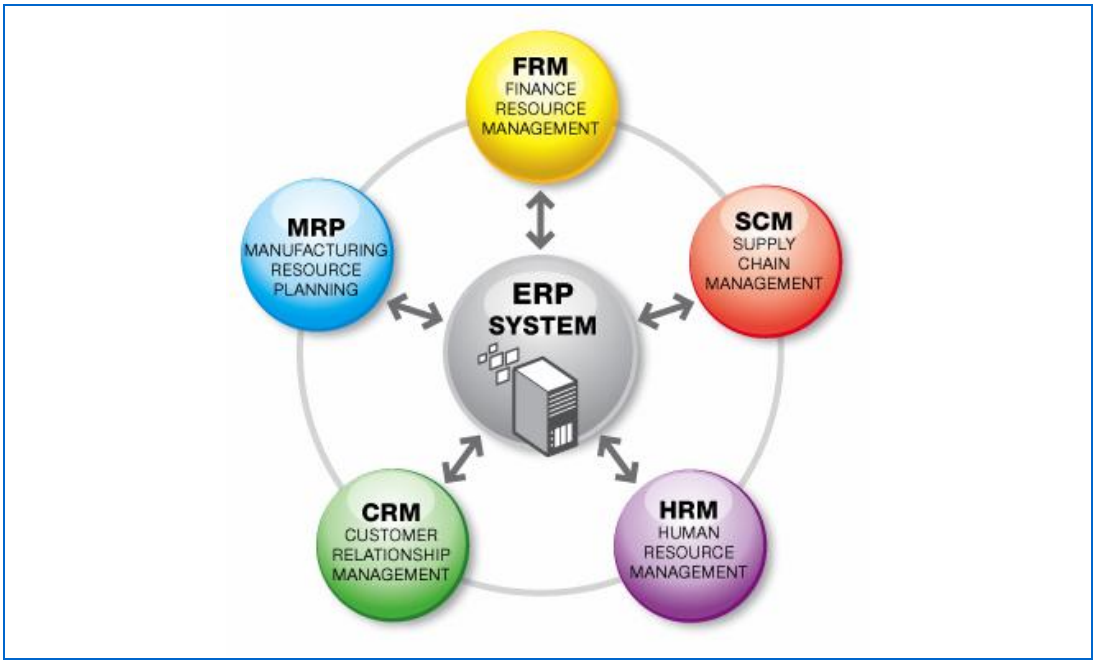
Both companies were planning to implement more advanced systems than those in place at the time of conducting the interview. FAT Meble intended to implement the Enterprise Resource Planning system (ERP) and Mebin a new Warehose Management system (WM).

Mebin intended to introduce a WM programme in order to systematise the control of the magazine turnover. Automatisation of the process could help reduce the error occurrence, reduce in-process inventory and improve the quality of communication with the suppliers. FAT Meble wanted to introduce an ERP system to integrate application programs covering all facets of the business, including planning, manufacturing, sales and marketing. This integration is accomplished through a database shared by all the application programs.

Some of the key traits of ERP system-integrated solutions are:

- They use unified databases to store data for all system modules (transparency coordination, control)
- They are modular, e.g. manufacturing, supply chain, customer-relationship management, human resources, warehouse management, decision-support systems (greater potential for further expansion through add-ons or outsourcing)
- Through internal coordination they facilitate external coordination and allow companies to reach to their suppliers, customers, and partners.

*Exhibit 3-7: Structure and functioning of the ERP system*




Source: www.extol.com.my

As discussed above the implementation of an ERP system leads to communications standardisation and central coordination, which can help to identify the inefficiencies and boost productivity, enable innovation and outsourcing and improve the relationships with the business partners.

## Obstacles

The key reasons for the non-implementation of the more advanced systems that have been identified through the interviews with the IT Managers of both companies are:

**Insufficient financial resources in relation to the perceived gains from the system implementation**

In case of FAT Meble, due to the high software and implementation costs (paralleled by lack of external financial assistance) the company had to resign from the implementation of a newer and better fitted to the company's specific needs program and buy a cheaper substitute ("Subjekt").

The introduction of the ERP system would involve substantial investment: software costs (60,000€) and implementation costs (15-20,000 €). The company has applied for an EU grant aiming at boosting competitiveness of SMEs within the new EU Member States, but its application has been rejected. The company's management has not been supplied with the reasons for rejection. According to the FAT Meble's IT Manager, other companies that FAT Meble has personal contact with did not receive the grant either.

Faced with the rejection of its grant application, the company decided not to invest in the advanced ICT system at the normal market price, but buy a cheaper but less effective substitute and expand its manufacturing base instead.

**Management's approach towards ICT as the competitiveness driver**

Both IT Managers have explained that investment in the expansion of ICT does not lie on the top of the management's agenda. When faced with the choice to invest in the expansion of the manufacturing unit, the work on ICT has been postponed.

The rationale behind such differentiation between ICT and other investment priorities lies in the fact that the effects of the ICT investment are visible only in the long-term, whereas the implementation requires deeper reorganisation of the employment structure, also including the skills requirements set in front of the employees. Mr Czyzewski mentioned that the managerial circles tend to share the perception that is it easier to control and improve the efficiency of the low-skilled worker working at the manufacturing unit than introduce an entirely new type of employees into the company, which may also have greater requirement from their work place.

As we have observed on the example of FAT Meble only additional financial assistance (as in the form of the EU grant) could have persuaded the management to invest in more advanced ICT solutions.

**Employment constraints**

Both IT Managers have highlighted that apart from the overall financial constraints of the SME, the managerial decision about the non-investment in the advanced ICT system has been driven by the costs attached to the organisational restructuring. Whereas the expansion of the manufacturing unit does not change the skills required from the employees, the ICT development would force the company to either change a considerable part of its personnel or invest time and money into additional IT trainings

### 3.5.3 Impact and lessons learned

Information and communication technology (ICT) introduces opportunities for enhancing effectiveness of the production activity at each project phase as well as creates new business opportunities, which is particularly important for the companies operating within the dynamically developing market sector, such as furniture sector in Poland.

This case study has illustrated the standard ICT implementation decision process within a SME using the example of two different medium-size furniture manufacturers in Poland. The interviews with the IT managers of both companies have helped to identify three main obstacles impairing the implementation of advanced ICT systems: insufficient financial capacity, managerial approach towards the ICT use and the employment requirements for the operation of a more advanced system. In order to address those problems, there are three main areas that would require greater attention.

