An Economic Assessment of ICT-Related Industrial Policy

Sectoral e-Business Watch
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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 at the SeBW website (www.ebusiness-watch.org).

This is a report of a topic study about an economic assessment of ICT-related industrial policy. The study describes current practice of such policies, analyses policies for ICT innovation and adoption in companies, and draws conclusions for further development of industrial policies. The findings are above all based on a theoretical analysis, an expert survey, case studies, and expert interviews.

Disclaimer

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Executive Summary

Key findings

ICT-related industrial policy as defined in this report comprises policies for ICT innovation in ICT-producing industries and ICT adoption in ICT-using industries. Both should be considered as two parts of the same coin to enhance the competitiveness of European industry as well as growth and employment in Europe.

Consider specificities of ICT R&D&I. ICT is different from other technologies in that it has shorter innovation cycles and a relatively higher need for investment into commercialisation as compared to R&D. Industrial policies could consider these differences and, for example, focus on commercialisation activities.

Downsides of R&D&I joint ventures. While joint R&D&I is normally considered as beneficial because it increases economies of scale and scope, industrial policy should also consider that companies involved in joint ICT R&D&I may use results to prevent market entry of competitors and to slow down innovation activities.

Conditioning of public R&D&I grants. A game theoretical analysis suggests that public grants for ICT R&D&I in joint European programmes should be conditioned on the firms' own investment, e.g. public funds are only granted for investments beyond a certain limit, and national governments should be prevented from establishing competing programmes and subsidising national firms.

Balancing SME policies. Theoretical considerations question whether policies to promote the participation of small and medium-sized enterprises in electronic value systems necessarily enhance efficiency. In particular, policy measures may imply that an inefficiently high number of SMEs remain active.

e-Business standards policies should take into account possible rent-seeking behaviour on the part of the companies meant to adopt the standards. Public entities should rather foster institutions like standardisation committees that do not rely on direct payments.

About this study

This is a report of a Sectoral e-Business Watch study about an economic assessment of ICT-related industrial policy. The study objectives are to describe current practices and trends in such policy, to analyse selected policy measures and to draw conclusions for developing industrial policy measures in the future.

The analysis in this report is based on a theoretical analysis, case studies, an expert survey, expert interviews and literature evaluation.

ICT-related industrial policy: definitions and current trends

ICT-related industrial policy is defined in this report as measures to promote ICT research, development and innovation (R&D&I) in ICT-producing industries as well as ICT adoption in ICT-using industries. The objectives of such policy are to foster competitiveness, growth and employment in the industries concerned (section 2.1).

This definition of industrial policy is open to different approaches which may be perfectly market conform. Possible instruments of ICT-related industrial policy include, as industrial policy in general, market regulation, infrastructure enhancement, financial incentives, and involvement in entrepreneurs' decisions.

The industrial policy of the European Commission (EC) combines horizontal and industry-specific approaches. Its objective is to "*create the right framework for industry to thrive*" without protectionism and subsidies. It is currently challenged to find appropriate answers not only to increasing global competition and climate change but also to the economic crisis (section 2.2).

ICT-related industrial policy of the EC

There is no defined "ICT-related industrial policy of the EU"; the term has been introduced for this study. The EC's ICT innovation policy includes for example ICT-related R&D&I under the seventh EU Framework Programme, in the Competitiveness and Innovation Programme, and in the European Research Area. Within DG

Enterprise and Industry, the following activities are related to ICT and e-business adoption: the e-Business Support Network for SMEs (eBSN), support for ICT standardisation and standards adoption, initiatives to improve e-skills, and activities to create a favourable legal environment for e-business (section 2.2).

The strategic priorities of the EC's ICT-related industrial policy have changed over the years, from co-financing ICT investments towards stimulating SMEs to explore the innovation potential of ICT and, more recently, supporting SMEs to develop their e-business strategy in cooperation with their business partners. A next shift may focus on innovation of key ICT and their adoption in companies of all sizes.

Study focus on ICT-producing and ICT-using industries

This report focuses on ICT-producing industries and on ICT-using manufacturing industries. The competitive position of European hardware and software producers is ambiguous. In some segments European firms are strong, for example in mobile phones and business software. In others Europe is weaker, for example in semiconductors and packaged software. A strategic challenge for the European software industry and policy makers is to strengthen Europe's competitive position in the course of a shift towards new paradigms such as the "internet of things" and the "internet of services".

ICT-using manufacturing industries have many characteristics in common. Their supply side is typically an important and fragmented business activity. As regards market structure, ICT-using manufacturing industries typically have at least some sub-sectors that are highly concentrated, with large dominating international players. As regards e-business adoption, large and medium-sized companies are typically better equipped with ICT and typically perform higher rates of e-business practice than micro and small companies (section 2.3).

Concept of the theoretical analysis

A theoretical analysis of selected ICT-related industrial policy measures is a key part of this report. **The overall objective of the theoretical analysis is to produce insights about strategies and behaviour of companies, Member States and the European Commission when interacting about funding of ICT research, development, innovation and adoption as well as about the design of related policies** (section 4.1).

Three analyses are conducted, one related to ICT-producing industries, one related to ICT-using industries and one applying game theory to joint European R&D&I programmes:

(1) Policies to foster ICT R&D&I in order to promote commercialisation of enabling ICT. The term "enabling" refers to the opportunity to use ICT for continued innovation in the ICT industry itself as well as in other industries.

(2) Policies to enhance electronic value systems in ICT using manufacturing industries, which is important for the competitiveness of European industries. Issues of e-business standards adoption will also be touched as they are indispensable for effective e-value systems.

(3) Policies for establishing and conducting joint European ICT R&D&I programmes such as European Technology Platforms.

Theories applied in the analysis

The theoretical analysis is based on the following four theoretical approaches (section 4.1):

- **Game theory** is the theory of strategic interactions ("games") between interdependent actors ("players"). The aim is to predict behaviour of players by looking at strategies which lead to outcomes no player seeks to change ("equilibrium").
- **Industrial organisation theory** deals with strategic behaviour and interactions of firms and the structure of markets.
- **Market failure theory** deals with situations in which free markets produce inefficient results. Market failures with respect to ICT innovation and adoption can be traced back to three factors: external effects, imperfect competition and imperfect information.
- **State failure theory** deals with possible failures in governmental decisions, i.e. inefficient policies.

Theoretical considerations about ICT R&D&I

The importance of ICT for growth and employment in Europe is undisputed. However, the EC sees a critical need for European ICT R&D&I to be better co-ordinated, concentrated and specialised. Policies to tackle this problem involve

intense cooperation between the European Commission, Member States and companies (section 4.3).

ICT R&D&I has some special features, which include short innovations cycles and relatively small investments for R&D but relatively high investments for commercialisation. Further aspects include standardisation or compatibility issues between existing and new products or technologies as well the cost of imitating innovations of successful competitors. These **characteristics of ICT R&D&I put large firms at a competitive advantage** versus SMEs.

Potential state failure related to ICT R&D&I funding can be due to at least three reasons:

- ICT **R&D&I grants can be allocated inefficiently** because incentive schemes for agents assessing firms' ICT R&D&I proposals are not necessarily efficient.
- Companies involved in **publicly supported R&D&I joint ventures may (mis-)use results** of the co-operation to restrict competition.
- The countries' **R&D&I grants to national companies** may be higher than compared to a situation in which countries coordinate their grants.

Considerations about ICT adoption for electronic value systems

Theoretical considerations question whether policies to promote companies' participation in electronic value systems necessarily enhance efficiency:

- Policy measures which simply focus on the participation of SMEs in larger firms' digital supply systems may not alter the firms' investment decisions or may distort equilibrium market structures so that an inefficiently high number of SMEs remains active.
- Large firms may opt for public policies which subsidise SMEs in order to ensure that their up- or downstream markets remain competitive.
- International harmonisation can well be detrimental for large domestic firms which may induce national governments to stick to national solutions.

As regards policies to standards adoption, policy makers need to be aware that companies may have strategic incentives to hide relevant information in order to reduce their costs of implementing a new standard or to receive direct grants (section 4.4).

Game theoretical considerations for joint European R&D&I programmes

The most important lessons for the European Commission are related to the optimal design of the framework conditions of joint ICT R&D&I programmes before their inception. The EC faces a dilemma: On the one hand it has to ensure that firms and national governments must find it profitable to participate at the outset; on the other hand the firms' and national governments' incentive to strategically exploit the programme once it has been created have to be as low as possible. Key insights from the analysis are that public grants for ICT R&D&I should be conditioned on the firms' own investment, e.g. public funds are only granted for investments beyond a certain limit, and that national governments must be prevented from establishing competing programmes and subsidising national firms (section 4.5).

Empirical findings

Empirical findings for this report support theoretical arguments. Three case studies were conducted.

A case study about the **US Networking and Information Technology Research and Development** (NITRD) programme shows a need for coordination of dispersed Federal activities to promote ICT R&D&I. In particular, it sheds light on the need to promote technology transfer not only from public organisations to the market, but also among public research organisations themselves (section 4.1.1).

A case study about the **Korean IT839/u-IT839 master plans** illustrate a massive public support to ICT R&D&I in this country, close intertwinement of public and private activities as well as support by a technology-friendly culture in the population. The master plans appear like a concerted activity targeting not only R&D but also venture capital and the educational system (section 4.1.2).

A case study about the initiative "**Cluster Automotive Region Stuttgart** (CARS)" illustrates the practical importance of e-business adoption in order to remain part of the supply chains to large automotive manufacturers. It

also highlights that the prevalence of proprietary e-business standards can be an important barrier to enhancing e-value systems (section 4.1.3).

Findings from an online expert survey with 46 respondents confirm that ICT R&D&I as well as e-business adoption in European industries need to be improved in order to enhance their competitiveness (section 4.2). The respondents saw a clear need for public policy to support ICT R&D&I and adoption. In fact, the majority of respondents found that the European Commission is focusing on the right issues but the policies were found to be insufficient in scope. The findings also suggest that there is a need for closer co-operation between the European Commission and the Member States in related policies and for clustering activities.

Policy implications

This study suggests a concept for developing ICT-related industrial policy that distinguishes between policy themes and counterparts. The principal themes are policies for ICT product innovation and policies for e-business adoption. The principal counterparts are companies and Member States. Taking these themes and counterparts together there are four distinct fields of ICT-related industrial policy. The study suggests twelve related specific implications (section 5.1):

European Commission ICT innovation policies towards companies:

1) The companies' problem of appropriating the returns from newly generated knowledge and the consequent underinvestment into R&D&I from a societal perspective is a general argument for public support of ICT R&D&I.

2) Since market introduction of new ICT products may be relatively costly compared to ICT R&D, public ICT R&D&I programmes may increase the contribution to commercialisation costs within companies – at least in SMEs which are facing disadvantages in this respect versus large firms.

3) While cooperative European R&D&I may be beneficial to create synergies, public policy should also prevent inefficient collusion and restrict the scope of agreements in joint ICT R&D&I because dominant companies may use results from joint ventures to restrict market entry of other companies.

4) In cooperative European ICT R&D&I programmes, the framework conditions should prevent later joining and leaving of companies in order to prevent self-serving behaviour.

European Commission ICT innovation policies towards national governments:

5) Coordination of national R&D&I policies and grants through the EU can help overcome inefficient grants, but coordination in joint European R&D&I programmes must be binding in order to prevent self-serving behaviour.

6) The EC should balance the number of countries in R&D&I joint ventures because the efficiency of international joint ventures tends to increase with the number of countries participating but at the same time transaction costs and free-rider problems increase.

7) National R&D&I programmes competing with joint EU programmes would be inefficient and prevent companies from participating in the EU-wide programme.

European Commission e-business adoption policies towards companies:

8) Since it may be economically rational for companies not to invest into ICT and e-business, the first step of policy making towards e-business adoption should be a clear understanding of the barriers to e-business adoption.

9) Policies to support e-value systems should consider market structures and intentionally decide about the level of industry specificity.

10) Policy makers could seek to indirectly support credible commitments of large firms versus small suppliers or customers when the small firms are meant to invest into relation-specific e-business solutions.

11) Policies for standards adoption should take into account hidden intentions on the part of the companies, for example by fostering institutions like standardisation committees that do not rely on direct payments.

European Commission e-business adoption policies towards national governments:

12) The EC should seek to coordinate the adoption of e-business standards in Europe in order to prevent competing national standards that may reduce incentives of ICT-using companies to invest into e-business systems.

1 Introduction

1.1 About this report

Objectives, sources and addressees

This is the final report of a Sectoral e-Business Watch (SeBW) study about an economic assessment of ICT-related industrial policy measures. The focus of the report is on policies for ICT innovation and adoption. The report describes current practices and trends in such policies, it analyses selected policy fields from a theoretical point of view, it presents case studies and findings from an expert survey, and it points at implications for developing policy measures in the future. The key part of this report is the theoretical analysis in chapter 3.

The study addresses, in particular, policy makers in the fields of innovation and ICT-related policies and in sectoral economic policy. It also addresses industry representatives, notably decision makers in industry associations as well as enterprise managers in ICT and R&D.

Study structure

The study is structured into **five main chapters**. Chapter 1 explains the background and context *why* this study has been conducted: it introduces the Sectoral e-Business Watch programme of the European Commission, a conceptual framework for the analysis of ICT and e-business, and the specific methodology used for this study. Chapter 2 provides definitions as well as general information about and trends in ICT-related industrial policy. Chapter 3 provides a theoretical analysis of ICT-related industrial policies, focusing on ICT innovation policy on the one hand and ICT adoption policies on the other. An exemplary analysis of ICT innovation based on game theory is also provided. Chapter 4 includes findings from primary empirical research conducted for this study, i.e. findings from three case studies and from an expert survey. Chapter 5, finally, presents initial conclusions for the development of ICT-related industrial policy measures in the future.

Combining descriptive and analytical approaches

The study approach is exploratory, descriptive and explanatory, applying a broad methodological basis: A **theoretical economic analysis** of policy measures (Chapter 3) is combined with a descriptive presentation of a **qualitative** approach using case studies (section 4.1), **quantitative** survey data (section 4.2) and expert interviews. This approach is meant to produce an in-depth understanding of current ICT-related industrial policy (the "practitioner's view") as well as the state of the art of policy practice (the “empiricist’s view”), while also *assessing* the economic effects of such policy (the "economist's perspective"). While the results from these different approaches are presented like self-sustained pieces of research in separate chapters, they are intertwined and cross-referenced.

1.2 About the Sectoral e-Business Watch

Mission and objectives

The "Sectoral e-Business Watch" (SeBW) studies the adoption and impact of ICT and electronic business practices in different sectors of the economy. It continues activities of the preceding "*e-Business W@tch"* which was launched by the European Commission, DG Enterprise and Industry, in late 2001, to support policy in the fields of ICT and e-business. The SeBW is based on a Framework Contract and Specific Contract between DG Enterprise and Industry and empirica GmbH.

Within the European Commission, DG Enterprise and Industry has the mission to help improve Europe's economic standing by ensuring that businesses are competitive and that they can compete openly and fairly. In ICT-related fields, DG Enterprise and Industry targets six policy fields: competitiveness of the ICT producing sector, ICT uptake in ICT using sectors, legal issues related to ICT uptake, ICT standardisation, e-skills and disruptive ICT.[1]

The services of the SeBW are expected to contribute to policies in these fields. The SeBW's mission can be broken down into the following main objectives:

- to assess the **impact of ICT** on enterprises, industries and the economy in general, including the impacts on productivity and growth, and the role of ICT for innovation 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, the SeBW is to support informed policy decision-making in policy domains also beyond ICT, including innovation, competition and industrial policy.

Policy context

The initial *e-Business W@tch* programme was rooted in the **eEurope Action Plans** of 2002 and 2005. The eEurope 2005 Action Plan had defined the goal "*to promote take-up of e-business with the aim of increasing the competitiveness of European enterprises and raising productivity and growth*".[2] The **i2010 policy**[3], a follow-up to eEurope launched in 2005, 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 policy rationale for the Sectoral e-Business Watch is still valid.

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1 See http://ec.europa.eu/enterprise/ict/index_en.htm#policy for more details.

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

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

Also in 2005, in consideration of globalisation and intense international competition, the European Commission launched a **new industrial policy**[4] 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. In a **mid-term review** of the new industrial policy in 2007, the EC identified three particular challenges: intensified globalisation and technical change as well as climate change. In 2009, the EC will issue a Communication related to the role of high technology and industrial policy in the **economic crisis**.

The SeBW is one of several policy instruments used by DG Enterprise and Industry in this context. Other key instruments include the following:

- 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,
- 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 sectoral innovation performance and challenges across the EU from an economic perspective.

Scope of the programme

Since 2001, the SeBW and its predecessor "e-Business W@tch" have published e-business studies on about **30 sectors** 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 cross-industry ICT issues. All publications can be downloaded from the programme's website at www.ebusiness-watch.org. In 2009, the main studies of the SeBW focus on the following five sectors and specific topics:

No.	Type of study and leader	Sector / topic
1	Sector study (NACE Rev.2 Division 35)	ICT and e-business impacts in the **energy supply** industry
2	Sector study (NACE Rev. 2 Division 23.1-6)	ICT and e-business impacts in the **glass, cement and ceramic** industry
3	Thematic study (cross-sector)	**ICT impacts on greenhouse gas emissions** in energy-intensive industries
4	Thematic study (cross-sector)	An economic assessment of **ICT-related industrial policy**
5	Thematic study (cross-sector)	**e-Skills** demand developments and challenges in manufacturing industries

ICT and e-business use in companies as well as related policy approaches have become increasingly sophisticated in recent years. For the SeBW this implies that there is also a need for **increasingly specific analyses**, conclusions and policy implications.

[4] See European Commission (2005a).

[5] Larger recent activities include a workshop on "IPR in ICT standardisation" in November 2008, and a conference on "European ICT standardisation policy at a crossroads" in February 2008. See http://ec.europa.eu/enterprise/ict/policy/standards/ict_index_en.htm for details.

1.3 ICT and e-business: key terms and concepts

A definition of ICT

Information and communication technology (ICT) is an umbrella term that encompasses a wide array of hardware, software and services used for data processing (the information part of ICT) as well as telecommunications (the communication part). The European Information Technology Observatory (2009) structures the ICT market into three broad segments with an estimated total market value of about € 718 billion in 2009 (Exhibit 1-1). Compared to 2008, the European ICT market has experienced a decrease of minus 2.2%. For 2010, EITO expects the ICT market to stabilise and to decrease by only 0.5% to 714 billion €.

Exhibit 1-1: European ICT market (sales volume) in 2009

Market segment	Products / services included	EU market value estimates (2009)	Development to 2008
Information Technology (IT)	IT hardware, software, services	€ 299 billion	-2.6%
Telecommunications (TC)	TC end-user equipment, carrier services, network equipment	€ 361 billion	-0.7%
Consumer electronics	Examples: flat-screen TVs, digital cameras and navigation systems	€ 58.5	-8%
Total ICT market		*€ 718 billion*	*-2.2%*

Source: EITO 2009

ICT is a technology with special and far-reaching properties. As a so-called **general purpose technology** (GPT), it has three basic characteristics:[6] First, it is pervasive, i.e. it spreads to all sectors. Second, it improves over time and hence keeps lowering the costs for users. Third, it spawns innovation, i.e. it facilitates research, development and market introduction of new products, services or processes. One may argue that only electricity has been of similar importance as a GPT in modern economic development.

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 framework for the discussion of ICT that has been applied in most studies of the Sectoral e-Business Watch.

A definition of e-business

In a maturing process over the past 15 years, electronic business has progressed from a specific to a broad topic. A central element is the use of ICT to accomplish **business transactions**. This means exchanges of goods – or, in economic terms: property rights – between a company and its suppliers or customers.

Transactions can be broken down into **three phases,** and related business processes (see Exhibit A3-2). First, the pre-sale (or pre-purchase) phase includes the presentation of (or request for) information on the offer, and price negotiations. Second, the sale or purchase phase covers ordering, invoicing, payment and delivery processes. Finally, the after-sale or purchase phase covers all processes after the product or service has been delivered to the buyer, such as repairs and updates. Practically each step in a transaction

[6] Cf. Bresnahan/Traijtenberg (1996) and Jovanovic/Rousseau (2005).

can be pursued either electronically ("online") or non-electronically ("offline"), and all combinations of electronic and non-electronic implementation are possible. Therefore it has to be decided which components must be conducted online for a transaction (as a whole) to be termed "electronic".

Exhibit 1-2: Process components of transactions

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

Source: Sectoral e-Business Watch

Electronic transactions, i.e. electronic procurement or sales, constitute **e-commerce**. The suppliers or customers can be other companies ("B2B" – business-to-business), consumers ("B2C" – business-to-consumers), or governments and their public administration ("B2G" – business-to-government).

The OECD proposed two definitions of e-commerce - one narrow and one broad. 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). [7] The addendum regarding payment and delivery illustrates the difficulty in specifying which of the processes along the transaction phases constitute e-commerce. The OECD definition excludes the pre-sale or pre-purchase phase and focuses instead on the ordering process. The SeBW follows the OECD position on this issue, while fully recognising the importance of the internet during the pre-purchase phase for the initiation of business.

The OECD Working Party on Indicators for the Information Society proposes a definition of **e-business** as "*automated business processes (both intra- and inter-firm) over computer-mediated networks*", with the imperative conditions that "*the process integrates tasks (i.e. a value chain) and extends beyond a stand alone / individual application*" and that "*the processes should describe functionality provided by a technology, not a specific technology per se*" (OECD, 2003, p. 6). Using this definition, e-commerce is a key component of e-business, but not the only one. This wider focus on business processes has been widely recognised: e-business also covers the digitisation of **internal and external business processes** that are not necessarily transaction-focused. Internal business processes include functions such as research and development, finance, controlling, logistics and human resources management. An example of external cooperative or collaborative processes between companies would be industrial engineers collaborating on a design in an online environment.

In addition, the OECD proposed that e-business processes should integrate tasks and **extend beyond a stand-alone application**. Thus, simply using a computer in a company

[7] These definitions remain useful today. For recent developments in definitions related to e-commerce and e-business see OECD (2009), pp. 41-48.

does not constitute e-business. The most rudimentary form of e-business may thus be to connect two computers in a local area network.

The term “automation” in the OECD definition refers 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). Advanced automatic machine-to-machine exchanges are just unfolding their technical and economic potential and may lead to new applications and services with profound impact on business and society. Such developments are related to what is called the “Future Internet”, comprising the “Internet of Things” and the “Internet of Services”.[8]

Electronic exchanges require interoperability, i.e. the agreement between the participants on electronic **standards** and processes for data exchange. In a wide sense, standards are defined here as “technical specifications”. Standards and standardisation remain a key issue in further sophistication of e-business.

Definition of key terms for this study

- ***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) 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 or purchase phase.*
- ***e-Business**: automated business processes (both intra- and inter-firm) over computer mediated networks. (OECD). e-Business covers the full range of e-transactions as well as collaborative processes such as joint online design processes which are not directly transaction focused.*

e-Business and a company's value chain

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 remains useful when describing the opportunities of e-business.[9] A **value chain** represents the main functional areas (“value activities”) of a company and differentiates between primary and support activities. These are "*not a collection of independent activities but a system of interdependent activities*" which are "*related by linkages within the value chain*".[10] These linkages can lead to increased process efficiency and competitive advantage through optimisation and co-ordination. This is where ICT can have a major impact.

The term **value system** expands this concept beyond the single company. The firm's value chain is linked to the value chains of (upstream) suppliers and (downstream) buyers. The resulting set of processes is referred to as the value system. All e-business processes occur within this value system. Key dimensions of the value system approach are reflected in the **Supply Chain Management** (SCM) concept.[11] This focuses on opti-

[8] See European Commission: Internet of Things – An action plan for Europe. COM(2009) 278 final. Brussels, 18.6.2009; and European Commission: Communication on future networks and the internet. COM(2008) 594 final, Brussels, 29.09.2008.

[9] See Porter, Michael E. (2004); original published in 1985.

[10] See Porter (2004), p. 48.

[11] See SCOR Supply-Chain Council: Supply-Chain Operations Reference-model.

mising the procurement-production-delivery processes, not only between a company and its direct suppliers and customers, but also in terms of a full vertical integration of the entire supply chain. Analysing the digital integration of supply chains in various industries has been an important theme in most sector studies by the SeBW.

The importance of e-skills and company organisation

The optimisation of value systems with ICT requires employees with particular skills. ICT skills or "e-skills" comprise ICT practitioner skills, ICT user skills and e-business management skills. Furthermore, the successful use of ICT is not only a matter of implementing technology but also of adapting the company's organisation to the specific needs of an electronic value chain. Organisational changes may for example relate to a rearrangement of strategies, functions, and departments.

e-Business in times of economic crisis

While e-business had regained momentum as a topic for enterprise strategy in recent years, the situation and outlook of ICT investment has become much less favourable with the economic crisis since mid-2008. In its Information Technology Outlook, the OECD stated that in 2009 "*ICT growth is likely to be below zero for the OECD, with considerable turbulence as the financial services sector restructures and the real economy experiences a deep economic downturn.*" (OECD, 2008, p. 15)

However, the economic crisis does not affect all ICT in the same way. The OECD expects that "*IT services and software will generally grow, along with new internet and communications-related products and infrastructure, as they are an essential part of spending, and partly recession-proof*" (OECD, 2008, p. 15). The OECD also expects that growth of the ICT industry is unlikely to suffer the collapse that accompanied the bursting of the "new economy" bubble in 2001 (p. 23). Furthermore, the development of ICT investment differs by industry. Industries exposed to deep demand cuts, such as the automotive industry, may have to reduce their ICT investment, while industries with more stable demand, such as energy suppliers, may sustain their ICT investment. In any case, the evolutionary development of e-business has certainly not come to an end with the economic crisis. "E"-elements have become an essential component of modern business, and trends such as "cloud computing" and "Web 2.0" are likely to intensify this process.

Increasing competitive pressure on companies, many of which operate in a global economy, has been a strong driver for ICT adoption. Companies use e-business mainly for three purposes: to **reduce costs**, to **increase revenues** and to **improve customer service**. In essence, all e-business projects in companies explicitly or implicitly address one or several of these objectives. Recently, the use of ICT to **save energy** and reduce greenhouse gas emissions emerged as a specific issue of cost reduction, one with wide impacts for the economy and society as a whole.

While cutting costs continues to be a key motivation for e-business activity, particularly in the current economic crisis, anticipatory firms exploit the **innovation** potential of ICT for key business objectives. They have integrated ICT in their production processes, quality management, marketing, logistics and customer services. These functions are considered crucial to improving the competitiveness of European economies. Competing in mature markets requires not only optimised cost and excellent quality of products or services; it also requires effective communication and cooperation with business partners. Companies that exploit the innovative potential of ICT even in times of economic crisis could emerge from the crisis stronger and more competitive.

1.4 Study objectives and methodology

Study rationale and objectives

One of the principal thrusts of the Sectoral e-Business Watch in comparison with its predecessor, the European e-Business Market Watch (2002 – 2006), is a stronger focus on industrial policy implications. More refined industrial policies may be important to sustain and enhance competitiveness of European industries in an increasingly competitive global business environment. Competitors are increasingly from major emerging economies, the so-called "BRICS" economies, i.e. Brazil, Russian Federation, India, China and South Africa. This applies also to the ICT industry.[12]

To this end, this report contributes to producing a **more refined concept** to develop ICT-related industrial policies. "Concept" means a set of elaborated guidelines, structured for example by the policy measures' target groups and effectiveness. Such a concept needs a sound theoretical and empirical foundation. Hence this report describes, analyses and assesses ICT-related industrial policy practices with theoretical and empirical methods.

Focuses of the study

ICT-related industrial policy is a complex field with a high number of actors as well as possible approaches and instruments. At the outset of the study, it is therefore necessary to target particular geographic entities, policy fields, industries and certain themes. With regard to **geographic entities**, the primary interest of the study is in activities by the European Commission. Activities in Member States and regions as well as in countries outside Europe play a secondary role.

The study focuses on policy fields of principal importance for current ICT and e-business development. The principal policy fields analysed are ICT innovation and adoption. With regard to ICT adoption, the primary interest is the enhancement of companies' **electronic value systems**, i.e. data exchange in inter-company business relationships.

The study focuses on policies for **ICT-producing industries** and **ICT using manufacturing industries**, not service industries. Particular reference is made to energy-intensive industries which are of special current interest for the EC, i.e. chemicals, pulp and paper, steel as well as glass, ceramic and cement.

The study report pays attention to a **theme** that emerged in recent academic and political discussions of ICT and e-business: the "enabling role of ICT for innovation". This theme is recurrent but it does not constitute a tight framework.

Methods

A fine-tuned set of methods was used for collecting data and analysing ICT-related industrial policy. Principal methods were a theoretical analysis, an online survey, and literature evaluation. Case studies, expert interviews, and evaluation of secondary data were additional sources.

[12] See OECD (2008), p. 30.

A **theoretical analysis** of ICT-related industrial policy is the key part of the report. It has a micro-economic approach and draws from game theory, the theory of industrial organisation, market failure theory and cursorily also from state failure theory.

Primary quantitative data was collected with an **online survey** of experts in the field of ICT and e-business policy. These predominantly included members of the European e-Business Support Network (eBSN) for SMEs and the European Network of Information Society Research (ENIR) which is managed by empirica.

A sound **literature evaluation** was conducted and relevant sources were evaluated. There is a multitude of valuable sources so that literature research needed to be limited to the most important items. As regards practical policy, most important sources included the European Commission, the OECD and principal European industry associations. Key articles of economics literature were followed up in particular for the theoretical analysis.

Three **case studies** about ICT and e-business support programmes as well as companies participating in them were conducted.

Five focused **interviews** were conducted with experts from different professional backgrounds.

There are not many quantitative studies about ICT-related industrial policy available so that **secondary data** plays a subordinate role in this study.

Validation of results – the advisory board

The study was conducted in close consultation with an Advisory Board, consisting of the following experts (in alphabetical order):

- Antti Eskola, Ministry of Employment and the Economy, Innovation Department, Finland; active member of the e-Business Support Network (eBSN).
- Paul Heidhues, University of Bonn, Professor, Economic Theory, Germany.
- Philipp Köllinger, Erasmus University Rotterdam, Assistant Professor in Economics, Netherlands.
- Paula Swatman, University of South Australia, Professor for Information Systems, Australia.

Two formal meetings of the Advisory Board were held, in addition to informal exchanges with the members. The first meeting took place on 30 April 2009 in Brussels. At this meeting, the research plan, the concept for the theoretical analysis and first findings were validated. At the second meeting which took place on 13 July 2009, concepts and findings of the interim report were discussed.

2 Context and background

2.1 ICT-related industrial policy: definition, instruments and approaches

A definition of industrial policy and its objectives

There are many different definitions of industrial policy.[13] Very broadly one may define it as policy measures to promote the economic performance of industries. While "industrial policy" is a widely used term in economics and economic policy, the term "ICT-related industrial policy" has been introduced for the purpose of this study. ICT-related industrial policy is defined here as **policy measures to promote the production and adoption of ICT in particular industries**. The production aspect is related to ICT-producing industries in this report; it includes research, development and innovation (R&D&I) of ICT hardware and software. ICT-using companies also produce ICT for internal purposes, e.g. embedded software, but this is not considered here. Adoption of ICT is an issue in all types of industries, ICT-using industries in particular. These two aspects, ICT R&D&I and production on the one hand and ICT and e-business adoption on the other hand, can be considered as two sides of the same coin.

The objectives of ICT-related industrial policy are to foster competitiveness, growth and employment in the industries concerned. However, this does not suggest that the adoption of ICT and e-business per se improves economic performance. While basic ICT such as computer and internet access are prevalent in almost any kind of company, it may be economically rational for companies not to invest into specific ICT and e-business because the return on investment would be too small.[14] Findings suggest that companies need to identify their optimal level of ICT investment into ICT products, services and processes that are optimal for the companies, depending on their business model. Thus ICT investment cannot be considered a panacea against economic distress, so that ICT-related industrial policy needs to be well-defined.

Industrial policy instruments

Instruments of ICT-related industrial policy include, as industrial policy in general, four basic types of interventions: regulation, infrastructure enhancement, financial incentives and involvement in entrepreneurial decisions. This comprises a vast array of particular measures, for example the following:

- **Framework regulation***:* definition of obligatory ICT standards or public support of standards developed by industry, public certification of electronic goods and processes, ICT professional codes, definition of entry rules to ICT markets, price interventions in the ICT market, tariffs or non-tariff barriers in foreign trade of ICT goods. Regulation policy may also include deregulation of industries such as telecommunications and the reduction of administrative burdens to e-business.

[13] As Pelkmans (2006), p. 46, noted: *"There is a great deal of confusion about what industrial policy is, only surpassed by the confusion of what* European *industrial policy might be."*

[14] See for example the case study of the Patina foundry in the SeBW study about the steel industry in European Commission (2008c).

- **Infrastructure enhancement***:* supply of electronic communication networks; building, maintenance and improvement of ICT applications in public traffic roads, railways and waterways, energy and water supplies, sewerage, education and health facilities. Infrastructure policy related to ICT and e-business may also include the provision of research and technology parks, the establishment of ICT expert councils and the provision of ICT and e-business-related information.
- **Financial incentives**: direct subsidies to costs of, for example, personnel and technical facilities to conduct ICT research and development, or costs of operations, for example marketing activities such as participation in trade exhibition. Indirect incentives may include tax reduction or public consulting services. A further option is resource sharing in public-private partnerships, for example in e-business development projects with public project managers.
- **Involvement in entrepreneurial decisions**: fostering concentration, public capital ownership, public executives in company's boards, nationalisation of companies.

Due to possible interventionist instruments, industrial policy has the image of an urchin in economic policy. Not long ago, the most interventional set of industrial policy instruments, i.e. involvement in entrepreneurial decisions, was clearly declining in Europe. However, due to the economic crisis, views have changed. In order to help key enterprises and industries of the European economy through the crisis, even nationalisation of companies has turned to become a sincere option in some cases.

Approaches to industrial policy

Five approaches to industrial policy can be distinguished, from clear market conformity to strong interventionism. The most market conform approach is **market economy policy for structural adaptation**. It implies to design a long-term framework for business activity in a market economy. Such policy is mainly aiming at enhancing mobility of production factors in order to improve competitiveness, leading to efficiency and growth. Instruments of such a policy approach include deregulation, privatisation and opening of markets.

Adaptation to structural change is a second industrial policy type; „positive" and „negative" adaptation can be distinguished. Positive adaptation means to seek to maintain or regain competitiveness of declining industries through innovation in products, services or organisation. The "new industrial policy" seeks to promote industries with key importance for national economies – which may for example be aeronautics – to ensure their strength versus foreign competitors. Negative adaptation means that political decision makers procrastinate the decrease of capacities in declining industries for the sake of preventing hardships for the employees concerned.

Anticipative structural design, also known as "strategic trade policy" is a concept to promote industries that are claimed to have high growth potential. These may for example be high technology industries. The underlying idea is to foster dynamic returns to scale that would not be achieved without public support.

Policies of **structural preservation** imply to support industries and companies that would not be viable under market conditions. The aim is to maintain jobs or income or to ensure supply with raw materials such as coal or with basic food. Instruments of such policy include subsidies and market entry restrictions, for example tariffs in foreign trade.

Finally, **structural planning** implies investment control and restrictions to decision making in private companies. This may include public capital shares in enterprises, state

commissioners guiding enterprises, or nationalisation of enterprises. Such policy is close to concepts of command economies.

In times of economic crisis and increasing global competition, policies of positive adaptation to structural change and anticipative structural design may be particularly attractive for governments to ensure industrial competitiveness and growth. However, several counter-arguments need to be considered:

- It is difficult even for private companies to anticipate what technologies and products will really be successful in the future; it is even more difficult for state governments that do not have direct market involvement.
- Grants to particular industries may lead to subsidy races between countries.
- Each subsidy needs to be funded. It draws purchasing power from consumers by way of taxes or public dept, and it redirects funds that could be invested into other purposes, e.g. infrastructure for education, health and transport.

2.2 ICT-related industrial policy in the EU and beyond

Industrial policy of the European Commission

Before describing ICT-related industrial policy of the EU in particular, it is meaningful to outline the EU's industrial policy in general because it provides a framework for more specific policies. The current framework for industrial policy in the EU has been set down in October 2005 in a Communication entitled "*implementing the Community Lisbon Programme: A policy framework to strengthen EU manufacturing – towards a more integrated approach for industrial policy*".[15] The term "integrated" refers to *"increased coherence and integration between policies*".[16] This means that the EC seeks to "*achieve a greater consensus over policy, by involving key stakeholders, social partners and Member States, at an early stage in policy making*".[17] The objective of the approach is to "*support adaptability and structural change to boost the competitiveness of EU manufacturing, especially in the light of increasingly strong competition from China and Asia.*"[18] The EC sees a critical need for structural adaptation because "*EU trade is still concentrated in sectors with medium-high technologies and low to intermediate labour skills*", which "*exposes the EU to competition from producers in emerging economies*".[19] The basic concept behind is to **"*create the right framework for industry to thrive*" without protectionism and subsidies**.[20] Thus, the main policy tool is "*better regulation*". The EC sees a clear need for EC industrial policy to complement Member States' activities because issues such as a competitive space industry could not be adequately addressed at national level.[21]

The launch of the new framework for industrial policy in 2005 included seven horizontal and seven sector-specific initiatives. The initiatives notably include two items related to

[15] See European Commission (2005a).
[16] See European Commission (2005b), p. 2.
[17] See European Commission (2005b), p. 2.
[18] See European Commission (2005b), p. 1.
[19] See European Commission (2005b), p. 3.
[20] Quotation by Commissioner G. Verheugen, see European Commission (2005b), p. 1.
[21] See European Commission (2006b), p. 1.

ICT: a "task force on the competitiveness of ICT" and a "series of competitiveness studies" including the ICT industry. This stresses the importance the EC attributes to ICT.

In a mid-term review in July 2007, the EC renewed its industrial policy in response to climate change, technological change and globalisation. As regards **climate change**, the EC urged industry to place greater emphasis on reducing carbon emissions and improving energy efficiency. The EC expresses a need to improve both competitiveness and environmental impact of energy-intensive industries in particular. As regards **technological change**, the EC recommends companies to integrate in clusters for innovative collaboration purposes, launched a "lead market initiative" and stresses standards as a means to speed up innovation. Responding to increased **globalisation**, EC initiatives focus on safeguarding access to raw materials, improving access to external markets and on facilitating structural change. With its focus on ICT-using manufacturing industries – including energy-intensive industries –, value systems and e-business standards, this report is very much in line with the targets of climate change and technological change.

ICT-related industrial policy of the European Commission

While there is a defined "industrial policy of the EU" there is no such defined policy for ICT-related industrial policy. Directorate-Generals that conduct policies that can be labelled as ICT-related industrial policy include mainly DG Enterprise and Industry, DG Information Society and Media and also for example those units in DG Transport and Energy that deal with ICT applications. Major EC policies related to R&D&I and production of ICT include for example the following:

- ICT-related R&D&I under the **seventh EU Framework Programme for R&D** (FP7)[22], including collaborative research, coordination of national research programmes, Joint Technology Initiatives (JTIs), and Technology Platforms. The budget will be devoted to supporting cooperation between universities, industry, research centres and public authorities throughout the EU and beyond. FP7 includes a total of € 9.1 billion for funding ICT R&D&I, making it the largest research theme in the FP7 cooperation programme, which is itself the largest specific programme of FP7 (with 64% of the total budget).[23]
- ICT-related R&D&I in the **Competitiveness and Innovation Programme** (CIP). The CIP covers entrepreneurship, SME policy, industrial competitiveness, innovation, ICT development and use, environmental technologies and intelligent energy. With a proposed budget of EUR 4,212.6 million, the CIP will fund actions in three different work programmes: (1) the Entrepreneurship and Innovation Programme, with a special focus on SMEs; (2) the ICT Policy Support Programme, supporting the use of ICT in businesses; and (3) the Intelligent Energy Europe Programme. The EC considers FP7 and CIP as mutually reinforcing components.[24]
- ICT-related R&D&I in **Europe Innova**, an initiative of DG Enterprise and Industry launched in 2006 to *"promote partnerships for innovation support"*.[25] It brings together public and private innovation support providers such as innovation agencies, technology transfer offices, business incubators, financing intermediaries, and clus-

[22] See http://cordis.europa.eu/fp7/cooperation/home_en.html.

[23] See http://cordis.europa.eu/fp7/ict.

[24] See http://cordis.europa.eu/fp7/cip_en.html and http://ec.europa.eu/cip/index_en.htm.

[25] See http://www.europe-innova.org, "about Europe Innova".

ter organisations. It has a sectoral approach to reinforce cooperation between business clusters, finance and standardisation practitioners through the establishment of networks. In 2009, a new set of Europe Innova actions is being launched, based on European Innovation Platforms in three policy areas: transnational cluster cooperation, knowledge-intensive services and eco-innovation. The actions are oriented towards the development and testing of new innovation support services for SMEs, notably start-ups.

