The Internationalisation of European ICT Activities

Martin Ulbrich and Geomina Turlea (Editors)

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THE INTERNATIONALISATION OF EUROPEAN ICT ACTIVITIES

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Executive summary

The production of ICT goods and services has developed into an international phenomenon and the internationalisation of ICT activities has become a major topic in policy debates and discussions. Besides the relocation of production facilities, this discussion is also about ICT firms relocating research and development activities outside their home countries.

ICT related R&D and production are currently perceived as forces enabling or even driving the current wave of internationalisation. The computer equipment industries as well as the computer service industry are generally seen as leaders in the international division of often knowledge-intensive labour. The relocation of ICT hardware production as well as ICT (enabled) services from the US and Western Europe towards Asia and Eastern Europe has recently gained momentum. Foreign direct investments, imports and exports are booming, especially in specific regions and countries like Estonia, Hungary, Poland and the Czech Republic. Moreover, as a general purpose technology, ICT also facilitates this dispersion of production. One can settle wherever it is thought to be attractive taking into account the location factors and one's own objectives.

In some respects, the use of ICT enables economic agents to be almost fully informed about their options. It comes as no surprise, then, that the geographic distribution of economic activity is determined more strongly than before by (dynamically evolving) comparative advantages between countries and firms. The modularity of production systems and the opportunities to tap into information flows allow for the division of productive activities not only at the level of final products, but also at the level of individual components of products. The uses of ICT by enterprises include interconnected systems that support this division of productive activities even at the level of individual production processes.

But not everything in this connected world is continuously in motion: path dependency still plays a role, as the evidence shows. Strong local manufacturing capabilities and local spillovers are often a crucial source of new R&D ideas in the high tech industries and, indirectly, a critical driver of local economic growth and competitiveness. Moreover, the process of economic integration is hampered by restrictions and hurdles, since current borders between countries are not negligible, even in the EU. This gives the national governments the responsibility to pursue a strategy to eradicate or maintain these borders, depending on the associated gains or losses in national (social) welfare. The speed and intensity of such processes is crucial to the competitiveness of a country.

This document summarizes the final report of a study carried out for the European Commission, DG JRC, IPTS, on the Internationalisation of European ICT activities.

Chapter 1 highlights the importance of both the production and the use of ICT for economic growth and productivity growth. The notion of ICT as a general-purpose technology is highly relevant for decision makers as it opens a new era of pervasive innovative activities with – often unforeseen – new applications and new dynamics and waves of creative

destruction. A second highly relevant observation is the expanding fragmentation of production processes due to standardization, reduced transaction and transportation costs and increased communication possibilities. Finally, this chapter shows the significance of life cycles of products and services and the relocation of certain types of activity. New knowledge intensive and profitable activities in the earlier stages of the product lifecycle are carried out in home countries whereas in later stages the products and services become more standardized, less knowledge intensive and easier subject to relocation. Main motives for internationalisation are market expansion, cost reduction and strategic considerations with respect to knowledge. From an economic point of view those production processes which are subject to economies of scale are more likely to be relocated since fixed transaction, communication and related costs are more easily recovered if scale effects are present. The combination of these characteristics makes the ICT sector and the use of ICT a highly relevant subject for policy makers.

The literature underlines three main channels of internationalisation: trade, foreign direct investment (FDI) and licensing. Chapter 3 analyses data on these three aspects: trade, FDI and international R&D activities. Evidence from trade data shows that EU's trade position with regard to *ICT goods* vis-à-vis the rest of the world shows a trade deficit whereas the EU25 shows a trade surplus in the trade of *ICT services*. Another remarkable outcome from the data analysis is that the differences in import and export prices have increased in the last decade and that the trade volumes are more pronounced. For some products, e.g. automatic data processing machines, the EU25 export price has increased as compared to the imported counterparts, whereas the exports volumes relatively decreased. On the other hand, for some products we see the opposite: the EU's relative export prices decline and relative volumes increase. The analysis of quality differences between imports and exports shows that, on average, EU25 exports more expensive and imports less expensive products and services. This reinforces the initial hypothesis that more mature products and services (and parts thereof) with lower profit margins are more likely to be relocated than new, innovative and high value added (parts of) products. Analysis of FDI data also shows a similar pattern. From the five European countries for which FDI data were available at a sectoral level we show that FDI concentrates on those sectors with a relative low R&D intensity. Moreover, inward and outward FDI seems to be in balance in most sectors except for the so-called "traditional scale" sectors where outward FDI is about three times higher as compared to inward FDI. Finally, analysis of R&D patterns shows that European ICT companies still perform most R&D activities in their home countries or in other EU countries. This does not mean, however, that there are no R&D activities relocated to Asia. What we find is that strategic R&D, of which patents issued by the European Patent Office protect the results, is still located in Europe. Overseas R&D activities focus on the markets of the target countries.

Chapter 4 presents the results of a set of 13 light and 5 in-depth case studies of international ICT companies, where we have found evidence for a geographical splitting up of functions. Concerning the place of the EU in the international division of activities within ICT companies our main conclusion is that the activities in the EU15 tend to be the relatively knowledge intensive, focussing on customisation and high quality. The functions

and activities located in Asia tend to be the more standardised and codifiable activities. New Member States take a middle position in this international division of ICT functions.