**Financial Assistance**

As the Case of FAT Meble illustrates, the SMEs are willing to implement more advanced but costly ICT systems when supported with external financial help. Although there are grants available within the institutionalized frames of the EU assistance to the SMEs, greater attention should be given to the assistance throughout the application process. There is the need to make clear the exact requirements set in front of the applicants, provide assistance in filling in the forms to avoid unnecessary procedural mistakes and supply the companies with the reasons for the application rejection do avoid discouraging them from applying in the first place. Only a transparent application and feedback

process can assure that the available financial resources will reach their potential beneficiaries.

**Disseminating information about the successful ICT use**

Both case studies have showed that the assessment of future advantages and return on investment in ICT are not tangible enough to motivate the SMEs' management to adopt advanced systems and commit themselves to the risk attached to additional investment. A lack of well-known success story in the ICT implementation may explain the reticence of the decision makers. A better understanding is needed about the impact of ICT on the company's efficiency and competitiveness, which would encourage the management to see the long-term results as equally valuable, if not more sustainable. Dissemination of information about the best practices in the sector could help encourage the management to reevaluate their investment priorities for the advantage of the ICT use.

**Incorporation of the IT culture into the company**

Both cases show that there is no well-grounded IT culture within both companies that would facilitate the implementation of the increasingly complex ICT systems, despite their overall commitment to use of advanced manufacturing technologies and steady improvement of the service quality. Lack of the IT skills on the side of the employees are one of the reasons behind the management's relative unwillingness to invest in ICT as the system implementation would require provision of additional training or restructuring of the whole sectors of the company. Therefore more focus should be placed on achieving a manageable level of IT literacy among the employees as well as work with the management to accommodate their fear of restructuring the company in favour of the high-skilled personnel.

### 3.5.4 References

Research for this case study was conducted by Monika Sztajerowska (msztajerowska@diw-econ.de), on behalf of the Sectoral e-Business Watch. Sources and references used: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- Interview with Mr Robert Purola, IT Manager of Mebin, 8. May 2008
- Websites:
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  - Mebin website, www.mebin.pl
  - Article on the Polish furniture sector, 18.03.2008, available at http://www.wirtualnemedia.pl/article/2266359_Wartosc_produkcji_polskiego_przemyslu_meblowego_to_27_mld_zl.htm.

## 3.6 Summary

This Chapter provides some real-life illustrations of issues discussed in Chapter 2. The main findings are consistent with the key findings of the empirical analysis. Two large firms, two medium-sized ones and a small firm were considered in this analysis. They covered the sectors retailing, steel, banking and furniture and thus, considered manufacturing as well as services sectors. The following provides a point-wise synopsis of the main findings in the case studies addressed.

- **ICT enabled business model**: The Zabka case study examines a start-up in the retailing sector. ICT allowed Zabka to enter the polish retailing market and steadily increase its customer base in this market. This case study provides an illustration as to how ICT can influence market structure, where ICT-enabled new business models allow firms to enter or leapfrog existing market innovators. It also provides credibility to the hypothesis that increased ICT is positively correlated with an increasing market share.
- **Restructuring as a driver of ICT adoption**: The DanSteel case study examined how restructuring in a company led to smaller and leaner firms that make use of computer networks to facilitate their operations through outsourcing. In this case restructuring was the driver in adopting ICT. The case study also provides an illustration of how the use of ICT in manufacturing streamlines the operations of a firm and increases their need to turn to the market to outsource their activities.
- **ICT-enabled innovation**: In this case study, a large financial services provider invested in ICT applications in order to facilitate the integration and standardisation of enterprise applications and automate all business processes across the company. This in turn enabled innovation within the bank including e-banking, telephone banking and so on. This case study illustrates how firms that invest in ICT applications aimed at information exchange are likely to introduce ICT enabled product and service innovations.
- **ICT use to strengthen competitiveness**: Since its foundation in 1992 FORTE Furniture Factories has become the leading producer on the rapidly growing Polish furniture market as well as an exporter to Western and Eastern Europe with increasing sales volumes. The case study illustrates how ICT usage has supported the firm in realising this position. In particular, the introduction of an Electronic Data Interchange System has enabled the firm to cut costs resulting from errors in data exchange, develop and deepen relationships with business partners, as well as to alter its work organisation.
- **Barriers to ICT use for small companies**: The fifths case study demonstrates that small companies still face significant barriers to adopt ICT. For the case of two Polish furniture producer, the most significant obstacles where financing, uncertainty concerning the impact that ICT might have on company performance as well as the need to recruit new personnel with specific IT skills.

# 4 Conclusions, key findings and policy implications

This report presents an empirical analysis for the economic impact of ICT on selected sectors in the EU. The central premise of our analysis is that the use of ICT as such does not affect the performance of firms, but that it enables them to improve labour productivity, rethink and improve processes and develop new products. Hence, ICT is understood to be an enabler for innovation and productivity increases.

Based on this central assumption we analyse the impact of ICT along an *ICT value chain* consisting of three main elements:

- First, firms need to **adopt ICT** and intensify the degree to which they **use** it;
- Second, ICT enables firms to **innovate** new products and processes as well as to change their organisational structures;
- Third, ICT-enabled innovations lead to improved **performance**, e.g. higher turnover and productivity levels.

For each of the three steps we have developed a number of hypotheses on the importance of specific firm and market characteristics. In particular, **ICT adoption and use** are expected to be correlated with structural characteristics of individual firms, such as the size, age or national specificities, or with the degree of competition on the markets in which a firm operates. The ability of a firm to deliver **ICT-enabled innovations** is expected to depend on structural characteristics or the availability of specific labour skills. Finally, we expect that ICT-induced changes through innovations improve **firm performance** indicators such as productivity, turnover or value added.

All hypotheses were tested empirically for six different sectors, banking, retailing, chemicals, transport and logistics, metals and furniture producers. The hypotheses on ICT adoption and innovation, which aim at understanding the constellation under which firm-level decisions are taken, were analysed based on information from a survey of firm-level decision-makers from five industry sectors in nine EU countries and the USA on the use of ICT and e-business (e-Business Survey 2007). In contrast, the hypotheses on the impact of ICT on performance were tested based on both, firm-level and sector-level data. In this way we can analyse not only the impact that ICT has on the performance of particular firms, but also on sector-wide developments.