- ICT-related R&D&I in the **European Research Area**, an initiative started in 2000 to *"optimise and open European, national and regional research programmes in order to support the best research throughout Europe and coordinate these programmes to address major challenges together"*.[26] Five new ERA initiatives were launched in 2008, addressing among other issues research infrastructures, joint programming and international science and technology cooperation. The initiatives aim at establishing durable partnerships with Member States and stakeholders, including business, universities and research organisations.[27]
- Supporting credits to the ICT industry from the **European Investment Bank**.[28]

As regards the second part of ICT-related industrial policy, the ICT adoption part, such policies are mainly in the field of activity of Directorate General (DG) Enterprise and Industry, Unit D.4 "ICT for Competitiveness and Innovation". The following activities can be considered as ICT-related industrial policy measures:

- The **e-Business Support Network** for SMEs (eBSN) brings together decision-makers from business and policy from all over Europe to discuss strategic policy directions. Since 2005, eBSN has focused on the following thematic priorities: identify which sectors are most promising for e-business support measures and whether sectoral policy initiatives are more efficient than others; discuss policies for micro enterprises; improving e-business solutions for SMEs; e-invoicing and e-procurement.[29] A recent eBSN initiative is the collection and distribution of 200 good practice examples of e-business in SMEs in a paper brochure and online database.[30]
- Support ICT standardisation and **ICT standards** adoption. For example, in the framework of the Europe Innova Programme, DG Enterprise and Industry supports several sectoral initiatives for standards adoption.
- The European Commission adopted in September 2007 a Communication on "**e-Skills** for the 21st Century"[31] presenting a long term e-skills agenda and including five major action lines at the European level. Initiatives to improve ICT and e-business skills include for example annual e-skills conferences.
- Activities to create a favourable **legal environment** for e-business. In spite of the harmonisation efforts at European level, national differences and legal barriers still

[26] See http://ec.europa.eu/research/era/index_en.html.

[27] See http://ec.europa.eu/research/era/specific-era-initiatives_en.html.

[28] See http://www.eib.org for the objectives and activities of the EIB.

[29] See "What is e-BSN?" at http://ec.europa.eu/enterprise/e-bsn/about/ebsn/index_en.html.

[30] See http://www.e-pme.eu for details.

[31] See European Commission (2007b).

exist, affecting cross-border electronic transactions. Issues include for example electronic signatures and electronic invoices.[32]

- The **Sectoral e-Business Watch**, established in 2002, monitors and analyses the use and impacts of ICT and e-business across different sectors of the economy in order to provide decision makers with up-to-date information about e-business.

The strategic priorities of the EC's ICT-related industrial policy has changed over the years. This is reflected by the priorities of the eBSN: At its first steps, eBSN confirmed a policy shift from sponsoring and co-financing ICT investments and internet connectivity towards policy instruments that stimulate SMEs to explore the innovation potential of ICT and e-business. More recently, eBSN confirmed a new policy trend, namely supporting SMEs to develop their e-business strategy in full cooperation with their business partners. This report reflects this shift by focusing on value system enhancement policies as the key policy field.

One of the experts interviewed for this study said that "*there is no powerful European industrial policy for ICT*". While there are many ICT-related activities, the expert sees a lack of focus, a lack of lighthouse projects and a lack of understanding of the crucial importance of ICT for the European economy beyond fostering broadband infrastructure. The expert continued that this also applies to the Member States, possibly with the exception of the Nordic countries.

The economic crisis that started in 2008 is forcing the EC to develop new approaches to industrial policy and possibly also to redefine the role of ICT in such policies. A next shift may focus on the adoption of key enabling ICT in companies of all sizes.[33]

ICT-related industrial policy in EU Member States

Responding to the strong implications ICT and e-business have for businesses and industries, many EU Member States pursue dedicated policies to promote ICT and e-business innovation and adoption in enterprises. For example, the SeBW's European e-Business Report 2008 includes descriptions of related activities in Ireland, France, Malta, Netherlands, Norway, Portugal and Spain.[34] Some examples:[35]

- **Austria**: The Protec II programme supports the implementation of ICT-aided strategic product development in SMEs. It is based on the recommendations of an evaluation of its predecessor programme Protec 2002+.
- **France**: TIC-PME 2010 (ICTs-SMEs 2010) aims to advance ICT uptake in SMEs. Measures include ICT training for SME managers and directors, uptake of software for business intelligence and enterprise resource management.
- **Germany**: The PROZEUS initiative focuses on showcasing SME e-business projects. The projects are documented in detail on the initiative's website (www.prozeus.de), a source of unbiased information about e-business projects.
- **Netherlands**: The "Digital Netherlands" initiative successfully uses a "cafeteria model", a modular programme offering ICT-related services to enterprises as a

[32] See http://ec.europa.eu/enterprise/ict/policy/legal/index_en.htm for details.

[33] See the Communication on Key Enabling Technologies in European Commission (2009c).

[34] See European Commission (2008a), Part 4.

[35] Examples from Austria, France and Spain taken from OECD (2008), p. 319.

broad suite of stand-alone programmes, permitting participants to select those that best fit their needs.

- **Portugal**: The "Digital SME" programme had two phases with specific objectives and activities. During the first phase, sector-specific support networks were established for reaching a large group of firms. In the second phase, projects specific to firms were supported at three levels of e-business sophistication.
- **Spain**: The Avanza Plan is intended to increase the use of ICT in SMEs. The aim is to connect 99% of companies with more than ten employees and 79% of micro-enterprises and self-employed to the Internet. The Plan also promotes the integration of ICT in business processes, for example e-invoicing.

There are also initiatives targeting specific industries. In recent years, several EU Member States, including France, Germany, Italy, Portugal and Spain, have launched initiatives to promote e-business exchanges within specific sectors. Some of these initiatives are confined to particular regions. An example is the CARS initiative for the automotive industry in the Stuttgart region in Germany, see the related case study in section 4.1.1.

A key objective of these initiatives is to strengthen the participation of small and medium-sized enterprises (SMEs) in larger firms' digital supply chains. As documented in the SeBW's European e-Business Report 2008,[36] large companies are increasingly streamlining and integrating their procurement and supply-chain processes. Smaller firms in lower tiers of the value chain risk elimination if they cannot comply with their customers' technical requirements – with negative effects for regional or national economies. Policy initiatives aim to counteract this digital divide, arguing that intervention will create a win-win situation for all players and positive overall effects.

ICT-related industrial policy in other regions of the world

Industrial policy is an issue all over the world, and ICT-related industrial policy is becoming more and more prominent. A comprehensive source for related issues is the OECD's Information Technology Outlook of 2008. It states that "ICT policies no longer concern the ICT sector alone, but increasingly target ICT-related developments in other sectors, e.g. the automotive and healthcare sectors".[37]

Exhibit 2-1: Top ten ICT policy priorities in OECD member countries in 2008

1	Government online, government as model user	6	Technology diffusion to individuals and households
2	Promote broadband uptake and use	7	Industry-based and on-the-job training
3	ICT R&D programmes	8	General digital content development
4	Promoting IT education	9	Public sector information and content
5	Technology diffusion to businesses	10	ICT innovation support

Source: OECD (2008), p. 309.

In a survey of decision makers in OECD member countries for the Information Technology Outlook 2008, most of the top ten ICT policy priorities can be interpreted at least partly as ICT-related industrial policy: (2) broadband, (3) ICT R&D programmes, (4) promoting IT education, (5) technology diffusion to businesses, (7) industry-based, and on-the-job training, and (10) ICT innovation support. (5) and (7) are explicitly ICT-related in-

[36] See European Commission (2008a), Part 2 – summaries of sector studies.

[37] OECD (2008), p. 309.

dustrial policy. Exhibit 2-1 shows the complete top ten of ICT policy in OECD member countries. ICT R&D programmes as well as technology diffusion to businesses are of principal importance for this report and thus worth looking at more detailed:

- As regards **R&D and innovation**, OECD countries *"increasingly establish R&D programmes that explicitly promote ICT-related R&D"*, [38] in contrast to just including ICT R&D in general programmes. The OECD found two specific trends: First, channelling of government support towards specific goals and instruments, for example to embedded systems and software, and, second, public-private co-operation in applied ICT research to further socioeconomic goals such as improved health care and environmental protection.
- As regards **technology diffusion**, many countries seek to increase the competitiveness of SMEs through effective use of ICT, for example by supporting uptake and use of business intelligence applications.[39] Almost all respondents to the OECD ICT policy survey mentioned initiatives for technology diffusion to businesses. In previous years, the focus has shifted from diffusion of basic technology such as personal computers and internet usage to more complex applications. For example, the OECD reports that the Korean Ministry of Commerce, Industry and Energy established a programme to promote inter-company integration of product design and manufacturing processes, RFID usage, and supply-chain management systems.

The OECD survey also asked governments about **institutional settings** and procedures for the formulation of ICT policies. The OECD found that public authorities are taking more steps to co-ordinate and set priorities in order to avoid overlapping and sometimes duplicating ICT initiatives. Japan and Korea were found to having established central government institutions to formulate ICT policies and oversee their implementation across ministries. Other countries, including Turkey, Ireland, Denmark and Switzerland, have established advisory bodies that coordinate the implementation of ICT policies across government. However, most countries were found to still have decentralised structures for formulating and implementing ICT policies.[40]

It is difficult to assess the **effectiveness and efficiency of such policies**. A case study about the former IT839/u-IT839 master plan of the South Korean government from 2004 to 2008 suggests that this master plan contributed decisively to Korea's current strength in world-wide IT markets, mobile markets in particular (see section 4.1.3). In the framework of this master plan, the Korean government paid particular attention to fostering ICT R&D&I, university education in engineering and venture capital markets. However, the case study also points to a specific cultural environment in Korea in which private entrepreneurs expect governmental leadership in business issues and in which intense cooperation between private and public decision makers goes without saying. In any case, little can be said about whether government funds spent would have been more effective in alternative investments. Programme **evaluation** would be required to gain deeper insights, but it is not yet sufficiently developed. The OECD found that *"evaluation standards and procedures differ among countries, making international comparisons of programme outcomes, their effectiveness and the promotion of best practices difficult. There are attempts to create cross-country benchmarking tools, but they need to be extended."*[41]

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[38] OECD (2008), p. 315.

[39] See OECD (2008), p. 310.

[40] See OECD (2008), p. 312.

[41] OECD (2008), p. 233.

Key ICT policy issues identified by Sectoral e-Business Watch

Formulating policy implications is a key task of the Sectoral e-Business Watch. SeBW derives its suggestions for policy actions from study findings and related analyses. From 2002 to 2009, the SeBW examined industries of more than 30 NACE divisions and separate groups, including the most important industries in terms of employees, value added and economic importance.

SeBW makes a caveat about the balance between industry policies and ICT policies. In some industries, the key competitive battles are not around ICT. Nevertheless, without improving productivity and customer service through e-business, companies in these industries may have serious problems beating or even keeping up with the competition. They therefore still need to foster effective use of ICT. All in all, the SeBW found solid arguments for policy makers to promote ICT and e-business adoption, but recommends that their policies should carefully consider the industry context and the specific role of ICT for competitiveness in different industries.

SeBW repeatedly identified three policy areas as playing a particularly important role: promoting industry value systems and SMEs, ICT standardisation and standards adoption policy, and ICT skills policy. A more recent development is special attention to the potential for ICT to reduce energy consumption and greenhouse gas emissions in general. All these issues are likely to remain important in the near future because they constitute essential and evolving issues. In this report, policies to promote value systems between companies will be focused, reflecting a current focus of the eBSN. Issues of standards and e-skills are closely related to value chain issues.

Exhibit 2-2: Summary of suggested key policy action lines of the SeBW in 2008

	Electronic value systems	**e-Business standards adoption**	**ICT skills**
Rationale	Lack of readiness of suppliers and customers the most important reason for not applying e-business more intensely; Large firms in particular report difficulties in convincing SMEs about e-business benefits	Low level of ICT standards adoption, frequent use of proprietary standards → interoperability problems	Difficulties in filling vacancies for ICT professionals, lack of development of ICT user skills and e-business skills
Objectives	Support industry-specific e-business networks, particularly including SMEs	Promoting industry-specific standards if they are not widely used but offer proven benefits	Develop, promote and implement a European e-competence framework and national e-skills strategies; support multi-stakeholder initiatives Enhance distribution of e-business knowledge for managers
Links with DG ENTR policy	eBSN activities to promote SME best practices	General standardisation policy Europe INNOVA standardisation projects	European e-Skills Forum Industry-specific e-skills

Source: European Commission (2008a), pp. 57-69.

2.3 Characteristics of ICT-producing and -using industries

A need to select industries for the analysis

Industries differ not only by type of business but also by overall number of companies, size class composition, and value chain characteristics, i.e. characteristics of suppliers, customers and other business partners. Hence, some industrial policy instruments may be better suited to particular industries than other instruments, and some industries may benefit from particular instruments more than other industries. Some industries may not need any industrial policy at all, others may need focused attention. In order to analyse ICT-related industrial policy in a focused manner, it is thus necessary to select certain industries. This report has a double focus, one on R&D&I policies for ICT-producing industries and one on policies for e-business adoption in ICT-using manufacturing industries. In any case the focus is on manufacturing, not on services. While manufacturing industries overall have fairly similar characteristics, service industries such as retail, banking, health or telecommunication services have different characteristics and would require quite a differentiated analysis that would be beyond the scope of this study.

Characteristics of the ICT-producing industries

The ICT-producing industry is of double relevance for this report. First because the report targets R&D&I policies in these industries, and second, with regard to e-business adoption, because any ICT investment involves buying relationships with ICT-producing companies. The ICT-producing industry is not clearly defined in official statistics, which is due to the general purpose character of ICT. While it is easy to subdivide ICT semantically into hardware and software, it is difficult to capture it in statistics. For example, ICT hardware is increasingly embedded in any types of products and software is produced by companies that are no original software producers. For the sake of simplicity, the ICT producing industry is nevertheless subdivided into hardware- and software-producing industries in this report.[42] Relevant is hardware and software for business purposes, not for example for entertainment such as consumer electronics and computer game software. Services for telecommunication, information technology and other information are excluded for the sake of not overloading the analysis.

Hardware industry

The hardware industry, or rather “ICT equipment industry”, includes large parts of NACE Rev. 2 Division 26 “manufacture of computer, electronic and optical products”:

- Group 26.1 comprises “electronic components and boards” such as microprocessors, semiconductors, display components or printer cables. This also includes hardware for RFID, a technology that may be of crucial importance for the development of the “internet of things”.
- Group 26.2, “computers and peripheral equipment”, comprises goods such as desktop, laptop or main frame computers and servers, drives and storage devices as well as printers, monitors, keyboards and “all types of mice”.
- Group 26.3, “communication equipment”, includes for example central office switching equipment, telephone and facsimile equipment and cellular phones.

[42] See http://www.eito.com/definitionsICT.htm for a comprehensive overview of ICT definitions.

- Group 26.51 “instruments and appliances for measuring, testing and navigation” is relevant for example for “smart meters” for electricity, gas and water.[43]

The computer hardware industry is highly concentrated – a few large companies dominate the world-wide market. In Europe a few percentages of companies employ a high share of employees and produce a high share of value added of the total industry. The European hardware industry has a strong position in some elements, for example in mobile phones and basic materials for liquid crystal displays, but a weaker position other segments. For example, European semiconductor production is facing a very difficult competitive situation.[44] In an expert survey conducted for this report, a majority of respondents assessed R&D in hardware manufacturing companies as insufficient for sustaining hardware production in Europe, while they assessed the situation in software production more positively.[45]

Software industry

The software industry is complex, developing fast and not well-defined in NACE and other official statistics.[46] The most relevant sections in NACE Rev. 2 for this report are Class 58.29 “other software publishing”, which comprises “publishing of readymade (non-customised) software”, 62.01 “computer programming activities” which includes “writing, modifying, testing, documenting and supporting software”, and Class 63.11 “data processing, hosting and related activities”, including for example application service provisioning.[47] Three types of software and related types of producers and vendors can be distinguished: packaged software sold by independent software vendors, custom software sold by IT service companies, and embedded software – i.e. software with no user interface integrated in products – produced by manufacturers in a wide range of sectors.

The software industry comprises a huge number of companies, from one-person firms to very large enterprises. In 2005 there were an estimated 18,000 European companies producing packaged software.[48] The European software markets are dominated by big US companies. European companies are generally smaller in size than their US counterparts and often specialise in certain areas and product segments. Market concentration is moderately high, with four companies (all US: IBM, Microsoft, Hewlett-Packard, EDS) capturing 21% of the software and IT services market in Western Europe.

The **competitive position** of European software producers is ambiguous. Europe is a major producer of in-house and embedded software but remains a large net importer of packaged software.[49] A strategic challenge for the European software industry and policy makers is to strengthen Europe’s competitive position in the course of a shift towards new

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[43] See the SeBW 2009 report about ICT and e-business impact in the energy supply industry for the importance of smart meters. – Not included here is group 26.4 “consumer electronics”, 26.52 “watches and clocks”, group 26.6 “irradiation, electromedical and electrotherapeutic equipment”, group 26.7 “optical instruments and photographic equipment” and group 26.8 “magnetic and optical media”.

[44] See ESIA (2008), p. 11.

[45] See section 4.2.

[46] Sources for this section: Capgemini (2006a) and (2006b), Pierre Audoin Consultants (2009).

[47] Not particularly relevant here are publishing of computer games (NACE 58.21), telecommunication services (Group 61), as well as other classes of Group 62 “information technology service activities” and 63 “information service activities”.

[48] IDC estimations according to Industry Expert Group on a European Software Strategy (2009), p. 7.

[49] See Industry Expert Group on a European Software Strategy (2009), p. 1.

paradigms such as Software as a Service (SaaS) and the Future Internet, comprising the so-called “internet of things” and the “internet of services”.

As regards **e-business standards**, though in competition with each other, the recent decades have shown that it is of mutual economic benefit for the software suppliers to agree on certain standards and define clear interfaces.[50] However, interoperability problems remain for many software products because software producing enterprises may seek to lock-in customers to their products or to further sell their services to make non-interoperable software products operate with each other.

Characteristics of ICT-using manufacturing industries

Commonalities of ICT-using manufacturing industries

ICT-using manufacturing industries have many characteristics in common. Their **supply side** is typically an important and fragmented business activity. A large and important part of their supplies is often raw materials, but they commonly depend on different types of intermediate inputs as well as maintenance, repair and organisation (MRO) goods.

As regards **market structure**, ICT-using manufacturing industries typically have at least some sub-sectors that are highly concentrated, with large dominating international players. Markets may thus be largely characterised by oligopolies or bilateral oligopolies. On the other hand, there are typically other sub-sectors that are rather dominated by SMEs with quite different business models.

As regards **e-business adoption**, large and medium-sized companies are typically better equipped with ICT and typically perform higher rates of e-business practice than micro and small companies. In large companies, enterprise resource planning (ERP) systems are crucial for business management. Small companies may not see a need or may not have the necessary funds and skills to invest more in ICT and e-business.

Development stages of electronic value systems

There are also distinct differences between ICT-using manufacturing industries. The most decisive difference relevant here is the development stage of electronic value systems and of e-business standards that support the value systems. Advanced development has normally been driven by large, globally operating companies that dominate the industry. Four industries previously studied by the SeBW represent different reference models of value system development: chemicals, paper, steel and glass-ceramic-cement. These industries are currently of particular interest to the e-Business Watch as well as DG Enterprise and Industry because they are energy-intensive, face particularly high competitive pressure and are key to climate change policy and may thus require particular attention with regard to industrial policy. They will be referred to in the analysis where appropriate.

2.4 Summary of context and background

ICT-related industrial policy: definition, instruments and approaches

ICT-related industrial policy is defined here as **policy measures to promote the production and adoption of ICT in particular industries**. ICT-related industrial policy may be

[50] Capgemini (2006a), p. 17.

considered as a special variation of industrial policy, which is defined here as policy measures to promote the economic performance of particular industries. The objectives of ICT-related industrial policy are to foster competitiveness, growth and employment. However, this does not suggest that the adoption of ICT and e-business per se improves economic performance.

Instruments of ICT-related industrial policy include, as industrial policy in general, four types of interventions: regulation, infrastructure enhancement, financial incentives and involvement in entrepreneurial decisions. This comprises a vast array of measures.

ICT-related industrial policy in the European Union and beyond

The basic concept behind the **EC's industrial policy** is to create a supportive framework without protectionism and subsidies. In July 2007 the EC renewed its industrial policy in response to climate change, technological change and globalisation. While there is a defined industrial policy of the EU there is no such definition for ICT-related industrial policy. Policy measures of the EC to support ICT innovation include Policy measures of the EC to support e-business adoption include mainly the following: the e-Business Support Network for SMEs (eBSN), support of ICT standardisation and ICT standards adoption, initiatives to improve ICT and e-business skills, activities to create a favourable legal environment for e-business, and the Sectoral e-Business Watch itself.

The **strategic priorities** of the EC's ICT-related industrial policy has changed over the years, from co-financing ICT investments and internet connectivity towards stimulating SMEs to explore the innovation potential of ICT and e-business and, more recently, supporting SMEs to develop their e-business strategy in full cooperation with their business partners. Priorities may change again in the course of the economic crisis.

Many EU **Member States** pursue policies to promote ICT and e-business uptake in enterprises, particularly in SMEs and sometimes in particular industries. As regards other industrialised countries, the OECD states that ICT policies no longer concern the ICT sector alone, but increasingly target ICT-related developments in other sectors.

SeBW repeatedly identified three **policy areas** as playing a particularly important role: promoting industry value chains and SMEs, e-business standardisation and standards adoption policy, and ICT skills policy. A more recent development is special attention to the potential of ICT to reduce greenhouse gas emissions.

Characteristics of the industries considered

This report focuses on ICT-related industrial policy for **ICT producing industries** as well as **ICT-using manufacturing industries**. As regards ICT production, hardware and software producing industries are considered in this report. The competitive position of these industries in Europe is ambiguous. While some segments are globally competitive, for example mobile phone production and business software production, others such as semiconductor production and packaged software production are particularly weak.

ICT-using manufacturing industries have many characteristics in common. As regards market structure, manufacturing industries typically have at least some highly concentrated sub-sectors with oligopolistic market structures. On the other hand, there are typically other sub-sectors that are dominated by SMEs. Large and medium-sized companies are typically better equipped with ICT and typically perform higher rates of e-business practice than micro and small companies. Small companies may not see a need or may not have the necessary funds and skills to invest more in ICT and e-business.

3 Theoretical analysis

3.1 Concept for a theoretical assessment of ICT-related industrial policy

General objective of the theoretical analysis

The objective of chapter 3 is to evaluate ICT-related industrial policy by means of selected economic theories. Such an endeavour is new in a study report of the e-Business Watch. The rationale behind is, first, the assumption that economic theory can contribute significantly to analyse and improve economic policy but, second, that there are few attempts to analyse industrial policies with a theoretical toolbox in a way that not only experts in economic theory comprehend the analysis. To the knowledge of the study team, there has been no similar theoretical analysis of ICT-related industrial policy yet. The theoretical analysis is key to this report and it has a distinct objective:

Objective of the analysis: The theoretical analysis is meant to produce insights about strategies and behaviour of companies, Member States and the European Commission when interacting about funding of ICT research, development, innovation and adoption as well as about the design of related policies.

The EC may use insights from the analysis for developing further industrial policies in order to strengthen competitiveness of European industry. "Competitiveness" is understood as a *"set of institutions, policies, and factors that determine the level of productivity"*.[51]

"Theoretical" analysis does not mean that the statements are purely abstract. Many theoretical arguments have been substantiated with empirical findings by third parties, and references to results of primary research for this study are provided where applicable.

Specific objective: exemplary analysis of selected policies

While the goal of the analysis is generic, the concept needs to be specific – the aspects analysed need to be confined in order to reach a satisfactory level of analytical depth. The task of chapter 3 is an exemplary analysis of particular types of policy. The task is not a benchmarking of selected policies, let alone of the industrial policy universe. In order to provide a specific and exemplary analysis, the study team developed a structured scheme explained in the following parts of section 3.1. The theoretical analysis has two different applications, dealing with two parts of the innovation process:

(1) An analysis of industrial policies to support research, development and innovation of key enabling ICT, with the aim of fostering their commercialisation (section 3.3).

(2) An analysis of policies to support the adoption and diffusion of ICT, focusing on e-business applications for enhancing electronic value systems (section 3.4).

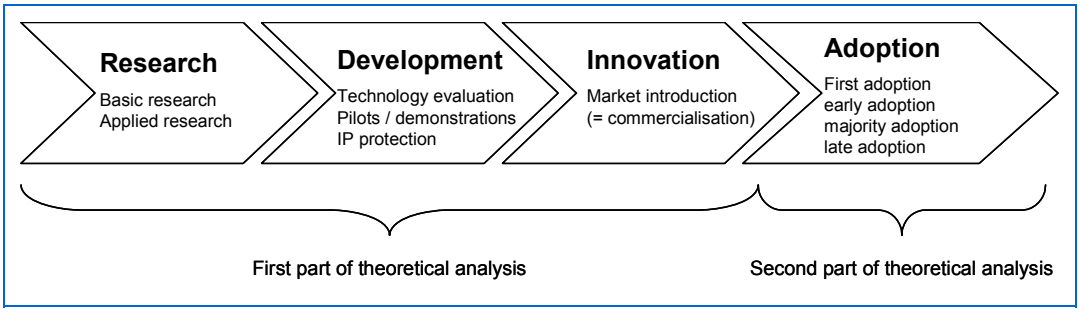
While the second part of the analysis (e-business adoption) is dealing with a traditional subject of the e-Business Watch, the first part (ICT R&D and innovation) expands the previous scope of the e-Business Watch.

[51] Definition by the World Economic Forum (2009), p. 3, there adding "of a country" as the World Economic Forum is focusing countries' competitiveness.

Targeting policies along the innovation stream

The analyses cover policies along the whole stream of research, development, innovation and adoption, as shown in Exhibit 3-1. This stream is of very high political importance. In its 2008 IT policy survey among OECD member countries, "ICT R&D programmes" ranked third behind "government as a model user" and "broadband", followed by "promoting IT education" and the second key issue here, "technology diffusion to businesses".[52]

Exhibit 3-1: Parts of the research, development, innovation and adoption stream covered by the theoretical analysis



Source: Rogers (1996), with modifications by empirica.

In this report, innovation is defined as the market introduction – i.e. commercialisation – of a new product, service or process.[53] Adoption (or diffusion) is defined as the uptake of an innovation by buyers – people or organisations – in the market. Research, development, innovation and adoption are parts of a complex stream. It begins with a problem or need that someone tackles with basic and applied research. The stream may continue with technology evaluation, piloting and demonstration and intellectual property (IP) protection. In the case of an opportunity for commercial use, the product – or service or process – may be introduced into the market, i.e. innovation may take place. If the product is successfully sold, one may distinct between various groups of buyers in the diffusion phase: the "first adopters", the "early adopters", the majority of buyers who may follow, and some "late adopters".

Innovation in practice is a much more complex process than indicated in this sequence. Innovations are complex technological and economical processes, implying feedback from users and other people involved, ongoing learning and further research.[54] Nevertheless the two-dimensional flow diagram illustrates the core events.

[52] See OECD (2008), p. 309.

[53] The definition used in this report follows the Schumpeterian tradition, i.e. the school of thinking based on the works of the Austrian economist Josef A. Schumpeter (1883–1950). There are schools of thought defining innovation in a different manner. See Sundbo (1998), pp. 1–2 for definitions and theoretical considerations on the concept of innovation.

[54] See Kline/Rosenberg (1986), above all pp. 285–294, for a more complex model of innovation, the "chain-linked model".

Distinct subjects of the theoretical analysis of ICT R&D&I

Subject of first analysis: The first part of the theoretical analysis deals with policies to promote research, development and commercialisation of key enabling ICT in ICT-producing industries.

More detailed, the analysis related to ICT R&D&I (section 3.3) has three distinct subjects:

(1) Targeted technology: key enabling ICT

The first analysis targets key enabling ICT. The term "enabling" refers to the opportunity to use ICT for continued innovation in the ICT industry itself as well as in other industries. SeBW surveys repeatedly found that ICT is often the basis for product, service and process innovation in any industry. ICT development is far from having crossed the zenith and ICT R&D&I may be crucial for ensuring future economic growth and employment in Europe. In infrastructure, ICT R&D&I may target optical broadband networks.[55] In hardware, ICT R&D&I may target future generations of ICT components based on nano-electronics, photonics and organic electronics.[56] In software, ICT R&D&I may target technologies required for developing the "future internet", made up of the "internet of things" and the "internet of services" which may have profound impacts on productivity, growth and employment.[57] The issue here is advanced ICT such as business grids for joint use of computer capacity in companies in any industry, ICT-enabled smart grids and smart metering in the energy supply industry or intelligent transport systems in the transport industry. The issue here is not basic ICT such as common personal computers, internet access and e-mail.

(2) Targeted industries: ICT-producing industries

The analysis of ICT R&D&I deals with ICT-producing industries, i.e. industries producing computer hardware and their components as well as software (see section 2.3 for a description of these industries). The focus is not on IT consulting and telecommunication service companies.

(3) Targeted issue of possible public support: co-operative R&D&I

The analysis targets co-operative international R&D&I, i.e. joint research, development and innovation that involves companies and other organisations from different countries. The issue is to develop economies of scale and scope in European R&D&I in the field of key enabling ICT.

The issue of co-operative R&D&I was selected because the EC considers it as a key issue for improving the competitiveness of the European ICT industry and because co-ordination of Member States' activities is in general a key task of the EC.[58]

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55 See OECD (2008), p. 144.

56 See European Commission (2009a), p. 3, and OECD (2008), p. 144.

57 See for example European Commission (2009b) for the EC's Action Plan on the internet of things, European Commission (2008e) for a Communication on future networks and the Internet, also SAP (2008) and Industry Expert Group on a European Software Strategy (2009).

58 See section 3.3.1 for more details.

Distinct subjects of the theoretical analysis of ICT adoption

Subject of second analysis: The second part of the theoretical analysis deals with policies to enhance electronic value systems in ICT using manufacturing industries through the further diffusion of ICT and e-business applications.

More detailed, the second part of the analysis (section 3.4) has three distinct subjects:

(1) Targeted technology: ICT for e-business purposes

The diffusion of ICT for e-business reflects the principle thrust of the SeBW. The targeted ICT include, first and basic, network facilities and related software for internet access. Second and most important for the analysis here, it includes applications for communication with business partners, for example systems for e-procurement or e-sales including e-catalogues and systems for co-operative design of new products or systems to jointly plan inventory. This may include developments such as cloud computing, i.e. the provision of any kind of software and services from the internet (the "cloud"), and business grids, i.e. the sharing of computer resources across companies. It may also include software systems for internal purposes that can be linked with other companies, for example for enterprise resource planning (ERP). ICT in production facilities is no subject in this report.

(2) Targeted industries: Key ICT-using manufacturing industries

The second part of the analysis deals with diffusion of ICT in ICT-using manufacturing industries and companies (see section 2.3 for characteristics of these industries). ICT-producing companies also play a role in the analysis in their role as suppliers to ICT-using companies. The subject is not ICT diffusion to governments or private households.

(3) Targeted issue of possible public support: electronic value systems

The second part of the analysis targets specific policies to enhance electronic value systems. Electronic value systems are defined here as computerised data exchange between companies particularly in their (vertical) supplier-buyer relationships but also in horizontal relationships such as joint planning of inventory. The study uses the term "value system" for inter-company relationships and "value chain" for intra-company processes, following the definition of Michael Porter.[59]

The value system issue has been selected because it is a current considered a key issue for enhancing the competitiveness of European enterprises and because it is a priority of the European e-Business Support Network (eBSN).[60]

A fictive example of applying game theory

A third part of the analysis (section 3.5) provides an exemplary application of game theory in promoting cooperative research, development and innovation on a European level. This example is meant to derive further policy implications.

[59] See section 1.3, "e-business and a company's value chains", for a more detailed explanation. The term "system" may be more appropriate for the complex multi-dimensional linkages between companies in producing goods, while "chain" suggests a simple one-directional flow.

[60] See section 3.4.1 for more details.

Important but not targeted: e-skills

A further important issue for electronic value chains that will however not be dealt with in detail is e-skills. The term includes ICT professional skills, ICT user skills and e-business management skills. e-Skills are indispensable for the knowledgeable use of ICT and e-business. As the OECD states, "*it is generally accepted that considerably higher levels of investment in intangibles, human and organisational capital are needed to complement ICT and broadband investments.*"[61] However, e-skills issues will not be included in the analysis because this would require a different theoretical approach. The theoretical approach applied here deals with relationships between companies, not for relationships between companies and current or potential employees. The analysis cannot deal with issues that would require to include theories of labour markets, education or human capital.

Theories applied and sequence of the analysis

The analysis is based on applied game theory and includes three steps, applying industrial organisation theory, market failure theory, and state failure theory. There will be no detailed analysis of state failure arguments because this would require a different comprehensive approach which is beyond the scope of this study. Why were these theories selected? The rationale behind was as follows:

- **Game theory** was chosen as the basic approach because it is the principal theory for analysing interactions of decision makers used in economics.[62] Industrial policy is much about interactions among companies, companies and political decision makers, and political decision makers among themselves.
- **Industrial organisation theory** was chosen because it is the principal approach to analyse the relationship between market structures, company conduct and company performance. Well-founded industrial policy cannot do without a profound understanding of market structures and developments in the industries concerned.
- **Market failure theory** was chosen because it is the principal approach to analyse whether there is actual need for political activity and, if so, of what type this political activity should be.
- **State failure theory** was called in to have an analytical tool to describe possible shortcomings of political activity. Interactions between companies and political decision makers as well as between political decision makes among themselves are crucial for industrial policy.

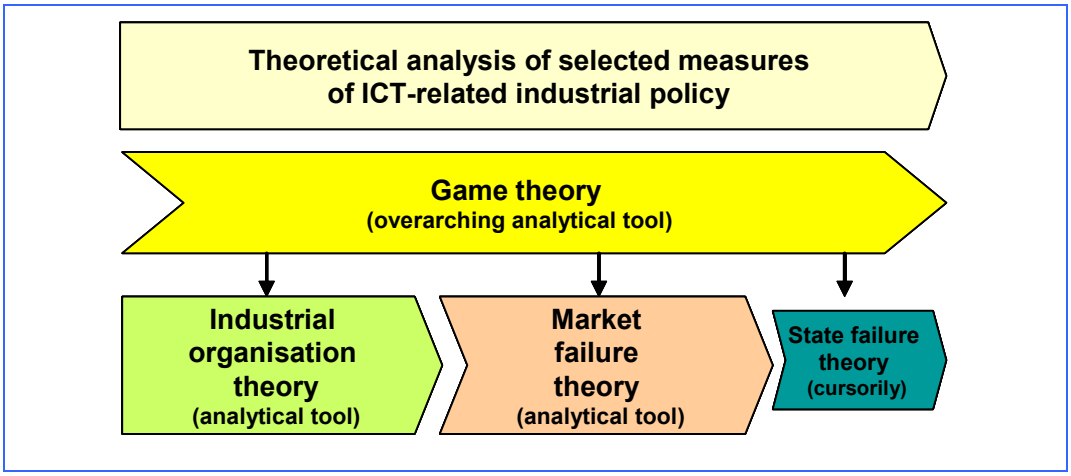
The theoretical analysis is conducted along the concept described in Exhibit 3-2.

All steps of the analysis are linked to produce concrete results. The theoretical analysis is target-oriented towards policy implications, it is not an exercise for the sake of itself.

[61] OECD (2008), p. 20.

[62] As Ross (2006) states: "Game theory is the most important and useful tool in the analyst's kit whenever she confronts situations in which what counts as one agent's best action (for her) depends on expectations about what one or more other agents will do, and what counts as their best actions (for them) similarly depend on expectations about her."

Exhibit 3-2: Theoretical concept for the study about industry-related ICT policy



Source: empirica/DIW

► **Overarching: characterise different kinds of strategic interactions and explain their relevance for ICT-related industrial policy**

Analytical tool: game theory

Game theory is used here to analyse possible strategic behaviour of companies and public entities. The following interactive constellations are considered: ICT using companies among themselves, ICT using companies versus ICT producing companies, companies versus governments as well as governments among themselves. Game theory contributes to refine and categorise arguments of market and state failure in this respect.

► **First step: Describe typical situations of ICT investment, analyse strategic interactions between firms, examine the impact of different market structures**

Analytical tool: industrial organisation theory

Specific approaches of the theory of industrial organisation are applied, also referring to game theory. The focus is on strategic conduct of firms and their performance in particular market structures. Individual companies' decisions to invest into ICT is explained.

► **Second step: Discuss whether distorted ICT investment decisions can be interpreted as market failure**

Analytical tool: Market failure theory

The next step is to discuss whether companies' distorted decisions to invest into ICT can be interpreted as market failures. From an economic theory point of view, market failures may be due to external effects, imperfect competition and imperfect information.

► **Third step: Discuss whether industry-related ICT policy measures comply with market failure arguments**

Reference tool: State failure theory

Finally, the study discusses to what extent selected policy measures comply with market failure arguments. Arguments from state failure theory are used to discuss possible shortcomings of policy measures. This theory mainly refers to imperfect information of public actors and potential commitment problems.

3.2 Assumptions and subjects of the theories considered

The theoretical concept applied in this report comprises numerous different aspects. The following Exhibit 3-3 provides an overview of the theories as well as their key assumptions and subjects.

Exhibit 3-3: Overview of theories applied in this report and key aspects

Game theory	
Definition:	Theory of strategic interactions ("games") between consumers, firms and policy makers ("players").
Key assumptions:	Rational behaviour: players use all information they have to choose their actions according to their impact on their payoffs. "Strategy": a complete plan of actions. "Best response": action maximising payoff given the actions of the other players.
Key subjects:	Aim: predict behaviour of players by looking at strategies constituting an equilibrium. Equilibriums are crucial because they allow to analyse the outcomes of games. Key concepts: Nash equilibrium, Harsanyi/Selten's refined equilibrium, dynamic games and subgame perfection, perfect Bayesian equilibrium
Industrial organisation theory	
Definition:	Theory of strategic behaviour of firms, their interactions and the structure of markets ("theory of imperfect competition").
Key assumptions:	Firm and industry performance determined by conduct of buyers and sellers, which in turn is determined by market structure
Key subjects:	Generally: relationships between market structures, enterprises' conduct and market outcomes; network effects and coordination problems. Here: Influence of horizontal and vertical market structures on ICT innovation and e-business adoption.
Market failure theory	
Definition:	A market failure is a situation in which free markets produce inefficient results.
Key types of market failure:	Market failures with respect to ICT investments can be traced back to three factors: (1) Difficulties in appropriating the returns from innovation due to external effects. (2) Imperfect competition and strategic behaviour distort the firms' investment incentives which may lead to sunk costs and inefficient investment levels. (3) Network effects and strategic complementarities can lead to coordination failures.
State failure theory	
Definition:	Theory of possible failures in governmental decisions, i.e. inefficient policies.
Key assumptions:	Companies and lobby groups seek to maximise their individual utility; governments seek to maximise social welfare.
State failure between governments and companies:	Imperfect information is principal source of state failure. Special issue: companies potentially benefiting from industrial policy may provide biased information.
State failure between EU and Member States (MS):	Possible negative external effects from national policies => suboptimal welfare on EU level Asymmetric information between EU enacting policies and MS implementing them => MS may implement ICT-related policies in unwanted manner => due to risk of infringement companies may hold up ICT investment decisions

Source: empirica/DIW

3.2.1 Game theory

Definition and importance

Game theory is the theory of economically rational decision-making of individuals in interactions. Game theory provides a basic framework for analysing strategic interactions (referred to as "**games**") between consumers, firms and policy makers. It considers the behaviour of decision-makers (referred to as "**players**") in settings where the players' payoff and thus their behaviour is interdependent. Game theory has developed to become a very important base for analysis in economics and also in social sciences since the 1990s.[63] The starting point of modern game theory was the book "theory of games and economic behaviour" by John von Neumann und Oskar Morgenstern in 1944.

Payoff functions, rational behaviour, actions and strategies

A player is an actor who makes decisions with the aim to maximise his or her payoff or, technically speaking, his or her **payoff function**.[64] Payoffs can for example be utilities of individuals or profits of companies. The notion which is closely related to the assumption that each player maximises his payoff is that of **economically rational behaviour**:[65] players are assumed to use all the information they have and to choose their **actions** according to their impact on their payoffs.[66] Since the payoff of a player depends on the actions of other players, it is important to distinguish between actions and strategies. A player's **strategy** is a complete plan of actions at any stage of the game in which he is supposed to act. A player's strategy thus specifies his action depending on the actions of the other players and the information he has. The information of a player comprises his knowledge about his possible actions, its expected impact on his payoffs as well as his information about the history of the game and the characteristics of the other players. For example, in a model where two firms, A and B, compete in a product market, possible actions of the firms comprise the decisions on the prices they set or the quantities they supply. Assuming that firm A decides first and that firm B can observe the price set by firm A, firm B's strategy specifies how it will react to all possible prices chosen by firm A.

