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Economic Drivers and Impacts of ICT Adoption and Diffusion

**A cross-sectional e-Business Watch study by
DIW Berlin**

Interim Report – Executive Summary



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 document is the interim report of a study on the economic drivers and impacts of ICT adoption. The study develops a conceptual framework to study the reasons behind ICT adoption and the resulting impacts on ICT adoption. Above all, it assesses implications thereof for firms and for the industry as a whole. The elaborations are based on econometric analyses, expert interviews and case studies.

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Executive Summary

Objectives and scope of the study

This is the interim report of the Sectoral e-Business Watch study on the economic impacts and drivers of ICT adoption. It proposes a conceptual framework for the analysis of factors that determine the diffusion of information and communication technology (ICT) in businesses ("drivers"), of ICT-enabled innovation processes and, ultimately, the impact of ICT on companies performance. The study focuses on the following six sectors:

- Furniture
- Steel
- Chemicals
- Banking
- Transport and logistics
- Retailing

These sectors had been selected as priorities for the work of the Sectoral e-Business Watch in 200708. Their business activities are defined by the NACE Rev. 1.1 classification.¹

The developed conceptual construct allows for an economic analysis based on recent literature, expert interviews, and case studies. The hypotheses developed in this report will be subject to empirical testing in the final study.

Conceptual Framework

The starting point of the analysis rests on the premise that ICT is an enabler of innovation, a direct consequence of the ambiguous relationship between ICT investment and firm performance. By considering ICT as an enabler

of innovation allows the assumption that ICT has strategic relevance for firms i.e. in facilitating innovation. It has several drivers as well as impacts industry and market structure and firm performance respectively.

In order to create a conceptual framework for the analysis of the interplay between the drivers of ICT adoption, impacts of ICT diffusion and innovation, reference to the **Structure-Conduct-Performance** (SCP) paradigm is made. This conceptualisation allows for an economic approach that studies the drivers and impacts of ICT at the firm and sector level for the following industry dimensions: work force composition, value chain characteristics, and market structure as structure elements, innovation dynamics as conduct parameter, and employment and productivity as performance indicator.

For the purpose of this analysis, market structure workforce composition and value chain characteristics are considered as drivers of ICT adoption. The impact of ICT adoption and ICT enabled innovation is studied through productivity and employment as proxies for firm performance. This construct enables the understanding of not only uni-directional causal relationships but recognises the presence of firm performance impacting upon the drivers of ICT adoption.

The conceptual framework defines two dimensions of the forthcoming analysis. First it identifies drivers of ICT adoption and the process of turning it into marketable products and production processes (i.e., ICT enabled innovations). Second, it identifies the impact of a firm's innovative activity enabled by ICT on firm and market structure characteristics. The data sources used for the empirical analysis are the SeBW Survey data and the EU Klems database².

¹ NACE 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 Rev. 1.1 on 1st January 2008. For the purpose of this study, the older version (Rev. 1.1) had to be used, as the databases used for the analysis were still based on Rev. 1.1.

² Please refer to www.eukelms.net

Innovation dynamics

The study aims to examine the varying heterogeneity across firms using two aspects; a firm's skill base and technology use. Economic literature suggests that there is a complementarity between high skill labour and ICT use. Further, firms that have previous experience with ICT tend to be more intensive adopters of new technologies implying path dependence with respect to ICT adoption.

The conceptualisation of **ICT as an enabler of innovation** allows for a market based analysis of why different sectors exhibit differing payoffs despite similar levels of ICT investment. The differing payoffs are the result of varying adoption patterns and environmental conditions that are sector specific.

The following hypotheses will be empirically tested for the sectors covered, on the basis of SeBW Survey data:

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

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-enabled innovations are correlated with a firm's turnover.

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

Value chain characteristics

The changing relationships between suppliers and buyers tend to promote the diffusion of ICT. Further, the readiness and technological competence of firms, their suppliers, customers and competitors determines the success of ICT use.

Similar to intra-firm changes, ICT has enabled new business structures and redefined B2B interactions through value chain management, thereby increasing efficiency through reduced

transaction costs. This new structure allows the separation of product and information flows and facilitates the exchange of information and better responses to real-time business conditions.

The following hypotheses will be empirically tested for the sectors covered, on the basis of SeBW Survey data:

Hypothesis V.1: Firms maintaining long-term relationships with suppliers and customers are more likely to use technologies supporting inter-firm collaboration, compared with their peer-group in the same sector.

Hypothesis V.2: Intensive ICT use is positively correlated with outsourcing.