## 4.1 Key Findings

The main findings of this study can be summarised as follows:

- Increasing levels of perceived competition induces companies to use ICT in order to cut costs and look for more innovative ways of conducting business. By contrast, there appears to be no evidence for the hypothesis that close and long-term relationships between buyers and suppliers play an important role in the diffusion of ICT applications.
- Once a firm has started to use ICT, employee skills and the intensive use of electronic information exchange systems such as SCM systems increase the likelihood for ICT-enabled innovations. Intensive ICT users are also more likely to change their organisational structure and to outsource non-core activities.

- Regarding the impact of ICT use on performance we find strong evidence at the firm level that ICT use is associated with increases in turnover, and some evidence for a similar impact on market shares.
- The positive impact that ICT use has on turnover and market share as well as on costs and labour productivity is also supported by different case studies. Specifically, the examples of a Danish steel firm, a Polish retailer, a Swiss bank and a Polish furniture producer all report that ICT use has helped reducing production costs and increasing output quality.
- However, these results are less pronounced at the sector level. In fact, we find almost no evidence for a direct relationship between ICT capital investment and value added growth, and only modest evidence for a relevant impact of ICT capital on labour productivity while we even find that aggregate labour productivity growth in the EU has been slowing down since 1980.
- Sector-level results suggest that only changes in intermediate inputs have an important impact on labour productivity changes across all sectors. Together with the previous finding that outsourcing activities increase with the intensity of ICT use by firms, this illustrates how ICT usage enables firms to increase labour productivity.
- Observed differences in the impact of ICT on economic performance at the firm and sector level seem to be due to a lag effect. At the micro level, certain firms assume a leading role in adoption and use of ICT. Those firms are first movers, which seek to secure the benefits of the first mover. At the sector level, the assessment is less pronounced since not all firms within a sector follow immediately. Hence, the aggregate information for all firms seems to suggest that the effect of ICT on performance is much weaker. In fact, the degree to which firm-level and sector-level results deviate indicates to which extent ICT is used by a small number of innovative firms rather than by the majority of companies in the sector. Against this background, the observed differences in this study seem to suggest that there remains a significant degree of still unexploited economic potential from increased ICT usage.
- Finally, we find further evidence that large firms are significantly more likely to use ICT than SMEs are. Given our other key findings, this also implies that large firms are more likely to introduce ICT-enabled innovations more often than their smaller competitors. In other words, this implies that the gap in ICT use between small and large firms (the so-called digital divide) will increase rather than narrowing down.

## 4.2 Policy implications

Because the decision to use or not use ICT is taken at the firm level, policy initiatives should target areas in which market failures may occur, such as issues related to research, development and technology transfer, knowledge and skills development, network effects, standardisation, and environment protection. Also, policy recommendations should be based on empirical evidence which demonstrates its actual need. This report provides such evidence based on econometric analyses at the firm and sector level as well as on case studies.

As summarised above, firm-level results suggest that ICT usage does have a significant impact on company performance, in particular by enabling different types of innovations. However, at the sector level a statistically significant impact of ICT usage on performance indicators such as value added or productivity can not be observed, at least not for all sectors. While this is at first surprising, several observations suggest it might be due to a lag effect where a smaller number of advanced firms already uses ICT with significantly positive results while the larger number of other firms lags behind. It hence appears that in order to strengthen the sector-level impact of ICT on economic performance, policy makers should focus on stimulating further ICT uptake. In this respect, the study identifies the following three key objectives for policy measures:

### Improve and adjust the education and training of e-skills

In a knowledge-economy driven by rapid technical change the ability to empower the work force through appropriate training and skill-formation is of crucial importance. The findings of this study demonstrate that firms with large shares of employees with higher university degrees and/or specific IT- skills are more likely to realise ICT-related product- and service innovations. Naturally, this requires and incentivises individual firms to invest into appropriate training and skill-formation of their employees. However, in a liberal market environment with flexible labour markets, co-operations between industry, governments and education institutions are likely to have a more effective leverage on the development and improvement of e-skills. The intended measures should focus on supporting the education of ICT professionals and users by developing innovative curricula in ICT training and promoting these training schemes among young people to attract talent. Inter alia, this includes:

- To improve the quality and business-relevance of education through specific development programs for teachers and ongoing teachers;
- To stimulate and allow for closer – preferably international – co-operations between universities and industry to promote research and development networks;
- To design new EU-wide training certificates and education degrees according to the needs of the industry;
- To promote the development of EU-wide quality criteria for e-skills training and certificates.

In addition, the study results also show that skill requirements differ substantially across sectors. Thus, industry-specific approaches should be considered as well. In this way, the specific skill requirements could be most effectively identified and the required education and training be promoted.

## Stimulate ICT adoption by SMEs

SMEs – the strong engine for growth and innovations in EU economies – are found to be significantly less likely to use ICT. While it is well known that SMEs lag behind in ICT adoption (see e.g. e-Business Watch, 2006), the study results imply that for this reason, SMEs are also less likely to benefit from ICT-enabled productivity increases and innovations.

Given the importance of SMEs for the EU economies, this result has far reaching implications. In particular, it is unlikely that labour productivity growth in the EU – which is found to be clearly below the levels observed in other economic areas like the U.S. (see e.g. Jorgenson et al., 2007) – will pick-up by itself, e.g. due to developments of European business cycles. Against this background, a key policy objective should be to stimulate ICT adoption by SMEs and to motivate the integration of SMEs into digital value chains.

While the strength of SMEs lies in the flexibility with which they can adjust towards changing market conditions, their small size makes them less capable to deal with developments that induce high up-front costs. For the case of ICT, this does not primarily mean the costs of investments in hard- and software, since competition on the respective markets keeps them at economically reasonable levels. Rather, it addresses the costs of gathering additional information which SMEs lack. In particular, small company size typically requires managers of SMEs to focus almost exclusively on operative activities.

Hence, little time remains for strategic planning and thus, new issues that require substantial up-front information are difficult to deal with. Accordingly, a policy to support the ICT adoption of SMEs should focus on informing inform managers and entrepreneurs about the effects and sustainability of e-business technologies. Ideally, this should be done in multi-national co-operations between governments, industry representatives (e.g. chambers of commerce) and the ICT-producing industry. For example, the establishment of networks of excellence between public research institutions, industry associations and companies could be supported to facilitate a transfer of knowledge about ICT and e-business practice.

Furthermore, SMEs could be supported by encouraging entrepreneurship through appropriate training (in coordination with the policies to improve and adjust education and training of e-skills), harmonization of data exchanges and standards that would push more firms (including SMEs) towards using more ICT, or through digital value chain projects that stimulate the electronic cooperation of different firms.