Best responses, strategic complements and strategic substitutes

It is often useful to analyse the behaviour of players in terms of their best responses. The **best response** of a player is the player's action which maximises his payoff given the actions of the other players. If the best responses of the players mutually reinforce each other they are called **strategic complements**, and if they mutually offset each other they are called **strategic substitutes**.[67] If for example the players are companies that must

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63 See Lambertini (2006) for an overview of "milestones" of game theory from an industrial policy point of view.

64 Unsatisfactory as it is, for the sake of briefness "he" and "his" will in the following be used instead of "he or she" and "his or her", always implying that the actor may be male or female.

65 The prefix "economically" is important here. From a non-economic point of view, "rational" has a different meaning, i.e. meaningful, thoughtful, reasonable; and the economic notion may even be found offending.

66 Players' rational behaviour is a simplifying assumption widely used in the theory of industrial organisation. It assumes, for instance, that a player possesses all the information necessary to make decisions and can properly analyse it. In other branches of modern economics this assumption is relaxed, for example in behavioural and experimental economics.

67 These terms were introduced by Bulow/Geanakoplos/Klemperer (1985).

decide how much to produce, the production decisions are strategic complements if an increase in one company's output (e.g. snowboards) increases the demand for the other company's products (e.g. winter sport sunglasses) and thus induces this company to increase its output as well. The companies decisions are strategic substitutes if an increase in the production of one company leads to lower prices (e.g. of snowboards) and thus induces other firms to decrease their output (those which also produce snowboards).

Basic equilibria concept: the Nash equilibrium

Game theory aims to predict the behaviour of the players and the outcome of the game by looking at the strategies which constitute an equilibrium. **An equilibrium is a state in which none of the players has an interest to change his behaviour or strategy.** Positively speaking, in an equilibrium every player responds optimally to the strategies of the other players. To prevent a possible misunderstanding: In an equilibrium the game is not over; it may still go on. Equilibria are of crucial theoretical interest because they allow to analyse the outcomes of games.

The most widely used equilibrium concept is the Nash equilibrium, named after the economist and mathematician John Nash. A Nash equilibrium represents a combination of strategies in which every player chooses his best response to the strategies of the other players. The Nash equilibrium is stable in the sense that **no player has an incentive to deviate from his strategy**. The basic insight of Nash's idea is that one cannot predict the result of several decision makers' actions if analysing those decisions in isolation. A Nash equilibrium does not necessarily imply the best cumulative payoff for all players involved. The players might improve their payoffs if they could agree on different strategies, for example firms forming a cartel to increase prices and profits.

The Nash equilibrium concept can be applied to the analysis of particular games. In his famous theorem Nash has shown that every game has at least one Nash equilibrium which can be in pure or mixed strategies.[68] In a **pure strategy** equilibrium every player chooses a particular action with a probability of one. In a **mixed strategy** equilibrium, players choose different actions, depending on the moves of the other players. A player's best response can be a mixed strategy only if the expected payoff from every action he may choose in equilibrium is the same. Indeed, if one of the actions would lead to higher expected payoff than any other action, then an economically rational player would surely choose this action. Only if the actions played in equilibrium deliver the same expected payoff a player is indifferent between choosing any of them.

The prisoners' dilemma: a fundamental example from game theory

A widely used game is the prisoners' dilemma which refers to a class of games in which the equilibrium in dominant strategies does not maximise the joint payoff of the players.[69] Hence, the outcome which is individually rational is not jointly optimal. For example, consider two firms (A and B) which compete in prices at the product market. Both firms have two actions (which are also strategies in this game): The firms can set either Low (L) or High (H) prices. The firms deliver the same products, so that the firm which sets the lower price gains the whole market. If firms set equal prices, then they are assumed to share

[68] See Nash (1950).

[69] The name "prisoners' dilemma" stems from the original example that was about two suspects arrested by the police, each one offered a deal with being set free if he testifies for the prosecution against the accomplice while the other one remains silent.

the market equally. The matrix in Exhibit 3-4 represents each firm's payoffs depending on its action and the action of its competitor.

Exhibit 3-4: Exemplary constellation of a Prisoners' Dilemma with two firms

		Firm B	
		Low	***High***
Firm A	***Low***	2 / 2	4 / 0
	High	0 / 4	3 / 3

Source: empirica / DIW

When both firms set low prices, each gets the payoff of 2. When both firms choose high prices, then both firms end up with a payoff of 3. Finally, if firms set different prices, then the firm with the low price realises a payoff of 4 (which would be shared between the two firms if both of them set the low price), while the other firm gets a payoff of zero. The only Nash equilibrium in this game is such that each firm chooses the low price. Moreover, the Nash equilibrium is also an equilibrium in dominant strategies such that for any of the firms it is optimal to choose the low price independently of what the other firm does.

Note also that the joint payoff of the two firms is highest when both of them choose the high price and is given by 6, while the joint payoff is lowest when both firms choose the low price and is given by 4. Hence, the equilibrium in dominant strategies does not maximise the joint payoff of the players. Furthermore, since the equilibrium outcome does not maximise the players' joint payoff, the firms would be better off if they were able to cooperate and to commit to choose the high price.

Harsanyi/Selten's refined equilibria concept: payoff or risk dominance

While every game has at least one Nash equilibrium, a game may also have several Nash equilibria. In this case, the Nash equilibrium concept cannot be used to predict the outcome of a game. Refined concepts have to be used. Among these concepts the refinements of Harsanyi and Selten are most prominent.[70] As selection criteria Harsanyi and Selten distinguish between payoff dominance and risk dominance. The **payoff dominance** criterion selects the equilibrium in which the payoff of every player is higher than the payoff in all the other equilibria. Harsanyi and Selten argue that if there is an equilibrium which is payoff dominant the players should be able to coordinate on this equilibrium. **Risk dominance** applies when the players face strategic uncertainty in the sense that they are not aware of the choices of all the other players and they prefer the equilibrium which "secures" them against strategic uncertainty and potentially low payoffs.

For applying the concept of Harsanyi and Selten, **standards adoption is a good example**. In many modern markets with pronounced network effects, users – which can be either firms or individuals – have to make their choices between several, most of the times two, incompatible standards. To predict what standard will be adopted the concept of risk dominance can be used. Risk dominance would lead to the equilibrium which best secures the players from strategic uncertainty. For example, in a risk-dominant equilibrium every firm would choose the standard which is compatible with other standards the firm already uses.

[70] See Harsanyi/Selten (1988).

Dynamic games and subgame perfection

Refinement concepts are also used in dynamic games, i.e. games where players can act sequentially. The most widely used refinement for dynamic games is subgame perfection. A subgame is the game which starts when the player knowing the actions taken by other players is supposed to take his action. Basically, **subgame perfection requires every player to choose his strategy anticipating the outcome of the following stages of the game.** A strategy profile constitutes a subgame perfect Nash equilibrium if it represents a Nash equilibrium in all subgames of the original game.[71]

To determine a subgame perfect equilibrium, one can use the method of **backward induction**. First, one has to find the equilibrium strategies of the players in the last stage of the game and then use this information in order to derive the equilibrium strategies in all the other stages consequently. To illustrate the procedure consider a two-stage game in which two firms first decide on whether to improve their production technologies (or innovate) and compete à la Bertrand by choosing simultaneously prices in the second stage. To find the subgame perfect Nash equilibrium the equilibria in all the possible subgames have to be determined. There are four subgames: a subgame in which both firms improve their production technologies, two subgames with only one firm innovating and the last subgame with both firms refraining from innovation. Knowing the equilibria in all the subgames the firms' innovations decisions and thus the equilibrium of the whole game can be determined. This procedure also implies that players may find it profitable to restrict their own behaviour in later stages of the game. For example, a firm may choose a strategy that commits itself not to increase its prices in later periods. This can be profitable inasmuch it may convince actual consumers to buy the firm's product in the current period.

Incomplete information and the perfect Bayesian equilibrium

There may be situations in which players are uncertain about the other players' types, referred to as games with incomplete information. The type of a player can be characterised for example by his ability to perform different tasks, his willingness to accept specific contracts or his payoffs from engaging in fierce competition. The equilibrium concept used to solve such games is the perfect Bayesian equilibrium. **A perfect Bayesian equilibrium results from a strategy profile and a system of beliefs such that the strategies constitute a Nash equilibrium given the belief system of the players.** For instance, in a game in which players belong to different types the belief of a player is given by his expectation about the distribution of the other players' types. Moreover, each player's belief has to be consistent with the strategies chosen by the other players.

For example, if player A observes an action of player B which is optimal only if player B is of one particular type, player A must update his beliefs in a way that he attributes player B to this particular type. Essentially, perfect Bayesian equilibria rule out equilibria in which players assign positive probabilities to types who would never choose actually observed actions.[72] Perfect Bayesian equilibria are used in signalling games where players who move first can signal their types to other players. For example, a high level education may serve as a signal for a worker's ability to perform difficult tasks.[73]

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71 For a formal definition see Selten (1965).

72 Games with incomplete information may also have multiple perfect Bayesian equilibria. Further refinements concepts such as the intuitive criterion proposed by Cho/Kreps (1987) are used to select one of these equilibria.

73 See Spence (1973).

3.2.2 Theory of industrial organisation

Definition and importance of the theory

The theory of industrial organisation deals with the strategic behaviour of firms, their interactions and the structure of markets. More specifically, it deals with imperfect competition, i.e. with deviations from perfect competition such as limited information, transaction costs, government activity and barriers to market entry. A key conceptual framework of industrial organisation theory is the "structure – conduct – performance" paradigm. Developed by Mason (1939) and Bain (1951), the paradigm states that firm and industry performance is determined by the conduct of buyers and sellers, which in turn is determined by the market structure. Industrial organisation theory has developed to become a major analytical framework for competition policy and also innovation economics.[74]

Game theory and industrial organisation theory are close relatives

Considering the basic subject of strategic interaction, industrial organisation theory and game theory are close relatives. In the following, the concepts of game theory discussed above as well as industrial organisation theory concepts are applied to the question of what determines the firms' ICT investment decisions. ICT investments are interpreted as R&D&I investments (in ICT-producing companies) as well as process innovations such as the adoption of systems for ERP or joint product design (in ICT-using companies).[75]

Horizontal and vertical market structures

As regards market structure, two different aspects need to be considered: horizontal and vertical markets. The term "horizontal market structure" refers to the competitive situation of companies selling the same or similar goods. "Horizontal" means that the companies considered are on the same level with regard to their business relationships with suppliers and customers, i.e. they target the same customers and procure from the same suppliers. Thus, the specific issues of horizontal market structure are market shares and concentration. The term "vertical" market structures refers to the relationships between companies and their suppliers and customers.

The analysis of industrial organisation theory in this report deals with the influence of horizontal and vertical market structures on ICT innovation and on e-business investment, i.e. e-business adoption.

[74] Most of the 2008 SeBW reports include an economic analysis of ICT impacts based on the structure, conduct, performance paradigm.

[75] See section 3.1 for a more detailed explanation of the innovations covered. ICT can also be supportive for product and service innovation which is not considered here.

3.2.3 Market failure theory

Definition and importance of the theory

A market failure is a situation in which free markets produce inefficient results.[76] Market failures imply that rational decisions of individuals based on self-interest lead to situations that are unfavourable from a societal point of view. The compilations and interpretations of market failures differ. There are some schools of economic thought that neglect the existence of market failures or the need for governments to intervene. Market failures with respect to ICT innovation and ICT investments can be traced back to three factors: externalities, imperfect competition and imperfect information.[77] These are elaborated more detailed in the following.

Externalities

An externality is an impact on a party that is not directly involved in a transaction. Externalities imply that prices do not reflect the full costs or benefits. There are **negative and positive externalities**. Greenhouse gas emissions from manufacturing companies which impose costs on society are an example of a negative externality. If a production plant had to pay for the negative external effects on the environment which it causes, prices for the plant's goods would be higher. The publication of knowledge for which others do not have to pay is an example of positive externalities.

A particular type of positive externalities are **public goods**. Public goods have two principal characteristics: first, users cannot be excluded from their consumption and, second, from a societal point of view it is in fact not desirable to exclude users. Private companies would have no or little incentive to provide such goods. Examples include monetary stability, national defence and lighthouses.

Imperfect competition

Roughly speaking, imperfect competition means that one or a few agents in the market are able to shape the equilibrium allocation by their own investment, pricing or quantity decisions. Imperfect competition may be due to entry barriers or increasing returns to scale. An example of entry barriers is high sunk costs in capital-intensive industries such as airplane production. In particular, "natural monopolies" describe a situation with high fix costs and very low marginal costs of production, leaving only one company in the market, as in railways and, some years ago, telecommunication services. While efficiency prescribes that only one firm should serve the market in this case, markets with only a small number of firms generally imply that the firms can exploit their market power to increase their profits. The implied strategic behaviour of the firms lead to market equilibria which do not correspond to socially efficient allocations. Potential distortions comprise prices above marginal costs, inefficient degrees of product differentiation as well as inefficient investment decisions. In reality there are few, if any, examples of perfect competition, so that there are many arguments in favour of state regulation or intervention to counteract market power.

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[76] The first use of the term "market failure" in economics literature was by Bator (1958).

[77] A further type of market failure not relevant here is time lags between production incentives and sales, leading to much lower prices compared to the time when production was initiated and much lower returns to investment than expected, as for example in a "swine cycle".

Imperfect information

Imperfect information may lead to inefficient investment decisions. For example, imperfect information related to network effects and the implied strategic complementarities can lead to coordination failures. A particular type of imperfect information is asymmetric information, i.e. one side is better informed than the other about a certain subject and may exploit this advantage for its own benefit. This may for example apply to vendors and buyers of used cars, the situation originally used to illustrate the implications of asymmetric information.[78]

3.2.4 State failure theory

Definition and scope of state failure theory in this report

State failure theory is the counterpart of market failure theory. It deals with possible failures in governmental decisions and policy making, i.e. with inefficient policies. Modern economic theory and theories of state failure in particular assume that policies are endogenously chosen by governments or policy makers, i.e. governments are part of the economic models and companies can influence their decisions.[79]

Assuming that governments as well as companies and industry lobby groups act rationally in an economic sense, political decision making is analysed as a game between these sets of players here. The analysis assumes that **companies and lobby groups maximise their individual utility** and the profits of their members, respectively. Governments may have different objectives. Some schools of economic theory assume that governments act in their own interests. For example, governments may seek to increase the probability for being re-elected or to adopt policy measures which are in line with their own ideology or which support specific lobby groups. However, citizens, their voting behaviour and its influence on political decisions are not included in the analysis in this report because this would be beyond the analytical framework chosen. Instead, the analysis assumes that **governments seek to maximise social welfare**.

Principal source of state failure: imperfect information

As regards the relationship between governments and companies, state failure can be traced back to one principal source: imperfect information. Policy makers' information is for example imperfect with regard to the way companies will react to policies as well as policy effects and side-effects in the future. For example, if competitive e-business standards are in use and governments seek to determine the use of one particular standard, governments may not know which one to support best.

A special issue of imperfect information which is important for this report is **biased information provided from companies** potentially benefiting from industrial policy. Even governments that try to maximise social welfare may have to base their decisions upon information provided by companies or lobby groups which act strategically. More precisely, if governments are imperfectly informed about the nature or the impact of a specific policy measure on overall social welfare, companies as well as lobby groups can try

[78] See Akerlof (1970).

[79] See Persson/Tabellini (2000) and Besley (2007) for overviews on recent models in political economics.

to influence the policy measures to be chosen by providing biased information to the government. Even though governments may perfectly know that the information they receive is strategically distorted, they may not be able to do better than to use this information because they do not have any other sources.[80]

Ramifications of the biased information issue need to be considered with regard to, first, **competition between several interest groups** and, second, **powerful small groups**. A social welfare maximising government will use information from companies and lobby groups only if it rationally believes that this will lead to more efficient decisions. As long as specific policy measures affect more than just one group of firms, additional information can be provided from differently interested sets of players. Competition between different interest groups may thus lead to the provision of more balanced information.[81] However, taking the costs for information gathering and communication into account, potential free-rider problems in large groups increase the likelihood that the overall provided information is distorted in favour of small groups with rather high gains from influencing actual policies. Although this does lead to the adoption of policies that are socially harmful, policies based on distorted information tend to redistribute economic wealth to the benefit of more powerful lobby groups.

State failure between EU and Member States

Issues of policy making and state failure do not only apply to "games" between governments and companies but also to governments on different institutional levels. In this report, the relationship between the European Commission and Member States' governments is considered. Essentially, there are two sources of potential state failure in this respect: negative external effects of national policies as well as asymmetric information between institutions enacting and implementing policies.

Possible negative external effects from national policies

Within a confederation of countries, decision rights can be allocated in a way that negative external effects from national policies are not taken into account appropriately.[82] For example, national regulations about e-business standards can lead to adjustment costs for foreign firms which are disregarded at a national level. The same holds with respect to market regulations, for example concerning consumer protection or privacy and safety issues. National regulations may distort competition in favour of domestic firms as regulation-induced costs may be an entry barrier for foreign firms. Such effects may be widespread as national governments can be assumed to pursue the objective of maximising welfare primarily on the national level and not on the supranational level – at least as long as it is not more beneficial for the nation state to assign decision rights to the supranational level. In the light of these arguments one may favour to allocate decision rights principally to the supranational level. However, there are two key arguments in favour of decentralised allocation of decision rights: subsidiarity and international competition.

- The **subsidiarity** principle stipulates that central authorities should have a subsidiary function, performing only those tasks which cannot be performed effectively at

[80] See Crawford and Sobel (1982).

[81] See Becker (1983) for a more general analysis of competition between interest groups.

[82] For a more general discussion of issues in fiscal federalism see Oates (1972) and Blankart (2008), chapter 26.

lower levels.[83] This principle seeks to safeguard the preferences of the citizens and firms affected in the national states.

- **International competition**: In general, competition can be interpreted as a discovery process, meaning that competing companies search for solutions to best please the needs of consumers – which leads to solutions which were unknown at the outset and which could thus not be implemented at the outset by a central agency. Similarly, the relationship between nations can be interpreted as a beneficial competition to search for most effective policy solutions. These may eventually be implemented in other nations, too.

Therefore, a too strongly centralised allocation of decision rights can constrain beneficial differentiations of national policies as well as dynamically efficient search processes. There may be **arguments in favour and against centralised decisions in ICT-related industrial policy**, and the allocation of decision rights between countries and supranational authorities needs to be well-defined.

Asymmetric information between institutions enacting and implementing policies

State failure in international relationships may also be due to institutional separation between decision makers enacting policies and the institutions implementing these policies. This applies particularly to enacting agencies on the supranational level and implementing agencies on the national level, as between the European Commission and the Member States. Centralised decision makers enacting policies can be assumed to have imperfect information about the implementation of a policy, and monitoring is costly. Information is “asymmetric” as the supranational institutions know less about actual implementation than the national institutions. Thus, centralised institutions may not be able to ensure that policy measures are implemented consistently by national or even local authorities. Instead, actual implementations may be driven by the national authorities’ preferences.

The decisive issue here is that **changes in the originally intended policy increase uncertainty on the part of companies**. As supranational decision makers may detect national deviations, they may seek to enforce the intended implementations. Potential legal actions such as infringement proceedings can lead to less certain expectations about the continuity of national policies and future policy measures.[84] Such considerations are far from being purely theoretical. A practical example of infringement proceedings of the European Commission is the case of VDSL broadband regulation in Germany.[85] Such incidents may be especially harmful for policy measures targeted at enhancing long-run investments into specific ICT. If companies perceive uncertainties about such policies, they will tend to delay their investment decisions as long as the risk due to potential policy changes is too high. Therefore, national discretions with respect to the implementation of policy measures enacted at a supranational level can lead to lower diffusion rates of new technologies.

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[83] Subsidiarity was established in EU law by the Treaty of Maastricht that became effective in 1993.

[84] See http://ec.europa.eu/community_law/infringements/infringements_en.htm for a detailed explanation of infringements of EU law.

[85] See European Commission (2007).

3.3 Analysis of industrial policies to support ICT innovation

3.3.1 Outline of the problem: a need for enhanced ICT R&D&I in Europe

Relatively low ICT R&D&I investments in Europe

The importance of ICT for growth and employment in Europe is undisputed.[86] In its Communication on ICT research, development and innovation (R&D&I) of March 2009, the European Commission considers ICT as vital *"to recover from the current economic slowdown, to build robust economies, bring the efficiency gains needed in our public sector and cut the rising costs related to e.g. ageing, energy and the environment"*. However, the EC sees a risk that the current economic crisis may *"undermine the recent improvement in private ICT R&D investments"* and calls for sustained or even increasing support for R&D&I.[87] Other organisations share this view.[88] Increased ICT R&D&I may be crucial to stay competitive with other regions of the world, considering findings that ICT R&D expenditure and investments per capita are much higher in the US and Japan.[89]

A need for better co-ordinated, concentrated and specialised ICT R&D&I

However, underinvestment in ICT R&D&I is not the only problem. The EC also sees a **critical need for European ICT R&D&I to be better co-ordinated, concentrated and specialised**.[90] The issue is that *"despite recent pioneering efforts, such as Joint Technology Initiatives (JTIs) and Joint Research Programmes under the seventh EU Framework Programme for R&D (FP7), Europe's ICT R&D landscape remains fragmented"*.[91] The consequences are *"duplication of efforts, lack of critical mass, difficulties in addressing common challenges jointly and, in the end, sub-optimal returns on R&D investments"*.[92] In Europe there is no powerful large-scale ICT cluster as the Silicon Valley in the US, and there are growing ICT clusters in competing countries such as Gumi City in Korea, Silicon Sea Belt in Japan or Bangalore in India.[93] Thus, there may be a big need for policy initiatives to strengthen co-ordinated, concentrated and specialised European ICT R&D&I. As the EU has no say on national R&D&I policies,[94] this is an issue that deeply involves interaction between the European Commission, Member States and companies – which is the key subject of the theoretical analysis of this report.

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86 The European Commission's Economic Recovery Plan has also an emphasis on ICT, see European Commission (2008f).

87 See European Commission (2009), p. 3.

88 See for example Digitaleurope (2009), p. 5-6.

89 See Industry Expert Group on a European Software Strategy (2009), p. 11, referring to a report named "Recherche et développement en sciences et technologies de l'information dans les grands pays industriels, Rapport CSTI, France, 2003, 2005".

90 See European Commission (2009a), p. 5. The Communication mentions as further problems: barriers to ICT companies' growth, complicated RDI funding schemes and fragmented markets for ICT products and services in Europe.

91 See European Commission (2009a), p. 5.

92 See European Commission (2009a), p. 5.

93 See SAP (2008), p. 14.

94 See Pelkmans (2006), p. 72: "The EU level has no say on the national [R&D] policies, their 'waste' or excessive duplication horizontally or with the EU".

3.3.2 Industrial organisation aspects in ICT innovation

(1) A single firm's view on ICT research, development and innovation

Four effects determining R&D&I investment

Firms' incentives to invest in the R&D&I of new products, services or processes are generally based on balancing expected profits versus investment costs. This applies to any kind of R&D&I, not only to ICT R&D&I. Whereas expected costs are related to the targeted size of the invention as well as the intended timing of the R&D&I project and the marketing of the product, expected profits depend on four different effects:[95]

(1) The "**stand alone effect**" which simply refers to increased revenues from offering new products or cost savings due to more efficient production.[96]

(2) The "**appropriability effect**" relies on the firms' ability to exclude other firms from using or imitating newly generated knowledge, technologies or products.

(3) The "**business stealing effect**", i.e. firms with successful innovation may increase their market share at the expense of other firms.

(4) The "**common effect**" refers to the observation that innovative firms are not able to exclude other firms from searching for similar ideas.

Combining these effects, the analysis of R&D&I decisions has to rely on dynamic optimisation models which take uncertainty, intellectual property rights as well as strategic effects and market structures into account. This leads to a rather **complex analysis of R&D&I incentives and potentially counteracting effects**, but the main insights from the extensive literature on R&D&I investments can be summarised as follows: As regards the stand alone effect and optimal investments in R&D&I, investments to accelerate research and to speedup market introduction are the higher the higher the stand alone value of new products or new production technologies. Considering the appropriability effect, the firms' incentives to invest increase with the success of protecting their inventions against imitations. This result is due to the fact that better protection enables firms to either monopolise their inventions or to charge higher licence fees to other firms. The common effect as well as the business stealing effect point to the impact that competition on the product market has on the firms' investment decisions. The business stealing effect motivates firms to invest more the higher the market shares are which they can gain from other firms if their R&D&I projects succeed.[97] Similarly, the common effect implies that competition tends to increase the firms' R&D&I investments as along as inventions are protected.[98]

Joint R&D&I

Given the four strategic effects just mentioned, particularly the fact that it may be difficult to exclude others from newly generated knowledge, firms investing in R&D&I projects can have high incentives to share their knowledge and to coordinate their investment deci-

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95 See Grossman/Shapiro (1987), Hirshleifer/Riley (1992) and Tirole (1989).

96 If the market size increases, the "stand alone effect" may not necessarily imply a "business stealing effect", see (3).

97 See for example Brander/Spencer (1984).

98 See Reinganumn (1989) for an comprehensive overview over the literature on the relation between R&D investments and competition.

sions. Information sharing can not only avoid inefficient duplication of research effort, it can also allow firms to exploit positive spill-over effects which may arise from interchanging results from different research approaches. Internalising these positive effects, the firms' coordinated R&D&I expenditures are higher as compared to the case without coordination. Coordination of investment decisions also allows firms to overcome the strategic effects induced by competition on the product market. While one may expect firms to lower R&D&I investments under coordinated investments, **research joint ventures may in fact lead to higher R&D&I investments when firms share information which have positive spill-over effects**. The same holds when sequential research processes with interdependent research projects are considered. Since information sharing leads to faster developments of successive inventions, firms can well have an incentive to cooperate and to share their information even though this may increase the risk of being driven out of the market by successful innovations of competing firms.[99]

(2) Incentives to invest into ICT product innovation

How do the size of a firm and the market structure affect the firm's incentives to innovate? It turns out that the competitive threat of the innovation is crucial. Considering product innovations and focusing on the stand alone effect, a firm's willingness to innovate is driven by the comparison of the expected revenues from selling the new product and the potential loss due to lower demand for its established products. This replacement effect leads to the observation that monopolies or large incumbent firms tend to have lower innovation incentives as compared to smaller firms or outside firms which try to enter the market by offering new products.[100] However, considering competition on the markets for new products, large or dominant firms also have to take into account the losses they incur if competing firms innovate. The higher this competitive threat, the more are the innovation incentives of large firms driven by their attempt to pre-empt potential innovations by competing firms.[101] Thus, **the more an expected or actual ICT product innovation hurts other firms, the higher are the innovation incentives of the other firms** as compared to their competitors.

The effects which different market structures have on the firms' innovation incentives are potentially opposed: On the one hand, a concentrated market with a few firms having high market shares may lead to strong competitive threats and thus to high investment incentives of the firms. On the other hand, high market shares also increase replacement effects, i.e. the firms' losses due to lower demand for their established products which are replaced by the new products. This in turn lowers the firms' incentives to innovate. Which of these effects dominates depends, among other issues, on the kind of innovation considered. For example, with drastic innovations which allows a firm to capture the entire market, the competitive threat is the same for all firms. The replacement effect, however, is higher the higher the firms' market shares are. Therefore, **more concentrated markets with firms having high market shares may well lead to lower investments into ICT product innovation**. Similarly, considering innovations which can be easily imitated, the competitive threat to the other companies tends to disappear. This again implies that competitive markets with firms having rather low market shares and thus facing low replacement effects lead to higher innovation incentives.

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[99] See Saint-Paul (2003).

[100] See the seminal paper of Arrow (1962).

[101] See Beath et al. (1989).

(3) Special characteristics of ICT product innovation and their implications

ICT R&D&I has some special features, including short innovations cycles[102] and relatively small investments for R&D but relatively high investments for commercialisation[103]. Further aspects include standardisation or compatibility issues between existing and new products or technologies as well as the cost of imitating innovations of successful competitors. The following analysis shows that these characteristics put large firms at a competitive advantage.

Short innovation cycles: advantages for large firms

Short innovation cycles imply that large firms have at least two advantages vis-à-vis small firms when R&D&I is considered: a large established customer base and reputation with regard to product quality. First, **a large established customer base reduces a firm's risk that demand is too low to make the innovation profitable**. The shorter the innovation cycles are and the more often actual products are replaced, the relatively more important becomes the firms' information about the potential number of the customers who will buy the new product. Large customer bases allow firms to better estimate the demand for new products and thus decrease the risk firms have to bear when they decide to invest in the development of new products. Similar reasoning holds with respect to transaction costs a firm has to incur in order to attract new customers. The lower these costs are the higher a firm's expected gain from innovating. Again, large and established customer bases tend to decrease these costs as firms can economise on well established relationships with their clients.

The second advantage large firms have when facing short innovation cycles is based on reputation effects. When new versions of a product are introduced quite frequently, the customers' decisions to adopt the new versions may rely on their expectations about the improvements made. **Adoption decisions may be based on the customers' beliefs and may therefore rely on the reputation a firm has with respect to the quality of its innovations.** Note that firms' optimal long-run strategies therefore include the creation of reputation and the provision of high quality products under asymmetric information. Since reputation effects lead to economies of scale they also lead to relatively higher incentives for large firms to innovate.

Standardisation and compatibility issues favour large companies

ICT R&D&I can be heavily shaped by existing standards and the firms' policies to (not) reveal technical specifications of interfaces, (not) enabling competing firms to offer compatible products. This is especially true if modular ICT systems consisting of different components are considered. Developing new components then requires access to interface specifications and thus relies on either cooperation with the firms offering other components or on disclosure obligations enforced by private or public standardisation committees. As long as publication of interface specifications is not enforced, **firms offering established systems with large customer bases can easily leverage their market power such that they become also dominant on the markets for new and compatible components**.

[102] See Digitaleurope (2009), p. 5.

[103] See Industry Expert Group on a European Software Strategy (2009), p. 40.

Potential imitations of innovations

Finally, turning to potential imitations of innovations, R&D&I generally becomes less profitable when innovations can be easily imitated.[104] Thus, ICT R&D&I targeted at innovations that can not be effectively protected by patent or copyright laws tends to provide rather low investment incentives for the firms. Furthermore, imitation costs do not only comprise the costs for developing similar products (or simply copying the innovation), they also include costs for marketing the product. **Large firms may be especially willing to imitate innovations of small firms** as this would allow them to offer the respective innovations without inducing fierce competition for customers. Additionally, the incentives of large firms to imitate innovations of small firms can be high even if the firms compete for the same customers. Although large firms may anticipate rather fierce competition, potential economies of scale as well as the possibility to replace small firms from the market can make imitation and market entry profitable. Anticipating this kind of behaviour, small firms will have rather low incentives to innovate.

While these considerations point to advantages of large firms in ICT R&D&I, they do not necessarily imply market failures. These will be analysed in the following section.

3.3.3 Possible market failures in ICT innovation

Overview of possible market failures in ICT innovation

As described in section 3.2.3, market failures may basically be due to three reasons: externalities, imperfect competition and imperfect information. The following market failures in ICT innovation derive there from: underinvestment or overinvestment into R&D&I due to externalities, non-commercialisation of a technology due to incomplete information about demand as well as the (mis-)use of incompatibilities and R&D&I joint ventures to prevent market entry of other companies. These are described more detailed in the following.

Externalities and inefficient R&D&I investments

Considering the firms' incentives to conduct R&D&I and to innovate, there is a fundamental problem of appropriability. The **appropriability problem** refers to the difficulty in appropriating the returns from knowledge due to external effects: **using the knowledge may imply that others learn about and use it, too, but do not pay anything to the one who generated the knowledge**. This applies to R&D&I for any technology, not only to ICT.

While the firms' incentives to innovate are driven by their expected profits, socially optimal investments in R&D&I are based on the overall social benefits. Technically speaking, in addition to expected company profits, potential increases of consumer rents have to be considered from a societal point of view.[105] As long as firms are not able to perfectly discriminate prices between consumers, i.e. as long as firms cannot charge the highest individual price that every single consumer is willing to pay, product as well as process innovations tend to increase consumer rents. This in turn implies that the firms are not able to

[104] See Teece (1986).

[105] Consumer rents comprise the difference between consumers' willingness to pay for a product or a service and the price they actually have to pay.

appropriate all gains from their investments. Moreover, taking into account that technological improvements may be contingent on each other, several specific R&D&I investments together can be efficient even though their stand alone value may be negative. These observations imply that the **firms' incentives to innovate may tend to be inefficiently low from a societal perspective**; there is underinvestment into R&D&I.[106]

Although these results may suggest that R&D&I incentives are generally inefficiently low, taking competition into account may lead to opposite conclusions and to arguments for overinvestment into R&D&I. **Since innovations may enable the innovating firms to increase their market shares at the expense of their competitors, firms may have an incentive to invest more than socially optimal.** The reason is that the "business stealing effect" implied by increased market shares can be interpreted as a negative external effect which the innovating firms do not have to compensate. Similarly, R&D&I targeted at developing new products or production technologies resembles competition for getting patents and potential monopoly profits. The firms' incentives to win the implied patent races can again lead to inefficiently high investments.[107]

Comparing these two lines of reasoning, clear cut conclusions with respect to market failures are not possible. However, even though the business stealing effect can lead to relatively high investment incentives, imperfect appropriability of future returns or imperfect price discrimination and the induced gains in consumer surplus imply that socially inefficient overinvestment is of minor importance in reality.

Adoption and demand issues

In addition to the general inefficiencies due to potential appropriability problems of R&D, short innovation cycles and high investment requirements for marketing new products or technologies can lead to additional market failures. First, **high investment requirements for marketing activities imply that new technology may not be commercialised because of the firms' incomplete information about potential demand**. Information about general market conditions, i.e. demand, resembles the classical properties of a public good which may not be provided by private markets. Therefore, ICT innovations may fail due to the non-existence of efficient markets for information.[108]

Furthermore, as long as adoption decisions are driven by reputation effects, customers of innovative firms pay them - technically speaking – reputation rents in order to ensure that the innovative firms do not have any incentive to exploit their reputation by offering products or technologies with no or only minor advancements. Reputation rents, however, lead to higher prices and thus to higher inefficiencies when prices of new ICT products or technologies are considered.

ICT incompatibility

Further market failures are implied by compatibility issues between different ICT products. While compatibility between new and existing ICT products generally raises consumer surplus and leads to higher social welfare, **firms may use incompatibility to establish new monopoly positions and to prevent market entry** of innovative new competitors. Incompatible ICT products establishing new monopoly positions can lead to ex-

[106] For a theoretical analysis see Radner (1979).

[107] See Reinganum (1989).

[108] See Vives (2008)

cess momentum and may thus lead to efficiency losses as compared to situations where firms use compatible ICT products. Similarly, firms supplying established technologies may refrain to provide technical specification for their interfaces in order to prevent innovative firms from making their products compatible. Again, this kind of strategic behaviour can lead to market failures inasmuch the firms' incentives to develop new ICT products are decreased (excess inertia).

Joint ventures in ICT R&D&I

The strategic use of joint ventures also tends to decrease overall efficiency. This is a general economic insight that also applies to ICT innovation. Considering asymmetric market structures, i.e. highly concentrated markets, it turns out that joint ventures can be used to prevent market entry. As long as markets are characterised by large asymmetries in the firms' market shares, joint ventures among large firms do not only serve to internalise positive spill-over effects. Asymmetric joint ventures also increase the large firms' incentives to invest, lead to more intense competition vis-à-vis potential competitors and may thus **prevent market entry**.[109] Large firms may also use R&D&I joint ventures with small firms to control their innovations and to try to **slow down the innovation race**.[110]

3.3.4 Potential state failure in ICT R&D&I support

Policy options to enhance ICT R&D&I

The European Commission runs numerous programmes and activities to support joint European R&D&I, many of them related to ICT. The most relevant activities for this report may be the following (see section 2.2 for details):

- Co-operative research under the **seventh EU Framework Programme for R&D**.[111]
- The **Competitiveness and Innovation Programme** (CIP).[112]
- **Europe Innova**, an initiative of DG Enterprise and Industry launched in 2006 to *"promote partnerships for innovation support"*.[113]
- The **European Research Area**, an initiative started in 2000 to *"optimise and open European, national and regional research programmes in order to support the best research throughout Europe and coordinate these programmes to address major challenges together"*.[114]

These activities involve interaction between the EC on the one hand as well as Member States and companies on the other. As regards the **relationship between the EC and companies**, companies and partnerships involving companies may apply for R&D&I grants according to the specific conditions of the EC programmes. An important principle of EC grants is that companies' R&D&I projects are complementarily funded; they never

[109] See Röller et al. (1997)

[110] See Jacquemin (1998).

[111] See http://cordis.europa.eu/fp7/cooperation/home_en.html.

[112] See http://cordis.europa.eu/fp7/cip_en.html and http://ec.europa.eu/cip/index_en.htm.

[113] See http://www.europe-innova.org, "about Europe Innova".

[114] See http://ec.europa.eu/research/era/index_en.html.

receive 100% of funding from the EU.[115] The share of EC grants is currently highest for basic research, smaller for application-oriented research and smallest for market introduction of new products. Further principles include that grants "*enable a given operation to break even financially and cannot lead to a profit for their beneficiaries*" and that they "*cannot be awarded retroactively for actions that are already completed*".[116] The EC funding programmes are competitive, i.e. companies need to convince the EC about the benefits of their proposed R&D&I projects and only the most convincing applications receive grants. There are calls that the EC should drastically reduce the administrative tasks required for applying and conducting for EC R&D&I projects in order to increase involvement of innovative SMEs.[117]

As regards the **relationship between the EC and Member States**, co-operation is necessary for developing and carrying out strategic and operative R&D&I policies, also involving funding issues. Co-operation between the EC and Member States is vitally important to support the competitiveness of the European ICT industry. A report about innovation in the European ICT sector funded by DG Enterprise and Industry concludes that *"cooperation and systemic forms of innovation governance for the ICT sector is deemed necessary to facilitate appropriate policy mixes, strategic agendas and a more thematic focus to research and innovation"*.[118] In order to promote such systemic forms of policy, the report suggests *"more horizontal cooperation between policymakers of relevant national ministries and of the most relevant DGs of the European Commission"*.[119] However, there may be diverging interests. For example, when the objective is to concentrate and specialise ICT R&D&I in particular locations, national and regional interests are touched. Member States may for example seek to receive funding to sustain existing clusters that may not be viable from an overarching point of view.

Types of potential state failure

Overview of potential causes of state failure

Potential state failure related to ICT R&D&I funding can be due to at least three reasons. First, the allocation of ICT R&D&I grants may not necessarily be efficient. Second, the companies involved in R&D&I joint ventures may well use the results of the co-operation to restrict competition. Subsidising R&D&I joint ventures without restricting the scope of the firms' coordination may thus lead to less competitive markets. Third, the interplay between firms, national governments and the EU may induce inefficiencies caused by strategic actions of the different players. These three issues are elaborated more detailed in the following.

Inefficient allocation of R&D&I grants

Inefficiencies may arise with respect to the rules for allocating budgets for ICT R&D&I. A first-best allocation would require to spend the budget in a way that the expected social value of all subsidised projects is maximised. However, this would require perfect information about all projects and their impacts which is not the case in reality. In practice, po-

[115] See http://ec.europa.eu/grants/introduction_en.htm.

[116] See http://ec.europa.eu/grants/introduction_en.htm.

[117] See for example Digitaleurope (2009), p. 5.

[118] See Wintjes/Dunnewijk (2008), p. vii.

[119] See Wintjes/Dunnewijk (2008), p. vii.

litical agents need to apply properly designed heuristics which will lead to second- or third-best solutions. State failures can not only exist vis-à-vis the first-best allocation, they can also occur with respect to second- or third-best solutions. For example, **requiring firms to divide their proposed ICT R&D&I projects into several subprojects and subsidising the projects or subprojects according to the relation between their expected social value and the grants the firms asked for constitutes a simple but efficient allocation mechanism**.[120] State failure in this case occurs whenever firms are not obliged to divide their projects into subprojects.

Finally, there are inefficiencies implied in the specific characteristic of ICT R&D&I that marketing new ICT products may require higher investments than the preceding R&D. Thus **grants focusing on basic research may have to be amended by grants focusing on application-oriented research and market introduction**. This result follows from the observation that the firms' decisions to invest in application-oriented research and market introduction take place after their investment in basic research. Therefore, subsidising only basic research may not be enough to guarantee that firms undertake all following socially valuable investments in application-oriented research and market introduction. A further argument in favour of grants for market introduction follows from possible positive external effects and network effects. If a new product has positive external effects because it facilitates further innovations by other companies ("sequential innovations"), then the market introduction of this product has social benefits that may be worth sponsoring.

R&D&I grants can be used to restrict competition

The second source of potential state failure comes from R&D&I joint ventures fostered by public policy. While joint ventures can lead to more efficient R&D&I investments as they allow to internalise spill-over effects, results of joint ventures can also be used by participating firms to restrict competition. For example, by agreeing on relatively high licence fees firms are able to shape ex post competition such that the collusive monopoly outcome is ensured. **R&D&I policies which encourage joint ventures without restricting the scope of the respective agreements may thus not only spur innovations, they can also facilitate inefficient collusion between firms.**

Strategic interaction between firms, national governments and the EU

Turning to possible strategic interaction between firms, national governments and the EU, the basic problem is the coordination of the policies of different countries. National grants are driven by the national governments' incentives to strengthen their domestic industries in order to foster competitive advantages and national growth. These strategic incentives can well lead to an **equilibrium in which the sum of the countries' grants is higher than compared to a situation in which countries coordinate their grants**.[121] Coordination may for example avoid inefficient duplication of R&D investments and mitigate administrative costs of providing grants. Thus, coordination between national governments or R&D&I policies managed by international institutions like the EU can help to overcome the otherwise implied inefficiencies.[122] However, that coordination must be

[120] See Ensthaler/Giebe (2009).