Market structure characteristics

Competitive market pressure often drives a firm's decision to adopt ICT. Though the incentive of monopoly profits and cost arguments, related to large firms, still remain, differing market structure characteristics and concentration levels imply differing ICT adoption across industries.

The onset of ICT and the internet have changed the traditional way in which business to consumer (B2C) and business to business (B2B) relations function, moving from supply driven to more demand driven production.³ Previously, a firm's response to demand depended on its inventory levels i.e. supply driven demand which meant increased costs of storage and deficiencies as a result of time and scale. With demand driven production, firms are able to reduce their dependency on inventories and instead use ICT to react in real time to the changing needs of the consumers. Thus, these 'lean manufacturers', are able to use ICT to deliver the right product, at the right place and time.

This shift highlights an important feature, namely, current market structure characteristics and technology determine future innovation, technology and market structure. For example, ICT has offered small and new firms the opportunity to enter markets and in some cases

to actually leap frog existing market leaders thereby changing market structure and determining the pattern of future innovation.

The following hypotheses will be empirically tested for the sectors covered, on the basis of SeBW Survey data:

Hypothesis M.1: Increasing rivalry in the market is a driver for the adoption of ICT.

Hypothesis M.2: Intensive ICT use is positively correlated with an increase in the number of customers.

Productivity

The productivity improvements that occur in using ICT result in increased firm performance, a higher skill base and more efficient products and processes all of which feedback in to the drivers of ICT indirectly making productivity a driver of ICT adoption.

Firm performance is assumed to be the outcome of its conduct. For example, this would include investments made in ICT, where the availability of resources that can be used for innovative activities depends on the type and intensity of competition in which a firm operates. Further, ICT readiness and technical competence influence a firm's ability to extract benefits out of the ICT investment. Despite extensive research on the use of ICT and its impact, empirical research is unable to state with clarity that ICT use leads to increases in productivity and firm performance.

However, we can say that ICT does have some impact on firm performance. This ambiguity, partially on account of measurement techniques, could be reduced when considering ICT as an enabler of innovation instead of being directly responsible for increased productivity or firm performance. In this context, the literature highlights the importance of complementary assets which include human capital, firm restructuring and working practices in combination with investment in ICT. However, as complementary and organisational investments are firm specific and vary strongly across organisations, the resultant payoffs and trajectories are varied. This implies that despite similar investments in ICT, firm and industry

dependent characteristics determine the resulting payoffs.

The following hypotheses will be empirically tested for the sectors covered, on the basis of EU KLEMS data:

Hypothesis P.1: ICT-capital investment has become a key element in productivity growth particularly in service industries while other capital inputs summarised as non-ICT-capital have diminished in their respective importance.

Hypothesis P.2: TFP-growth accelerates with increased investment in ICT-capital especially in certain ICT-using industries like retailing, wholesale and banking.

Hypothesis P.3: Industries like chemicals are much less ICT-capital investment driven and productivity impacts depend therefore, on other types of innovations and investments in non-ICT-capital.

Hypothesis P.4: There is a general structural shift across countries where ICT-using service industries gain while non-ICT using lose in their importance with respect to gross value added shares.

Employment

The skill base and ICT complementarity is increasingly recognised in literature. Investment in human capital allows the deployment of more advanced ICT and higher productivity levels. More advanced levels of ICT usage require professionals that are able to use the technology for optimal firm performance. In this sense, the relationship between ICT and skill base is circuitous i.e. greater investment in human capital facilitates more sophisticated ICT use which in turn increases the need for more trained professionals.

An important question in this context is whether ICT increases or decreases employment levels, and how this impacts on workforce composition. ICT enables either, product or process innovations; while the former normally is labour enhancing, the latter is labour saving. However, this being said, the impact of ICT on employment is not clear. Thus, this study aims to provide some new evidence to this question

through empirical analysis which will follow in the final report.

The following hypotheses will be empirically tested for the sectors covered, on the basis of EU KLEMS data:

Hypothesis E.1: There are significant differences between service industries regarding overall labour compensation and substitution between employment and ICT-capital.

Hypothesis E.2: There are significant differences in skill-premiums between different service industries.

Policy implications

Increasingly more low skilled jobs in the EU are being facilitated through networks, sub-contracting and outsourcing. The efficacy of ICT and ICT enabled innovation is dependent on high skill labour. Thus, in order to increase labour demand, the quality of labour should be improved. Therefore, EU and national government policy should focus on increasing education levels, promoting research and development ventures to improve human capital and create favourable conditions for ICT investment, which in turn would increase innovative potential. This policy implication will be further elaborated and consolidated in the final report.