## Create fully integrated common markets

Despite significant efforts and progress, European product and factor markets are still not fully integrated. Instead, various institutional and structural impediments prevail. For example, key product, service and financial markets such as banking and financial services, telecommunications, or energy are governed by specific – and in part even overly rigid – legislation which differs in almost all Member States. Moreover, numerous structural impediments like differences in educational degrees and – even worse –

exemptions from fully integrated labour markets for new Member States, or differences in national wage formation and social standards, all hamper full labour mobility in the EU.[51]

It is commonly argued that all of these impediments and rigidities limit the usage of ICT (see e.g. van Ark, Inklaar and McGuckin 2003). The analysis in this report further substantiates this observation and its implication on firm performance. For example, several case studies demonstrate that the need to harmonise and standardise supply chain and quality management as well as information exchange across firms are key reasons for using ICT-based systems. In turn, the empirical evidence suggests that this enables firms to implement new organizational structures and ICT-enabled innovations and to benefit accordingly. In practice, however, strong market fragmentations and the existence of different national legislations and regulations make it more costly for firms to expand their reach and enter into specific ICT-based relationships with companies in other EU Member States, to change and adjust their organizational structures, or to enter into new markets which ICT would enable them to do. In fact, given the numerous country-specific regulations and impediments, companies cannot simply develop and implement uniform strategies and solutions at a European scale. Rather, they need to adjust their operations for various country-specific differences.

Hence, what is called upon is strong additional effort and progress in the creation of liberal and truly integrated product and factor markets. While this has been a predominant objective of the EU commission for many years, its implication has been repeatedly slowed down by various types of political resistance. As a result, empirical evidence still suggests that different markets of EU Member States are not yet sufficiently enough integrated with one another.

Admittedly, all objectives have already been on the policy agenda of the EU commission for a long time. Nevertheless, the findings of this analysis clearly show that there remains a long way to go until those objectives are fully implemented in reality. Hence, more consolidated efforts along the lines suggested here are necessary. The evidence shown in this report should also be used in political discussions to substantiate the need for market integration, improvements in education and SME support, as well as to demonstrate the costs of not-acting.

[51] Arguably the most comprehensive source of evidence for this assessment is the website of the EU commission which includes specific reports on the state of single market for goods, services labour and capital.

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# Annex I: The e-Business Survey 2007 – methodological notes

## Background and scope

The Sectoral e-Business Watch collects data relating to the use of ICT and e-business in European enterprises by means of representative surveys. The e-Business Survey 2007, which was the fifth survey after those of 2002, 2003, 2005 and 2006, had a scope of 5,325 telephone interviews with decision-makers from five industry sectors in nine EU countries and the USA. Interviews were carried out from August to October 2007, using computer-aided telephone interview (CATI) technology. The overall survey was divided into four separate projects (each with a different questionnaire), which focused on different sectors and specific topics (see Exhibit A1-1). This document contains methodological notes for Projects 1 and 2, which accounted for 4,369 of all interviews conducted.

***Exhibit A1-1: Components ("projects") of the e-Business Survey 2007***

| Survey project | Focus | Sectors covered | No. of interviews |
|---|---|---|---|
| 1 | e-Business in manufacturing | - Chemical, rubber and plastics<br>- Steel<br>- Furniture | 2121 |
| 2 | e-Business in retail, transport & logistics | - Retail<br>- Transport & logistics services | 2248 |
| 3 | RFID adoption | - Manufacturing sectors<br>- Retail<br>- Transport services<br>- Hospitals | 434 |
| 4 | Intellectual Property rights in ICT SMEs | - ICT manufacturing<br>- ICT services<br>- Software publishing | 683 |

## Questionnaire

The questionnaires for Projects 1 and 2 contained about 70 questions which were structured into the following modules:

- A: ICT Infrastructure and e-Business software systems
- B: Automated data exchange (Project 1) / e-Business with customers and suppliers (Project 2)
- C: e-Standards and interoperability issues (Project 1)
- D: Innovation activity of the company
- E: ICT Skills requirements and ICT costs
- F: ICT Impacts, drivers and inhibitors
- G: Background information about the company

Some of the questions were the same or similar to those used in previous surveys, in order to be able to observe trends (notably in sectors that had been surveyed before, such as the chemical and retail industries). Other questions were newly introduced or substantially modified, in order to reflect recent developments and priorities. A special focus in this survey was to assess the degree of process automation in companies, i.e. to

what extent paper-based and manually processed exchanges with business partners are substituted by electronic data exchanges. Some questions were filtered, for example follow-up questions which were only relevant for companies depending on their answer to the entry question. No open questions were used.

The questionnaires of all e-Business Watch surveys since 2002 can be downloaded from the project website (www.ebusiness-watch.org/about/methodology.htm).

## Population

As in 2005 and 2006, the survey considered only **companies that used computers**. For the first time, a cut-off was introduced with regard to company size: in Project 1 (manufacturing), only companies with at least 10 employees were interviewed. In Project 2, the population also included micro-companies with fewer than 10 employees, reflecting the high importance of micro companies in retail and transport services. Therefore, sector totals are not directly comparable between the two projects.

The highest level of the population was the set of all computer-using enterprises (and, in Project 1, with at least 10 employees) which were active within the national territory of one of the eight countries covered, and which had their primary business activity in one of the five sectors specified on the basis of NACE Rev. 1.1.[52] Evidence from previous surveys shows that computer use can be expected to be 99% or more in all sectors among medium-sized and large firms.

***Exhibit A1-2: Population coverage of the e-Business Survey 2007***

| No. | Sector name | NACE Rev. 1.1 activities covered | Population definition | No. of interviews conducted |
|---|---|---|---|---|
| **Project 1 – Manufacturing** | | | | |
| 1.1 | Chemicals, rubber & plastics | 24, 25 | Companies which have at least 10 employees and use computers | 911 |
| 1.2 | Steel | 27.1-3, 27.51-52 | | 449 |
| 1.3 | Furniture | 36.12-14 | | 761 |
| **Project 2 – Retail and transport** | | | | |
| 2.1 | Retail | 52 | Companies that use computers | 1,151 |
| 2.2 | Transport services and logistics | 60.10, 60.21+23+24 63.11+12+40 | | 1,097 |

## Sampling frame and method

The sample drawn (for each sector) was a random sample of companies from the respective sector population in each of the countries, with the objective of fulfilling minimum strata with respect to company size-bands per country-sector cell (see Exhibit A1-3).

Samples were drawn locally by fieldwork organisations based on official statistical records and widely recognised business directories such as Dun & Bradstreet (used in several countries) or Heins und Partner Business Pool.