[121] The seminal paper on this issue is Spencer/Brander (1983).

[122] These inefficiencies take the form of the "prisoners' dilemma", i.e. a theoretical situation in which two prisoners would be better off if they agreed on strategic testimonies to the judge, while both of them cannot be sure that the other one abides by the agreement.

binding as national governments may have an incentive to use national grants in addition to what has been agreed internationally. The same holds with respect to grants provided by international institutions. As long as national governments can strengthen the positions of their firms by providing additional grants, the resulting equilibrium grants will again mirror the outcome of a prisoners' dilemma.[123]

As regards potential competitiveness effects, **international joint ventures tend to be more efficient the more countries participate**. With a large number of outside countries, governments of participating countries again have an incentive to subsidise the joint venture since this will strengthen the competitive advantage of their domestic firms vis-à-vis the outside countries. However, the sum of national grants provided for international joint ventures comprising only a low number of countries can be inefficiently high. It may, for example, require more funds and be inefficient to subsidise against companies in ten outside countries than in only two. On the other hand, while the competitive effect implies that the efficient number of countries to be involved in international joint ventures is rather high, potential transaction costs and free-rider problems with respect to investments in basic R&D&I lead to the opposite result.

3.4 Analysis of industrial policies to support ICT adoption for enhanced value systems

3.4.1 Outline of the problem

A need for improving electronic value systems

Developing electronic value systems is a key issue for the competitiveness of European ICT-using manufacturing industries. In an SeBW expert survey in June 2009, the vast majority of respondents see a need for enhanced e-business adoption in European industries (see section 4.2 and Exhibit 4-10). In recent e-Business Watch surveys, the most important reason to not apply e-business more intensely was found to be that business partners are not prepared which points to underdeveloped e-value systems.[124] Sources such as the OECD Information Technology Outlook 2008[125] and a recent Deutsche Bank Research article about e-business in Western Europe[126] highlight the importance of electronic value systems. "Business sophistication" including networks is one pillar of competitiveness as defined by the World Economic Forum in its recent Global Competitiveness Reports.[127] The adoption of ICT to enhance electronic value systems is closely related to e-business standards adoption which will be analysed as a specific issue here.

Streamlining outward-oriented processes in larger companies

More specifically, there is wide agreement that e-business adoption needs to be improved in SMEs.[128] Large manufacturing companies are increasingly streamlining their outward-oriented processes with e-business applications. This applies to vertical busi-

[123] See Fan/Wolfstetter (2005).

[124] See results of the SeBW Manufacturing Survey 2007 in European Commission (2008a), p. 98.

[125] See OECD (2008).

[126] See Stobbe (2009).

[127] See ch. 1.1 in Porter/Schwab (2008).

[128] See the findings of the SeBW expert survey 2009 in section 4.2, Exhibit 4.7 and related text.

ness relationships, i.e. procurement and sales, as well as to horizontal relationships, i.e. co-operation with other companies. On the supply side, they may for example introduce electronic sourcing platforms[129] so that any company who seeks to sell to them needs to offer through this sourcing system. In continuous or "captive" supplier-buyer relationships,[130] the buyer may require the suppliers to integrate their computer systems with that of the buyer. On the sales side, large companies may introduce electronic sales platforms and electronic logistics systems. In horizontal business co-operation, joint product development and design may be conducted through e-business applications.

Value system drop-outs or unrealised efficiency gains

This advancement of ICT and e-business in larger companies requires business partners to adapt to technological needs. Companies supplying to or buying from large companies risk to be eliminated from the value system if they cannot or do not want to comply with the technical requirements. The large companies may look for suppliers in other regions or countries. This may apply in particular to small and medium-sized companies.[131]

Another problem may be that large companies do not find business partners to buy from or to sell to in online mode. For example, a large company may want to renovate and refurbish an office room but none of the SME suppliers in the region may be prepared to exchange related data online, i.e. to use electronic product catalogues, e-offers and e-invoices. For the large company this means that it cannot realise possible efficiency gains from electronic data exchange.

SMEs may for various reasons not be ready to invest into e-business and to comply with the demands of large companies: Above all, investment costs for technology and personnel may be too high considering the expected return on investment. Financial constraints are a typical shortcoming of SMEs. Another reason is that in some companies directors or managers may not be knowledgeable about ICT and not know about the opportunities of e-business. Further reasons, as revealed in several e-Business Watch surveys, may include interoperability problems, an unclear legal situation, privacy and security risks, and lack of reliable ICT providers.

Whether some companies are eliminated from the value system or whether large companies cannot realise efficiency gains, the outcome is unsatisfactory from a regional or national economic point of view in either case. Companies or industries in certain regions or countries may loose competitiveness. Thus there may be arguments for public policy to support electronic value systems. Public policy may seek to enhance the uptake of e-business applications in companies.

3.4.2 Industrial organisation aspects in electronic value systems

The following exposition of industrial organisation theory issues related to e-value systems comprises of five parts. It starts with a single firm's point of view on ICT process innovation (1); it carries on with competition effects on firms' investment decisions in horizontal markets (2), vertical markets between ICT supplying companies and ICT using

[129] See the case study of ThyssenKrupp, Germany, in the 2008 steel industry report of the SeBW.

[130] See Gereffi/Humphrey (2005) for an insightful distinction of global value system types by level of explicit coordination.

[131] See for example the case study about the CARS initiative in section 4.1.4.

companies (3) as well as vertical market structures among ICT-using companies (4); and it concludes with coordination and network effects (5).

(1) A single firm's view on process innovation

The general reasoning about firms' incentives to invest in ICT product innovation (see section 3.3.2) can also be applied to the firms' decisions on e-business process innovations. This means that firms' incentives to invest in e-business innovation are generally based on balancing expected profits versus investment costs. More specifically, **investment into process innovations is influenced by expectations about future ICT prices and quality of technologies as well as the company's size.** This observation has at least two important implications as follows.

First, taking into account that investments and the implied restructuring cost are largely sunk, i.e. they cannot be reimbursed in case the investment fails, investment decisions crucially depend on the firms' expectations about future prices and technologies. As long as firms expect that prices for ICT will decrease or that technologies will be improved substantially, **firms may have an incentive to forego actual cost savings by delaying their investment in order to economise on lower prices and better technologies in the future**.[132] The same holds if firms expect that current technologies will be incompatible with future developments. Delaying investment may then result in lower current profits but will save future costs due to further reorganisations or adoptions of new standards.

The second implication of the general trade-off between investment costs and potential cost savings is related to size. If process innovations lead to lower production costs per unit, a firm's gain from investing increases with the quantity the firm produces. The same applies to investments which reduce the transaction costs a firm incurs with its trading partners. Again, the higher the number of transactions the higher are the firm's incentives to invest in order to reduce the costs per transaction. Thus, **firms producing large quantities or interacting with many suppliers and customers are more willing to invest in process innovations** than firms producing smaller quantities and interacting with less business partners. This result holds also for expected production quantities and transactions. Therefore, large firms and firms expecting to grow are more likely to invest than small firms and firms expecting to shrink.

(2) Horizontal market structure issues: market shares and concentration

Although the subject in this section is value systems, which imply mainly vertical relations between companies, i.e. supplier and buyer relationships, it is nevertheless useful to consider horizontal market structures. It is useful because the position of a company towards its competitors also affects the company's incentives to invest into e-business solutions.

Markets with high demand and relatively high concentration ratios may foster investments into e-business process innovations, for the reason of economies of scale. Assuming that necessary investments are fixed, expected gains increase with the potential number of business functions or trade relations the investments can be used for. Thus, **large firms with large market shares generally have higher e-business investment incentives than small firms**. This will lead to asymmetric ICT investment, i.e. large firms invest

[132] More precisely, the optimal point of time to invest is determined by comparing the expected net gains from investing at that time with the value of having the option to invest later.

more in ICT than small firms. In fact, e-Business Watch findings in recent years confirmed that large companies are more sophisticated in e-business than SMEs.

Consequently, asymmetric market structures, i.e. situations with firms having different market shares, may well be preserved. Starting with an asymmetric market structure the equilibrium investments will be such that the firms with the highest market shares will invest more than firms with lower market shares. Thus, the largest firms will augment their relative cost advantages which in turn results in even higher market shares. This kind of market development is especially likely in the case in which the firms' investment decisions are strategic substitutes. As high investments of large firms tend to reduce the investments of small firms, **horizontal markets tend to become more concentrated over time**.

In the case of drastic innovations which allow one firm to monopolise the market, multiple equilibria in pure strategies as well as equilibria in mixed strategies may exist. This is due to the fact that either innovation costs may be rather high or that competition with two or more firms operating with low marginal costs may be so fierce that the firms' ex ante profits become negative. Therefore, any equilibrium in pure strategies must be such that only one firm innovates and that the other firms are driven out of the market. Furthermore, there exist equilibria in mixed strategies where firms randomise between their decisions to innovate or not to innovate. While equilibria in pure strategies lead to monopolised markets, equilibria in mixed strategies can lead to the situation that more than one firm innovates and that investments turn out to reduce the firms' profits ex post. Additionally, in an equilibrium with mixed strategies it may also be the case that relatively less efficient firms invests while firms with higher gains from innovating do not invest and leave the market.

(3) Vertical market structure issues between ICT suppliers and ICT users

Investments into e-business applications tend to be long-run, and in long-run investments contracts between ICT producers and users are very likely to be incomplete. **Incomplete contracts** imply that they are unable to specify the legal and economic consequences of any event that may happen after concluding the contract. This holds especially for upgrading services with respect to further technology developments and compatibility issues. Since future technology developments are highly unpredictable it is difficult to specify these services contractually in advance. The consequence is that ICT using companies may be very cautious about their ICT investments and rather hold up such investments than do a wrong move. In previous e-Business Watch surveys, around 20% of manufacturing companies with low or no use of e-business stated that a lack of reliable IT providers was an important reason to not practice e-business more intensely.[133]

ICT producers may apply three specific means to increase demand for their products: **reputation building**, **relational contracts** and **second sourcing**.[134] Relational contracts are informal agreements sustained by the value of future agreements.[135] Second sourcing means that an ICT producer (the "first source") licenses other companies (the "second sources") to manufacture and sell its components. While reputation effects and relational

[133] See the results of the e-Business Survey 2006 in the related table report, sheet A23, and the table report of the 2007 survey, sheet 16, both available at http://www.ebusiness-watch.org/statistics/table_chart_reports.htm.

[134] Relational contracts are discussed in Levin (2003).

[135] Definition by Baker/Gibbons/Murphy (2001).

contracts are based on long-run relationships between firms, second sourcing strategies serve as a mechanism to ensure that ICT producers can not exploit potential "**lock-in effects**" due to sunk and irreversible investment. Similar reasoning applies to the strategic use of common or open standards. The easier it is for the investing firm to switch to other suppliers, the lower its risk to be later left exposed to its initial supplier.

Whereas second sourcing strategies and the use of common or open standards are not related to the supplying firm's size or market share, relational contracts as well as contracts based on reputation effects tend to be more efficient the greater the supplier's losses due to a breakdown of firm specific relations or the higher the reputation losses. These results are based on the observation that the rents to be paid in order to ensure honest behaviour decrease with increasing expected losses from deviating. This also implies that large ICT-producing firms may be able to economise on their reputation which can ultimately lead to rather concentrated market structures.[136]

(4) Vertical market structure issues among ICT using companies

In vertical value systems of ICT using companies, two important issues arise: First, it may be necessary for the companies involved to invest into e-business applications on all markets along the value system, implying strategic behaviour of the companies involved. Second, companies may hold up e-business investments in relation-specific investments due to lower bargaining power compared to the related company.

Coordination problems related to "investment on all markets"

The issue of "investment on all markets" can be explained with investments into, for example, supply chain management systems. Investments may have to be coordinated between firms which supply inputs, which produce final products and which distribute final products to retailers. Efficiency losses may result due to incomplete information about each firm's efficiency gains. Firms may then have strategic incentives to manipulate the information they reveal about their investment costs or their expected gains from investing. Distending their own investment costs or understating their potential efficiency gains alters the firms' bargaining positions when negotiations on agreements to share the investment costs or on side payments are considered. Similarly, if firms have the option to choose among different e-business solutions, each firm has the incentive to manipulate the information it reveals in a way that the solution is chosen which maximises its own profit. Overall, these **strategic incentives imply that firms may not be able to coordinate their mutually related e-business investments or that they agree on e-business solutions which do not maximise the firms' overall profits**.[137]

Relation-specific investments and asymmetric bargaining power

Considering relation-specific investments and asymmetric bargaining power, efficient e-business investments in small firms can only be ensured if the investing firms can prevent self-serving behaviour on the part of the related large company. This is because large firms have better abilities to replace individual SMEs on the supply side by other firms, especially if the products offered by the SMEs are rather similar. In contrast, the revenues of small supplying firms may rely to a large extend on the trade relationships with only

[136] See Strausz (2005).

[137] See Myerson/Satterthwaite (1983) for a general impossibility theorem on efficient trade under incomplete information.

one large firm. The stronger this dependency is the lower the small firm's outside option, the lower its bargaining power and thus the lower the share it receives from the additional surplus generated by ICT or e-business investments. Therefore, **asymmetric vertical market structures imply asymmetric bargaining power which in turn leads to asymmetric ICT investment incentives**, **favouring large companies and putting small suppliers at a disadvantage**.

This result is strengthened by the fact that contracts between the firms tend to be incomplete. As long as large firms do not ensure their small trading partners against possible selfish behaviour in the future, large firms may expose small firms to situations which further reduce their investment incentives. For example, the larger partner can propose unattractive terms of trade to its smaller partner (e.g. lower prices for the delivered products, tougher delivery terms) anticipating that the small firms will not be able to refuse the deal. These considerations apply similarly for the relationship between large firms and small firms on the customers' side.

Supporting empirical findings

The theoretical arguments explaining suboptimal investment into e-business solutions are supported by SeBW research findings. In the SeBW Manufacturing Survey 2008 and the SeBW Energy Supply Survey 2009, those companies that had stated that only "some" or even "none" of their business processes were conducted electronically were asked why they did not use e-business more intensively. Among seven possible reasons, the circumstance that "suppliers or customers are not prepared for e-business" stands out as the major barrier. For example, companies representing more than 60% of employment in the chemicals, rubber and plastics industry as well as the steel industry said that this was an important barrier. This points towards a "chicken-and-egg" problem, as non-users are in a way blaming each other.

(5) Coordination and network effects

Direct and indirect network effects

ICT investments may not only lead to coordination problems between the firms engaged in actual trading (direct network effects). ICT investments can also cause network effects and coordination problems with other firms in a value system. These effects are based on *potential* trade relations between firms in the value system (called "direct network effects", too, because they take place on the same market) as well as indirect network effects due to positive spill-over effects to markets not directly related to the value system.

As regards **direct network effects**, as long as ICT solutions require investments on both sides of a specific market, the prospect to use the respective solutions with other than the actual trading partners implies that investment decisions are strategic complements, i.e. they mutually reinforce each other. A firm's gain from investing into a particular technology is higher if more firms are expected to use compatible ICT solutions. Thus, ICT solutions which focus on lowering transaction costs generally imply that coordination with other firms on compatible ICT solutions increases the firms' investment incentives and leads to more efficient usage of ICT.

In contrast, **indirect network effects** are rooted in the observation that efficiency of markets for ICT support or maintenance services increases with demand for these services. Indirect network effects are especially likely to be present if entry into the markets for these services is costly or if firms have substantial fixed costs of production. Then, the

number of firms operating in the market and the degree to which differentiated services are offered are positively related to overall demand. A similar reasoning holds when investment in human capital is considered. Employees tend to be more willing to invest in ICT-specific skills if they can use these skills more flexibly.

Proprietary standards as a strategic device against network effects

Although coordination on compatible e-business solutions can increase overall industry efficiency, coordination or compatibility is not ensured per se. **Firms at either level of the value system may try to use their own e-business standards to protect their positions against market entry.** Firms with higher market power can be more likely to succeed in setting their own standards. Forcing competitors to use different standards or incompatible e-business solutions increases their entry costs inasmuch they may also have to subsidise suppliers or customers to adapt additional ICT. Hence, firm-specific e-business standards (e.g. standards for ordering or invoicing solutions) can be used as a strategic device to reduce potential competition.

3.4.3 Possible market failures in electronic value systems

Imperfect competition

Potential market failures in electronic value systems may mainly be related to imperfect competition. There are two important aspects related to imperfect competition in the context of adopting e-business applications. The first aspect is related to the inefficient investment by ICT using firms, the second to imperfect competition between ICT supplying firms.

Market failures related to inefficient e-business investment

Potential market failures in e-business adoption may be directly related to inefficient investment decisions. These may be caused by asymmetric bargaining power between large and small firms, incomplete contracts, and coordination failures between the companies in a value system (see section 3.4.2 (4) “vertical market structure issues among ICT using companies”). While the hold-up problem implied by asymmetric bargaining power and incomplete contracts can lead to inefficiently low ICT investments in small firms, one also has to consider that under certain conditions it may be efficient if only a few firms invest in ICT. In the extreme case in which the firms’ production technology exhibits constant returns to scale and firms produce goods that can be rather perfectly substituted with each other, it is – from a theoretical point of view – inefficient if more than one firm invests in ICT as this would lead to an inefficient duplication of investment costs.

Similarly, in not so extreme cases **e-business investments may imply that the efficient number of firms in a market decreases**, meaning that some companies have to quit the market. This applies to both horizontal and vertical markets. With sunk investment costs and efficient pricing mechanisms or rather intense ex post competition, more concentrated market structures are perfectly in line with lower production or transaction costs. As long as lower transaction costs increase the intensity of competition and lead to more efficient prices or delivery contracts, sunk investment costs imply that the efficient number of firms serving the market decreases in order to economise on overall investment costs.

Taking these two arguments together, **the observation that markets become more concentrated due to e-business investment does not imply any market failure per se**.

Market failure due to inefficient ICT investment would have to be based on the firms' inability to negotiate efficient contracts or on coordination failures. The risks of inefficient contracts and coordination failures tend to increase with the specificity of the investments. **If large firms invest in proprietary e-business solutions so that small firms can use their e-business solutions for data exchange with specific firms only, the small firms' risk of becoming locked-in is high.** In contrast, compatible e-business solutions or the use of common platforms increase the expected number of trading partners and thus tend to decrease efficiency losses due to inefficiently low investments.

Market failures related to delivery contracts

Considering delivery contracts, supplier and buyer have to determine the quantities traded as well as the price the buyer has to pay. While asymmetric bargaining power – large firms have more power than small ones – alters the distribution of the gains from trade, it does not per se lead to inefficient contracts. As long as firms rely on bargaining they have an incentive to maximise their joint surplus from trade by choosing efficient quantities and to split the joint surplus according to their bargaining power. **Even though overall gains from trade may be distributed asymmetrically between supplying and buying firms, this does not imply any market failure.**

Thus, market failures related to imperfect competition between ICT supplying firms has to be based on imperfect information on the potential gains from trade or the inability of ICT supplying firms to perfectly discriminate between their customers. Imperfect information on the gains from trade lead to the possibility of inefficient bargaining outcomes. The inability to perfectly discriminate between ICT using firms, i.e. the inability to conclude supply contracts conditioned on the specific characteristics of each ICT using firm, implies that prices for ICT tend to be inefficiently high and that firms with a rather low willingness to pay will not invest.

3.4.4 Potential state failure in supporting electronic value systems

Political activities to enhance electronic value systems

In recent years, several EU Member States have launched **national or regional initiatives to promote e-business exchanges** within specific sectors. A key objective of these initiatives is to strengthen the participation of SMEs in larger firms' digital supply chains. Against this background, the e-Business Support Network (eBSN) of DG Enterprise and Industry issued a study in 2007 to assess sectoral policy approaches and to identify good practices in these initiatives.[138]

Support to e-value systems by such initiatives implies **mainly two instruments: providing grants and information**. Grants are provided to fund, for example, investment into e-business applications for inter-company data exchange and related training or to obtain specific consulting. Provision of information about the benefits and risks of e-business

[138] See European Commission (2007).

takes place for example in the form of brochures, websites or telephone hotlines, as well as the organisation of discussion forums such as conferences and workshops.

Many of these policies **focus on manufacturing sectors**, in particular on the textile and automotive industries. This is no coincidence. e-Business has great potential in manufacturing sectors with deep and well-structured supply systems, in particular if there is still substantial scope for ICT adoption, for example in the textile industry. Moreover, the use of standards for data exchange, such as electronic catalogues and transaction standards, is generally less advanced in manufacturing sectors than in, for instance, retail.

This eBSN study found that **sectoral e-business initiatives are not necessarily more effective than other programmes**. A sectoral focus of value system policies was found to have two main advantages: First, improved involvement of stakeholders, notably strong support from industry associations. Second, its suitability for addressing advanced e-business goals such as data exchange in specific value systems, where there is a trade-off between depth and scope. However, a sectoral focus is neither a guarantee of nor a condition for success. The decision to focus on specific industries must derive from the objectives of the initiative. The study also found challenges to the sectoral approach, in particular the typically cross-sectoral characteristics of value systems. Most SMEs trade with different sectors. The study found that the harmonisation of data exchange models across sectors may be one of the key ICT-related issues in the future.

At **EU level**, there is no dedicated programme supporting sectoral e-business initiatives but there are several funds or programmes which may include them. First of all, the EU supports related regional or national initiatives through the European Regional Development Fund.[139] The European Commission also funds Europe-wide projects related to e-value chains through its Europe Innova Standards Networks[140] and potentially through the Competitiveness and Innovation Programme (CIP).[141] The eBSN does not provide funds to such initiatives but offers a forum for related information and policy co-ordination.

Possible state failure

The insights from industrial organisation theory in section 3.4.2 and from market failure theory in section 3.4.3 as well as the potential challenges to sectoral policy approaches lead to the question whether policies to promote electronic value systems are efficiency enhancing. First, as long as companies find it profitable to invest in new ICT solutions any policy measure would simply lead to windfall gains for the investing firms. Second, long-run relationships between firms entail the incentives to employ endogenous measures to overcome potential hold-up problems by using relational contracts or side payments in order to induce companies to invest in relation-specific ICT solutions. Third, the observation that only a number of firms invest in ICT and that markets become more concentrated over time can simply reflect the fact the efficient number of firms decreases due to sunk investments. Thus, **policy measures which simply focus on the participation of SMEs in larger firms' digital supply systems may not alter the firms' investment**

[139] For example, approximately 37.5% of the funding for the Greek "Digital Future Initiative" was contributed by the Regional Development Fund; 12.5% was contributed by national public sources and 50% by the participating companies. See European Commission (2007), p. 95.

[140] An example is Innovafun, "Applying open standards to INNOVAte FUrNiture business processes", see http://standards.eu-innova.org/Pages/InnovaFun/default.aspx.

[141] For example, for June 2009 a call for proposals for "Knowledge Networks for the competitiveness and sustainability of European tourism" was open that may also fund projects related to e-value systems in the sense of this report.

decisions or may distort equilibrium market structures so that an inefficiently high number of SMEs remains active.

A second source for state failure is due to the design of the policy measures enacted. While sectoral policy approaches increase the participation of stakeholders and can ease coordination problems it must be taken into account that (voluntary) participation is an endogenous decision of a firm. Participating industry associations may not be neutral; they may well be dominated by large firms with potentially high gains from adopting specific ICT solutions or from building up new e-business platforms. Furthermore, higher participation rates of SMEs also affect ex post market structures. The higher the number of SMEs which actually adopt specific ICT solutions is, the more intense will be the competition between these firms. As long as SMEs serve as suppliers or buyers vis-à-vis large firms, higher participation rates and intensified competition are in the interest of large firms. Thus, **large firms may opt for public policies which subsidise SMEs in order to ensure that their up- or downstream markets remain competitive**. Again, this may lead to an inefficiently high number of SMEs active in the market.

Closely related to this last observation is the danger that sectoral policies are not harmonised between different countries. While national programmes to support the adoption of ICT may increase the competitiveness of domestic firms, internationally harmonised ICT solutions may also lead to more integrated markets. However, as long as this mainly increases the potential number of trading partners for SMEs, larger firms tend to loose market or bargaining power vis-à-vis their small suppliers or buyers. Thus, **international harmonisation can well be detrimental for large domestic firms which may induce national governments to stick to national solutions** which may induce high transaction costs and inefficiently narrow markets.

3.4.5 Specific issues of e-business standards adoption

Outline of the problem

Electronic value systems are closely related to e-business standards because e-business applications used for data exchange between companies operate with particular technical specifications. e-Business standards can be subdivided into several groups:[142]

- Identification standards for identifying enterprises and establishments in different locations as well as products and parts of products in production processes;
- classification standards to unambiguously describe industries, products and services;
- catalogue exchange standards for the exchange of product data catalogues between suppliers and customers;
- transaction standards for ordering, order confirmation, shipping notice, claims, invoicing and payment;
- other business process standards for interaction between companies, for example for exchanging inventory information.

[142] Subdivision according to the Prozeus initiative, see www.prozeus.de, “Prozesse & Standards”.

For example, e-business transaction standards help to automate communication in sales processes and reduce the costs of concluding contracts between selling and ordering companies. The necessity for time-consuming paper mail, phone calls and faxes between sellers and buyers as well as the time from order to settled payment may be reduced. However, the adoption of e-business standards is a common problem in many ICT-using industries. It is often the case that many conflicting standards, often proprietary ones, are in use. The consequence is that computerised communication between companies or even the communication between computerised systems within a single company is hampered. This implies hampered growth of companies, industries and the economy at large. There may thus be a case for political activity.

Analysis of industrial organisation aspects in standards adoption

The vertical market structures in ICT-using manufacturing industries are typically either a bilateral oligopoly, i.e. a few large companies deal with a few large customers, or an oligopoly: a few large companies procure from many SMEs.

The market situation is characterised by **network effects**: It is beneficial for the companies in manufacturing value systems to invest in common e-business standards in order to economise on contracting costs. However, in order to reach an efficient level of standards adoption companies have to coordinate their decisions with respect to both the implementation of the standard – what standards to adopt when? – as well as potential compensation payments between the companies. Compensation payments may be necessary if the companies involved are heterogeneous with respect to their costs of adopting the standard and their benefits from using it. Companies with relatively high benefits and low implementation costs may have to pay for standards implementation in companies with relatively high implementation costs and small benefits. Such a **process of aligning the decisions about standards adoption and potentially how to compensate costs may involve intense information, negotiation and control activities**, i.e. transaction costs. In general, adoption of standards tends to involve higher transaction costs the larger the number of companies is and the more they are specialised with respect to the goods they produce or the technologies they use. For example, in the steel industry value system, the number of companies involved and their specialisation is large at least on the suppliers side. Transaction costs of introducing a common standard may also be high if dominant customers are able to use their buyer power to enforce company specific procedures or contracts. e-Business Watch studies in 2006 and 2008 confirmed that this is not rarely the case.[143] Additionally, lock-in effects and incompatibilities between existing and new standards may also tend to increase the costs for efficient adoption decisions.

The relevant interactions in this case are first of all between ICT-using companies and their customers and suppliers. The companies involved are heterogeneous, the future costs and benefits of standards adoption are uncertain, and potential contracts between the companies about standards adoption are incomplete due to asymmetric information. Negotiations about potential compensation payments are distorted due to free-rider effects: companies may have strategic incentives to hide their own benefits or to exaggerate their costs. Lack of credible commitment mechanisms and uncertainty about future benefits and costs lead to opportunism which may result in strategically delayed invest-

[143] Results of the 2006 and 2007/8 sector studies are included in the study reports to be available for download from the project website at http://www.ebusiness-watch.org.

ment or adoption decisions. Thus, the companies' adoption decisions are mainly based on their private costs and benefits and on their expectations about the decisions of other companies. All in all, there is a **potential lack of commitment for aligning standards adoption decisions and potential compensation payments. Efficient adoption decisions can not be expected.**

Analysis of possible market failures in standards adoption

Types of market failures in standards adoption

Arguments for market failure in e-business standards adoption can be derived from positive external effects, imperfect competition due to sunk costs, imperfect information and the implied coordination problem between the companies:

- **External effects:** The companies' profit functions do not include the positive external effects of using a common standard for the network as a whole. Company investments in standards adoption are thus smaller than desirable from an overarching economic point of view.
- **Imperfect competition:** Taking into account that investments may well turn out to be sunk later on, an equilibrium with an inefficiently low use of the standard is likely to occur.
- **Imperfect information:** With positive network effects, a company's best response to the decisions of its competitors to adopt a standard is to act equally. However, due to this strategic complementarity the number of firms that will actually adopt the standard is uncertain as it may be optimal for a firm to adopt the standard if and only if the number of other firms adopting the standard is high enough. This increases the companies' risk related to investing into the adoption of a common standard.

Imperfect information in standards adoption

Without explicit coordination among firms, adopting particular ICT solutions operating with particular standards involves the danger of investing in the wrong technology. Especially the early adopters of a new technology are exposed to the risk that few others will follow. If few firms or potential users are willing to make the first step to enter a network, even an otherwise valuable technology can remain unutilised. The situation where the fear from insufficient followers results in a socially suboptimal level of adoption of a new technology is referred to as ***excess inertia***. Excess inertia is more likely to occur if firms have incomplete information about the "eagerness" of other potential adopters to join the network.[144] While excess inertia can result in the inefficient adoption of an otherwise high-value technology, the contrary is also possible. Under certain conditions a technology can become socially excessively adopted. This phenomenon can occur for example if firms strongly differ in terms of their valuation of a new standard. A small number of firms can favour to switch to a new technology although the others strongly dislike it. After the firms favouring the new standard switch, the later group may prefer to adopt the new technology to staying alone with the old one. This phenomenon may result in the emergence of socially inefficient standards and is referred to as ***excess momentum***.

[144] See Farrell/Saloner (1985).

The pattern of adoption of a standard also depends on whether the technology is sponsored. The sponsor of a standard has property rights to the technology and can exclude others from adopting it. Since the sponsor owns the technology it is willing to invest in promoting it. If a single firm owns the standard of a technology or there are entry barriers into the supply of that technology, then the owner tends to over-promote the standard: The owner will subsidise early adopters and recoup the investment by charging high prices from firms who decide to join later.[145] Excess momentum can occur if some competing technologies are sponsored while others are not. In this case, **even a lower quality technology can become a standard if it is sponsored**.

Considerations from game theory

The existence of inefficient equilibria can not be ruled out in static economic models that consider only one point of time. However, dynamic models of standardisation point to the possibility that inefficiencies can be avoided over time. For example, companies which value the standard and the implied network effects most can move first in order to signal that the standard will be actually adopted. Moreover, potential coordination problems can be avoided if all players opt for the strategy with the highest expected payoff (risk dominance) or if they act according to signals which they believe are correlated to the real state of the world (theory of global games). However, fully efficient decisions can not be expected. While early adopters can push the market in the right direction, they also face a free-rider problem which leads to strategically delayed investment decisions on their part. Similarly, **coordinated behaviour based on expected payoffs or on signals implies that the equilibrium with the lowest coordination requirements will be chosen. This is, however, unlikely to be the equilibrium with the largest benefits for the industry as a whole.**

Possible political activities and potential state failure

Policy options

Policy makers could intervene in various ways: For example, they could subsidise further development and adoption of a particular e-business standard. They could also fund **standard adoption projects** in which several companies of the respective industry value system adopt this standard. Such projects could prove the benefits of this standard which could be published through industry associations and through conferences, workshops, brochures and related websites. DG Enterprise and Industry funds such standards adoption projects for example in the framework of its Europe Innova programme[146] and in the framework of the eBSN. Projects are being or have been funded for example in the furniture and bio-health industry.

However, there is a need for policy makers to consider differences in the development of electronic values systems and e-business standards development. For example, chemicals, rubber and plastics represents an industry with an advanced, market-driven e-value system with established transaction standards (Chem eStandards) and an “interoperability hub” service company (Elemica).[147] The pulp, paper and paper products industry has a medium-high developed e-value system with an established e-business standard (Pap-

[145] See Katz/Shapiro (1986).

[146] See http://standards.eu-innova.org/.

[147] See the SeBW study report on the chemicals industry in European Commission (2008b).

iNet).[148] Basic iron and steel has developed an e-business standard (ESIDEL) but it is not yet sufficiently sophisticated and widely used.[149] Finally, the glass, ceramic and cement industry has no specific e-business standard at all.[150]

Potential state failure

The option to subsidise standard development may not necessarily be justified by market failure because the **companies themselves and their industry associations could fund e-business standards development**. This would ensure equivalence of costs and benefits of standards development.

As regards standards adoption, the option to fund exemplary projects for adoption of the standard may imply possible state failure in the form of imperfect information. **Policy makers may not be able to assess which standard is the best possible one to support.** Thus, before initiating a standards adoption project, policy makers should seek information about the standards used and available in the industry.

A further problem is that **national governments may promote standards that are prevalent within their country**. However, the large Member States with the strongest power to promote their standards may not necessarily have the best standards from a European point of view. Furthermore, if two or more different national standards compete on international markets, there are uncertainties about which standard may turn out to be most successful. Thus, companies may hesitate to invest into related ICT in order to prevent to become locked-in later on in an unsuccessful standard.[151]

Game theory implications

Potential policy interventions should reflect asymmetric information between policy makers and companies, i.e. a situation in which policy makers do not know the actual intentions of the companies. More precise: Policy makers need to be aware that the companies involved have strategic incentives to hide relevant information in order to reduce their costs of implementing a new standard or to receive direct grants. Therefore, efficient policy instruments for standards adoption should **implement mechanisms which reduce the benefits of hidden intentions**, i.e. the companies' information rents. For example, policy makers could focus on fostering institutions like standardisation committees that do not rely on direct payments. Such committees can serve to reduce asymmetric information between the companies, to coordinate the development of new standards or to force compatibility with existing standards.

[148] For more details see the related e-Business Watch study in European Commission (2006c).

[149] For more details see the related SeBW study in European Commission (2008c).

[150] See the related SeBW study report of 2009, forthcoming.

[151] The issue of competing national standards has also been dealt with in an SeBW special study about ICT standards in the health sector in 2008, see European Commission (2008g).

3.5 An exemplary analysis of ICT innovation policy applying game theory

3.5.1 Basic assumptions

A fictive example of technology R&D&I policy

In order to produce specific insights about ICT R&D&I policy, an exemplary analysis of ICT innovation policy applying game theory is conducted in the following. The analysis is related to a fictive example of a joint European R&D&I programme. The reason for selecting a fictive example is that is very difficult to gain sufficiently detailed information about real-life R&D&I programmes and policy making.

The example assumes that the European Commission establishes R&D&I policies for a certain ICT industry which produces products based on a certain ICT. This industry is highly research intensive, requires continuous high investment and is subject to intense competition from Asia and the US. The European Commission seeks to promote innovation in this industry with a dedicated European programme. In the framework of this programme, the EC, Member States and companies a) decide about a strategic research plan and b) jointly fund projects for research, development and market introduction of products. The share of EC funding is highest for basic research, lower for application-oriented research and smallest for projects preparing market introduction.

These framework conditions are similar to the organisation of European Technology Platforms.[152] In reality, research organisations such as universities and non-university institutes also play an important role. However, for the sake of simplicity the following example assumes that all research and development is conducted within companies.

The following statements are based on literature on R&D policies and international trade; see for example Qui/Tao (1998), Brander (1995) and Brander/Spencer (1985). The structure of the game and the possible strategies of the players correspond to the multi-stage games analysed in this literature and in the literature on industrial organisation.

Elements of the game

The establishment of the dedicated R&D&I programme is understood here as a strategic interaction of players in terms of game theory. The game assumes the following three groups of players and target functions: the European Commission seeking to maximise expected welfare in the EU; national governments seeking to maximise expected welfare in the country; and companies seeking to maximise expected profit. The game assumes four levels, as elaborated in Exhibit 3-5:

(1) **Determination of framework conditions** for the research programme. The first level of the game is the determination of framework conditions for the joint R&D&I programme. On this level, the European Commission, Member States and companies negotiate about the objectives, contents and methods of the research plan, the funding conditions, the parameters for Member States and the parameters for companies.

(2) **Basic research**: On this level, countries and companies decide whether they participate and, if so, in what scope, and what additional activities they initiate.

[152] See http://cordis.europa.eu/technology-platforms/ for further details.

(3) **Application-oriented research and development**: The players decide whether they continue to participate and, if so, in what way.

(4) **Market introduction and competition**: The players decide whether and how they support market introduction of new products derived from the joint R&D&I programme.

Exhibit 3-5: Actions of the players on different levels of the exemplary game

European Commission decides…	National governments decide…	Companies decide…
Stage 1: Joint determination of framework conditions		
Research plan: ▪ Determination of research objectives, contents and methods ▪ Determination of property rights of research findings Funding: ▪ Duration, total amounts, public grant rates of funding in following two levels ▪ Participation of national governments (total amounts, shares in particular projects) ▪ Participation of companies (total amounts, shares in particular projects) Parameters for national governments: ▪ Alignment or limitation of possibly competing national programmes ▪ Termination options for national governments on the following two levels Parameters for companies ▪ Scope of allowed or desired cooperation of companies on all levels ▪ Termination options		
Stage 2: Basic research		
	▪ whether they participate and in what scope ▪ what national competing or complementary programmes they initiate	▪ whether they participate and in what scope ▪ whether they take part in co-operations and, if so, in which ▪ what projects they suggest ▪ whether they conduct self-sustained or nationally supported research
Stage 3: Application-oriented research		
▪ whether they continue the project and, if so, in what scope ▪ whether the framework conditions for application-oriented research should be modified and, if so, in what way (reduced funding, changed contribution of companies, modified requirements with regard to co-operation between companies)	▪ whether they continue to participate and, if so, in what scope ▪ what national competing or complementary programmes they initiate	▪ whether they continue to participate and, if so, in what scope ▪ whether they take part in co-operations and, if so, in which ▪ whether they conduct self-sustained or nationally supported research and whether they initiate co-operations outside the joint R&D&I programme
Stage 4: Market introduction and competition		
	▪ whether they take part in competition about establishing companies and, if so, in what scope ▪ whether they promote the supply side and, if so, in what scope (cost of capital and labour)	▪ where and how much they invest in production capacities

Source: empirica / DIW

3.5.2 Solution of the game by backward induction

The following sections characterise the equilibria which can occur in the last three stages of the game, i.e. competition, application-oriented research and basic research. Using the results from this analysis, the fourth and final section then discusses the potential impact which different framework conditions have on the players' strategies and the equilibrium of the game. In order to simplify the exposition, the analysis abstracts from any uncertainty concerning the demand for new products. While this restricts the scope of the analysis, extending the analysis by incorporating demand uncertainty does not alter the basic trade-offs the players' have to consider when they choose their strategies.

Alternative equilibria in the competitive stage

The outcome of the market game is the competitive situation in stage four, competition. It depends on the outcome in the third stage of the game, i.e. application-oriented research. Essentially, the companies' behaviour and the strategies of the national governments depend on the knowledge each company has acquired during its research activities as well as on the production technology.

Symmetric and asymmetric market equilibria

Symmetric knowledge acquisition (i.e. all firms gained the same knowledge about new production technologies and products) and linear production technologies (i.e. production functions with constant returns to scale and relatively low upfront investment necessities) tend to lead to symmetric market equilibria (i.e. market equilibria with a rather large number of firms with similar market shares.).

In contrast to symmetric market equilibria, **asymmetric knowledge acquisition** may allow firms which conducted successful research to dominate the market and to earn high profits. Similarly, pronounced **economies of scale and scope** lead to high competitive advantages of large firms and again induce asymmetric market equilibria with a small number of dominant firms. The same holds if early market entrants can exploit **first mover advantages** in order to secure their initially dominant market position. Both, economies of scale and scope as well as first mover advantages imply that competition can be characterised as "competition for the market" as opposed to "competition on the market". In such situations, the companies' strategies are driven by their attempt to gain dominant market positions and to earn the related high profits.

While the prospect of high profits spurs all companies' investments incentives, actual equilibrium investments in production capacities or the market introduction of new products depend on whether firms are able to solve the induced **coordination** problem (i.e. the issue which company will serve the market). As long as neither explicit nor implicit coordination takes place (which should be the normal case in a market economy), equilibrium investments tend to be based on mixed strategies where all firms have a positive probability of winning the market. Equilibria in pure strategies occur when explicit or implicit coordination is possible.[153] Whereas explicit coordination allows the firms to coordinate their investment efficiently, implicit coordination based on the firms' reputation, their financial capabilities or simply their size leads to potentially inefficient equilibria with positive investments of a small number of firms only.

[153] See section 3.2.1, sub-section "basic equilibria concepts: the Nash equilibrium", for the definition of pure and mixed strategies.