The survey was carried out as an enterprise survey: data collection and reporting focus on the enterprise, defined as a business organisation (legal unit) with one or more establishments. Due to the small population of enterprises in some of the sector-country cells, target quota could not be achieved (particularly in the larger enterprise size-bands) in each country. In these cases, interviews were shifted to the next largest size-band (from large to medium-sized, from medium-sized to small), or to other sectors.

***Exhibit A1-3: Strata by company-size***

[52] NACE Rev. 1.1 was replaced by the new version NACE Rev. 2 in January 2008. When the survey was conducted, sectors still had to be defined on the basis of NACE Rev. 1.1, however, because business directories from which samples were drawn were based on the older version.

| Size-band | Target quota specified | |
|---|---|---|
| | Project 1<br>Manufacturing | Project 2<br>Retail & transport |
| Micro enterprises (up to 9 employees) | -- | up to 30% |
| Small companies (10-49 employees) | up to 40-50%* | at least 30% |
| Medium-sized companies (50-250 employees) | at least 40-45%* | at least 25% |
| Large companies (250+ employees) | at least 10-15%* | at least 15% |

* depending on sector

## Fieldwork

Fieldwork was coordinated by the German branch of Ipsos GmbH (www.ipsos.de) and conducted in cooperation with its local partner organisations (see Exhibit A1-4) on behalf of the Sectoral e-Business Watch.

***Exhibit A1-4: Institutes that conducted the fieldwork of the e-Business Survey 2007 and number of interviews conducted per country (total for Projects 1 and 2)***

| Country | Institute conducting the interviews | Total achieved |
|---|---|---|
| France | IPSOS Insight Marketing, 75628 Paris | 551 |
| Germany | IPSOS GmbH, 23879 Mölln | 555 |
| Italy | Demoskopea S.p.A., 20123 Milano | 553 |
| Poland | IQS and Quant Group Sp.z.o.o, 00-610 Warszawa | 546 |
| Spain | IPSOS Spain, 28036 Madrid | 549 |
| Sweden | GfK Sverige AB, 22100 Lund | 542 |
| UK | Continental Research, London EC1V 7DY | 548 |
| USA | Market Probe International, Inc, New York, NY 10168 | 525 |
| **TOTAL** | | **4,369** |

Pilot interviews prior to the regular fieldwork were conducted with about 10 companies in each sector in Germany in August 2007, in order to test the questionnaire (structure, comprehensibility of questions, average interview length).

The two sector surveys had a total scope of 4,369 interviews, spread across eight countries and five industries. In each of the eight countries, all five sectors were covered. The target was to spread interviews as even as possible across sectors; however, due to the comparatively small population of companies in the steel and (in some countries) in the furniture industries, some interviews had to be moved, either between countries (within a sector) or between sectors (i.e. from steel or furniture to larger sectors, notably to the retail industry). Exhibit A1-5 shows the final distribution of interviews across sectors and countries.

***Exhibit A1-5: Interviews conducted per sector and country:***

| Sector Country | DE | ES | FR | IT | PL | SE | UK | USA | Total |
|---|---|---|---|---|---|---|---|---|---|
| **Project 1 - Total** | **305** | **290** | **235** | **303** | **254** | **170** | **264** | **300** | **2,121** |
| 1.1 Chemical | 100 | 120 | 135 | 105 | 120 | 105 | 126 | 100 | **911** |
| 1.2 Steel | 100 | 50 | 20 | 87 | 24 | 30 | 38 | 100 | **449** |
| 1.3 Furniture | 105 | 120 | 80 | 111 | 110 | 35 | 100 | 100 | **761** |
| **Project 2 – Total** | **250** | **259** | **316** | **250** | **292** | **372** | **284** | **225** | **2,248** |
| 2.1 Retail | 120 | 131 | 166 | 126 | 151 | 184 | 148 | 125 | **1,151** |
| 2.2 Transport | 130 | 128 | 150 | 124 | 141 | 188 | 136 | 100 | **1,097** |

**Non response:** In a voluntary telephone survey, in order to achieve the targeted interview totals, it is always necessary to contact more companies than just the number equal to the target. In addition to refusals, or eligible respondents being unavailable, any sample contains a proportion of "wrong" businesses (e.g., from another sector), and wrong and/or unobtainable telephone numbers. Exhibit A1-6 shows the completion rate by country (completed interviews as percentage of contacts made) and reasons for non-completion of interviews. Higher refusal rates in some countries, sectors or size bands (especially among large businesses) inevitably raises questions about a possible refusal bias. That is, the possibility that respondents differ in their characteristics from those that refuse to participate. However, this effect cannot be avoided in any voluntary survey (be it telephone- or paper-based).