Expected behaviour of national governments

In symmetric market equilibria, national governments are not likely to intervene. Symmetric market equilibria with a potentially high number of firms imply that industry policies in favour of specific firms would not alter the companies' market shares substantially. Moreover, competitive markets also imply that market prices are close to marginal costs, which serves the national governments' interest to maximise national welfare, so that there is no need to intervene.

National governments are more likely to intervene if the expected market equilibrium tends to be asymmetric. Asymmetric market equilibria with a small number of dominant firms and competition for the market change the national governments' optimal strategies considerably. Strong support for national firms tends to increase national welfare as it increases the probability that the national firm will win the competition for the market and thus gain a dominant market position. Since this argument applies for all governments, **national governments may well face a prisoners' dilemma where the only Nash equilibrium is such that all governments support their national firms but where the intended effects of the national policies compensate each another**.

As with coordination between firms, **coordination between governments can avoid the implied inefficiencies**. Moreover, coordinating their national policies governments might be able to ameliorate the firms' coordination problem by signalling which firm or which group of firms is intended to serve the market. However, in order to reach the equilibrium with coordinated national support programmes, national governments must be able to commit themselves to the respective policy measures.

Exhibit 3-6: Equilibria in the competitive stage

Knowledge acquisition and technology	▪ Symmetric knowledge acquisition ▪ Linear production technology	▪ Asymmetric knowledge acquisition ▪ High economies of scale or scope ▪ Capacity investments as commitment
	⇓	⇓
Market equilibria	▪ High number of firms ▪ Symmetric market structures	▪ Low number of firms ▪ Asymmetric market structures ▪ Inefficient investments without coordination of investments
	⇓	⇓
National policies	No policies to support national firms	▪ Policies to support national firms to win the market ▪ Inefficiently high support without coordination between national governments

Source: empirica / DIW

Alternative equilibria in the stage of application-oriented research

In view of the different equilibria which can arise in the competitive stage of the game, the firms' and national governments' strategies in the third stage of the game, i.e. application-oriented research, are governed by their decision which equilibrium they aim to reach.

Firms' and governments' aims in markets with a few dominant firms

The aims of the companies and governments are determined by the differences in the firms' profits and the countries' national welfare in the two different equilibria and by the

assumption that either the production costs are likely to exhibit pronounced economies of scale and scope or that early investments can in fact serve as a credible mechanism to monopolise the markets for new products. Hence, it turns out that a firm is more likely to benefit from non-cooperative research the higher the probability that the firm's own research will be successful and that the firm will be able to win the market. The same considerations apply for national governments. As long as the firms' gains from dominating the market more than compensate any welfare loss due to relatively higher market prices, the interest of national governments and their firms are perfectly aligned. Therefore, the equilibrium in the third stage of the game tends to be such that **firms with a high probability of winning the subsequent market game invest in their own application-oriented research and are supported by their national governments**. Aligning a firm's size with its financial capabilities and its potential to do successful research shows that large firms are more likely to either leave the programme or to quit any co-operative research projects they have with other (smaller) firms. This strategy can also serve as a credible signal to fight for the market and can thus induce other firms to leave the programme and to quit their research investments.

Firms' and governments' aims in markets without dominant firms

While the equilibrium just described is based on the assumption that the competitive stage leads to asymmetric equilibria with a small number for dominant firms, the firms' behaviour and the strategies of national governments differ significantly if symmetric market equilibria are likely to occur. In this case the firms' strategies are driven by their incentives to economise on their research costs and to ensure that they participate in the market game. Hence, this equilibrium is more likely to be characterised by cooperative research which allows firms to internalise potential positive spill-over effects and thus to lower their overall research costs. Whether the equilibrium investments will be efficient from a social welfare point of view depends on the firms' ability to form efficient research co-operations and to solve the free-rider problem entailed in these co-operations. Accordingly, **in symmetric market equilibria, national governments seeking to maximise the social welfare in their countries will have an incentive to support joint European R&D&I programmes whenever they can increase the firms' investments**. Although potential free-rider problems may lead to inefficiently low national supports, the equilibrium will nevertheless be characterised by national governments continuously participating in the programme.

Equilibria with differing aims of firms and governments

So far the discussion has been based on the assumption that market equilibria are either asymmetric or symmetric. However, whether market equilibria tend to be asymmetric or symmetric depends endogenously on the strategies chosen in the third stage of the game. More precisely, taking into account that application-oriented research may fail, the range of possible equilibria also comprises equilibria in which individual firms or countries try to establish asymmetric market equilibria while other firms or countries rely on co-operative strategies in order to ensure that the market will not be dominated by a small group of large foreign firms. The decisions which strategy to follow obviously depends on the comparison of the expected profits and the strategies followed by other firms or countries. The strategic interdependency tends to be characterised by strategic complementarity in the sense that **groups of firms and countries acting co-operatively make non-co-operative research strategies targeted at monopolising the market less valuable**. Similarly, given that a number of large firms has adopted non-cooperative

strategies overall investments will be rather high and co-operative research of rather small firms is unlikely to be successful. Summarising these findings: **while the application-orientated research stage can lead to a variety of different equilibria, where firms either act co-operatively or non co-operatively, a relatively small number of firms or countries may well trigger a non co-operative equilibrium where only large firms invest and compete for the market**.

Exhibit 3-7: Equilibria in the application-oriented research stage

Market Equilibria	Symmetric market equilibria with competition **on** the market	Asymmetric market equilibria with competition **for** the market
Firms' strategies	▪ Firms tend to act co-operatively and to continue to participate in the programme ▪ Efficiency increasing co-operations to internalise positive spill-over effects	▪ Large firms invest in their own research and tend to act non-cooperatively ▪ Small firms tend to leave the programme and to quit their research
	⇓	⇓
National Policies	▪ Support of the programme ▪ Incentives for international co-ordination	▪ Support of own national firms likely to undertake successful research and to win the market

Source: empirica / DIW

Equilibria in the stage of basic research

The possible equilibria in the second stage of the game, i.e. basic research, can be divided in two categories. First, the programme may not emerge; second, firms and national governments participate in the programme.

Reasons for non-emergence of a joint technology R&D&I programme

There are basically three different reasons for non-emergence of joint European R&D&I programmes: the free-rider problem, commitment problems, and independent research by large firms.

- **Free-rider problem**: One of the reasons which can lead to the outcome that a technology R&D&I programme does not emerge is the free-rider problem among the firms. The firms which have to decide whether to join the programme or not compare their expected benefits from joining the programme and from not joining the programme given the equilibrium strategies of the other players. When potential new knowledge is easily transferable, every firm may find it optimal not to join the programme independently of what the other firms do. Easy transfer of new knowledge is the case when the framework conditions oblige the firms to share their new knowledge with other members of the programme and to publish newly generated knowledge. Indeed, **if the other firms join the programme an individual firm will free ride on their efforts if the research results are easily transferable**. If none of the firms participate in the programme, then every single firm will better conduct its own research without joining the programme, in which case it will guarantee itself the competitive advantages in the further stages of the game.
- **Commitment problems**: The other reason for non-emergence of a programme is due to possible commitment problems in the later stages of the game. Equilibria in the first stage of the game, i.e. in the stage of determining the conditions of the programme, are determined by the equilibrium strategies which the players use in the

second and the third stages of the game. When national governments are not able to commit themselves to not support national firms in the following stages of the game, firms may receive national support in later stages of the game even without participating in the programme. Hence, **the possibility of national support not conditioned on the participation in the programme decreases the firms' incentives to participate in the programme**.

- **Independent research by dominant firms**: It is also possible that the programme does not emerge when the horizontal market at the outset of the game is asymmetric, i.e. dominated by a few large firms with strong ability to conduct independent research. **If there are large firms which are able to conduct independent research successfully and if these firms have to share their research results with the smaller firms under participation in the programme, then the incentives of the larger firms depend on whether they get attractive enough grants from the programme.**

Characteristics of possible emerging joint R&D&I programmes

If the equilibrium in the first stage of the game is characterised by the emergence of the joint R&D&I programme, the **equilibrium outcomes can be different with respect to the number of firms which participate in the programme**. It is possible that only part of the firms will participate. Some firms may join only in the stage of application-oriented research with the aim to free ride on basic research, the results of which may be easily transferable. Firms which expect to be supported by their national governments in the following stages of the game may find it unattractive to participate in the programme. Large firms may also forgo the opportunity to join the programme if they expect to buy small and successful firms after the research is completed.

The most important equilibrium outcome of the first stage of the game is the amount of investment in basic research. This **investment in basic research can be both inefficiently high or inefficiently low** depending again on the players' equilibrium strategies. The following three outcomes may occur:

- **Inefficiently low investment into basic research**: When the free-rider problem is very severe, then the total amount of investment will be lower than the optimal one, because too few companies participate and too little funds are invested into basic research. An optimal level of investment into basic research would be one that maximizes the sum of expected profits and consumers' surplus minus excepted costs for basic and development-oriented research.
- **Inefficiently high investment into basic research**: It is also possible that the national governments will make excessive investments with the strategic aim to increase their own weight (or the weight of the national firms) in the programme as a dominant strategy. Since all the countries will have such an incentive, none of them will be able to increase its weight in the programme, but total investment will nevertheless be excessively high.
- **Unaffected investment into basic research but substitution effects**: The total amount of investment may also be unaffected by the programme, namely if firms are able to coordinate their conduct of research and if free-rider and commitment problems are not important. In this case grants received by the firms may simply substitute their own investments. The pure substitution effect will emerge if firms receive a fixed grant from the programme. If the amount of the grant depends on the

firms' own investments, then the total amount of investment will increase but the substitution effects will still be present.

Exhibit 3-8: Equilibria in the stage of basic research

Market Equilibria	Programme emerges	Programme does not emerge
Possible Reasons	The reasons identified on the left side are not strong enough to make the option of non-participation more attractive	▪ Free-rider problem among the firms (sharing and publishing of research results) ▪ No commitment of national governments to not support national firms in later stages ▪ Firms with asymmetric research abilities and large firms do not get attractive enough support from the programme
Equilibrium Amount of Investment	▪ Inefficiently low amount of investment due to free-rider problems among firms ▪ Inefficiently high amount of investment due to the strategic behaviour of national governments	▪ Firms conduct their own research either cooperatively or non-cooperatively ▪ The equilibrium amount of investment may not be lower than in the case when the programme would emerge (the substitution effects are strong enough)

Source: empirica / DIW

3.5.3 Implications for formulating framework conditions

General implications

The considerations from the last stages lead to the first stage of the game, the definition of framework conditions for the joint R&D&I programme. These conditions should be designed with the aim to maximise the expected welfare of the EU through eliminating strategic behaviour of individual firms and national governments. The optimal design of the framework has to ensure two aspects: First, firms and national governments must find it profitable to participate at the outset; second, the firms' and national governments' incentive to strategically exploit the programme once it has been created are as low as possible.

There are several general instruments the EC could use – and to some extent actually uses – to prevent possible strategic behaviour of companies. Prior to establishing the programme at all, the European Commission may carefully **consider the industry's history** to see whether firms realised similar joint research projects and co-operations even without public funding in the past. If this is not the case, the programme is more likely to provide new and efficient mechanism for co-operations and exploiting synergies between firms.

In the basic research and application-oriented research stages, there are two further instruments: First, through **independent evaluation of the firms' research proposals** it is possible to understand whether the firms were able to conduct research projects independently even without external support. Second, while it is generally difficult to exclude windfall gains from public support, windfall gains can be reduced by **conditioning public funds on the firms' own investment**. Whereas rather simple schemes like proportional funding mechanisms (e.g. the state grants additional 10% to a firm's R&D funds) ensure

that the firms' marginal investment incentives increase, proportional funding also subsidises the firms' infra-marginal investments. Non-linear funding schemes based on the firms' absolute R&D investment levels (e.g. the state grants additional 10% only to R&D investment beyond 10 million €) provide lower risks of generating windfall gains but are also more demanding with respect to the information required for an efficient design.

Participation in the programme and free-riding in the first stage of the game

When the market structure is initially characterised by large asymmetries between the firms' abilities to perform independent research, the incentives of large firms to participate tends to be rather low. Obliging large firms to co-operate with small firms and to share their knowledge with them, the programme's fund should thus compensate large firms for potential competitive disadvantages they incur through participation in the programme. Thus, **the programme's funds have to be larger the more the framework conditions force firms into co-operations and oblige them to share their knowledge**. Furthermore, the participation of firms may depend on the ability of national governments to not support them. This kind of commitment is more credible if it is also supported by the framework conditions, i.e. if **the framework provides explicit rules for national governments not to establish competing national research programmes**.

Turning to the firms' investment in basic research, firms may have an incentive to free ride on the research efforts of other firms participating in the programme. To avoid this free-rider problem **the framework can prescribe minimum investment requirements into basic research**. Additionally, the framework might provide the firms with the possibility to delay the publication of their research results within the programme. Firms not investing in R&D co-operations can thus be hurt by a delayed access to new knowledge. This can be especially the case in ICT markets where the presence of large network effects, switching costs and lock-in effects induces large first-mover advantages – firms that invest first define the properties of the technology and take the market, while following firms find it difficult to gain market shares.[154]

The rules of participation in a programme can be also designed such that **firms that did not participate in the stage of the basic research are not allowed to join the programme in later stages**, i.e. in the stage of the application-oriented research. The efficiency of this measure depends on the attractiveness of participation in the programme in the stage of application-oriented research. When firms are heterogeneous and have expertise in different areas relevant for the application-oriented research, then synergies are likely to emerge and firms will participate at the stage of basic research in order to not to forgo the opportunity to participate in the stage of application-oriented research.

Strategic behaviour in later stages of the game

Considering the later stages of the game, **the framework has to ensure that neither firms nor national governments have an incentive to leave the joint programme and to perform their own research programmes**. Starting with national governments, the

[154] The term "network effects" refers to technologies whose utility increases the more individuals or firms use them (e.g. telephones); "switching costs" refers to the costs of switching to a different technology that may appear more attractive; "lock-in effect" are implied by sunk investments needed for using a specific technology. See in particular section 3.4.5 "Analysis of industrial organisation aspects in standards adoption" for these terms.

framework conditions can either explicitly prohibit national programmes or they can entail indirect measures to reduce the governments' incentives to leave the programme. These measures can rely on financing rules which prescribe that governments have to deposit their overall contributions in the first stage of the game and that refunding is only possible when a potentially qualified majority of countries agrees.[155]

The firms' incentives to leave the programme in order to establish asymmetric market equilibria can be reduced by forcing the firms to share their generated knowledge. However, if firms anticipate that the ensuing market equilibria will be asymmetric due to high economies of scale or scope or due to large first-mover advantages, the framework conditions may influence the attractiveness of the asymmetric market equilibria, but can hardly prevent the firms from leaving the programme. **Preventing national governments from subsidising their national firms** and to co-ordinate their policies in order to signal which firm is intended to serve the market is an indirect measure to decrease the firms' expected profits in an asymmetric equilibrium.

[155] Compared to a simple majority rule, qualified majority rules tend to be more efficient if the participating countries and firms are heterogeneous with respect to their benefits from participating in the platform (see Caplin and Nalebuff, 1988, for a discussion of optimal majority rules with heterogeneous agents).

3.6 Summary of the theoretical analysis

Concept of the theoretical analysis

The theoretical analysis in this report is meant to produce insights about strategies and behaviour of companies, Member States and the European Commission when interacting about ICT innovation and adoption and related policies. To this end, the analysis applies four theories: game theory, theory of industrial organisation, market failure theory and state failure theory. The report presents two separate analyses: one about ICT R&D&I in ICT-producing industries, one about e-business adoption to enhance electronic value systems in ICT using manufacturing industries. Both issues are important for enhancing the competitiveness of European enterprises. Furthermore, an exemplary analysis of ICT R&D&I based solely on game theory is conducted.

Insights from the analysis of policies to promote ICT innovation

The importance of ICT R&D&I for growth and employment in Europe is undisputed. However, the European Commission sees a critical need for European ICT R&D&I to be better co-ordinated, concentrated and specialised in order to improve competitiveness of ICT-producing industries. Exhibit 3-4 presents the key results of a theoretical analysis related to ICT R&D&I in companies (see section 3.3 for the detailed analysis).

Exhibit 3-9: Key findings from the theoretical analyses of ICT R&D&I

Insights from industrial organisation theory	**Large firms may have more incentives to innovate and may be more successful in innovation than small firms**. Reasons: ▪ Short innovation cycles imply two advantages of large firms in R&D&I: a large customer base and reputation with regard to product quality. ▪ Firms offering established systems with large customer bases can easily become also dominant on the markets for new and compatible components. ▪ Large firms may be especially willing to imitate innovations of small firms.
Possible market failures	**Underinvestment** into R&D&I: While the firms' incentives to innovate are driven by expected profits, socially optimal investments in R&D&I are based on overall social benefits. Possible **overinvestment** into R&D&I: Since innovations may increase market shares at the expense of competitors, firms have an incentive to invest more than socially optimal. **Incomplete information about potential demand** when facing high marketing costs may imply that firms do not commercialise new technology. With **strategic use of incompatibility** of their products, firms may seek to establish new monopoly positions and to prevent market entry. Large firms may **(mis-)use R&D&I joint ventures** with small firms to control their innovations.
Possible state failures	ICT **R&D&I grants can be allocated inefficiently** because incentive schemes for agents assessing firms' ICT R&D&I proposals are not necessarily efficient. Companies involved in **publicly supported R&D&I joint ventures may (mis-) use results** of the co-operation to restrict competition. Each countries' **R&D&I grants to national companies** may be higher than compared to a situation in which countries coordinate their grants.

In summary, industrial organisation theory suggests that large firms may have more incentives to conduct ICT-related innovation and may be more successful in innovation than small firms. Potential market failures related to ICT R&D&I include above all underinvestment into R&D&I from a societal point of view and non-commercialisation of new technology due to incomplete information about potential demand. Possible state failures in ICT R&D&I support are related to inefficient allocation of grants, misuse of the results of publicly supported R&D&I joint ventures to restrict competition, and national grants that are higher than they could be when countries would coordinate their grants.

Insights from the analysis of policies to promote electronic value systems

The use of e-business for electronic communication between companies can enhance value systems and increase business process efficiency as well as the competitiveness of the companies involved. In particular, SMEs may benefit from e-business adoption in order to remain suppliers or customers in large companies' value systems.

Industrial organisation theory suggests numerous problems related to the development of electronic value systems, above all failure to coordinate mutually related e-business investments and larger e-business investment incentives in large companies than in SMEs. There is also an argument for market failure related to SMEs' risk to become locked-in a certain e-business solution if it only serves interaction with a single large company. However, theoretical considerations about e-business adoption question whether policies to promote SMEs' participation in electronic value systems necessarily enhance efficiency. Exhibit 3-5 summarises related findings (see section 3.4 for a detailed analysis).

Exhibit 3-10: Key findings from the theoretical analyses of e-business adoption

Insights from industrial organisation theory	**1. A single firm's view on e-business process innovation** ▪ firms may have an incentive to forego actual cost savings by delaying their investment in order to economise on lower prices, better technologies or compatible standards in the future ▪ firms producing large quantities or interacting with many suppliers and customers may be more willing to invest in process innovations **2. Horizontal market structure issues** ▪ the more an expected or actual e-business innovation hurts other firms, the higher are the innovation incentives of the other firms ▪ investment incentives increase with the size of the market as well as the firm's market shares; large firms may invest more in ICT than small firms **3. Vertical market structure issues between ICT suppliers and users**: ICT producers may increase demand for their products by reputation building, relational contracts, second sourcing **4. Vertical market structure issues among ICT-using companies** ▪ strategic incentives imply that a group of firms may not be able to coordinate their mutually related e-business investments or that they agree on suboptimal e-business solutions. ▪ asymmetric vertical market structures lead to asymmetric ICT investment incentives, favouring large companies and disadvantaging small suppliers **5. Coordination and network effects**: Firms at either level of the value system may try to use their own e-business standards to protect their positions against market entry of other firms
Possible market failures	**Market failures in developing electronic value systems** ▪ As e-business investment may reduce the efficient number of firms in the market, it does not imply any market failure per se if markets become more concentrated. ▪ If large firms invest in proprietary e-business solutions, the small suppliers' risk of becoming locked-in with this specific solution is high. ▪ Even though overall gains from trade may be distributed asymmetrically between supplying and buying firms, this does not imply any market failure as long as quantities are chosen efficiently.
Possible state failures	Policy measures which simply focus on the participation of SMEs in larger firms' digital supply systems may not alter the firms' investment decisions or may distort equilibrium market structures so that an inefficiently high number of SMEs remains active. Large firms may opt for public policies which subsidise SMEs in order to ensure that their up- or downstream markets remain competitive. International harmonisation can well be detrimental for large domestic firms which may induce national governments to stick to national solutions.

As regards policies to e-business **standards adoption**, policy makers need to be aware that the companies involved have strategic incentives to hide relevant information in order to reduce their costs of implementing a new standard or to receive direct grants. National governments may tend to promote standards that are prevalent within the country.

Insights from a game theoretical analysis of joint R&D&I programmes

In order to produce specific insights about ICT R&D&I policy from game theory, an exemplary analysis of ICT innovation policy applying game theory has been conducted for this report. The example is related to joint European R&D&I programmes and fictive. The establishment of dedicated programmes is understood as a strategic interaction of players in terms of game theory: the European Commission seeks to maximise expected welfare in the EU, national governments seek to maximise expected welfare in the country, and companies seek to maximise expected profit.

By means of backward induction, i.e. by analysing possible outcomes of the game beginning with the last stage (competition), the analysis leads to the findings presented. The most important lessons for the European Commission are related to he optimal design of the framework conditions of the joint R&D&I programme before its inception. The EC faces a dilemma: On the one hand it has to ensure that firms and national governments must find it profitable to participate at the outset in order to create critical mass; on the other hand the firms' and national governments' incentive to strategically exploit the programme once it has been created have to be as low as possible in order to ensure that the programme benefits the broad European public. The design of joint R&D&I programmes may thus need special attention. Key insights are that public funds need to be conditioned on the firms' own R&D&I investment, i.e. public funds are only granted for investments beyond a certain limit, and that national governments must be prevented from establishing own programmes and subsidising national firms – see Exhibit 3-11.

Exhibit 3-11: Key findings from the game theory analysis of joint R&D&I programmes

Stage	Implications
Competition	Asymmetric knowledge acquisition, economies of scale and scope and first mover advantages may lead to high competitive advantages of large firms and induce asymmetric market equilibria with a small number of dominant firms. National governments may face a prisoners' dilemma: all governments support their national firms but the intended effects of compensate each other. Coordination between governments can avoid the implied inefficiencies.
Application-oriented research	Firms with a high probability of winning the subsequent market game invest in their own application-oriented research and are supported by their national governments. Groups of firms and countries acting co-operatively make non-co-operative research strategies targeted at monopolising the market less valuable. While the application-orientated research stage can lead to a variety of different equilibria, a relatively small number of firms or countries may well trigger one of the extreme equilibria leading to either symmetric or asymmetric market equilibria.
Basic research	There are basically three different reasons for non-emergence of an R&D technology programme: the free-rider problem, commitment problems, and independent research by large firms. Investment in basic research can be both inefficiently high or inefficiently low depending on the players' equilibrium strategies.
Framework conditions	**General instruments** of the European Commission to prevent strategic behaviour of companies: ▪ consider the industry's history (joint R&D without public support in the past?) ▪ independent evaluation of the firms' research proposals ▪ conditioning public funds on the firms' own investment. Instruments for the **first stage** of the game (basic research): ▪ explicit rules for national governments not to establish competing national research programmes ▪ prescribe minimum investment requirements into basic research ▪ firms that did not participate in basic research are not allowed to join the programme later Instruments to prevent strategic behaviour in **later stages** of the game: ▪ firms and national governments must not have an incentive to leave the programme and to perform their own research programmes ▪ Preventing national governments from subsidising their national firms

4 Empirical findings

This chapter presents primary empirical findings of research conducted for this report. Primary research was conducted in three ways: case studies (section 4.1), an expert survey (4.2), and additional personal expert interviews (at appropriate parts of the text). These data collections supplement and substantiate the descriptions in chapter 2 and the theoretical analysis in chapter 3, and they provide further arguments for policy implications in chapter 5. The findings are presented as self-sustained pieces of research, but they are cross-referenced in chapters 2, 3 and 5 of this report.

4.1 Case studies on ICT-related industrial policy

4.1.1 Introduction to case studies

Relevance of case studies for this report

Since the key part of this study is a theoretical analysis, case studies play only a supporting role. However, case studies provide additional insights that are valuable to put theoretical arguments more concrete, and they contribute to ensuring that the theoretical analysis is close to real business and policy life.

Overview of case studies conducted for this report

Three original case studies were conducted for this study – see Exhibit 4-9. They provide a critical view on public policies for ICT innovation and adoption. Two case studies deal with ICT innovation support: the Network and Information Technology Research and Development (NITRD) programme in the USA, and the former IT839/u-IT839 master plan in South Korea. One case study is about e-business adoption and electronic value systems, namely the one on the Cluster Automotive Region Stuttgart (CARS) in Germany.

Exhibit 4-1: Case studies presented in this report

Case	Company / project	Country	Industry	Topic(s)
1	Network and information technology research and development (NITRD)	US	ICT manufacturing	Fostering ICT research, development and innovation through a federal agency
2	Former IT839/u-IT839 master plan	South Korea	ICT manufacturing / mobile	Large-scale public programme to support innovation in ICT manufacturing industries
3	Cluster Automotive Region Stuttgart (CARS)	Germany	Automotive	Promotion of electronic value systems in a regional automotive industry cluster through a public-private partnership

Source: Sectoral e-Business Watch (2009)

Relevance of case studies for eBSN study on "sectoral e-business policies"

In addition to the primary case studies, a brief summary of some of the most important findings of the case studies for the eBSN study about "sectoral e-business policies in support of SMEs" is presented after the three primary case studies (section 4.2.5).

4.1.2 Networking and Information Technology Research and Development (NITRD) Programme, USA

Abstract

Initiated by the United States Congress in 1991, the Networking and Information Technology Research and Development (NITRD) programme has evolved into the principal tool to support, manage, and coordinate the US Federal government's non-classified ICT-related R&D. The NITRD programme comprises of more than a dozen Federal member agencies and maintains an operating budget of 3.5 billion US dollar (projected for 2009). This budget is directed towards grants for advanced ICT R&D, workshops designed to foster R&D and innovation in the ICT-producing industry, and working partnerships with academia and the private sector to foster technology transfer. This case study provides an overview and analysis of the key issues, the specific areas of funding and examples of programs that NITRD oversees. Furthermore, it analyses specific issues and areas that the NITRD must address moving forward, for example, the extent to which the US Federal government creates and sponsors more high-risk ICT-related R&D.

Case study fact sheet

■ *Full name of organisation:*	*Networking and Information Technology Research and Development (NITRD)*
■ *Location:*	*Arlington, Virginia, USA (National Coordination Office)*
■ *Main activity:*	*Source and coordinating point for federally funded R&D in networking information technologies*
■ *Year of foundation:*	*1991 (originally called High Performance Computing and Communications Program)*
■ *Number of organisations involved:*	*13 Federal member agencies as well as numerous other participating federal agencies*
■ *Budget in last financial year:*	*3.341 billion US dollar*
■ *Geographical region covered:*	*entire USA*
■ *Type of ICT promoted:*	*Fundamental, long term research and development (R&D) in advanced networking and information technology*

Background and objectives

Technologies targeted and organisation

The Networking and Information Technology Research and Development (NITRD) programme represents the US Federal government's portfolio of unclassified investments – i.e. investments not requiring security safeguards – in "*fundamental, long term research and development (R&D) in advanced networking and information technology (IT)*".[156] This includes high-end computing, large scale networking, cyber security and information assurance, human-computer interaction, information management, high confidence soft-

[156] Statement of Christopher L. Greer, Director, National Coordination Office for Networking and Information Technology Research and Development to the Committee on Science and Technology. US House of Representatives, 31 July 2008.

ware and systems, software design, and socioeconomic, education and workforce implications of IT.

The NITRD comprises of 13 member agencies, including the most important national organisations promoting and conducting R&D.[157] The specific mandate of NITRD is to serve as a clearinghouse or facilitator for inter-agency coordination, R&D organisation and implementation. This is accomplished through managing and organizing the transfer of IT-related technology and R&D between Federal agencies. Technology transfer between federal agencies is important for increasing the benefits of technological innovations through implementation across agencies. The NITRD programme transfers technological knowledge by hosting regular conferences, workshops and working groups where federal agencies and private sector researchers meet to identify important areas of research and discuss ways to put this R&D to practice both within the Federal government and in the private sector. In a broader sense, the NITRD's mission is to formulate and promote Federal ICT R&D to meet national goals, in particular to boost the competitive position of US-based ICT producing industries. The NITRD's activities are run from a National Coordination Office (NCO) based in Arlington in the state of Virginia.

Initiated by Congress in 1991, known as the High-Performance Computing Act, the NITRD has evolved into the US Federal government's most important tool in the development and coordination of high level IT and innovation driven R&D. The driving force behind the initiation of this Act, and subsequently the NITRD programme, was two-fold[158]: First, expand Federal support for research, development, and application of high-performance computing. Second, improve the interagency planning and coordination of Federal research and development on high-performance computing and maximizing the effectiveness of the Federal Government's high performance computing network research and development programs.

Strategic objectives

The strategic objectives of NITRD have been evolving as a result of shifting national priorities. Beginning in 1999, NITRD and the President's Council of Advisors on Science and Technology outlined a series of strategic objectives. These objectives were updated and revised in 2007 and represent a current assessment how and where NITRD will seek to focus its attention and funding resources. The four strategic objectives include:

1. **Large-scale, long-term and high-risk R&D:** NITRD and Federal member agencies should rebalance their networking and IT R&D funding portfolios by increasing (1) support for projects that require large-scale and long-term R&D and (2) place an emphasis on innovative and therefore higher-risk but potentially higher payoff explorations.
2. **Multidisciplinary R&D:** Increasing the emphasis on multidisciplinary research in challenging, nationally important issues in the ICT research community in the US

[157] Agency for Healthcare Research and Quality (AHRQ), Defence Advanced Research Projects Agency (DARPA), Department of Energy, Office of Advanced Science Computing Research (DOE/SC), Department of Energy-National Nuclear Security Administration (DOE/NNSA), Environmental Protection Agency (EPA), National Archives and Records Administration (NARA), National Aeronautics and Space Administration (NASA), National Institute of Health (NIH), National Institute of Standards and Technology (NIST), National Oceanic and Atmospheric Administration (NOAA), National Security Agency (NSA), National Science Foundation (NSF), Department of Defence (DOD).

[158] See www.nitrd.gov. NCO/NITRD Governing Documents, Section 3.

by creating a greater level of collaboration, not only across technology-related fields, but also between the public sector, the private sector and academia.

3. **Technology transfer:** The NITRD member agencies should use all available resources to facilitate the transfer of research results and technology into practical application and commercial products.
4. **Research fields:** The NITRD Programme and Federal member agencies prioritises selected areas for funding and research considered as particularly important (see next section).

Activities to support ICT research, development and innovation

Overview of disciplines supported

Structurally, the NITRD programme is divided into seven distinct technical disciplines:

- high end computing, including infrastructure and applications as well as R&D;
- cyber security and information assurance;
- human computer interaction and information management;
- high confidence software and systems;
- large scale networking, including jet engineering, middleware and grid infrastructure coordination as well as network research;
- software design and productivity;
- social, economic and workforce implications of IT.

Exhibit 4-2: NITRD budget by programme component area (fiscal year 2009, million $)

Agency	High End Computing Infra-structure and Applic-ations	High End Computing R&D	Cyber Security & Information Assurance	Human-Computer Interaction & Informa-tion Man-age-ment	Large Scale Networking	High Confi-dence Software & Systems	Social, Economic, & Work-force Im-plic-ations of IT	Software Design & Productivity	TOTAL
NSF	323.4	77.6	63.3	250.3	99.0	62.1	73.8	54.8	**1,004.3**
NIH	419.1	66.4		248.1	61.5	93.6	13.2	33.9	**935.8**
DARPA		139.0	125.4	184.9	129.7				**579.1**
DOE	285.2	79.1			49.3		6.0		**419.5**
DOD	235.0	3.4	71.1	83.8	94.9	27.9		16.7	**532.7**
NSA		122.7	36.9		1.6	7.5			**168.7**
NIST	11.8	3.6	23.4	12.3	5.7	4.5		4.9	**66.1**
NASA	58.0			7.5	2.4	4.0		2.2	**74.0**
AHRQ				43.8	1.0				**44.8**
NOAA	24.8	0.2		0.5	2.0			0.5	**28.0**
DOE	4.8	9.4			1.0		2.9		**18.1**
EPA	3.3			3.0					**6.3**
NARA				4.5					**4.5**
TOTAL	**1,365.4**	**501.3**	**320.1**	**838.7**	**448.0**	**199.6**	**95.9**	**113.0**	**3,882.0**

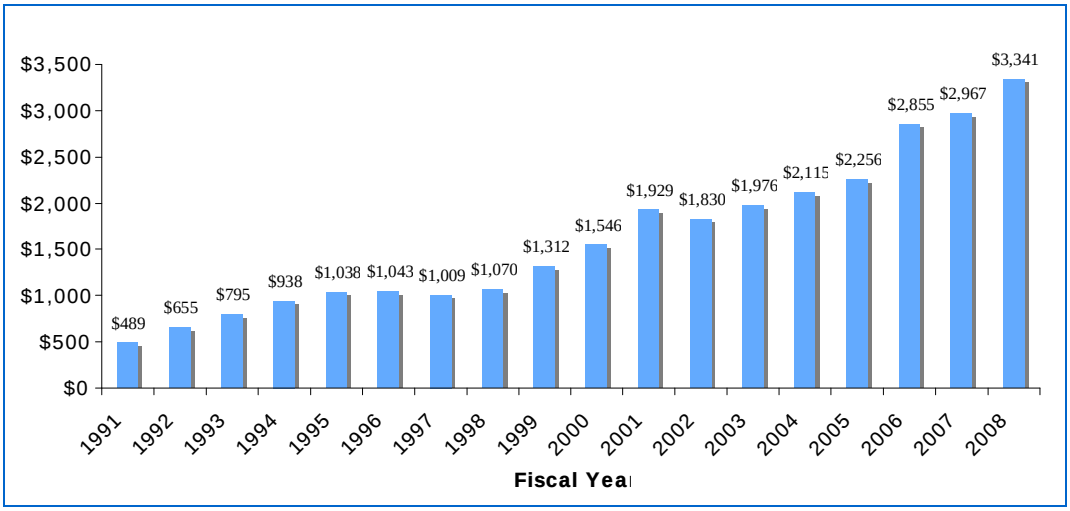
Source: www.nitrd.gov

Within these seven disciplines, high end computing (HEC) receives by far the largest amount of budget outlays by the member agencies, representing 48% (or 1.87 billion US dollar) of the NITRD 2009 budget (see Exhibit 4-10). The principal reason for the high level of funding in this area can be attributed to the extraordinarily high cost of super computers, as well as the broad interest and popularity of the field. Research areas within HEC include hardware (micro-architecture, memory subsystems, interconnect, packaging, input/output and storage), software (operating systems, languages and compilers, development environments, algorithms), and systems technology (system architecture and programming models).

Budget allocation and development

NITRD's budget has expanded to 3.341 billion US dollar in 2008 – see Exhibit 1. The projected 2009 budget is expected to grow further to 3.5 billion US dollar. The NITRD does not receive this funding directly. Rather, the budget amount represents the combined budget outlays earmarked for ICT-related R&D from the federal government to the 13 member agencies that comprise the NITRD programme. Therefore, it is the responsibility of each of these member agencies to put this budget to use, funding for example ICT-related programmes, grants for universities and the private sector.

Exhibit 4-3: NITRD funding 1991 – 2008 (million US dollar)



Source: www.nitrd.gov

The NITRD NCO itself receives an annual budget of roughly 4-5 million US dollar for salaries and administration costs. The growth of the NITRD's budget is in line with other OECD countries, which in recent years "*have substantially increased their overall public funding for ICT R&D*".[159] Nevertheless, there is significant variation among the countries, for both the amount and the direction of ICT R&D. For example, while the US NITRD's 2008 budget exceeded 3 billion US dollar, in Japan funding for ICT-related R&D projects totalled 1.4 billion US dollar. Furthermore, the European Union has approved a budget of 12.5 billion US dollar for 2007-2013.[160]

[159] OECD Information Technology Outlook 2008, p. 165.

[160] See OECD Information Technology Outlook 2008, p. 166. Funding totals may vary as these represent proposed funding in the US, approved funding in Japan and approved funding in the European Union. Sub-national funding programmes are not included. In 2007 exchange rates.

Planning and coordination

Specifically related to planning and coordination, the NITRD program uses five general mechanisms to accomplish its mission:

(1) monthly meetings of the seven Federal Interagency Working Groups (IWGs) and Co-ordinating Groups;

(2) workshops, most including private-sector as well as Federal participants;

(3) formal reports, including the annual NITRD Supplement to the President's Budget and strategic planning documents;

(4) support for external studies and assessments;

(5) outreach to the Federal and private sectors.

Each of the member agencies collaborate with the NITRD programme to both financially support and directly conduct ICT-based research and development. However, they do so to varying degrees, reflecting the size and scope of each agency's mandate and in some cases – such as the National Security Agency and Department of Defense – security issues that hinder a more intense involvement. The most involved member agency is the National Science Foundation, which in fiscal year 2009 collaborated with the NITRD on an estimated 1.004 billion US dollar of R&D in ICT-related fields. At the other end of the spectrum, the National Archives and Records Administration's participation in 2009 amounted to 4.5 million dollars.

Impacts

Importance of NITRD and publicly funded research in ICT R&D

Due to the high cost and levels of risk associated with ICT-related R&D, public funding for ICT research and innovation is becoming increasingly important world-wide. According to the OECD's 2008 Information Technology Outlook, in recent years OECD countries have significantly increased their overall public funding for R&D. Additionally, most OECD governments currently operate multi-annual funding programmes for ICT R&D with the objective of promoting cooperation between government and the private sector. Examples of these programmes include: NITRD in the United States, Council for Science and Technology Policy in Japan, the former IT839/u-IT839 programme in Korea, and ICT-related funding in the Seventh Framework Programme for the European Union.[161]

This means that the role that NITRD plays, as the principal coordinator for the US government's ICT-related research budget, in coordinating public funding for research is growing. Also, this public funding is assessed as clearly impacting the private sector – while difficult to quantify –, and as a result bolstering the United States' ability to promote competitiveness: "*In the United States, for example, 70% of the R&D performed by all domestic and foreign computer and electronics firms in 2005 took place in four locations, all in close proximity to public research institutes. (…) The relative importance of access to public research results increases in times of falling company budgets for basic research.*"[162]

[161] OECD Information Technology Outlook 2008, p. 165

[162] National Science Foundation: http://www.nsf.gov/statistics.

The location of all of these technology companies in close proximity, and with funding ties to public research institutes, may impact the US ICT industry's competitiveness in a positive way.

Examples of NITRD impact

Two key impacts that the NITRD Programme has had are in (1) facilitating the transfer of research findings and technological knowledge between Federal agencies within the US government and (2) coordinating the disbursement of public research funds to the private sector and academia.

Example:

The Cluster Exploratory Programme by Google, IBM and the National Science Foundation

In October 2007, Google teamed up with IBM to launch the Cluster Exploratory Programme (CLuE). The progamme gives six major US universities (University of Washington, Carnegie Mellon, Massachusetts Institute of Technology, Stanford University, University of California in Berkeley, and the University of Maryland) access to a large-scale computing cluster together with the software and services to utilise it properly. The Cluster Exploratory Programme (CLuE) was designed to provide researchers access to massively scaled, highly distributed computing resources. While the principal focus of the programme is the promotion of research advances in computing, the potential to stimulate simultaneous advances in other fields of science and engineering is also recognised and encouraged.

In February 2008, the NSF joined this initiative by providing grants with the purpose of broadening the reach of this initiative and making it available to even more researchers throughout the country. The anticipated total funding amount offered by the NSF totalled 5 million US dollar and is restricted to non-profit and non-academic organisations as well as US universities and colleges.

The CLuE programme invites researchers to submit proposals that outline new, innovative use of the cluster and probe the possibilities and fundamental limits of the computing paradigm it enables. Investigators should consider the Google/IBM cluster an active storage system rather than a computer cluster; the chief characteristic is massive data storage with compute cycles nearby.

The reasons and impact in a programme such as this are clear in that it gives a greater amount of researchers access to high-end-computing resources and allows them to conduct research that they might not otherwise be able to conduct due to lack of funding or proper infrastructure. The ultimate impact of this programme has yet to be realised, however, the hope is that it will produce valuable advances in the field of high-end-computing research.

Sources:
NITRD website (www.nitrd.gov); National Science Foundation, Cluster Exploratory (CLuE) Programme Solicitation, NSF 08-560. Official Google Blog: http://googleblog.blogspot.com/2007/10/let-thousand-servers-bloom.html.