***Exhibit A1-6: Interview contact protocol, completion rates and non-response reasons***

| | | DE | ES | FR | IT | PL | SE | UK | US |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Sample (gross) | 6188 | 6435 | 6538 | 3071 | 10642 | 3016 | 8246 | 15862 |
| 1.1 | Telephone number not valid | 541 | 31 | 53 | 299 | 645 | 38 | 611 | 1811 |
| 1.2 | Not a company (e.g. private household) | 82 | 209 | 6 | 36 | 327 | 2 | 57 | 431 |
| 1.3 | Fax machine / modem | 19 | 0 | 72 | 9 | 300 | 33 | 69 | 389 |
| 1.4 | Quota completed **à** address not used | 973 | 2018 | 1531 | 101 | 2492 | 84 | 1087 | 193 |
| 1.5 | No target person in company | 992 | 267 | 264 | 129 | 975 | 101 | 662 | 821 |
| 1.6 | Language problems | 4 | 0 | 6 | 1 | 77 | 6 | 6 | 72 |
| 1.7 | No answer on no. of employees | 0 | 8 | 0 | 1 | 9 | 1 | 6 | 24 |
| 1.8 | Company does not use computers | 35 | 75 | 32 | 76 | 35 | 5 | 110 | 398 |
| 1.9 | Company <10 employees (manufacturing only) | 90 | 30 | 7 | 0 | 78 | 0 | 670 | 21 |
| 1.10 | Not targeted sub-sector (transport only) | 0 | 16 | 0 | 3 | 4 | 3 | 14 | 24 |
| | Sum 1.1 – 1.10 | 2076 | 2654 | 1971 | 655 | 4942 | 273 | 3292 | 4184 |
| 2 | Sample (net) | 4112 | 3781 | 4567 | 2416 | 5700 | 2743 | 4954 | 11678 |
| 2.1 | Nobody picks up phone | 65 | 462 | 1061 | 0 | 440 | 147 | 112 | 2280 |
| 2.2 | Line busy, engaged | 0 | 0 | 37 | 0 | 54 | 479 | 82 | 99 |
| 2.3 | Answering machine | 0 | 0 | 1022 | 0 | 168 | 14 | 86 | 1655 |
| 2.4 | Contact person refuses | 1546 | 0 | 136 | 435 | 2207 | 236 | 1960 | 2242 |
| 2.5 | Target person refuses | 1666 | 2540 | 932 | 351 | 338 | 573 | 1558 | 3363 |
| 2.6 | no appointment during fieldwork period possible | 63 | 0 | 97 | 70 | 392 | 477 | 352 | 0 |
| 2.7 | open appointment | 170 | 88 | 692 | 988 | 1384 | 261 | 140 | 1514 |
| 2.8 | target person is ill / cannot follow the interview | 1 | 0 | 13 | 3 | 33 | 2 | 4 | 0 |
| 2.9 | Interview abandoned | 46 | 142 | 17 | 17 | 138 | 4 | 112 | 0 |
| 2.10 | Interview error ( **à** interview cannot be used) | 0 | 0 | 9 | 0 | 0 | 8 | 0 | 0 |
| | Sum 2.1 – 2.10 | 3557 | 3232 | 4016 | 1864 | 5154 | 2201 | 4406 | 11153 |
| 3 | Successful interviews | 555 | 549 | 551 | 553 | 546 | 542 | 548 | 525 |
| | **Completion rate (= [3]/[2])** | **13.5%** | **14.5%** | **12.1%.** | **22.9%** | **9.6%** | **19.8%** | **11.1%** | **4.5%** |
| | **Average interview time (min:sec)** | **20:16** | **20:12** | **19:50** | **16:51** | **20:417** | **18:17** | **18:21** | **21:25** |

## Feedback from interviewers

No major problems were reported from the fieldwork with respect to interviewing (comprehensibility of the questionnaire, logical structure). The overall feedback from the survey organisations was that fieldwork ran smoothly and that the questionnaire was well understood by most respondents. The main challenge was the fulfilment of the quotas, which was difficult or impossible in some of the sectors, in particular among the larger size-bands. More specific comments from fieldwork organisations, which point to difficulties encountered in the local situation, are available in the detailed field-report from

Ipsos, which can be downloaded from the e-Business Watch website at (www.ebusiness-watch.org/about/methodology.htm).

## Weighting schemes

Due to stratified sampling, the sample size in each size-band is not proportional to the population numbers. If proportional allocation had been used, the sample sizes in the 250+ size-band would have been extremely small, not allowing any reasonable presentation of results. Thus, weighting is required so that results adequately reflect the structure and distribution of enterprises in the population of the respective sector or geographic area. *e-Business W@tch* applies two different weighting schemes: weighting by employment and by the number of enterprises.[53]

- Weighting by employment: Values that are reported as employment-weighted figures should be read as "enterprises comprising x% of employees" (in the respective sector or country). The reason for using employment weighting is that there are many more micro-enterprises than any other firms. If the weights did not take into account the economic importance of businesses of different sizes in some way, the results would be dominated by the percentages observed in the micro size-band.
- Weighting by the number of enterprises: Values that are reported as "x% of enterprises" show the share of firms irrespective of their size, i.e. a micro-company with a few employees and a large company with thousands of employees both count equally.

## The use of filter questions in interviews

In the interviews, not all questions were asked to all companies. The use of filter questions is a common method in standardised questionnaire surveys to make the interview more efficient. For example, questions on the type of internet access used were only asked to those companies that had replied to have internet access. Thus, the question whether a company has internet access serves as a filter for follow-up questions.

The results for filtered questions can be computed on the base of not only those enterprises that were actually asked the question (e.g. "in % of enterprises with internet access"), but also on the base of "all companies". In this report, both methods are used, depending on the indicator. The base (as specified in footnotes of tables and charts) is therefore not necessarily identical to the set of companies that were actually asked the underlying question.

## Statistical accuracy of the survey: confidence intervals

Statistics vary in their accuracy, depending on the kind of data and sources. A 'confidence interval' is a measure that helps to assess the accuracy that can be expected from data. The confidence interval is the estimated range of values on a certain level of significance. Confidence intervals for estimates of a population fraction (percentages) depend on the sample size, the probability of error, and the survey result (value of the percentage) itself. Further to this, variance of the weighting factors has negative effects on confidence intervals.

Exhibit A1-7 gives some indication about the level of accuracy that can be expected for industry totals for the EU-7[54] (based on all respondents) depending on the weighting scheme applied. The confidence intervals differ depending on the industry and the

[53] In the tables of this report, data are normally presented in both ways, except for data by size-bands. These are shown in % of firms within a size-band, where employment-weighting is implicit.

[54] The EU-7 are composed of those countries which were covered by the survey. To ensure data comparability, only interviews from these countries are included in the aggregated "total" values.

respective value; on average, it is about +/-5 percentage points (in both weighting schemes). Confidence intervals are highest for the steel industry, due to the small number of observations, and because this sector is more sensitive to weights due to its structure (i.e. the dominance of large firms in a comparatively small population). Data for this industry are therefore indicative and cannot claim to have statistical accuracy.

The calculation of confidence intervals is based on the assumption of (quasi-) infinite population universes. In practice, however, in some industries and in some countries the complete population of businesses consists of only several hundred or even a few dozen enterprises. In some cases, literally each and every enterprise within a country-industry and size-band cell was contacted and asked to participate in the survey. This means that it is practically impossible to achieve a higher confidence interval through representative enterprise surveys in which participation is not obligatory. This should be borne in mind when comparing the confidence intervals of e-Business Watch surveys to those commonly found in general population surveys.