Both of these impacts are important: First, technology transfer between Federal agencies plays a pivotal role in the efficiency and competitiveness of the US government. Better

utilisation of technology within the US government will likely lead to better government support for technology R&D and innovation in the private sector and academia in the United States. Second, the disbursement of public research funds affects to a large degree the type of research that is being conducted in the private sector in the US today. For example, according to Dr. Ernest McDuffie, the Associate Director of the National Coordinating Office for NITRD, the NITRD programme plays an important role not only by steering funding into multidisciplinary projects, but also through the working groups and research conference that they organise. However, it is very difficult to assess whether the type of research funded today will turn out to be the "right" one in the future.

As regards technology transfer into the marketplace, the NITRD Programme may have fallen short with respect to impact. Despite some positive results, many promising ideas and technologies were not successfully transitioned into commercial products.

Two concrete examples of how these impacts have been put into practice are presented here: the "Cluster Exploration Programme" (CLuE) and the "Focus Centre Research Programme" (FCRP). CLuE represents a case of how public funding and private infrastructure can collaborate to offer a space for high level academic research. FCRP represents a project that utilises large-scale, long-term, multidisciplinary R&D addressing potentially high-payoff, but currently high-risk, challenges – which, if successful, could lead to a larger presence in the NITRD portfolio.

Example:

The Focus Centre Research Programme in the semiconductor industry

The Focus Centre Research Programme (FCRP) is a jointly funded programme by semiconductor and semiconductor supplier industries and the Department of Defence to advance semiconductor chip technologies. The FCRP supports 200 research professors and 400 graduate students at 38 universities organised into five centres. Technology transfer mechanisms include programme reviews, technical briefings at sponsor sites, workshops, and an internet presence. Industry participants assign staff to the centres for the purpose of optimising the transfer of new knowledge to companies. The FCRP facilitates the recruitment of students performing research, viewed by some as the most effective method of technology transfer.

Through R&D, the FCRP is tackling the problem of power conservation in semiconductor designs (e.g., by reducing the amount of power needed per instruction). Results flow directly into the US semiconductor industry to improve performance and enable new products that meet stringent military requirements and benefit the civilian economy.

While this is clearly a promising programme that appears to have significant scope and participation, it is difficult to directly measure the impacts that it has had within the context of technology transfer. Again, this represents an example of how and where both NITRD and US Federal agencies as a whole can seek to improve both the process and the analysis of their support for technology transfer in the ICT arena.

Sources:
NITRD website: www.nitrd.gov; President's Council of Advisors on Science and Technology Annual Assessment, August 2007 (http://www.nitrd.gov/pubs/Index.aspx)

Lessons learned

Evaluation by the Council of Advisors on Science and Technology

The NITRD programme's principal mechanism for assessment and evaluation of their overall operational performance is the President's Council of Advisors on Science and Technology (PCAST). The August 2007 assessment (with a new assessment scheduled to be conducted and published in 2010), *Leadership Under Challenge: Information Technology R&D in a Competitive World*, provides a review of the global ICT competitive environment, the domestic ICT landscape and an assessment of how well "*the NITRD programme is positioned to help sustain and strengthen US leadership in these critical technologies*". According to the PCAST's assessment, the most critical challenge for the NITRD programme in the future is to expand and improve the ways in which networking and information technology R&D is funded and conducted. This pertains not only to the Federal government but also to universities and ICT producing industries. Some critical lessons that can be learned from the NITRD's programmes and projects in the past are related to groundbreaking research and technology transfer, as described in more detail in the following.[163]

Focus on groundbreaking research

In its present state, the Federal ICT R&D portfolio is skewed towards low risk, small scale and short-term efforts. Few projects, whether large or small, can be seen as visionary or groundbreaking. Therefore, Federal agencies, as well as the NITRD programme itself, should seek to support R&D projects that operate on a large scale and have longer time horizons. Moreover, greater emphasis should be placed on innovative, and often-high risk, R&D that would have the opportunity to improve upon current paradigms or standards in the ICT arena.

Technology transfer and commercialisation

To date, the NITRD programme has not been used to its fullest potential as a conduit for ICT-related R&D to the private sector through the process of technology transfer. Historically, the bulk of the attention has been placed on coordination of ICT R&D through the various Federal agencies that are members of the programme. However, as more nations pursue an aggressive ICT public policy, the ability of the private sector to flourish in ICT-related fields may have important implications and spill-over effects on the Federal government's use of IT as both a public policy tool and a strategic resource. Therefore, to increase both the breadth and depth of communication that exists between Federal agencies and the private sector might help facilitate technology transfer to a greater degree. While regular working groups can be an effective tool to accomplish such communication, this should serve as a starting point for a more robust relationship, where leaders of industry and Federal agencies meet regularly to talk about strategic issues facing both industry and Federal agencies, rather than simply organising policy functions and projects. For technology transfer to be truly effective, public-private communication and partnerships needs to be institutionalised as a process and used as a starting point rather than a concluding point. Furthermore, clear strategic objectives should be published, with metrics for how to evaluate and analyse the success or failure of any given partnership or programme.

[163] *Leadership Under Challenge: Information Technology R&D in a Competitive World.* President's Council of Advisors on Science and Technology, August 2007. See www.nitrd.gov.

Current developments: American Recovery and Reinvestment Act

Finally, due to recent legislation and the implementation of the American Recovery and Reinvestment Act of 2009 (ARRA)[164], the funding environment in the US Federal government has changed dramatically. Specifically, member agencies to NITRD such as NSF and NIH have received rather large increases in their funding. This funding has the express purpose of stimulating the US economy, yet no concrete agenda has been laid out for its use. While new funding is rarely a negative, the rapid progression of this funding has placed great responsibility on these agencies to use it effectively. Much of this funding, particularly for the National Science Foundation, will be used for science and technology based R&D and grants for researchers throughout the country.

The impacts of this new legislation are still unclear, as they are currently unfolding. However, larger budgets and more funding will not automatically translate to success for NITRD and a greater level of ICT R&D both in the public and private sector. Therefore, it will be the responsibility of NITRD to assure that their current strategic objectives are fulfilled. This means directing new funding and R&D projects on higher risk and long-term research. It also means a greater emphasis on communication and technology transfer with the private sector, specifically IT and ICT-related industries.

References

Research for this case study was conducted by Maria Salazar, Rafael Preciado Foundation, Mexico City, Mexico, and J. Cameron Verhaal, University of Utah, US, on behalf of the Sectoral e-Business Watch. Sources and references used include desk research plus:

- Interviews with Dr. Ernest McDuffie, Associate Director of NCO/NITRD
- Websites:
  - www.nitrd.gov
  - www.nsf.org/statistics
- Information from:
  - OECD Information Technology Outlook 2009
  - President's Council of Advisors on Science and Technology Annual Assessment, August 2007

[164] A complete copy of the American Recovery and Reinvestment Act of 2009 can be downloaded from: http://www.gpo.gov.

4.1.3 South Korea's former IT839/u-IT839 strategy

Abstract

South Korea's economy depends heavily on international trade and its IT-related products account for almost one third of its total exports. In particular, the mobile telecommunication sector is a strategic trade commodity for South Korea to maintain its global market leadership for mobile telephony services and cell phone production. This study seeks to illustrate the impact of the former IT839/u-IT839 master plan, from 2004 to 2008, and its impact on the South Korean mobile telecommunications sector. Having successfully pioneered the world's first commercialisation of the Code Division Multiple Access (CDMA) mobile telecommunications services since 1996, South Korea forged ahead with the deployment of next-generation techniques that evolved from CDMA such as Wideband CDMA (W-CDMA) and Orthogonal Frequency Division Multiplexing (OFDM) technologies under the new directions of the IT839 master plan in 2004. As a result, Korea became exceptionally strong in mobile telecommunications and broadband technologies. The IT839/u-IT839 master plan contributed to the strengths of South Korea's mobile phone industry today: world class mobile communications infrastructure, leading position in business related to the CDMA mobile standard, and the presence of diverse content developers.

Case study fact sheet

■ *Organisation/programme:*	*The IT839/u-IT839 master plan, spearheaded by the then Ministry of Information and Communication under President Roh Moo-hyun's administration (political reign ended on 24 February 2009)*
■ *Geographical region:*	*South Korea*
■ *Main activity:*	*Developing South Korea's ICT and broadcasting sector*
■ *Strategic objectives*	*Enable South Korea to achieve 20,000 US dollar per capita GDP for its citizens*
■ *Year of foundation:*	*IT839 master plan first launched in 2004; in 2006 revised as "Ubiquitous-IT839" (u-IT839)*
■ *Budget*	*In 2004, the estimated overall investment cost for government and private industry was more than US$ 70 billion by 2010*
■ *Industries covered:*	*ICT and broadcasting industries*
■ *Type of ICT promoted:*	*Spearhead policies for ICT and broadcasting sectors*

Background and objectives

Characteristics of the IT839/u-IT839 master plan

According to 2008 data for nominal GDP of members of the International Monetary Fund, South Korea's economy is the 5th largest in Asia Pacific and 15th largest in the world. This is due to the rapid growth and maturity of its semiconductor, broadband internet, computer, digital electronics and mobile telecommunications industries. The then Ministry of Information and Communication (MIC), currently known as the Korea Communications Commission, under President Roh Moo-hyun (2003 – 2008) estimated that the Korean IT industry accounts for almost one-third of total national exports. Mobile technologies plays a key role to its global IT industry commercialisation success.

In 2004, the MIC launched a national ICT roadmap, coined as the “IT839 master plan” – shorthand for IT industrialisation focuses in eight services areas, three infrastructure plans, and nine hardware-related businesses. The upper part of Exhibit 1 shows the focuses of the original IT839 master plan. Two years later, an updated and renamed IT master plan - the "ubiquitous IT839" or "u-IT839", was commissioned to realise the vision of a knowledge-based economy for South Korea. The programmatic shift from the IT839 master plan to the u-IT839 master plan included the following new growth areas:

- **Services changes.** "Broadband Convergence Services" and "IT Services" were included as internet telephony had been put into commercial service, and Digital Multimedia Broadcast (DMB) and digital TV were subsequently combined.
- **Infrastructure changes.** Internet Protocol Version 6, one of the three infrastructure networks specified in the IT839, was unified under the Broadband Convergence Network (BCN) and "soft infraware[165]" was added as the new infrastructure focus.
- **Hardware-related businesses changes.** Mobile telecommunication and telematics had converged and radio frequency identification (RFID) and universal sensor networks (USN) were newly added to the next-generation growth engines.

Hence the then Roh administration sought to enhance South Korea's economic competitiveness and productivity through the aggressive promotion of the IT industry and the application of IT throughout the society as a whole. Exhibit 1 explains the IT839/u-IT839 master plans in detail.

Exhibit 4-4: The IT839 and u-IT839 master plans

Initial IT839 Master plan proposed in 2004		
8 Services ▪ Wireless Broadband (WiBro) Service ▪ Digital Multimedia Broadcasting (DMB) Service ▪ Home Network Service ▪ Telematics Service ▪ RFID-based Service ▪ W-CDMA Service ▪ Terrestrial Digital TV (DTV) ▪ Internet Telephony (VOIP)	3 Infrastructures ▪ Broadband convergence Network (BcN) ▪ Ubiquitous Sensor Network (USN) ▪ Internet Protocol Version 6 (IPv6)	9 Hardware-Related Businesses ▪ Next-Generation Mobile Communications Devices ▪ Digital TV & Broadcast Devices ▪ Home Network HW/SW ▪ IT System-on-Chip (SoC) ▪ Next Generation PC ▪ Embedded SW ▪ Digital Content, SW Solution ▪ Telematics Devices ▪ Intelligent Service Robot
Updated u-IT839 Master plan revisions in 2006		
New services changes ▪ VOIP Excluded ▪ Convergence of DMB & DTV ▪ Broadband Convergence Service added ▪ IT Service added	New infrastructure changes ▪ IPv6 included in BcN ▪ Soft Infraware added	New hardware-related businesses changes ▪ Convergence of Mobile Communications and Telematics ▪ RFID ▪ Ubiquitous Sensor Network

Source: The then South Korea’s Ministry of Information and Communications (MIC)

According to Miok Jun, IT Business Development Manager with the Korea Business Centre in Singapore for the Korea Trade-Investment Promotion Agency (KOTRA), the

[165] Soft infraware is software infrastructure that effectively realises IT convergence and creates a reliable and convenient user environment. It is composed of u-computing common platforms such as Wireless Internet Platform for Interoperability (WIPI), u-service linked platforms using webservices, SW quality guarantees, and information security. Source : Korea’s IT839 Strategy (Ministry of Information and Communications, South Korea), http://www.localret.cat/revistesinews/broadband/num19/docs/num4.pdf.

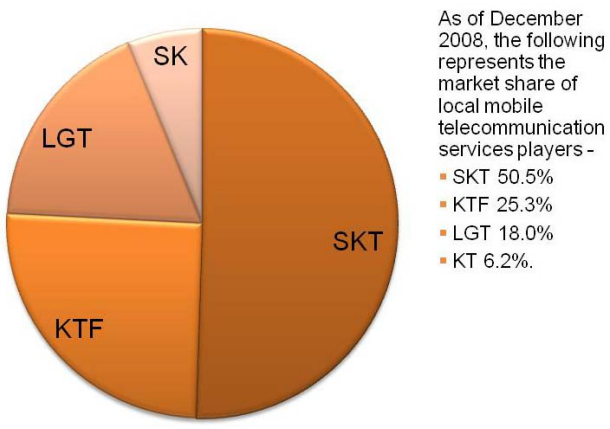
IT839/u-IT839 served as *"an influential government platform with strong economic interests in the promotion of the South Korean ICT industry such as telecommunications companies, cable television operators, IT manufacturers and software developers. In addition, it created a vision for the rapid and widespread acceptance of computing culture within the local society."*

The importance of IT839/u-IT830 for the mobile industry

Having successfully pioneered the world's first commercialisation of the Code Division Multiple Access (CDMA) mobile telecommunications services since 1996, South Korea forged ahead with the deployment of next generation techniques that evolved from CDMA such as Wideband CDMA (W-CDMA) and Orthogonal Frequency Division Multiplexing (OFDM) technologies under the new direction of the IT839 master plan in 2004. As a result, Korea became exceptionally strong in mobile telecommunications and broadband technologies.

"The strengths of South Korea's mobile phone industry can be summed up as follows: world class mobile communications infrastructure, leadership position in the CDMA business, and the presence of diverse content developers," says Miok. *"The current challenges however are found in the lack of information on foreign markets, considerably low brand awareness internationally, high dependency on key components imports, and profit drops due to high raw material costs."*

Exhibit 4-5: Market share of South Korea's mobile communication service providers



Source: IDC 2009

In the fourth quarter of 2008, IDC's Asia/Pacific Mobile Voice, Data and Multimedia Service Tracker estimated a total of 45.6 million mobile subscribers in South Korea. This amounts to a high statistical mobile services penetration rate of 93.8% of the population. Key players in South Korea's mobile telecommunication services market include SKT (SK Telecom), KTF (Korea Telecom Freetel), LGT (LG Telecom) and KT (Telecom Korea). Exhibit 2 shows the market shares for these four companies.

Replacement of the IT839/u-IT839 strategy in 2008

The then Ministry of Information and Communication (MIC) under President Roh Moo-hyun transformed the Korean IT industry through the years 2002 to 2008 with the IT839/u-IT839 master plans. However, the reputation of Roh's administration was continually plagued with allegations of incompetence and conflicts. On 25 February 2008, a political changeover ensued with a new administration under President Lee Myung-bak taking office. This brought about new administrative reforms which consequently affected certain changes towards the government's push for Korean IT.

The new government through the newly formed Ministry of Knowledge Economy came up with a new IT master plan called the "3-3-7" strategy[166]. This new strategy however still incorporated large elements from the previous IT839/u-IT839 master plan. The focus however is aimed at providing better market positioning and support for the Korean IT sector to penetrate the global market. 13 items were selected and divided into the following categories:

- **3 strategic items** - DMB, WiBro, e-government
- **3 flagship items** - semiconductors, display, wireless
- **7 potential items** - RFID/USN, robot, network, software, e-health, light-emitting diodes (LEDs), security

With the new "3-3-7" strategy, South Korea has apparently maintained certain elements of the IT839/u-IT839 master plan such as ensuring market leadership in research for broadband, mobile and wireless technologies. However, the new government has also recognised the need for increased government marketing support schemes that can help invigorate the globalisation of its ICT sector.

Activities to support ICT research, development and innovation and their impact

Embracing growth-positive development policies

The IT839/u-IT839 strategy served as a powerful economic engine that helped propel South Korea into a leading information economy that it is today.

The IT839/u-IT839 strategy outlined a holistic economic roadmap to develop both the South Korean technological infrastructure and its electronics manufacturing capabilities, with technology "growth engines" that fuelled a regenerative cycle of investments, returns, and ultimately rising national income levels. It provided guidance on how to fully exploit the country's existing academic, technical, and social resources in a focused and well-targeted manner, so as to enable its electronic industry to play a more dominant role in several critical electronics markets. It was estimated that the IT839/u-IT839 strategy would cost both government and the private sector as much as 70 billion US dollar by 2010. In 2006, with the introduction of the updated u-IT839 masterplan, the-then MIC expected South Korea's ICT and ICT-related industries to grow at an annual average of 14.2% through 2010, so as to achieve almost 500 billion US dollars in total revenues with an estimated 230 billion US dollars in production value-add across all economic sectors. These expectations of the Korean government suggest that the investments of the master plan would trigger considerable additional yields that justify the activity

Overall, the IT839/u-IT839 strategy helped align South Korea to succeed strongly in the IT industry due to the swift adoption of growth enablement policies such as investing robustly in R&D and education, creating substantial trust and reliance in the local private sector, some degree of marketing and research support internationally through the establishment of Free Technology Zones (FTZ), and creating a favourable climate for capital investment.

[166] South Korea's "3-3-7" strategy under the new President Lee Myung-bak's administration. Source : Korea Insight, http://www.koreaninsight.com/2009/03/korean-government%E2%80%99s-new-drive-for-the-it-globalization/.

There are several key components of the IT839/u-IT839 strategy that impacted strongly on the IT industry and on the mobile industry in particular, as outlined in the following.

Government's support for mobile technologies: ETRI

What distinguishes South Korea from other economies such as the US and Europe is the intense cooperation between the IT industry and the government, where the government allocates adequate resources towards the development of broadband, mobile and wireless technologies. In fact, the birthplace to several of Korea's technologies is not in the laboratories of corporate IT giants such as Samsung Electronics or mobile operator SK Telecom, but at the non-profit government-funded Electronics and Telecommunications Research Institute (ETRI). The ETRI was established in the year 1976 and located in Daeduk Valley, a high-tech region in Daejeon City, 170 kilometres south of Seoul. In 2008, ETRI had hired an approximate 3000 employees with almost two-thirds being researchers.

The ETRI's primary objective is to develop basic and core technologies which subsequently are sought to feed into new products by private companies. Over the years, the ETRI has successfully invented information technologies such as the TDX-Exchange, the high density semiconductor microchips and the TiCOM mini-super computer. Notably, it pioneered the widely used CDMA.

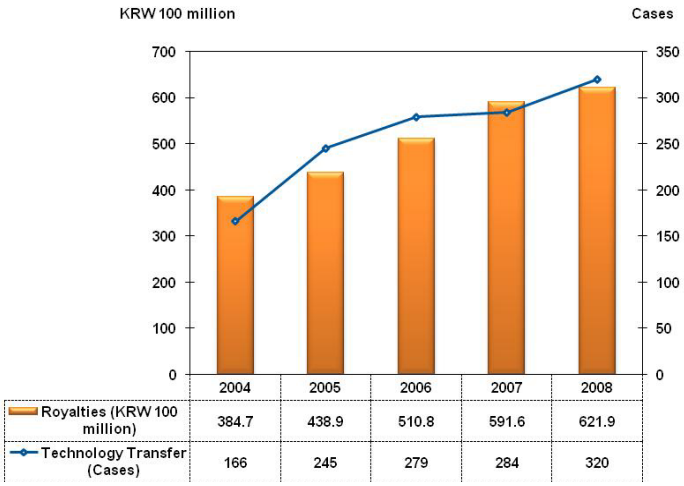
Under the IT839/u-IT839 strategy, the ETRI championed the terrestrial Digital Multimedia Broadcasting (DMB) technology that institutionalised the global "TV in my hand" phenomenon. DMB services – which enable the transfer of digital media content such as music and video clips via mobile devices like mobile phones, PDAs or portable TVs – is expected to generate an estimated 13.36 billion US dollar in revenues by 2010.

In addition, wireless broadband (WiBro) technology was introduced by the ETRI under the IT839/u-IT839 strategy for mobile internet connectivity. WiBro is a Korean-developed portable internet service that provides high-speed wireless internet connection. The service operates in the range of 2.3Ghz frequency bandwidth, and is designed to provide a 1Mbit/s internet connection to mobile devices moving at speeds up to 70 kilometres per hour.

At an e-government forum in April 2008 Dr Jeongwon Yoon, Director of the IT Policy Division in the Global Cooperation Team of the National Information Society Agency, attributed the commercial success of WiBro in Korea to the government's IT strategy and the tech-savvy culture of the Korean public. He added that the u-IT839 strategy allowed many Korean companies to penetrate the mobile market and compete against foreign rivals. Furthermore, he asserted that the Korean public is very well informed of developments in the IT industry and continually remain receptive to the adoption of new technologies. Consequently, Dr Yoon notes that this brought about a sustainable mobile sector ecosystem within Korea.

Most recently, the ETRI is spearing ahead with its New Nomadic Local Area Wireless Access (NoLA) technology, which is quoted as the 4th Generation (4G) mobile data transfer system. The South Korean government funds the ETRI – with budgets amounting to hundreds of million US dollar annually – to focus on intensive IT research. However this does not take into account the billions invested into commercial packaging of the technologies developed by the ETRI through private enterprises such Samsung Electronics, LG Electronics and SK Telecom for product research and marketing rollouts.

Exhibit 4-6: ETRI's earnings from technology royalties and cases of technology transfer 2004 - 2008



	2004	2005	2006	2007	2008
Royalties (KRW 100 million)	384.7	438.9	510.8	591.6	621.9
Technology Transfer (Cases)	166	245	279	284	320

Source: ETRI

In a five-year period from 2004 to 2008, the ETRI earned more than 254.8 billion South Korean won (200 million US dollar) in technology royalties with a total of 1,294 cases of technology transfer. Exhibit 3 shows the ETRI's total earnings from technology royalties and its cases of technology transfer.

Significant investments in education

The improvements of academic infrastructure and standards at Korean universities encouraged more students to stay at home for advanced training as compared to travelling overseas (for instance, to the US) to complete their advanced degrees. Due to extensive educational reforms from 1986 to 1999, the number of students graduating locally in South Korea with PhDs tripled. This ensured a large supply pool of creative scientists and engineers, which became a key factor in the successful execution of the IT839/u-IT839 strategy. However, according to Prof. Jin Hyung Kim, President of the Korea Information Science Society and Professor at the KAIST Computer Science Department, Korean schools of engineering began facing a reduction of enrolment at the turn of the century, not only in the conventional fields of engineering but also in high-tech areas. This was attributed to the lack of industrial relevance in curricula. The consequence may be a potentially serious decline of technology transfer to Korean IT industries. To counteract this, the then MIC, through the IT839/u-IT839 strategy, supported the reformation of the IT education system. It turned educational focuses towards providing a robust IT industry curricula and the pursuit of industry-oriented research in academia. For example, the new curriculum was jointly developed between industry experts and professors with strong funding support from the government. This resulted in better training and retention of local computing talent.

Dedicated promotion of the local mobile sector

The mobile telecommunications market, both globally and locally, was widely seen as a strategic economic opportunity for South Korea to establish leading market positions. The IT839/u-IT839 strategy recognised the following characteristics of the mobile industry: mobile technologies are relatively lightweight and thus easily to be exported at low costs; the adoption of universal standards facilitates entry of new firms; explosive global demand for mobile technologies offers large business opportunities; and the largest market, the US, was relatively open. Examples of government promotion of the local mobile sector included trade protection, incentives for private R&D, intensive government spending on R&D, creation of dedicated research institutes (beside ETRI), recruitment of foreign

expertise (e.g. recruitment of foreign scientists at the ETRI), supply of inexpensive and efficient real estate and tax breaks.

On 8 February 2006, the MIC launched an ambitious M1 Project (Mobile No. 1) in tandem with the u-IT839 strategy which had a vision to create a "100% mobile literacy, 0% mobile virus" environment for South Korea. In doing so, the MIC designated a special district that will host all existing and potential mobile technologies worldwide as a test bed for burgeoning mobile platforms – dubbed as “mobile paradise”. This “special mobile-district” was expected to be a free technology zone that will create a new environment of services through the use of mobile communication technologies.

Consequently, this project was aimed at nurturing the technological competitiveness of South Korea’s next generation mobile technology as well as standardisation activity strengthening; initiating the evolution of a whole new mobile business environment such as the establishment of the mobile content industry and mobile software field; laying the foundation to groom creative manpower for the mobile industry; and building a solid mobile industry infrastructure. “Mobile paradise” is expected to be a mobile technology test bed district which can allow constituents to leverage on the various services without an obstacle of technology and standardisation.

This is part of the government’s efforts to promote Korea as a Free Technology Zone (FTZ) so as “to enhance product competitiveness with curtailment of the development period as well as timely market entry, plus supporting innovative product development through a free test/experience environment” [167].

Promoting local entrepreneurship in the IT industry

In addition to massive research and development funding, the then MIC and its various IT institutions also promoted sustained and bold investments in the IT industry by nurturing the Korean venture capital industry. In the framework of the IT839/u-IT839, the South Korean government allocated a substantial amount of public funds into creating a domestic venture capital market for the IT industry. Prominent examples of government venture capital funds include the Small and Medium Business Fund (SMBF) which comprise of initiatives like the ”Dasan Venture” and ”Limited partnership funds”, the ”Technology Credit Guarantee Fund”, and special funds such as ”Informationalisation Promotion Fund” and the “Science and Technology fund”. In addition, the government has encouraged entrepreneurship through certain legislation such as the freedom of venture investments by banks, extending tax incentives to venture capitalists, and the creation of the Korean Securities Dealers Automated Quotations (KOSDAQ) for trading activities of high technology start-ups.

Promoting industry and adapting to behaviour in society

The national ICT strategies of South Korea are an example of policies not only adopted to promote the national ICT industry, but also adapted to the types of behaviour that are entrenched in society and not quickly changed. A good example is the business behaviour of the South Korean IT industry to accord market leadership and guidance roles to the then MIC while working closely in tandem. This intense cooperation of business and government within South Korea can be considered as key to the continuous development of cutting-edge technologies.

[167] Source: Korea IT Times, 28 February 2006, http://www.koreaittimes.com/story/2403/m1-project-make-korea-global-mobile-leader.

Lessons learned

The South Korean economy is heavily dependent on international trade, of which IT-related products account for almost one-third of total exports. Considering this high dependence on external trade and the huge potential of the IT industry, it is rational for the national government to focus development efforts on the IT industries.

The following highlights the lessons learned from the IT839/u-IT839 master plan for the successful development of the mobile industry.

- **Proactive government support is crucial:** The South Korean government plays a dominant role in influencing the country's IT industry. The proactive role of government policy in the telecommunications industry was crucial in propagating new standard platforms such as ADSL for the Internet and CDMA for mobile phones. As the policy of IT839/u-IT839 has shown, the integrated development of IT services, infrastructure, and devices creates synergies and is essential along the industry's value chain. The government also fosters business networks and develops well-equipped infrastructures to support entrepreneurship in the local IT industry. Furthermore, the government maintains close international linkages.
- **Assisting entrepreneurs and enabling them to help others:** With the presence of an increasing number of successful entrepreneurs, the South Korean government can tap into a pool of positive role models to help mentor the less experienced ones. Through support programmes and entrepreneurial educational programmes, potential inventors can be encouraged to commercialise their ideas. Many established entrepreneurs have become key players in establishing business networks among technical specialists, venture capitalists and angel investors. A noticeable obstacle that most technical specialists faced is the difficulty in launching their inventions despite inventing technologically innovative and cutting-edge products. A positive business atmosphere that shares market-related knowledge such as customer contact and access to distribution channels would in turn motivate innovative scientists and engineers to create new firms.
- **Internationalisation:** The IT839/u-IT839 strategy has encouraged entrepreneurs to build ventures based on technical innovations, however most venture firms are noted to concentrate primarily on the domestic market. This is in part due to the lack of contacts, experience and business collaborations with and in foreign markets. Thus, strategic partnerships could be encouraged to alleviate this trend. As with the current "3-7-7" IT strategy of the Ministry of Knowledge Economy under the newly-elected presidential administration, the focus is now aimed at providing better market positioning and support for the Korean IT sector to penetrate the global market even stronger.

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4.1.4 Fostering electronic value systems in the Cluster Automotive Region Stuttgart (CARS), Germany

Abstract

Cluster Initiative Automotive Stuttgart Region (German: Clusterinitiative Automotive Region Stuttgart - CARS) is an initiative of the regional economic development agency in Stuttgart, Germany, which seeks to enhance co-operation between car manufacturers and their suppliers and to foster innovation. Establishing and improving electronic linkages in the companies' value systems and addressing problems related to e-business standards are among the important objectives of the initiative. CARS includes three IT initiatives which seek to raise awareness for the benefits of e-business and which provide guidance for implementation. These three initiatives also develop new technologies for the electronic linkage of the value system. However, the prevalence of proprietary e-business standards hampers interoperability and value system enhancement within the cluster. Large manufacturers require their SME suppliers to introduce certain standards but SMEs are facing financial difficulties to fund related investments. CARS seeks to mitigate this problem by raising awareness among care manufacturers and suppliers as well as co-operating with standards adoption initiatives of the European Commission.

Case study fact sheet

■ *Full name of organisation:*	*Cluster Initiative Automotive Stuttgart Region (CARS) / Stuttgart Region Economic Development Corporation (Wirtschaftsförderung Region Stuttgart - WRS, regional economic development agency)*
■ *Location (HQ / main branches):*	*Stuttgart, Germany*
■ *Main business activity:*	*Cluster management, promoting cooperation*
■ *Year of foundation:*	*1995 (WRS),2007 (CARS)*
■ *Number of companies involved:*	*Over 700*
■ *Budget in last financial year:*	*WRS ≈ 8,000,000 € (2008)*
■ *Industries covered:*	*Automotive*
■ *Geographical region covered:*	*Stuttgart Region*
■ *Main e-business applications supported:*	*Product Development Management, ERP, CRM, Virtual Collaborative Engineering, Virtual Reality*

Background and objectives

Characteristics of the Stuttgart region's automotive cluster

The Stuttgart Region in the Southwest of Germany calls itself the birthplace of the automotive industry. This is true insofar as Carl Benz and Gottlieb Daimler, founders of the Daimler-Benz company (today Daimler AG) located in Stuttgart, invented the combustion engine at the end of the 19th century. The region is one of the most prosperous in Germany. The automotive industry and related industries take the first place in employment (≈200,000 employees) and in export sales (70% share in the region's exports). With the headquarters of Daimler, Porsche and the world's largest automotive supplier Robert Bosch, the Stuttgart region also takes a leading role in the global automotive industry. Altogether 222 companies that manufacture motor vehicles, trailers and semi-trailers as

well as their bodies, parts and accessories (NACE Rev. 2 Group 29) are located in the region. Hereof 186 have less than 250 employees, while the other 36 large enterprises contract 95% of the workforce. The region has a long tradition and ongoing importance of SMEs. Today the majority of supply system relationships are within the region.

Owing to its long automotive tradition the region has developed a specialised research infrastructure with public and private institutions. These include above all the University of Stuttgart, several Fraunhofer institutes conducting application-oriented research and Max Planck institutes conducting basic research.

Characteristics and objectives of CARS

The Stuttgart regional association (Verbandsregion Stuttgart) and its affiliated economic development agency - Stuttgart Region Economic Development corporation -, funded largely by the region's municipalities, seek to act as strategic players for networking in the region's automotive industry. Despite the region's wealth and the success of its automotive industry, the WRS sees a need for political activity. Due to globalisation effects, car manufacturers and suppliers are facing growing pressure on costs and to innovate. While one could assume that such pressure would lead to even closer cooperation in the cluster, the opposite was the case: work intensification within the companies led to reduced cooperation and communication between the companies, implying reduced knowledge spill-overs. The WRS found that this could harm the cluster's innovativeness and competitiveness. Therefore the WRS founded an initiative named "Cluster Initiative Automotive Region Stuttgart" (CARS) in March 2008 in order to foster strategic business networks in four dimensions:

- **horizontal** among automotive component suppliers and specialised services,
- **vertical** between original equipment manufacturers (OEMs), tier-one suppliers as well as suppliers and services firms of lower tiers,
- **institutional** between industry, public administration and research and
- **external** between regional and non-regional enterprises.

The initiative is managed by three WRS employees who invest a large percentage of their time in the initiative. WRS itself has around 50 employees.

The theoretical idea behind CARS is the cluster concept. It proclaims that networks promoting interaction of companies, public authorities and research organisations in a region produce knowledge spill-overs, particularly of tacit knowledge, and, as a consequence, foster innovation and economic growth. In contrast to similar initiatives, CARS has no formal members and thus does not charge a membership fee. CARS is open to all firms in the region's automotive industry and has the principal activities of fostering cooperation and location marketing:

- **Fostering cooperation** is mainly fulfilled by means of meetings and information management, e.g. conferences, key-note speeches and workshops. These activities are meant to increase face-to-face interaction, foster trustful relationships between regional actors as well as increase cooperation and innovation. The meetings, which are held two to three times a month, deal with new developments in the industry, e.g. innovative ICT solutions for production or customer relationship management. They are attended by approximately 30 to 100 participants representing the whole variety of players in the region, i.e. SMEs, larger firms, research and public authorities. In the first place companies did not see any benefits from these events. Having participated continuously, regional firms recognised the advan-

tages. However, they are still reluctant to contribute to funding and appreciate an independent organiser. Furthermore CARS acts as a broker between regional actors and specific regional and external experts for planned co-operation or investment. This is a reasonable activity for two reasons: First, most of the times actors themselves do not recognise mutual benefits if cooperating with other firms of the same branch as they often fear competition and the transfer of corporate secrets. Second, they are not well informed about possible cooperation partners inside and outside the region.

- **Location marketing**, i.e. making the region better known and attracting investors, thus drawing new knowledge into the Stuttgart region and preventing innovation insufficiencies due to knowledge shortages and lock-ins. Location marketing also takes place within the project "Bench Learning in Cluster management for the Automotive sector in European Regions" (BeLCAR), in which the regional automotive industry takes part. BeLCAR is funded by the Europe INNOVA programme of DG Enterprise and Industry.

At the time of conducting this case study, the Stuttgart region automotive cluster faced an enormous decrease in sales volume due to the economic crisis, especially at Porsche and Daimler, and a consequential supplier crisis. WRS and CARS managers consider their initiatives as important to help mitigate the crisis.

Activities to support electronic value systems

The CARS management regards e-business linkages as exceptionally important for process efficiency and fostering innovation, especially in a business environment of just-in-time production and economies of scale. However, the management of CARS recognises a lack of awareness about e-business benefits among regional automotive actors and barriers to implement e-business solutions. Many CEOs and managers are not well informed about the benefits of e-business applications or underestimate possible impacts. Thus the CARS managers inquired about and actively promoted ICT and e-business use in their face-to-face meetings which they conducted to promote CARS. Furthermore, there are three closely related ICT initiatives in the region, one for the regional automotive industry named "Cluster Initiative Automotive Stuttgart Region – IT" (CARS-IT) and two with cross-sector approaches: "Virtual Dimension Competence Center" (VDC) and "Collaborative Virtual Engineering for SMEs" (COVES).

- **CARS-IT** assists the activities that relate to the development and application of dedicated embedded software and process-oriented software applications and services for automotive sector. As regards process-oriented software, which is of special interest for electronic value systems, CARS-IT seeks to create awareness of its benefits especially among SMEs. The focus is on awareness raising about the importance of e-business relationships in general rather than on promoting particular software products. Towards this end, CARS-IT can build upon a well-developed and specialised software industry in the Stuttgart region.
- **VDC** focuses on raising awareness for and developing virtual reality (which helps in the development phase, e.g. three dimensional illustration of products being developed) and virtual collaboration products (which helps employees to virtually interact within one or between several companies, e.g. with video conference tools specified for the needs of engineers). According to the interviewees, such technologies are important for process efficiency in the automotive industry, mainly because they simplify inter-firm cooperation. VDC seeks to expose SMEs to new techniques of

virtual reality in product and production engineering, reducing complexity and providing improved virtual visualisation of products for engineers. Here VDC provides guidance for possible investments and allocates virtual reality technology premises to SMEs.

- **COVES** is a project funded by the European Commission's DG Information Society and Media running from 2006 to 2009. It seeks to enhance the idea of VDC by developing a platform for virtual collaborative engineering. Several regional and international partners from the ICT and automotive industry as well as research institutions are involved. The platform is based on an open source software architecture which allows to integrate e-business applications such as product development management (PDM), enterprise resource planning (ERP) as well as collaboration techniques such as chat, voice over internet protocol and video conferences. The interviewed cluster and COVES actors regard this as especially important for simplified communication and cooperation within and beyond the cluster and also for innovation. Simultaneously the platform acts as a "translation layer" between different ICT standards used in the connected companies. COVES contributes to external linkages of the cluster as the platform allows to quickly integrate ICT standards of external firms to standards used in the region.

COVES and VDC are not directly managed by WRS and CARS but they maintain close relationships and VDC receives funding from them.

Impacts and barriers to more intense impacts

General impacts of CARS and other ICT initiatives

According to feedback from regional enterprises, CARS initiatives contributed to productivity improvements and they eased and shortened the search for co-operation partners. According to the CARS managers, CARS and the related ICT initiatives may be very relevant for coping with the economic and automotive crisis. With regard to enhancing electronic value systems, the experts considered three issues as particularly important for further developing the automotive cluster:

- e-business standards with regard to digitally linking the value system;
- e-skills, especially practitioner skills and e-business management skills;
- ICT research and development, especially the EU's Framework Programme.

Proprietary e-business standards as a major difficulty

All three ICT initiatives as well as CARS itself reported that the major difficulty in enhancing e-business use is the prevalence of proprietary standards for hardware and software. As a WRS employee put it: *"Standards are so important, it is an evergreen. We always try, together with other regions, to communicate the issue"* to relevant authorities. The interviewees expected the European Commission to have an important role in standardisation policy. In particular they referred to software standards from basic office applications to specific e-business standards for PDM, CRM, ERP and CAD software. Standards of the most prevalent products are owned by large software enterprises.

A particular issue is the power of automobile manufacturers. Suppliers are highly dependant on using particular e-business systems for inter-firm cooperation with the large companies. If suppliers do not comply, they risk to be excluded from the procurement process if alternatives exist. Thus the pressure of investment into systems operating with

proprietary ICT standards is on suppliers. However, many SMEs face severe difficulties to fund investment into such systems and thus risk to get replaced by competitors – or they cannot become part of the value chain in the first place. There have been cases of companies that dropped out of the value chains because they did not comply with large companies' requirements. This may have adverse consequences for the car manufacturers and for the region as a whole:

- Exclusion of some SMEs from the supply system due to financial inability to invest into e-business may reduce competition among suppliers and thus reduce pressure to innovate.
- Proprietary standards may also diminish the linkage with enterprises from outside the region, while such linkages may be important for regional economies to access innovative knowledge.

e-Skills issues

The interviewees reported that e-skills are highly relevant for the CARS cluster with regard to being able to apply and manage increasingly complex and complicated hardware and software. The ICT initiatives VDC and COVES themselves need highly special e-skills. The Stuttgart region's specialised universities, training organisations and employers provide a large pool of well-educated ICT practitioners. Nevertheless, CARS-IT and VDC perceive a demand for e-business and practitioner e-skills in SMEs within the cluster. They try to play a broker role between regional training institutes and SMEs and develop own curricula for specialised e-skills.

Research and development issues

COVES' open collaboration platform integrates and translates commonly used digital standards in communication and production and therefore helps to mitigate the standards problem. A solution to that obstacle appears to be far away due to the complex business and policy issues involved. According to interviewees much more research is needed for the development of e-value systems.

Lessons learned and further initiatives

Assessing the usefulness of CARS

The interviewees consider CARS as a very useful approach to horizontally and vertically foster communication and cooperation and thus support innovation. As the initiative was founded in early 2008 it is difficult to asses more detailed outcomes yet.

Tackling the issue of proprietary standards

With regard to e-business and ICT-related industrial policy one issue has been omnipresent in the interviews: proprietary standards impeding innovation. Actors in the Stuttgart region tackle the e-business standards problem mainly with two measures:

- CARS managers articulate the topic towards the European Commission within a network of other cluster initiatives within Europe Innova. Policy making in the field of e-business standards was reported to have a long tradition, but regional actors have not seen many major improvements.
- The regional development agency WRS and CARS-IT try to raise awareness among car manufactures and suppliers about the e-business standards issue with

regard to the barriers to innovation and probable solutions. Some interviewees saw the application of open source software as the key to the problem and an alternative to providing subsidies to SMEs as they could more easily afford the often free software. By now, open-source software cannot replace sophisticated IT applications, but some interviewees reported much recent progress in this respect.