***Exhibit A1-7: Confidence intervals for the sector surveys (EU-7)***

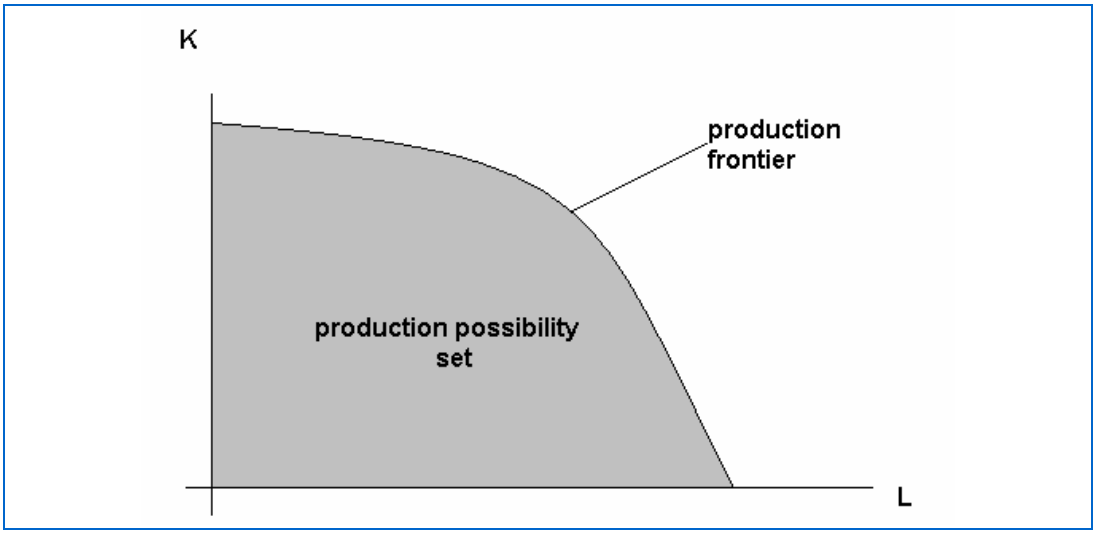
| | | Confidence interval | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Survey result | if weighted as "% of firms" | | | if weighted by employment | | | unweighted | | |
| **Sectors (aggregate, EU-7)** | | | | | | | | | | |
| Chemical, rubber and plastics | 10% | **8.0%** | - | **12.4%** | **6.5%** | - | **15.0%** | **8.4%** | - | **11.9%** |
| Steel | 10% | **7.5%** | - | **13.2%** | **4.8%** | - | **19.6%** | **7.7%** | - | **13.0%** |
| Furniture | 10% | **8.0%** | - | **12.5%** | **7.1%** | - | **14.0%** | **8.2%** | - | **12.1%** |
| Retail | 10% | **7.0%** | - | **14.0%** | **7.0%** | - | **14.1%** | **8.6%** | - | **11.7%** |
| Transport & logistics | 10% | **7.0%** | - | **14.1%** | **7.4%** | - | **13.4%** | **8.5%** | - | **11.7%** |
| **Sectors (aggregate, EU-7)** | | | | | | | | | | |
| Chemical, rubber and plastics | 30% | **26.8%** | - | **33.5%** | **24.0%** | - | **36.8%** | **27.4%** | - | **32.7%** |
| Steel | 30% | **25.8%** | - | **34.5%** | **20.3%** | - | **42.0%** | **26.1%** | - | **34.2%** |
| Furniture | 30% | **26.7%** | - | **33.5%** | **25.0%** | - | **35.5%** | **27.1%** | - | **33.0%** |
| Retail | 30% | **25.0%** | - | **35.6%** | **24.9%** | - | **35.7%** | **27.7%** | - | **32.4%** |
| Transport & logistics | 30% | **24.9%** | - | **35.7%** | **25.7%** | - | **34.7%** | **27.7%** | - | **32.4%** |
| **Sectors (aggregate, EU-7)** | | | | | | | | | | |
| Chemical, rubber and plastics | 50% | **46.3%** | - | **53.7%** | **43.0%** | - | **57.0%** | **47.1%** | - | **52.9%** |
| Steel | 50% | **45.2%** | - | **54.8%** | **38.2%** | - | **61.8%** | **45.6%** | - | **54.4%** |
| Furniture | 50% | **46.3%** | - | **53.7%** | **44.3%** | - | **55.7%** | **46.8%** | - | **53.2%** |
| Retail | 50% | **44.2%** | - | **55.8%** | **44.1%** | - | **55.9%** | **47.4%** | - | **52.6%** |
| Transport & logistics | 50% | **44.1%** | - | **55.9%** | **45.1%** | - | **54.9%** | **47.4%** | - | **52.6%** |
| **Sectors (aggregate, EU-7)** | | | | | | | | | | |
| Chemical, rubber and plastics | 70% | **66.5%** | - | **73.2%** | **63.2%** | - | **76.0%** | **67.3%** | - | **72.6%** |
| Steel | 70% | **65.5%** | - | **74.2%** | **58.0%** | - | **79.7%** | **65.8%** | - | **73.9%** |
| Furniture | 70% | **66.5%** | - | **73.3%** | **64.5%** | - | **75.0%** | **67.0%** | - | **72.9%** |
| Retail | 70% | **64.4%** | - | **75.0%** | **64.3%** | - | **75.1%** | **67.6%** | - | **72.3%** |
| Transport & logistics | 70% | **64.3%** | - | **75.1%** | **65.3%** | - | **74.3%** | **67.6%** | - | **72.3%** |
| **Sectors (aggregate, EU-7)** | | | | | | | | | | |
| Chemical, rubber and plastics | 90% | **87.6%** | - | **92.0%** | **85.0%** | - | **93.5%** | **88.1%** | - | **91.6%** |
| Steel | 90% | **86.8%** | - | **92.5%** | **80.4%** | - | **95.2%** | **87.0%** | - | **92.3%** |
| Furniture | 90% | **87.5%** | - | **92.0%** | **86.0%** | - | **92.9%** | **87.9%** | - | **91.8%** |
| Retail | 90% | **86.0%** | - | **93.0%** | **85.9%** | - | **93.0%** | **88.3%** | - | **91.4%** |
| Transport & logistics | 90% | **85.9%** | - | **93.0%** | **86.6%** | - | **92.6%** | **88.3%** | - | **91.5%** |

confidence intervals at α=.90

# Annex II: Econometric methodology

A production frontier indicates the maximum possible production in a given period of time, using a given amount of production factors. The frontier may for example refer to a particular country or industry. The production possibility frontier approach, in contrast to the more traditional production function approach, allows to disentangle the overall productivity growth[55] into two components: first, the rate of technological progress expanding the frontier, and second, the movements of decision-making units (e.g. firms and, on an aggregate level, industries and countries) towards the frontier, i.e. towards optimal usage of production factors (see Exhibit A-II-1).

***Exhibit A.II-1 Production possibility set and frontier***




The stochastic production possibility approach is not a method for directly estimating impact factors on labour productivity. However, through modifying the variables, i.e. through dividing them by total working hours (TWH), a constellation can be created that allows to draw conclusions about the contribution of single variables on labour productivity.

If, given the factor input set, the produced output level stays below the potential maximum level, then the respective inefficient use of resources indicates indirectly that the whole production system or, at the micro level the single producer, faces an inability to match the best available practice. Farrell (1957) was the first to distinguish between technical and allocative efficiency. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs. Allocative efficiency is used for the ability of a firm to use the inputs in optimal proportions, given their respective prices. The combination of both gives a measure of the total economic efficiency.

Assuming log-linear production function where i countries produce their output given the technological parameter $b$, the stochastic production possibility frontier is now

[55] Measured as changes in the ratio of total output produced over all inputs used in the production process.

determined by two types of random errors. The always positive inefficiency random variable $u_i$, and the new random error term $v_i$, which has the usual properties of identical independent normally distributed errors with a mean value of zero and a constant variance, $s_v^2$ .

$$\ln(y_i) = b_0 + \sum_{j=1}^{m} x_{ij} \cdot b_j + v_i - u_i \qquad \text{for} \qquad i = 1,...,N$$

The production frontier is therefore determined by the deterministic part plus a stochastic part consisting of a mixture of two probability distributions: a non-negative one, for instance a positive truncated normal distribution, and the usual normal distribution of the error term. Estimating a stochastic production possibility frontier therefore involves estimating the parameters of the two probability distributions simultaneously.

The stochastic frontier function is accordingly bounded from above by

$$\ln(y_i) = b_0 + \sum_{j=1}^{m} \ln x_{ij} \cdot b_j + v_i \qquad \text{for} \qquad i = 1,...,N \ .$$

The model equation can be estimated by using standard maximum-likelihood methods. This approach requires explicit assumptions on the underlying probability distributions of the two random variables. However, the estimation function cannot be derived explicitly, so the maximum likelihood (ML) function has to be optimised numerically. This is achieved here by the Frontier 4.1 programme (see Coelli, 1996). For the exact specification of the ML-function see Battese and Corra (1977). They showed that the ML-estimators are consistent and asymptotically efficient (Aigner, Lovell, Schmidt, 1977).

The model is not limited to a Cobb-Douglas function estimation; it could easily be adjusted to a more flexible functional form of a translog production function.[56]

$$\ln(y_i) = b_0 + \sum_{j=1}^{m} \ln x_{ij} \cdot b_j + \sum_{j=1}^{m} \sum_{k=1}^{m} b_{juk} \cdot \ln x_{ik} \cdot \ln x_{jk} + v_i - u_i \qquad \text{for} \qquad i = 1,...,N$$

One-sided generalised likelihood-ratio-tests for such estimators were derived in later research (Coelli, 1995).

In this study, the stochastic production possibility frontier approach was used **to measure the degree of inefficiency of factor inputs** between industries in different countries. Since we do not estimate a single frontier for each country's industry separately but instead assume a common production possibility frontier, this approach is referred to as a common stochastic production possibility frontiers approach (see e.g. Berger, Humphrey 1997). The production possibility frontier approach does not explain the causes of the inefficiencies studied. It only indicates that a certain combination of factors is used inefficiently. Organisational or institutional failures are not revealed as they are not explicitly included in the estimation of the stochastic production possibility frontiers.

[56] In our econometric analysis translog specification were estimated but the results are not included in this report due to limited space. They will be published separately in a forthcoming working paper. By incorporating the cross-terms of a translog function or other flexible functional form one is able to determine variable substitutions elasticities between the different factor inputs. Assuming a Cobb-Douglas specification one assumes constant unity substitution elasticities between all different factor inputs.

For this analysis a panel-data approach was used because of the low number of countries sampled. The only way a cross-section approach could be used would be by pooling industry and country data. Further trends can be drawn from the stochastic production possibility frontier model although a complete analysis is beyond the scope of this study.

To incorporate intermediate inputs in the analysis, the gross production value was used, gpv of the respective industry instead of the gross value added, gva, as the output variable. This enables us to estimate the output elasticities[57] for intermediate inputs.

$$\ln(gpv_i) = b_0 + \sum_{j=1}^{m} \ln x_{ij} \cdot b_j + v_i - u_i \qquad \text{for} \qquad i = 1,...,6$$

$$\text{with} \quad x_{j.} \in \{imi, ict, nict, hswh, mswh, lswh\}^{58}$$

Combining the industries production possibility frontiers for each country to one common production possibility frontier for an industry across all countries, we obtain a multi-country data panel with a common stochastic production possibility frontier.

$$\ln(gpv_{j,i}) = b_0 + \sum_{j=1}^{m} \ln x_{ijj} \cdot b_j + v_i - u_{j,i} \qquad \text{for} \qquad i = 1,...,6 \qquad \text{and} \qquad j = 1,...,12$$

To impose constant returns to scale we normalised the production possibility frontier by subtracting the natural logarithm of total working hours from both sides of the equation. This normalised common production possibility frontier equates the gross production value labour productivity in working hours on the left hand side with respective factor intensities such as ICT-capital intensity on the right hand side.

$$\ln(gpv^*_{j,t}) = b^* + \sum_{j=1}^{m} \ln x^*_{ij,t} \cdot b^*_j + v_i - u_{j,i} \qquad \text{for} \qquad i = 1,...,6 \qquad \text{and} \qquad j = 1,...,12$$

To include Harrod-neutral technical change in the multi-country industry common production possibility frontier a time trend variable is also included. The respective parameter value $b_7$ measures the average TFP-growth rate. The long-term rate of Harrod-neutral technological progress therefore determines the outward shift attributed to a steady technical change in the common production possibility frontier.

$$\ln(gpv^*_{j,t}) = b^* + \sum_{j=1}^{m^*} \ln x^*_{ij,t} \cdot b^*_j + b^*_7 \cdot t + v_i - u_{j,i} \qquad \text{for} \qquad i = 1,...,6 \qquad \text{and} \qquad j = 1,...,12$$

[57] An output elasticity is a dimensionless measure for the ratio of marginal percentage changes of output with regard to a particular input variable, i.e. a 1% increase in the input variable changes the output variable by x%.

$$e_{o,x} = \frac{\partial \ln o_t}{\partial \ln x_t} = \frac{\partial o_t}{o_t} \Big/ \frac{\partial x_t}{x_t} = \lim_{\Delta \to 0} \frac{\Delta o_t}{o_t} \Big/ \frac{\Delta x_t}{x_t}.$$

[58] The symbols used denote the following: imi - intermediate inputs, ict – ICT-capital stock, nict – Non-ICT-capital stock, hswh – high-skilled total working hours, mswh – medium-skilled total working hours, lswh - low-skilled total working hours.