Tackling mentality differences between engineers and IT developers

Many interview partners mentioned a further issue relevant for enhancing e-value chains: mentality differences between engineers and IT developers. Due to different experiences and expert knowledge backgrounds, a broker between the different knowledge types may be needed to bring both sides together. This may help to connect different segments of the value chain.

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4.1.5 Findings from case studies for an eBSN report about e-business policies

Study background

15 case studies about policies to enhance electronic value systems were conducted for a study for the European e-Business Support Network (eBSN) published in November 2007".[168] The objective of the study was to promote the adoption of good policy practices in this field in Europe. The study compares and assesses different policy approaches in terms of their strengths and weaknesses and identifies innovative practices and lessons to learn. The study grouped policy activities into three main categories:

- Activities focusing on establishing or enhancing B2B networks;
- support activities for individual companies, typically providing grants for projects;
- actions aiming to improve the framework conditions for e-business adoption, for example by promoting agreements on e-business standards and research projects developing ICT solutions for SMEs.

While the case studies for the eBSN report had a different context, they were presented in a format similar to the one used by the e-Business Watch so that they provide valuable information that can be used for this study.

Key study findings about good policy practice

The study identified several good policy elements, of which the following are most important for this report:

- **Document project results** and assess or even measure the return-on-investment in ICT. This evidence can then be used for show-casing success stories.
- **Hold projects accountable**, in the sense that the impact of large-scale networking projects on the productivity of firms and the sector as a whole must be clearly demonstrated already in advance in order to receive grants.
- **Reinforce strengths** instead of addressing weaknesses. While many of the earlier initiatives addressed "starters" with little or no ICT experience, more recent policies exhibit a trend towards focusing on more advanced and motivated SMEs.
- **Address standards** and interoperability issues because this is of paramount importance to get SMEs digitally connected within their supply chains.
- The **participation of large enterprises** is an important success factor for supply chain oriented initiatives, as they are normally key nodes within "their" chain.
- **Neutral moderators** from third parties should coordinate working groups and other joint activities within the project because conflicts of interest cannot be avoided when many stakeholders have to agree on common processes and standards.
- Use **modular approaches** in policy design to stay flexible in longer-term initiatives.
- Consider the cross-border and **European dimension** in e-business; there are still issues to be tackled to fully establish the single market in electronic exchanges.

[168] See European Commission (2007a).

4.2 Findings from an expert survey

Method description

Objectives and concept

In June 2009, empirica conducted an expert survey about ICT innovation and adoption as a part of this report, in the following named the SeBW ICT Innovation and Adoption Survey 2009. The purpose of this survey was to validate, extend and deepen insights from literature evaluation, theoretical analyses and interviews also conducted for this report.

The survey was conceptualised as an online survey along the lines of the successful survey of e-health experts which the SeBW conducted in November 2007: invite a targeted group of experts to fill an online questionnaire with a focused set of questions that can be answered in a few minutes.

Expert selection

The largest share of experts who were invited to participate in the survey were members of the European e-Business Support Network (eBSN).[169] These experts were primarily related to national ministries of economics or industry, national competent authorities, ICT manufacturing and services enterprises, universities, research institutes, professional associations, and other organisations.

Furthermore, through numerous international projects and professional relationships, empirica has access to European and internationally renowned experts in the field of e-business, many of them in leading professional positions. This informal group is named "European Network for Information Society Research" (ENIR).[170] empirica selected the experts most suitable for questions related to ICT and e-business from this group of people in a deliberate process.

Since the selection of experts was deliberate, not random, findings presented in the following are not representative in a stochastic sense. Nevertheless the survey provides insightful opinions about ICT innovation and adoption.

Survey design

The survey took place in end-June 2009. On 23 June, empirica sent out an e-mail to invite 236 people to participate in the online survey; 192 from eBSN and 44 from ENIR. The experts covered all countries of the European Union and Switzerland. The experts were asked to fill in an online questionnaire by 30 June 2009, allowing one week to respond. Altogether 45 complete replies were received, resulting in a good response rate of 19%.

The form of an online survey was chosen because it ensured an effective procedure: resources required for set-up, conduction and data evaluation were relatively low compared to telephone interviews or paper-based surveys. Survey participants could access the survey easily over the web. The participants received an individual token to ensure that the questionnaire was being answered exactly once by each invited expert. A key design aspect of the online survey was to allow for a reasonably quick completion while ensuring insightful findings. The intended average time to fill in the questionnaire was ten minutes.

[169] See http://ec.europa.eu/enterprise/e-bsn/index_en.html.

[170] See http://www.enir.org.

Several interviewees confirmed that the questionnaire met this intention. The experts were ensured that they remain anonymous.

Survey contents

The survey included seven sets of questions:

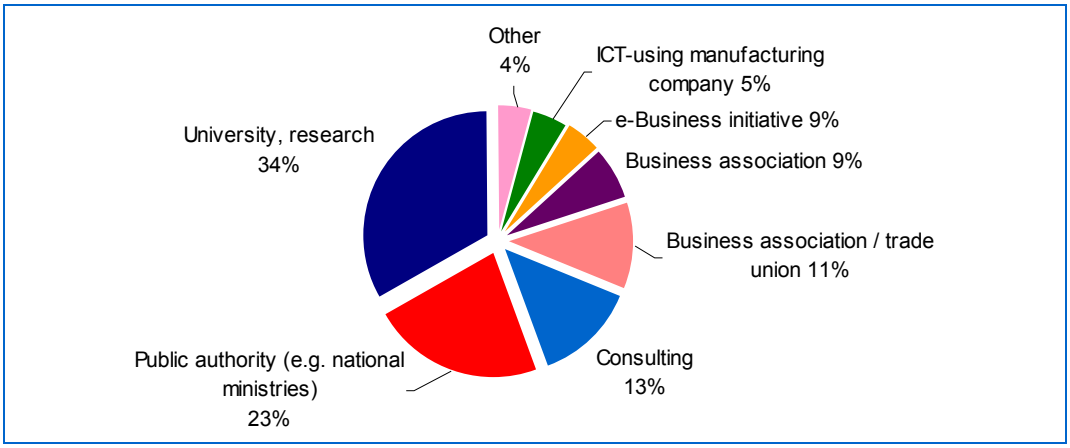
- interviewee's professional affiliation and continent – in case of Europe also country – of origin,
- current situation of ICT research, development and innovation,
- current situation of ICT and e-business diffusion,
- competitiveness of ICT-producing companies,
- competitiveness of ICT-using manufacturing companies,
- policies for ICT-producing companies,
- policies for ICT-using manufacturing companies.

The first question set was useful to learn about the participant's main professional affiliation – for example public organisation or ICT industry – and their continent or country of residence. The remaining six question sets were related to ICT innovation and adoption. At the end of each question set, the interviewees had the opportunity to provide individual comments on the topic. Many of the respondents made active use of this opportunity. The survey questionnaire is provided in Annex 1 to this report, the complete set of individual statements is provided in Annex 2.

Respondents' professional affiliation and country of origin

The respondents were asked to indicate their professional affiliation according to eight pre-defined options. If several options applied, the respondents were asked to choose the most appropriate one or the one that they feel most affiliated with. Exhibit 4-7 shows the related indications. The majority of respondents is affiliated with universities and research organisations (34%) as well as public authorities (23%). The other respondents are affiliated with consulting (13%), business associations or trade unions (11%), e-business initiatives (9%), ICT-using manufacturing companies (5%) and other organisations (4%).

Exhibit 4-7: Respondents' affiliation in ICT innovation and adoption survey 2009

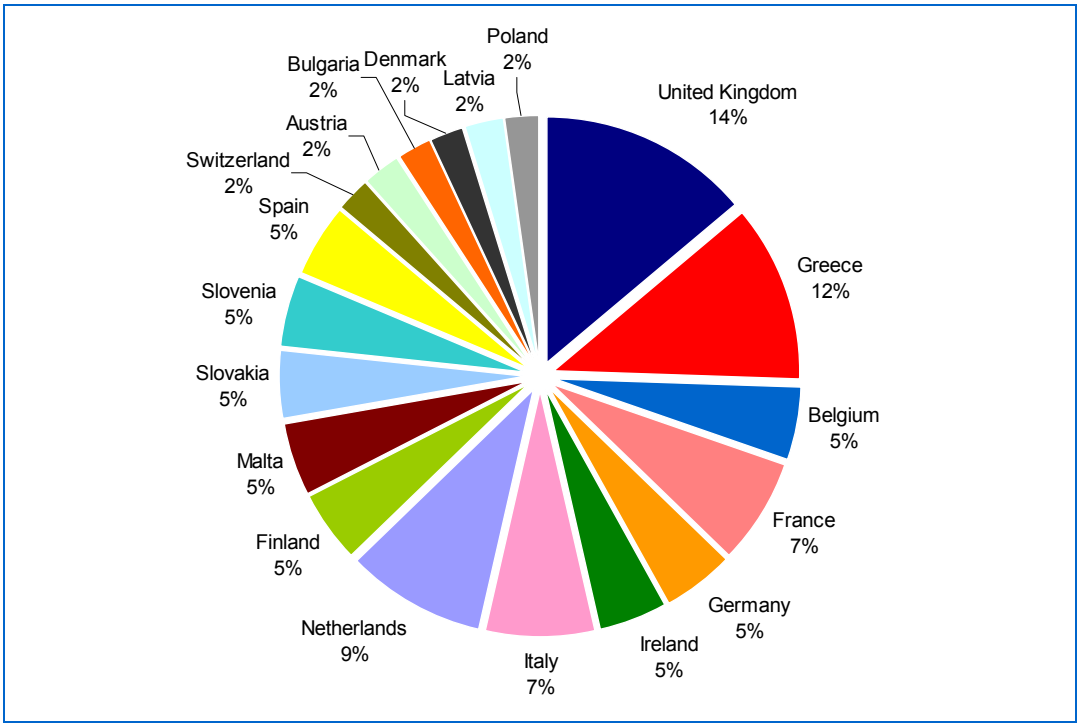


n = 45 respondents

Source: SeBW ICT Innovation and Adoption Survey 2009

Respondents from 19 European countries answered the questionnaire, among them the six largest countries: UK (14%), France (7%), Germany (5%), Italy (7%), Spain (5%) and Poland (2%). A relatively large share of respondents comes from Greece (12%). All in all the sample is fairly balanced with regard to countries of origin; no country dominates.

Exhibit 4-8: Respondents' countries of origin



n = 45 respondents

Source: SeBW ICT Innovation and Adoption Online Survey 2009

Current situation of ICT research, development and innovation

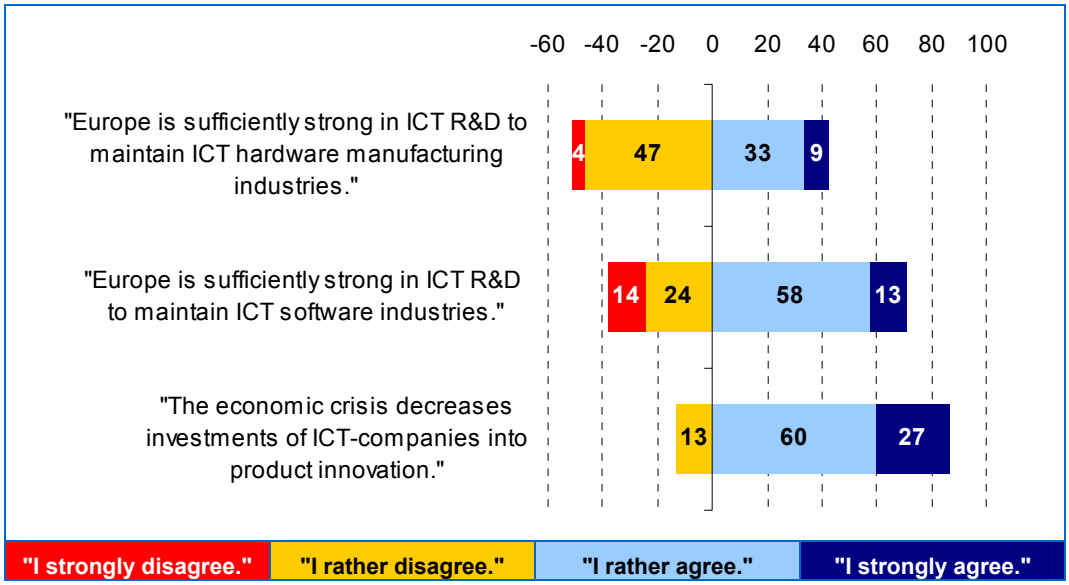
The questionnaire began with statement about Europe's strength in ICT R&D&I. The first question was whether the experts agree with the statement "Europe is sufficiently strong in ICT R&D to maintain **ICT hardware manufacturing** industries". The share of respondents disagreeing with this statement was larger than the share agreeing (see Exhibit 4-

9): 47% “I rather disagree”, 4% “I strongly disagree” versus 33% “I rather agree” and 9% “I strongly agree”. 7% did not answer this question. The larger share of pessimistic respondents may reflect the currently difficult competitive situation of the European hardware industry. When asked about **software**, the respondents were more optimistic. Two thirds of the respondents agreed that “Europe is sufficiently strong in ICT R&D to maintain ICT software industries” (58% “I rather agree”, 13% “I strongly agree”). Only a minority disagreed (24% “I rather disagree”, 4% “I strongly disagree”). Among the individual statements there was one that “*the future of Europe lies in software and services*”. This reflects the common view that European software production is more competitive than hardware production (see section 2.3).

There was even stronger agreement that the economic crisis decreases investment of ICT-producing companies into product innovation: 60% rather agreed, 27% agreed strongly, and only 13% rather disagreed. This indicates that there is widespread fear that the European ICT-producing industries may loose ground to competitors in the economic crisis.

One of the respondents stated that one should “make a distinction between R&D and innovation. They are not necessarily linked!” This view is also expressed in the Commission’s Communication on key enabling technologies of September 2009: “*the EU has very good research and development capacities in some key enabling technology areas; however it is not as successful in commercialising research results through manufactured goods and services*”.[171] Another respondent said that “*research, innovation etc. is not what will sustain ICT manufacturing industries in Europe. Low cost economies surely will be the driver for locating these firms*”. Two other respondents pointed to a lack of venture capital.

Exhibit 4-9: Experts’ assessment of the situation in European ICT R&D&I in 2009



n = 45 respondents. Figures do not necessarily add up to 100% because answers of “no response” are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009

[171] European Commission (2009c), p. 3.

Current situation of ICT and e-business diffusion

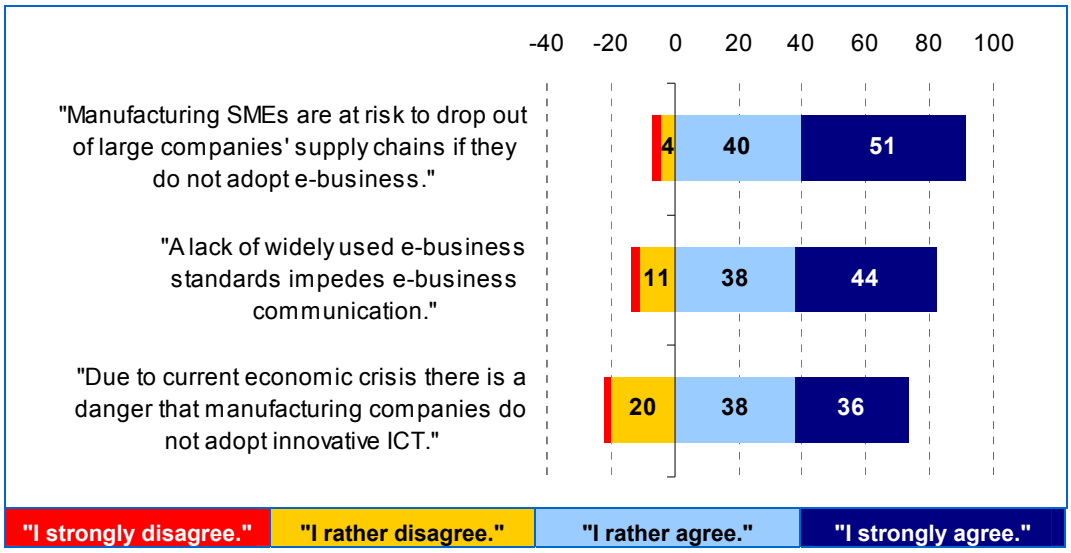
The majority of respondents agreed with the three statements related to ICT and e-business adoption in manufacturing companies – see Exhibit 4-10:

- 40% agreed somewhat and 51% agreed strongly to the statement that “manufacturing SMEs are at risk to drop out of large companies’ supply chains if they do not adopt e-business”.
- 38% rather agreed and 44% agreed strongly that there is a “lack of widely used e-business standards that impedes e-business communication”. One expert stated that "standards alone will not solve the problems”, there is a need for “*better mapping between standards in use, good stories on implementations (not just case studies) and other actions to increase willingness to risk new approaches.*"
- 38% rather agreed and 36% agreed strongly that “due to the current economic crisis there is a danger that manufacturing companies do not adopt innovative ICT”.

For all questions there was a minority of respondents who not agreed.

One of the experts said that "*e-business and e-business standards are not the main barriers to growth in this sector*". This statement reminds that ICT and e-business may be of minor importance for companies’ and industries’ competitiveness, other aspects such as production technology may be crucial.

Exhibit 4-10: Assessment of current situation of ICT and e-business diffusion (in %)



n = 45 respondents. Figures do not necessarily add up to 100% because answers of “no response” are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009

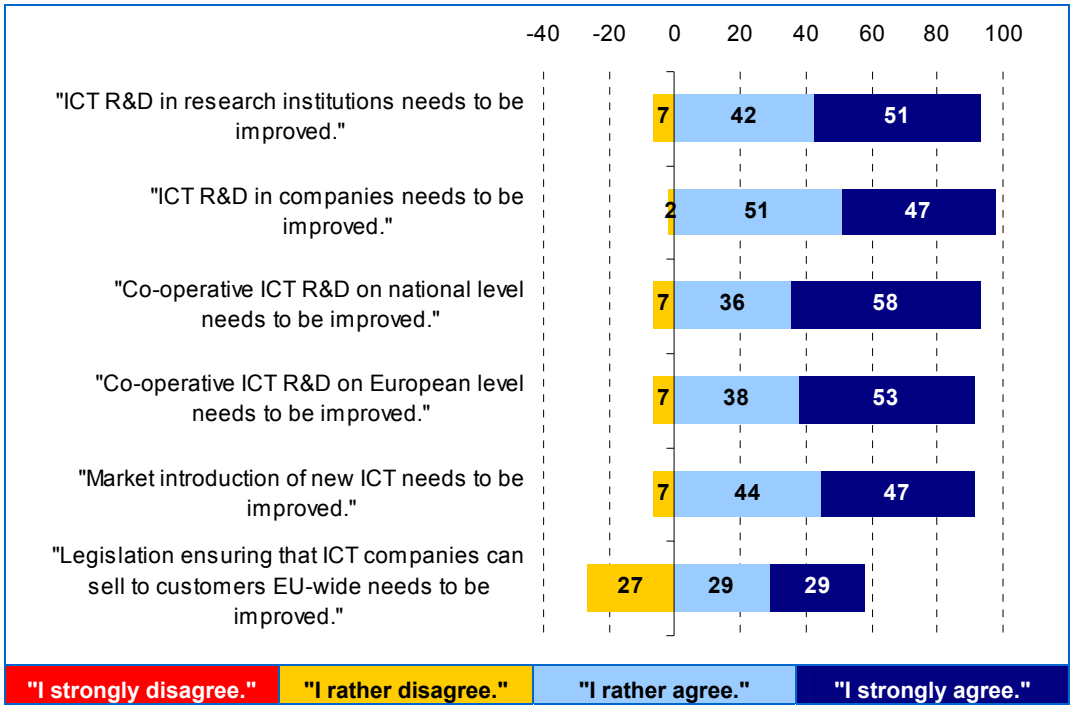
Competitiveness of ICT-producing companies

There was almost unequivocal agreement among the survey respondents that ICT R&D and innovation in Europe needs to be improved – see Exhibit 4-11. The agreement was strongest for the statement that "ICT R&D in companies needs to be improved": 51% of the respondents agreed somewhat and 47% agreed strongly; no one disagreed. The experts also see a need for improvement of ICT R&D in research institutions, of co-operative R&D on national and European levels and of market introduction of new ICT. For all these items, more than 90% of the respondents agreed strongly or somewhat.

The lowest level of agreement was for the statement that "legislation ensuring that ICT companies can sell to customers EU-wide needs to be improved" (29% each for "I strongly agree" and "I rather agree"; 27% rather disagreed). For this statement, the share of respondents providing no answer (16%) was the second highest in the whole survey. Possibly the importance of the single market for the ICT companies' ability to sell their products is less well understood than the importance of ICT research, development and innovation.

Two individual statements pointed out the need for co-operation on a European level: "*Europe cannot overcome USA, Japan and China competition without a united approach*" and "*Framework [Programme] 7 is a major opportunity*". Another expert pointed to the marketing aspect of innovation: "*Good products generate customer demand. R&D organisations should set more challenging and impact-full goals and engage stronger multi-disciplinary teams beyond technology/engineering/science expertise alone.*"

Exhibit 4-11: Assessment of competitiveness of ICT-producing companies



n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009

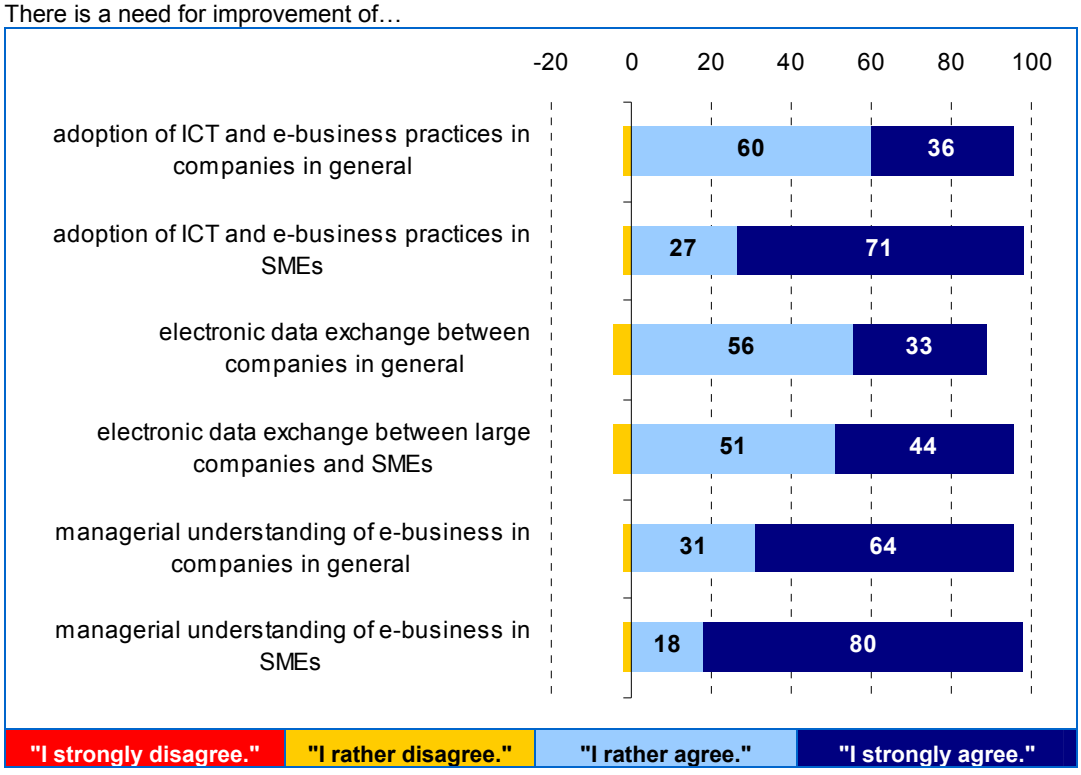
Competitiveness of ICT-using manufacturing companies

There was very high agreement with the statements about improvement needs related to e-business adoption in ICT-using manufacturing companies in Europe: more than 85% agreement for any statement (Exhibit 4-12). One may expect this considering the purpose of the eBSN and the mind set of its members. One expert stated that it is "*difficult to disagree with any of the previous statements which are somewhat self-evident*". However, these unequivocal assessments may be useful for decision makers who have to decide about issues related to ICT and e-business adoption without being experts in the field.

In any case it is useful to look closer how the shares of answers of strong agreement and some agreement are split. The highest levels of strong agreement were indicated for a need for improvement of "managerial understanding of e-business in SMEs" (80%) and "adoption of ICT and e-business practices in SMEs" (71%). Apparently the experts believe that these are the most important issues in which SMEs need to catch up, while the improvement of "electronic data exchange between large companies and SMEs" is a little less urgent (44% "agree strongly"). On the other hand, the levels of strong agreement were much smaller for "electronic data exchange between companies in general" (33%) and "adoption of ICT and e-business practices in companies in general" (18%).

Exhibit 4-12: Assessment of competitiveness of ICT-using manufacturing companies

There is a need for improvement of…



n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

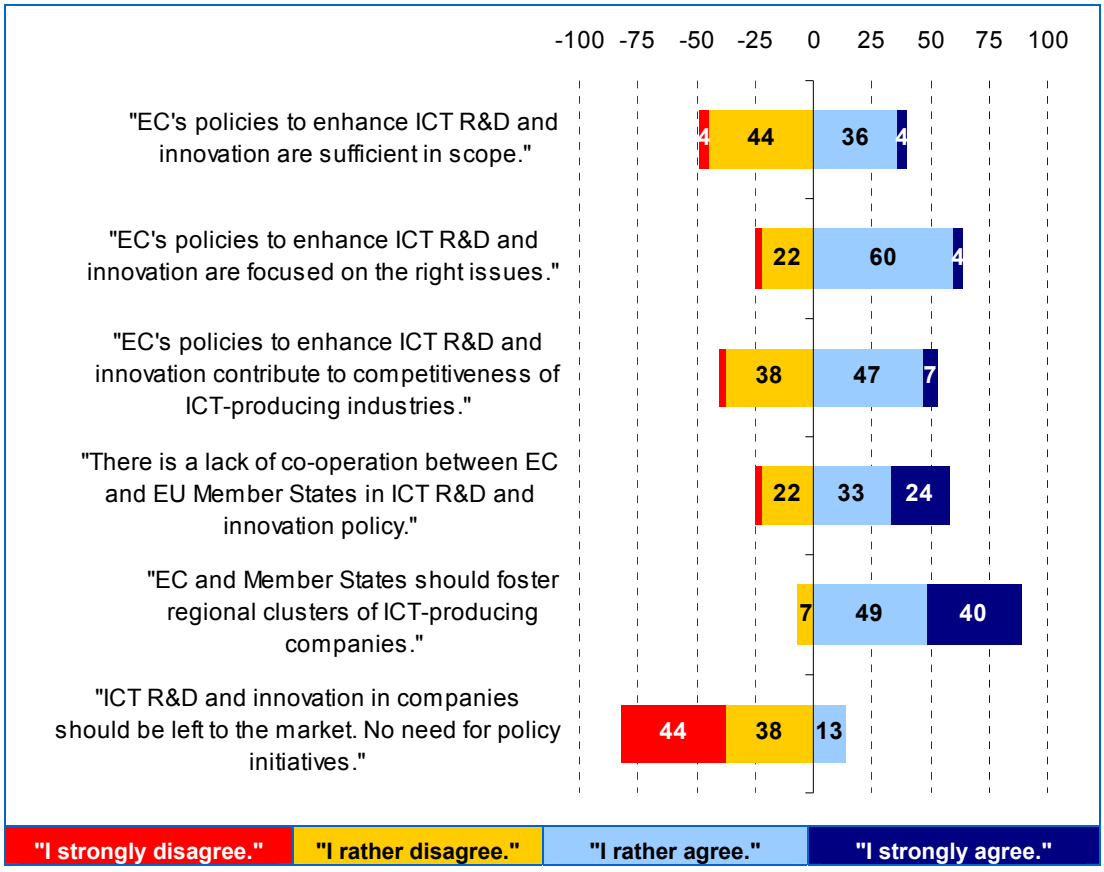
Source: SeBW ICT Innovation and Adoption Survey 2009

Policies for ICT-producing companies

Six questions were asked about policies to support ICT-producing companies. The picture was mixed, as shown in Exhibit 4-13. Asked whether "the European Commission's policies to enhance ICT R&D innovation are **sufficient in scope**", the majority disagreed (4% strongly and 44% rather disagreed). A slightly smaller share of 40% agreed to this statement (4% strongly and 36% somewhat). Thus, considering that ICT R&D&I investment in the EU is behind the US and Japan, there may be slight encouragement that the European Commission should extend its ICT R&D&I efforts.

There was agreement for the statement that "the European Commission's policies to enhance ICT R&D and innovation are **focused on the right issues**": 60% rather agreed strongly and 4% agreed strongly, while 22% rather disagreed and 2% disagreed strongly. Thus, according to the majority of respondents, there is no need for the EC to realign the focus of ICT R&D&I support. However, there was an extended individual statement indicating downsides of the EC's R&D&I policies: *"By their fruits shall you know them. EU policies are not working as intended. Projects do not have sufficient impact on real products, there is little building on existing knowledge research, there are also strong nationalistic determinants in ensuring local benefits rather than pan-European community wide benefits; a way through this could be to encourage regional-based community clusters. Policy initiatives are essential, but they must be effective and structured in a way to ensure the best from the community of interest."*

Exhibit 4-13: Assessment of policies for ICT-producing companies (in %)



n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009

Contribution to competitiveness: Slightly more than half of the respondents also believe that the EC's policies to enhance ICT R&D and innovation contribute to the competitiveness of ICT-producing industries (44% rather agree, 7% agree strongly). However, there was a considerable share of respondents who believe that this is actually not the case (35% rather disagreed, 2% strongly disagreed). One expert stated that *"the word decisively is crucial in explaining my answer. Has contributed but not decisively.*" Another expert stated: "*Regarding competitiveness of ICT industry, the knowledge transfer or exploitation of research results should be more supported (although the best solution is research on demand). Possibly, each project should have WP for exploitation and transfer and employ some specialist for ideas selling."* Knowledge transfer is also a key issue of concern in the European Commission's Communication on key enabling technologies.[172]

The majority of respondents agreed with the statement that "there is a lack of **co-operation between the EC and EU Member States** in ICT R&D and innovation policy" (33% "I rather agree", 24% "I strongly agree"). However, there was also a large share of respondents who gave no answer (18%), in fact the largest share in the whole survey, which indicates that this is a difficult question.

The clearest majority was found for the statement that "EC and Member States should foster **regional clusters** of ICT-producing companies": 49% rather agreed, 40% agreed strongly, and only 7% rather disagreed. In turn, one may conclude that there is apparently widespread comprehension that the ICT R&D&I landscape in the EU is too fragmented, as the European Commission points out in its recent Communications on key enabling technologies[173] and on ICT R&D&I[174]. One of the respondents commented on the type of clustering: *"Be careful: we do not need to support 'one way' to do somewhat: for example ICT clusters; we need to focus the adoption of standards for e-business through all the different types of actors and solutions (ERPs, ASP services, ...)*".

Reflecting the previous answers that indicated more or less appreciation of the European Commission's policies, there was clear disagreement with the statement that "ICT R&D and innovation in companies should be left to the market; there is no need for policy initiatives". 44% disagreed strongly, 38% rather disagreed, only 13% rather agreed.

Policies for ICT-using manufacturing companies

The last set of questions was about policies for ICT and e-business adoption in ICT-using manufacturing companies. Similarly to policies for ICT-producing companies, the answers were quite differentiated – see Exhibit 4-14.

Two thirds of the respondents (65%) disagreed with the statement that "the European Commission's policies to enhance ICT and e-business adoption in companies are sufficient in **scope**". 9% disagreed strongly, 56% rather disagreed. A minority of 27% agreed somewhat. The level of disagreement was higher than for the similar question for ICT-producing industries. This may reflect that the eBSN members among the respondents see a particular need for extending policies in their field of expertise. However, extending the scope of e-business policies should not neglect quality, as one expert pointed out: "*The European Community needs to be able to better facilitate more integrated economic R&D and the application of interim and final results across communities of interest. Re-*

[172] European Commission (2009c), pp. 7-8.

[173] See European Commission (2009c).

[174] See European Commission (2009a).

look at mechanisms to review projects and terminate ones that are not delivering as expected and agreed. Use the money saved on more important and effective programs."

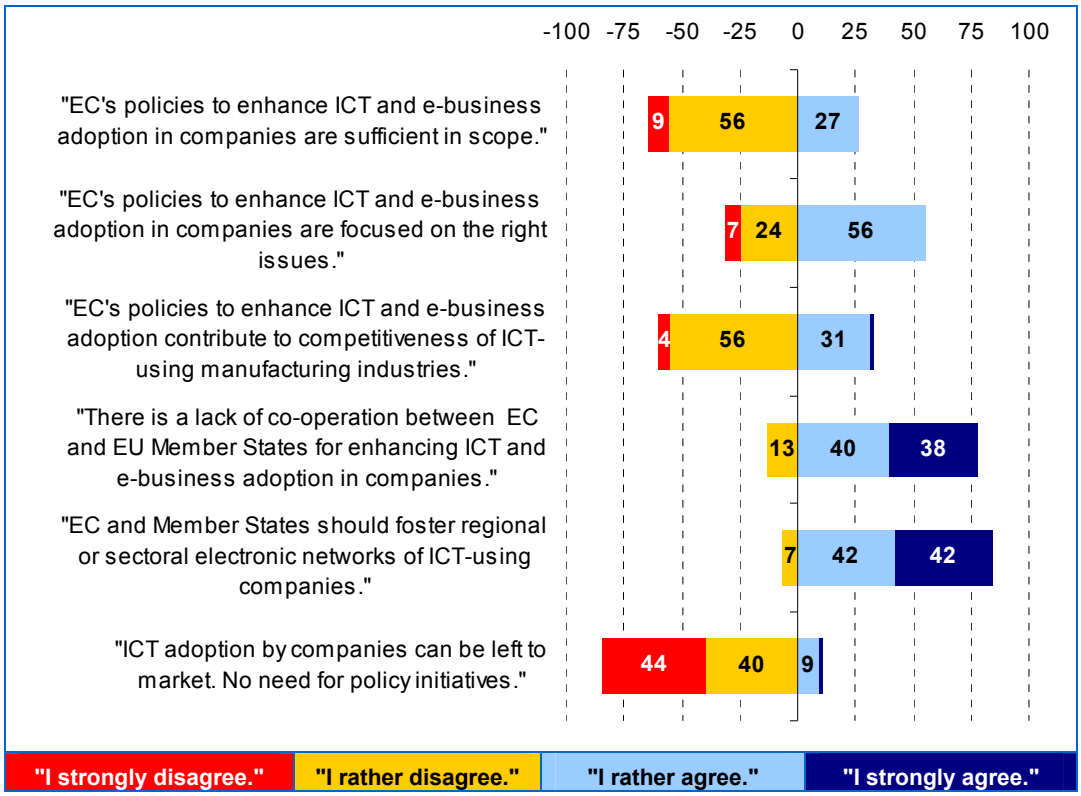
There was similarly high disagreement with the statement that "the EC's policies to enhance ICT and e-business adoption contribute to the **competitiveness** of ICT-using manufacturing industries" (51% "I rather disagree", 5% "I strongly disagree"). This may have several reasons. It may refer to the assessment that the EC's policies are not sufficient in scope, or it may indicate that e-business adoption is not crucial for the competitiveness of manufacturing industries.

There was also large disagreement with the statement that "ICT adoption by companies can be left to the market; there is **no need for policy initiatives**". 81% of the respondents disagreed with this; 44% strongly and 37% rather disagreed. Only 9% agreed. One of the respondents stated "*I strongly disagree especially with regard to SMEs*".

On the other hand, more than half of the respondents (56%) rather agreed to the statement that the "EC's policies to enhance ICT and e-business adoption in companies are **focused on the right issues**". This can be taken as a confirmation of the focus on electronic value system enhancement, e-business standards adoption and e-skills development. As regards standards, one respondent pointed to shortcomings on the part of the European Commission: "*EC activities partially fail in standard promotion, nevertheless something new is appearing recently in the right direction (DG enterprise and sectoral standardisation and harmonisation).*"

Taken together, the answers to these four questions confirm the EC's e-business policies but encourage the EC to do more of the right things.

Exhibit 4-14: Assessment of policies for ICT-using manufacturing companies (in %)



n = 45 respondents. Figures do not necessarily add up to 100% because answers of "no response" are included but not shown.

Source: SeBW ICT Innovation and Adoption Survey 2009

The respondents would also appreciate more **co-operation between the EC and the Member States** for enhancing ICT and e-business adoption in companies. Almost four fifths (78%) agreed that there is "a lack of co-operation between EC and EU Member States for enhancing ICT and e-business adoption in companies" (40% somewhat and 38% strong agreement). An even higher share of respondents (84%) agreed that "EC and Member States should foster **regional or sectoral electronic networks** of ICT-using companies." This is in line with the current eBSN focus to foster electronic data exchange between companies.

Summary of key findings of the online expert survey

Overall, the findings from the expert survey confirm that ICT research, development and innovation as well as e-business adoption in European industries need to be improved in order to enhance the competitiveness of companies and industries. The respondents see a clear need for public policy to support ICT R&D&I in ICT-producing companies as well as to support e-business adoption in ICT-using manufacturing companies. In fact, the majority of respondents expressed the opinion that the European Commission is focusing on the right issues but the scope of their policies is insufficient. The respondents see a particularly high need to support ICT R&D in hardware producing industries and to support e-business adoption in SMEs.

However, findings of the survey indicate shortcomings of policy design. In particular, the findings also suggest that there is a need for closer co-operation between the European Commission and the Member States in related policies and for clustering activities.

Finally, the importance of the single market for the ICT companies' ability to sell their products is possibly less well understood than the importance of ICT research, development and innovation.

Findings from additional expert interviews

Focused interviews about policies to foster ICT innovation and adoption were conducted with five experts from different professional backgrounds – see references at the end of this report. The interviews were conducted in order to gain additional views about and insights into ICT-related industrial policies of the European Commission. Experts from third-party organisations as well as the European Commission itself were interviewed. The experts represent the following backgrounds:

- Digitaleurope as the largest business association representing the European ICT industry.
- The OECD as an international organisation with sound expertise in the observation of ICT and ICT policy developments.
- The unit for development of industrial policy in the European Commission's DG Enterprise and industry.
- The European e-Business Support Network as a major activity of DG Enterprise and Industry to support e-business adoption to foster electronic value systems within industry.
- The European Commission's unit for the Lisbon strategy and the i2010 programme as the European Commission's overarching activity to foster ICT and e-business innovation and adoption.

The interviews were conducted face to face in order to ensure sufficient depth of the statements. The interviews took approximately one hour on average. In order to ensure sufficient openness, the interviews were not recorded electronically and the interviewees were ensured that their statements will be presented anonymously in the report. The interviews were conducted along a semi-structured questionnaire (see Annex 2 of this report). All interviews were conducted by Stefan Lilischkis, study leader.

The most relevant findings from the expert interviews are included in this report at appropriate places.

4.3 Summary of empirical findings

Findings from case studies (section 4.1), an expert survey (4.2) and additional expert interviews conducted for this report revealed several insights that complement and substantiate elaborations in the descriptive chapter (chapter 2) and the theoretical analysis (chapter 3) of this report. Key findings include the following:

Two **case studies** conducted for this report describe activities to improve ICT R&D and innovation in major competing countries of the EU:

- The case study about the US Networking and Information Technology Research and Development (**NITRD**) programme shows a need for coordination of dispersed Federal activities to promote ICT R&D and innovation. In particular, it sheds light on the need to promote technology transfer not only from public organisations to the market, but also among public research organisations themselves. Furthermore, the NITRD case study shows that successful technology transfer does not go without saying in the US.
- The case study about the **Korean IT839/u-IT839 master plans** illustrate a massive public support to ICT R&D and innovation in this country, close intertwinement of public and private activities as well as support by a technology-friendly culture in the population. The master plans appear like a concerted activity targeting not only R&D – especially in a large-scale publicly funded R&D facility – but also venture capital and the educational system.

A further case study about the initiative "**Cluster Automotive Region Stuttgart** (CARS)" in Germany illustrates the practical importance of e-business adoption in order to remain part of the supply chains to large automotive manufacturers. It also highlights that the prevalence of proprietary e-business standards can be an important barrier to enhancing e-value systems.

In a European expert survey in June and July 2009, 45 respondents from the e-Business Support Network and empirica's European Network for Information Society Research assessed the situation of European ICT-producing and ICT-using industries and ICT-related industrial policies of the European Commission:

- The respondents expressed a clear need for public policy to support ICT R&D&I in ICT-producing companies as well as to support e-business adoption in ICT-using manufacturing companies. Related policies of the European Commission were assessed as **focusing on the right issues but having insufficient scope**. The respondents expressed a particularly high need to support ICT R&D in hardware producing industries and to support e-business adoption in SMEs.

- However, findings of the survey indicate **shortcomings of policy design**, such as individual statements pointing to little impact of projects on real products and nationalistic determinants ensuring local rather than European benefits. In particular, the findings suggest that there is a need for closer co-operation between the European Commission and the Member States in related policies and for clustering activities: the majority of the respondents were in favour of more such cooperation with regard to policies for ICT-producing companies and for e-business adoption in companies.

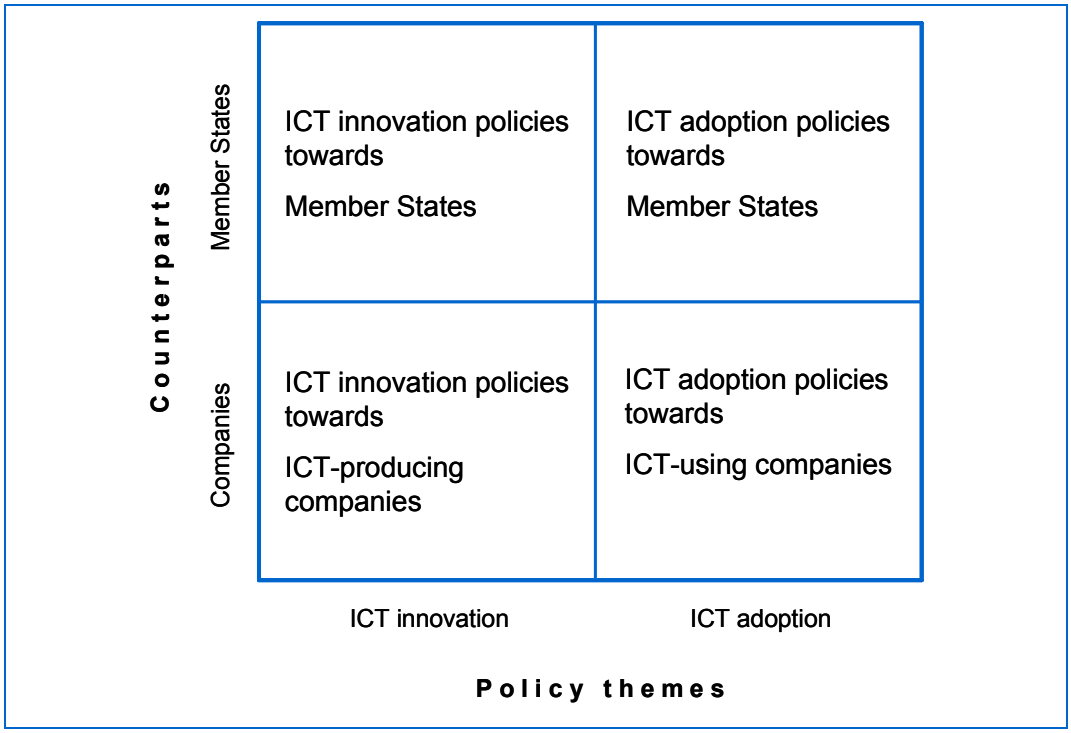
5 Policy implications

5.1 A concept for ICT-related industrial policies of the EC

A proposed matrix for ICT-related industrial policies of the EC

One of the objectives of this report is to contribute to a concept for developing more refined ICT-related industrial policies of the European Commission. Such a concept can draw from the theoretical analysis in chapter 3 and the empirical findings in chapter 4. The following concept distinguishes between policy themes and counterparts. The two principal themes are policies for ICT product innovation and policies for e-business adoption. The two principal counterparts – or target groups – are companies and Member States. Taking these themes and target groups together leads to a matrix with four distinct fields of ICT-related industrial policy of the EC, as depicted in Exhibit 5-1.

Exhibit 5-1: Matrix of ICT-related industrial policy of the European Commission



Source: empirica

This matrix may be considered as a starting point for further, more complex breakdowns of themes and target groups, depending on the specific objectives of policy makes. For example, ICT-producing companies can be broken down into hardware and software producing companies; Member States can be broken down into regions or subdivided into groups of countries with diverging interests.

In the following paragraphs of section 5.1, the rationale behind this distinction is explained. Section 5.2 then elaborates on specific policies in these four fields. They are largely based on theoretical considerations in chapter 3, supplemented by empirical findings from chapter 4. Section 5.3 points out further, more general policy implications that emerged from the analysis for this report.

Policy themes: ICT innovation and e-business adoption

The analysis in this study found that it is meaningful to distinguish between two types of ICT-related industrial policies: policies for ICT product innovation and policies for ICT and e-business adoption (see section 2.1). Both types of policies can be considered as two parts of the same coin. An expert survey conducted for this study suggests that Europe may need to improve both types of policies (see section 4.2). On the one hand, policies for ICT product innovation are targeted towards ICT-producing industries, i.e. industries producing hardware and software. According to an expert survey conducted for this study, R&D&I in the European hardware industry appears to be weak, threatening the sustainability of hardware manufacturing in Europe, while software production was assessed to be less endangered (section 4.2). A recent Communication from the European Commission about key enabling technologies points out the importance of innovation policy for the competitiveness of European industries.[175]

On the other hand, policies for ICT and e-business adoption are targeted towards ICT-using industries (see section 2.3 for general characteristics of such industries). A current key theme of e-business adoption is the enhancement of electronic value systems, i.e. improvement of computerised data exchange between companies. Enhancing e-value systems is much about fostering the adoption of advanced ICT which is often key enabling high technology.

Counterparts: companies and Member States

On analysing ICT-related industrial policies, this report pays special attention to the relationships between the European Commission, companies and EU Member States. Industrial policy necessarily involves companies, an in a European Union that is growing together ever closer, the EC's interaction and coordination with Member States is indispensable to design and carry out effective policies. Consequently, the concept developed here distinguishes further between the two counterparts of companies and national governments from the perspective of the European Commission. "Counterparts" does not mean "opponents" – it may well mean "team mates" considering a common objective to strengthen the European economy versus competitors in other parts of the world.

A note about assessing the implications

Two notes need to be made about the following implications. First, they are largely drawn from theoretical arguments, hence they are on a highly abstract level of argumentation. From a practitioner's point of view one may easily find that the implications do not sufficiently consider practical policy making and institutions existing in real life. One could also argue that there are competing theories which may lead to other results. Second, one may also object that the implications are on a very high level of aggregation, considering the EC, companies and Member States as fairly unified entities. This may not sufficiently consider the complexity of interaction between the EC, Member States and companies and the diverging interests of different companies and Member States. These objections are correct. However, the following implications may nevertheless provide insights and guidance in that they are valuable "food for thought" or a "rubbing surface" for current policy practice. The implications are not meant as concrete recommendations but as an invitation to question existing practices and to consider counter-intuitive arguments.

[175] See European Commission (2009c).

5.2 Implications by policy fields

5.2.1 European Commission ICT innovation policies towards companies

Appropriability as an argument for public support of companies' R&D&I

ICT research, development and innovation (R&D&I) raises a general problem of appropriability (section 3.3.3): It is difficult for companies to appropriate the returns from the creation of new knowledge due to external effects. Creating and using knowledge may imply that others learn about and use it, too, but do not pay anything to the one who generated the knowledge. ICT product innovation implies the creation of new knowledge. This implies that the firms' incentives to innovate may tend to be inefficiently low from a societal perspective – there tends to be underinvestment into R&D&I.

More specifically, there may be underinvestment into ICT R&D&I in the current economic crisis. In an expert survey conducted for this study, 87% of the experts agreed with the statement that "the economic crisis decreases investment of ICT-producing companies into product innovation" (section 4.2). The respondents also agreed unequivocally with the statement that "ICT R&D in companies needs to be improved".

Policy implication 1:

The appropriability problem is a general argument for public support of ICT R&D&I

Problems to appropriate the returns from newly generated knowledge and from product innovations imply that there is underinvestment in ICT R&D&I from a societal perspective.

Possible revision of contributions to commercialisation costs

The European Commission believes that Europe is not as successful in commercialising research results as it is in conducting R&D.[176] As regards ICT R&D&I, difficulties to capitalise on research results may be related to special features of ICT, which may include short innovation cycles and relatively small investments for R&D but relatively high investments for commercialisation (section 3.3.2 (3)). High investment requirements for commercialisation and marketing activities may imply that companies do not commercialise new ICT products because of the firms' incomplete information about potential demand (section 3.3.3). Further aspects aggravating this problem include standardisation and compatibility issues between existing and new ICT products as well as the possibly low cost of imitating innovations by competitors (section 3.3.2 (3)). It could thus be worth while for public policy makers to think about revising public funding schemes so as to increase the contribution to costs of individual commercialisation activities.

Furthermore, the characteristics of short innovation cycles, high commercialisation costs, compatibility issues and opportunities to imitate innovations favour large ICT-producing companies (section 3.3.2 (3)). Short innovation cycles imply that large firms have at least two advantages vis-à-vis small firms when R&D&I is considered: a large established customer base and reputation with regard to product quality. Furthermore, large firms offering established ICT products with large customer bases can easily leverage their market power such that they become also dominant on the markets for new and compatible components. Finally, large firms may be especially willing to imitate ICT innovations of

[176] See European Commission (2009c), p. 3.

small firms as this would allow them to offer the respective innovations without inducing fierce competition for customers.

A possible revision of funding schemes in the way described should however be designed very carefully in order to prevent windfall profits on the part of the companies and to prevent market distortions caused by favouring some technologies over others.

Policy implication 2:

Rethink percentage of public contribution to commercialisation costs

Considering high commercialisation costs and relatively low R&D costs of innovative ICT products, it could be worth while to increase the maximum percentage of public contributions to commercialisation costs of ICT-producing companies. As large firms were found to have advantages over SMEs with regard to ICT product innovation, the percentage of contributions to commercialisation costs could at least be higher for ICT-producing SMEs.

Prevent inefficient collusion between firms in R&D&I joint ventures

The SeBW ICT Innovation and Adoption Survey 2009 found that cooperative ICT R&D on national and international levels needs to be improved (section 4.2). The theoretical analysis in this report suggests that research joint ventures may lead to higher R&D&I investments when firms share information which have positive spill-over effects (section 3.3.2 (1)). However, there may also be downsides of cooperation (section 3.3.3): Asymmetric joint ventures increase the large firms' incentives to invest, lead to more intense competition vis-à-vis potential competitors and may thus prevent market entry. Large firms may also use R&D&I joint ventures with small firms to control their innovations and to try to slow down the innovation race.

Policy implication 3:

Prevent inefficient collusion – restrict scope of agreements in joint ICT R&D&I

R&D&I policies which encourage joint ventures without restricting the scope of the respective agreements may thus not only spur innovations, they can also facilitate inefficient collusion between firms. Policy makers should thus carefully consider the possible downsides of R&D&I joint ventures when enacting policies to promote them.

Prevent free-riding and self-serving behaviour in joint R&D&I programmes

Joint European R&D&I programmes, for example European Technology Platforms, constitute a specific means of fostering technological innovation in the Community. A game theory analysis of such programmes (section 3.5) suggests that the European Commission should seek ways to prevent both later joining and later leaving of companies. This means that, first, firms that did not participate in the basic research stage of a joint programme are not allowed to join the programme in later stages. Second, there need to be instruments to prevent strategic behaviour in later stages of the game: firms must not have an incentive to leave the programme and to perform their own research programmes with insights they gained in public programmes. Such self-serving behaviour will be difficult to prevent if firms anticipate high economies of scale or scope and large first-mover advantages. An indirect measure in this respect may be to prevent national governments from subsidising their national firms that participate(d) in joint European research programmes (section 3.5.3).

Policy implication 4:

Prevent later joining and leaving of companies in joint R&D&I programmes

In order to prevent free-rider behaviour in the first stage or self-serving behaviour in later stages, R&D&I programmes should prevent companies from later joining or leaving.

5.2.2 European Commission ICT innovation policies towards national governments

Coordination of national ICT R&D&I policies and grants

The European Commission sees a critical need for enhanced cooperation between the Community and the Member States in R&D&I in order to create critical mass and to prevent inefficient duplication of efforts.[177] The majority of respondents of the SeBW ICT Innovation and Adoption Survey 2009 (57%) agreed with the statement that "there is a lack of co-operation between the EC and EU Member States in ICT R&D and innovation policy". Such coordination problems may apply to dispersed R&D&I activities in any region, as the example of the US Networking and Information Technology Research and Development programme shows (section 4.1.3).

From a theoretical point of view, there is a basic argument in favour of coordinating the ICT R&D&I policies of different countries (section 3.3.4). National R&D&I grants are driven by the national governments' incentives to strengthen their domestic industries in order to foster competitive advantages and national growth. These strategic incentives can lead to an equilibrium in which the countries' grants are higher than compared to a situation in which countries coordinate their grants. Coordination of national governments' R&D&I policies and grants through the EU can help overcome inefficiencies of national grants. However, coordination in dedicated joint R&D&I programmes would have be binding – there would have to be sanction mechanisms – as national governments may have an incentive to use national grants in addition to what has been agreed internationally. One should also consider that coordination is not efficient per se because there may also be beneficial effects of competitive R&D&I (section 3.4.2, "market failure between EC and Member States").

Policy implication 5:

European Commission could coordinate national ICT R&D&I grants

Coordination of national R&D&I policies and grants through the EU can help overcome inefficiencies, but coordination in joint R&D&I programmes would have to be binding.

Balance number of countries in R&D&I joint ventures

The theoretical analysis suggests that international joint ventures tend to be more efficient the more countries participate (sections 3.3.4 and 3.5.3). With a large number of outside countries, governments of participating countries have an incentive to subsidise the joint venture since this will strengthen the competitive advantage of their domestic firms vis-à-vis the outside countries. However, facing a large number of outside countries, grants may be inefficiently high. On the other hand, potential transaction costs and free-

[177] See the Communication on Key Enabling Technologies in European Commission (2009c), section 4.3.

rider problems with respect to investments in basic R&D&I suggest that the number of participating countries should not be too high.

Policy implication 6:

Balance the number of countries in R&D&I joint ventures

With regard to spill-over effects and national grants, the efficiency of international joint ventures tends to increase with the number of countries participating but at the same time transaction costs and free-rider problems increase. Policy makers should consider this.

Prevent national programmes competing with EU programmes

In early stages of a joint R&D&I programme, i.e. in basic research, there should be explicit rules for national governments not to establish national research programmes that compete with joint European R&D&I programmes because this would be inefficient and prevent companies from participating (section 3.5.3). In later stages of the game, national governments must not have an incentive to leave the programme and to perform their own research programmes.

Policy implication 7:

Prevent Member States from establishing competing national programmes

R&D&I programmes competing with joint European R&D&I programmes in the basic research stage as well as later on would be inefficient and prevent companies from participating in the EU programme.

5.2.3 European Commission e-business adoption policies towards companies

Identifying e-business adoption barriers

While policy makers may tend to focus on the benefits of e-business applications for industries or regional economies, one needs to be aware that it may be perfectly economically rational for individual companies not to invest into e-business. The theoretical analysis in section 3.4 indicates several possible reasons for not adopting e-business:

- Firms may have an incentive to forego actual cost savings by delaying their investment in order to economise on lower prices and better technologies in the future (section 3.4.1 (1)).
- For small firms the returns from e-business investment may be smaller than the investment costs; large firms producing large quantities or interacting with many suppliers and customers are more willing to invest in process innovations (see section 3.4.1 (1)). This does not only apply to vertical markets, i.e. supplier-buyer relations, but also to horizontal markets (section 3.4.1 (2)).
- Investments contracts between ICT producers and users may be incomplete, i.e. the parties may be unable to specify the legal and economic consequences of any event that may happen after concluding the contract. ICT using companies may thus be very cautious about their ICT investments (section 3.4.1 (3)).

- Self-serving behaviour of companies in a value system may imply that the companies may not be able to coordinate their mutually related e-business investments (section 3.4.1 (4)).
- Small companies that trade only with one or a few large companies may refrain from relation-specific e-business investments because they cannot be sure about the behaviour of the large company and the benefits of the investment in the future (section 3.4.1 (4)).

Policy implication 8:

Consider companies' reasons not to invest into ICT

The first step of policy making towards e-business adoption should be a clear understanding of the barriers to e-business adoption.

Defining the level of industry specificity

A large share of respondents of the SeBW ICT Innovation and Adoption Survey 2009 (84%) agreed that "EC and Member States should foster regional or sectoral electronic networks of ICT-using companies" (section 4.2). This is in line with the current focus of the European e-Business Support Network to foster electronic data exchange between companies. From a theoretical point of view, policy makers should carefully consider market structures when designing ICT-related industrial policy, i.e. market concentration and the power of large companies versus SMEs. The theory of industrial organisation suggests a close relationship between market structure, conduct of companies and performance of companies (sections 3.2.2). Barriers related to incomplete contracts, coordination failures and asymmetric market structures may be interpreted as market failure due to imperfect competition and incomplete information (section 3.4.2). They may thus justify political activity.

Lessons in this respect can also be drawn from the eBSN study about e-business policies. The study found that "*initiatives with a sectoral focus are not successful per se*", but they "*can certainly be recommended*".[178] Advantages of a sectoral approach include, first, facilitated involvement and commitment of stakeholders such as industry associations as well as, second, the opportunity to address advanced e-business objectives. However, the study also found challenges of sectoral approaches, in particular that value systems are typically cross-sectoral – most companies trade with companies from different sectors. The eBSN study found that "*harmonisation of data exchange models across sectors will probably be one of the key ICT-related issues in the future*".[179]

Policy implication 9:

Consider market structures in policies to support electronic value systems

In particular, the policies should make an intentional decision about the level of industry specificity in activities to enhance value systems.

[178] See European Commission (2007), p. 26.

[179] See European Commission (2007), p. 26.

Small versus large companies

In the SeBW ICT Innovation and Adoption Survey 2009, 91% of the respondents agreed with the statement that "manufacturing SMEs are at risk to drop out of large companies' supply chains if they do not adopt e-business" (section 4.2). The survey also found that there is apparently a strong need to improve the adoption of e-business processes in European companies. Industrial organisation theory and game theory can help to predict whether a small firm makes a relation-specific investment vis-à-vis a large partner (section 3.4.3). The small firm knows that if it invests its larger partner may nevertheless terminate the business relationship later on despite this investment. Thus, the small firm may decide not to invest. However, if the large firm is able to credibly commit not to exploit the small firm, for example by signing long-term contracts with the small firm, the payoff of the small firm in the subgame in which it invests can be larger than in the subgame in which the firm does not invest. In market economies such decisions are left to the companies; public policy may intervene indirectly if at all. For example, political agencies such as the CARS initiative for the automobile industry in the Stuttgart region (see section 4.1.4) may support communication between large and small companies and the finding of credible commitment solutions.

Policy implication 10:

Support credible commitments of large firms versus SMEs

Policy makers should seek to support credible commitments of large firms versus small suppliers or customers when the small firms are meant to invest into relation-specific e-business solutions.

Policies to support e-business standards

In the SeBW ICT Innovation and Adoption Survey 2009, 82% of the respondents agreed that there is a "lack of widely used e-business standards that impedes e-business communication" (section 4.2). There was also almost unequivocal agreement that electronic data exchange between companies in general needs to be improved (89% agreement) and that electronic data exchange between large companies and SMEs needs to be improved (96%). Economic theory suggests that there is a potential lack of commitment among ICT-using companies for aligning adoption decisions about e-business standards and potential compensation payments (section 3.4.5). Efficient adoption decisions can not be expected. As regards policies related to e-business standards adoption, policy makers need to be aware that the ICT-using companies involved have strategic incentives to hide relevant information in order to reduce their costs of implementing a new standard or to receive direct grants. It may thus be more efficient for the state to leave standards adoption to the companies and focus on an earlier stage, namely the support of standards development in standardisation committees.

Policy implication 11:

Do not foster e-business standards adoption but standards development

Policies for standards adoption should be aware of hidden intentions of the companies involved. Public policy should rather foster institutions like standardisation committees that do not rely on direct payments.

5.2.4 European Commission e-business adoption policies towards national governments

In the SeBW ICT Innovation and Adoption Survey 2009, almost four fifths of the respondents (78%) agreed that there is "a lack of co-operation between EC and EU Member States for enhancing ICT and e-business adoption in companies" (section 4.2). From a theoretical point of view, there is a particular problem that national governments may promote specific e-business standards that are prevalent within their country (section 3.4.5). However, the large Member States with the strongest power to promote their standards may not necessarily have the best standards from a European point of view. Furthermore, if two or more different national standards compete on international markets, there are uncertainties about which standard may turn out to be most successful. Thus, companies may hesitate to invest into related ICT in order to prevent to become locked-in later on in an unsuccessful standard.

Policy implication 12:

Coordinate e-business standard adoption on EU level – prevent national standards

The European Commission should seek to coordinate the adoption of e-business standards on a European level, thereby considering related developments beyond Europe, in order to prevent competing national standards that may reduce incentives of ICT-using companies to invest into e-business systems.

5.3 Additional implications

Consequences from the assumption of economically rational behaviour

Beside the twelve implications mentioned above which are related to the European Commission's ICT innovation and adoption policy towards companies and national governments, there are further more general policy issues that emerged from the analysis for this report. Several implications follow from the assumption of economically rational behaviour, which is a basic assumptions of game theory (section 3.2.1). While it has been questioned in recent years to put rational behaviour in economic science absolute, there are still strong indications that economic rationality – i.e. a behaviour of seeking to maximise own benefits – can often reasonably be assumed in interactions. Several implications for policy formulation follow from this assumption, as described in the following: first, a need for policy evaluation, and second, results documentation as well as obligatory e-skills training and change management within publicly funded projects.

Policy evaluation

The possibility of rational behaviour of company managers and policy makers may call for adequate evaluation of publicly funded policy initiatives in order to verify whether public funds are spent in a way that public benefits are maximised. Ideally, evaluation should take place ex ante, ongoing and ex post. Ex post evaluation means that the applicants have to explain the expected benefits of a project in detail, and they have to explain why the benefits cannot be achieved without public support. This is for example a characteristic of the Prozeus initiative, an initiative to spread the use of common e-business standards in SMEs.[180] At the same time, ease of application needs to be ensured – which im-

[180] See European Commission (2007), pp. 64-82, and www.prozeus.de.

plies a trade-off. Ongoing evaluation is carried out while a project or programme is running, and ex-post evaluation assesses the outcomes after it has been concluded.

In this context it is notable that the OECD calls for improved international evaluation of ICT policy measures, mainly for two reasons. First, *"many evaluations still focus on particular policies rather than a coherent evaluation of national ICT policy as a whole"*; second, *"evaluation standards and procedures differ among countries, making international comparisons of programme outcomes, their effectiveness and the promotion of best practices difficult"*.[181] Thus, harmonisation of applied evaluation standards may help to increase benefits from publicly funded ICT R&D&I projects.

Results documentation

A further measure to ensure public returns from public funding is obligatory results documentation. The companies participating in ICT innovation and adoption projects may be obliged to document the results of their activities, and the documentation should be made publicly available. This approach has been adopted by the Prozeus initiative in Germany: "*companies receive grants only on the condition that they meticulously document the project, and that this documentation can be made available to other firms.*"[182] Thus, even if companies would have invested into ICT and e-business without public support, this approach ensures that the companies' experiences are at least used for further promotion of e-business and standards adoption – "positive external effects" in economic terms. However, there is a trade off of such documentation requirements with ease of SME's participation in public R&D&I projects. Public agencies should also ensure ease of participation in order to attract SMEs which typically have limited administrative capacity. SMEs that do not participate at all in public R&D&I projects may be considered as forgiven positive external effects.

Obligatory skills development and organisational change

A very important success factor for ICT and e-business implementation is parallel investment into employees' skills and organisational change.[183] This has been confirmed by third party studies, by previous e-Business Watch studies and also by the eBSN study about e-business policies. Therefore, ICT-related industrial policy initiatives should recognise the importance of e-skills and change management in ICT investment. From a game theory point of view, companies' readiness to engage in employee training and change management may be an indicator for the seriousness of the companies' intentions to really improve e-business practices and not merely to seek public funding. Employee training on e-skills and change management may thus be obligatory components in publicly funded e-business adoption projects. Related demands should however consider that the readiness to offer e-skills training depends on issues such as firm-specific rates of labour turnover and the share of fixed-term employees within the staff.

A possible new organisation for industrial policy advice

The analyses in this report point to high complexity of ICT-related industrial policy – whereas ICT-related industrial policy is only one part of the EC's technology policy. It may

[181] OECD (2008), p. 333.

[182] See European Commission (2007), p. 65.

[183] See the results of econometric analyses of the SeBW in 2007/8, summarised in European Commission (2008d), particularly p. 24 on "internal capacity".

thus be advisable to establish an advisory council for the European Commission's technology policy or, specifically, ICT policy. Such a council could emerge from the high-level group for key enabling technologies proposed in the European Commission's Communication on such technologies.[184] The European Policy Centre (EPC) has launched a call for a Council of Technology Advisors as summarised in the following box text.

The EPC's call for a Council of Technology Advisors

"The advent of a new European Commission provides an opportunity to consider ways of strengthening the scientific advice available to its President. This is important for a number of reasons. Firstly, it is necessary because of the magnitude of the challenges facing the EU. (…) Secondly, the emergence of new global players including China and India as technological powerhouses over the past decade has significantly changed the centres of innovation across the world. (…) Many of the existing knowledge 'pools' are away from the centre of action and focus on very technical issues. The new structure should be closely linked to the Commission President, functioning as his or her 'Council of Advisors on Science and Technology'. It should bring together scientists of exceptional calibre, similar to those in the US administration, and retain a large degree of independence (i.e. it should not be formally linked to any cabinet or Directorate-General). (…) These advisers would provide insights and intelligence on science and technological progress, and help strike the right balance in cases where the science is disputed. They could also be called on for advice on how to improve the EU's approach to science."

Source: Fandel (2009).

The case study about the Korean IT839/u-IT839 programme (section 4.1.3) substantiates this call's hint to "changed centres of innovation" in the world and a need for Europe to react. Korea has implemented a concerted action to promote ICT innovation in general and mobile technology innovation in particular and has apparently been successful with its operations on world markets.

Economic theory may contribute to policy formulation

All in all, the analyses in this report show that economic theory may have something to tell to ICT-related industrial policy designers. A theoretically-based approach to industrial policy helps to analyse political activities, to identify particular strengths and weaknesses of them and also possible directions for the future. In this way, this report may possibly contribute to a bridge between the often separate worlds of policy, consulting and academic science.

[184] See European Commission (2009c).

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Expert interviews

Andreas Tegge, SAP, Chair of Digital Economy Policy Group, Digitaleurope.

Graham Vickery, OECD (Paris), Directorate for Science, Technology and Industry; Head of the Information Economy Group in the Information, Computer and Communications Policy Division.

European Commission:

Ken Ducatel, DG Information Society and Media, Head of Unit C.1, Lisbon Strategy and i2010

Iordana Eleftheriadou, DG Enterprise and Industry, Unit D.4 ICT for Competitiveness and Innovation, project manager "economic and policy aspects of e-business", coordinator of the e-Business Support Network

Ronald Mackay, DG Enterprise and Industry, Unit B.2 Development of Industrial Policy, policy officer "industrial policy / sectoral overview"

Annex 1: Questionnaire for online expert survey

Expert survey on ICT and e-business policies to enhance industrial competitiveness

Research, development, innovation and adoption of information and communication technology (ICT) is widely assessed as crucial for the competitiveness of European industry. empirica currently investigates possible future directions of related policies. The study includes policies for companies producing ICT (hardware and software) as well as manufacturing companies using ICT.

empirica asks a selected group of leading experts in the field of ICT and e-business policy to participate in this survey. We would be very pleased if you answered the following questions to support our analysis. Filling in the questionnaire will take you approximately ten minutes. If you wish to interrupt the survey and continue later, please click the related buttons at the bottom. If you encounter any difficulties or if you have any questions, please contact stefan.lilischkis@empirica.com.

This survey is conducted within the framework of e-Business Watch, a service for the European Commission, Enterprise and Industry Directorate General. The survey is agreed with Iordana Eleftheriadou, the co-ordinator of the European e-Business Support Network (eBSN) at DG Enterprise and Industry.

For further information about this project, please visit http://www.ebusiness-watch.org. Results of the study will be made public at this website and sent personally to you on request; please see the last page of the survey.

The survey includes 32 questions.

(1) Your affiliation and origin

What type of organisation are you affiliated with? Please tick a box. If several options apply, choose the one that is most appropriate.

1.1.1	☐ Public authority (e.g. Ministry of Economics)	
1.1.2	☐ ICT company (manufacturing, software or service)	
1.1.3	☐ ICT-using manufacturing company	
1.1.4	☐ e-Business initiative	
1.1.5	☐ Business association (e.g. industry or professional association)	
1.1.6	☐ University, research	
1.1.7	☐ Consulting	
1.1.8	☐ Other (please specify):	

Please state the European country or continent of your origin:

1.2.1	☐ Europe (please select country)
1.2.2	☐ America
1.2.3	☐ Asia
1.2.4	☐ Australia / New Zealand
1.2.5	☐ Africa

(2) Current situation of ICT research, development and innovation

Please indicate your level of agreement to the following statements which are related to ICT-producing companies in Europe:

		I strongly agree	I rather agree	I rather disagree	I strongly disagree	No answer
2.1	Europe is sufficiently strong in ICT research, development and innovation to maintain ICT hardware manufacturing industries	☐	☐	☐	☐	☐
2.2	Europe is sufficiently strong in ICT research, development and innovation to maintain ICT software industries	☐	☐	☐	☐	☐
2.3	Due to the current economic crisis there is a risk that ICT-producing companies decrease their investments into product innovation and thus loose competitiveness	☐	☐	☐	☐	☐
2.4	If you like, you can comment on the current situation of ICT research, development and innovation:					

(3) Current situation of ICT and e-business diffusion

Please indicate your level of agreement to the following statements which are related to ICT-using manufacturing companies in Europe:

		I strongly agree	I rather agree	I rather disagree	I strongly disagree	No answer
3.1	Manufacturing SMEs are at risk to drop out of large companies' supply chains if they do not adopt related e-business practices	☐	☐	☐	☐	☐
3.2	There is a lack of widely used e-business standards which impedes e-business communication between manufacturing companies	☐	☐	☐	☐	☐
3.3	Due to the current economic crisis there is a danger that manufacturing companies do not adopt innovative ICT and thus loose competitiveness	☐	☐	☐	☐	☐
3.4	If you like, you can comment on the current situation of ICT and e-business adoption in European manufacturing companies:					

(4) Competitiveness of ICT-producing companies

Do the following issues in your opinion need to be improved in order to increase global competitiveness of the European ICT-producing industry?

		Yes, strong need to be improved	yes, moderate need to be improved	no need to be improved	No answer
4.1	ICT research and development (R&D) in universities and other research organisations needs to be improved	☐	☐	☐	☐
4.2	ICT R&D in companies needs to be improved	☐	☐	☐	☐
4.3	Co-operative ICT R&D on national level needs to be improved	☐	☐	☐	☐
4.4	Co-operative ICT R&D on European level needs to be improved	☐	☐	☐	☐
4.5	Market introduction of new ICT needs to be improved, for example through shortened innovation cycles in companies or improved technology transfer from public research organisation	☐	☐	☐	☐
4.6	Legislation to ensure that ICT-producing companies can sell their products to customers EU-wide needs to be improved	☐	☐	☐	☐
4.7	If you like you can comment or note other issues you consider as important:				

(5) Competitiveness of ICT-using manufacturing companies

Do the following issues in your opinion need to be improved in order to increase global competitiveness of European ICT-using manufacturing companies?

		Yes, strong need to be improved	yes, moderate need to be improved	no need to be improved	No answer
5.1	Adoption of ICT and e-business practices in companies in general needs to be improved	☐	☐	☐	☐
5.2	Adoption of ICT and e-business practices in small and medium-sized enterprises (SMEs) needs to be improved	☐	☐	☐	☐
5.3	Electronic data exchange between companies in general needs to be improved	☐	☐	☐	☐
5.4	Electronic data exchange between large companies and SMEs needs to be improved	☐	☐	☐	☐
5.5	Managerial understanding of e-business in companies in general needs to be improved	☐	☐	☐	☐
5.6	Managerial understanding of e-business in SMEs needs to be improved	☐	☐	☐	☐
5.7	If you like you can comment or note other issues you consider as important:				

(6) Policies for ICT-producing companies

Please indicate your level of agreement or disagreement to the following statements:

		I strongly agree	I rather agree	I rather disagree	I strongly disagree	I do not know
6.1	The European Commission's policies to enhance ICT research, development and innovation are sufficient in scope	☐	☐	☐	☐	☐
6.2	The European Commission's policies to enhance ICT research, development and innovation are focused on the right issues	☐	☐	☐	☐	☐
6.3	The European Commission's policies to enhance ICT research, development and innovation contribute decisively to the competitiveness of ICT-producing industries	☐	☐	☐	☐	☐
6.4	There is a lack of co-operation between the European Commission and EU Member States in ICT research, development and innovation policy	☐	☐	☐	☐	☐
6.5	The European Commission and Member States should increase efforts to foster regional clusters of ICT-producing companies	☐	☐	☐	☐	☐
6.6	ICT research, development and innovation in companies should be left to the market. There is no need for policy initiatives.	☐	☐	☐	☐	☐
6.7	If you like, you can comment on policies for ICT-producing companies:					

(7) Policies for ICT-using manufacturing companies

Please tick the box indicating your level of agreement or disagreement to the following statements related to policies for ICT-using manufacturing companies:

		I strongly agree	I rather agree	I rather disagree	I strongly disagree	I do not know
7.1	The European Commission's policies to enhance ICT and e-business adoption in companies are sufficient in scope	☐	☐	☐	☐	☐
7.2	The European Commission's policies to enhance ICT and e-business adoption in companies are focused on the right issues	☐	☐	☐	☐	☐
7.3	The European Commission's policies to enhance ICT and e-business adoption contribute decisively to the competitiveness of ICT-using manufacturing industries	☐	☐	☐	☐	☐
7.4	There is a lack of co-operation between the European Commission and EU Member States for enhancing ICT and e-business adoption in companies	☐	☐	☐	☐	☐
7.5	The European Commission and Member States should increase efforts to foster regional or sectoral electronic networks of ICT-using companies	☐	☐	☐	☐	☐
7.6	ICT adoption by companies can be left to the market. There is no need for policy initiatives to enhance adoption.	☐	☐	☐	☐	☐
7.7	If you like, you can comment on policies for ICT-using manufacturing policies:					

Final report contact information

These were all our questions. We would like to thank you very much for taking the time to fill in the questionnaire.

The final report will be made available at the e-Business Watch website (http://www.ebusiness-watch.org) towards the end of the year. You can provide your e-mail address so that we will send you the report as soon as it is published:

Annex 2: Individual statements in online expert survey

Current situation of ICT research, development and innovation
Driven by the need for immediate returns, lack of venture capital.
well done research, state level development very bad marketing low level Venture funding
a) Underdeveloped in comparison with the US b) Rather large differences between EU member states
There is a significant distinction to be made between hardware and software industries. The software industries continue to be innovative (e.g. in open source). However they suffer most (more than manufacturing) from barriers associated with the lack of a single market in services. So generally they will be taken over by US firms, alternatively small US firms will fuyklly benefit from the large US market.
I would rather make e distinction between R&D and innovation. They are not necessarily linked!
Needs to be focussed on real longer term strategic issues involving SME relevance; near term projects or closed research projects still predominate.
The future for Europe lies in software and services.
Research, Innovation etc is not what will sustain ICT Manufacturing Industries in Europe. Low cost economies surely will be the driver for locating these firms??
Current situation of ICT and e-business diffusion
Very many different standards no need We need 264 dataelement to run 80%-90% of global trade also ecustoms.
Manufacturing companies are confronted with structural global location changes, the economic crisis is likely to reinforce this.
Standards alone will not solve the problems. Need better mapping between standards in use, good stories on implementations (not just case studies) and other actions to increase willingness to risk new approaches.
e-business and e business standards are not the main barriers to growth in this sector
Competitiveness of ICT-producing companies
Europe cannot overcome USA, Japan and China competition without a united approach.
Legislation and European procurement policies
What do you mean by improved? More public grants?
Good products generate customer demand. R&D organisations should set more challenging and impact-full goals and engage stronger multi-disciplinary teams beyond technology/engineering/science expertise alone.
Framework 7 is a major opportunity
there is a lack of support in the research and adoption of 'standard aware' solutions; also awareness in poor in public decisors
Competitiveness of ICT-using manufacturing companies
I have special understanding of SME point of view
Difficult to disagree with any of the previous statements which are somewhat self-evident
Data exchange, in general, and between companies could be dangerous for market competitivity.
This is the big challenge especially for SMEs!
All must recognise that e-business is just another tool. Most importantly, this tool provides better information and knowledge that can be used to restructure business performance, understanding and relations inside companies and between parts of different companies. Increase awareness of the gap and the significance of the gap between the status quo and the potential and reality of real change enabled by good use of ICT.
Policies for ICT-producing companies
Regarding competitiveness of ICT industry, the knowledge transfer or exploitation of research results should be more supported (although the best solution is research on demand). Possibly, each project should have WP for exploitation and transfer and employ some specialist for ideas selling.
Under statement 3, the word decisively is crucial in explaining my answer. Has contributed but not decisively.
By their fruits shall you know them. EU policies are not working as intended. Projects do not have sufficient impact on real products, there is little building on existing knowledge research, there are also strong nationalistic determinants in ensuring local benefits rather than pan-European community wide benefits; a way through this could be to encourage regional-based community clusters. Policy initiatives are essential, but they must be effective and structured in a way to ensure the best from the community of interest.

I think Next Generation Broadband is a strong opportunity
Be careful: we do not need to support 'one way' to do sw: for example ICT clusters; we need to focus the adoption of standards for e-business through all the different types of actors and solutions (ERPs, ASP services, ...)
Policies for ICT-using manufacturing companies
There is no difference here with previous set of questions. I would have expected a different set of questions with respect to ICT-using and adoption industries and companies.
Answer to last question: I strongly disagree especially with regard to SMEs
The European Community needs to be able to better facilitate more integrated economic R&D and the application of interim and final results across communities of interest. Re-Look at mechanisms to review projects and terminate ones that are not delivering as expected and agreed. Use the money saved on more important and effective programs.
EC activities partially fail in standard promotion, nevertheless something new is appearing recently in the right direction (DG enterprise and sectoral standardisation and harmonisation).

Annex 3: Questionnaire for expert interviews

Interviewee:	
Interview time:	
Location:	

Industry competitiveness and importance of ICT R&D&I and adoption

- How do you assess the competitiveness of European ICT-producing industries?
- How important is R&D&I to strengthen the competitiveness of European ICT-producing industries?
- How do you assess the competitiveness of key ICT-using manufacturing industries in Europe?
- How important is ICT and e-business adoption to strengthen the competitiveness of ICT-using manufacturing industries in Europe?

Current issues to strengthen ICT R&D&I and adoption

ICT R&D&I:

- What are in your opinion the currently most important issues to strengthen ICT R&D&I in Europe?
- *If not mentioned*: How important are in your opinion the following issues?

  a) co-operative ICT R&D&I involving companies and organisations from several countries?

  b) strengthening clusters in particular ICT industries? If important: Which, where and how?

  c) a more systematic and strategic approach to ICT R&D&I in Europe?
- What role could strengthened ICT R&D&I have to overcome the economic crisis?

ICT adoption:

- What are in your opinion the currently most important issues to improve ICT and e-business up-take in European companies?
- *If not mentioned*: How important are in your opinion the following issues?

  a) enhancing SME participation in large companies' value systems?

  b) fostering the adoption of e-business standards?

  c) improving ICT skills, i.e. professional skills, user skills and e-business management skills?
- What role could enhanced ICT adoption have to overcome the economic crisis?

Policy design

- How should public policy address these issues?
- Are there particular sections of the ICT producing industry which public policy should target?
- Are there particularities of ICT R&D&I versus R&D&I of other technologies which policy makers should consider?
- Are there particular ways how ICT and e-business adoption in companies should be promoted?

Activities of the European Commission

ICT R&D&I:

- What strengths and weaknesses do ICT R&D&I policy measures of the EC currently have?
- How could the European Commission improve its related policies?
- Can the EC's ICT R&D&I policy strengthen the competitiveness of particular ICT-producing industries?

ICT and e-business adoption:

- What strengths and weaknesses do policy measures of the EC to promote e-business adoption currently have?
- How could the European Commission improve its related policies?
- Can e-business adoption policy of the EC strengthen the competitiveness of particular ICT-using industries?

Activities of Member States

ICT R&D&I:

- Do you know of particularly valuable initiatives in Member States to enhance ICT R&D&I in companies?
- What strengths and weaknesses do Member States' policy measures to promote ICT R&D&I in companies have?
- Are there particular issues in which Member States and the EC should co-operate better?

ICT and e-business adoption:

- Do you know of particularly valuable initiatives in Member States to enhance uptake and use of ICT and e-business in companies?
- What strengths and weaknesses do Member States' policy measures to promote ICT and e-business uptake in companies have?
- Are there particular issues in which Member States and the EC should co-operate better?

International view

- Do you know of particularly valuable related initiatives in countries outside Europe?