Finally, chapter 5 draws the conclusions of the study and presents policy options. The conclusions include the following key thesis:

ICT is different from other technologies in several dimensions. Technological change is very fast in ICT. Moreover, ICT is a general-purpose technology that induces innovations also in adjacent areas. Digital goods and services can be transferred at no cost and without time delays. These aspects make the ICT sector and ICT goods and services an important and crucial sector for economic growth and dynamics.

Internationalisation is a key feature of ICT. Increased standardisation and codification allow for fragmented production processes in such a way that innovation and production activities can be easily relocated. In this sense, internationalisation should be viewed as a challenge, not as a threat.

The EU has stabilised its position in ICT, and improved in some areas. Data show that the production of some products has been relocated in recent years. However, further analysis also shows that mainly less knowledge-intensive and more standardized products are relocated, whereas more knowledge-intensive and customized products and services remain in and even come to the EU.

Europe needs to continue moving up towards higher knowledge-intensity, quality, and the development of skills. Our analysis shows that the competitive advantages of European firms lie in knowledge-intensive goods and services. High value added per employee coincides with high levels of educational attainment of the labour force in ICT production. These strengths have to be fostered in order to meet competitive challenges in ICT producing industries. Moreover, the development of skills is also important to fully grasp the benefits of ICT in user sectors.

ICT is not per definition knowledge intensive. It is important to realize that, mainly due to the fast diffusion of knowledge and skills and due to short lifecycles, many ICT products become more or less standard after a short period of time. What is highly innovative today will be standard tomorrow and outdated next week.

Fostering the responsiveness of institutions and innovation systems to the dynamics of ICT is a key challenge. The ICT sector is highly dynamic with many innovations and very short lifecycles. This implies that policy and the political process should be innovative and flexible, too. ICT is not a homogenous sector in terms of standardisation and knowledge intensity. However, since ICT generally creates new opportunities for product differentiation, innovation and accelerated diffusion (both within the ICT sector itself and across the overall economy), the ongoing expansion and internationalization of the ICT sector is crucial for the EU and its member countries.

Preface

The Institute for Prospective Technology Studies (IPTS) of the Joint Research Centre of the European Union commissioned a study on "The Internationalisation of European ICT activities" to be carried out by a consortium of institutes consisting of:

- Maastricht Economic Research Institute on Innovation and Technology (UNU-MERIT; consortium leader)
- Europäisches Institut für Internationale Wirtschaftsbeziehungen (EIIW)
- ARC systems research GmbH (ARC-sys)

The project started in July 2005 and was completed in August 2006.

This report summarises the methodology and the main findings of the project. Readers who are particularly interested in the theory of internationalisation should read Chapter 2. The main quantitative findings are contained Chapter 3. Chapter 4 is of interest for people interested in company strategies, while readers with limited time should read the conclusions in Chapter 5.

The complete study will become available as: Dachs, B, HHM Meijers and PJJ Welfens (eds.), “Internationalisation of European ICT activities”, Springer, Heidelberg, New York, Tokyo, forthcoming.

The final report of the study is equally available upon request from the project coordinator: huub.meijers@merit.unimaas.nl

Valuable contributions were made by Hans Lööf, Tim Kelly, Christian Müller, and Rajneesh Narula who took part as experts in the project workshops.

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1. Introduction

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countries. This does not mean, however, that there are no R&D activities relocated to Asia. What we find is that strategic R&D, of which patents issued by the European Patent Office protect the results, is still located in Europe. Overseas R&D activities focus on the markets of the target countries.

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2. Theory and Concepts

2.1 Conceptual Issues

The expansion of information and communication technologies (ICT) is a well known aspect of OECD countries and many newly industrialized countries since the 1980s; e.g. in the US and in many EU countries like Germany ICT value-added has doubled in the 1990s and reached about 10% of GDP at the beginning of the 21st century. The ICT sector continues to be a sector with high growth rates; and it largely still is a high-technology sector (although this is starting to change) with a high technological progress rate. While the latter gives rise to the expectation of a positive long run impact on growth, it also is important to take into account specific characteristics of ICT dynamics that affect structural change and overall economic internationalization. A global economy that is increasingly digitally networked poses major challenges for the business community and policy makers. From a Community's perspective, ICT is a crucial element in a knowledge society, which in turn is important against the background of the Lisbon Agenda, which aims at raising employment and growth.

One can distinguish ICT production and the use of ICT. The literature shows clear evidence for contributions of ICT production to productivity increases and growth, respectively. It is also increasingly clear that the use of ICT, requiring prior ICT investment of the respective firms, brings high potential growth effects. This potential can be fully explored if society and individuals, respectively, invest in human capital formation.

While the ICT sector contains many different sub-sectors, there is a general observation that ICT products are strongly internationalized, e.g. computer chips, mobile phones, or ICT services (ranging from software development and IT services to call centre services). Take for instance computer chips: the design is often still located in Europe, but the mass production of chips is done in Asia. Software design and system design are located in Europe but software coding takes place in e.g. India. The services sector is, however, both a new opportunity field and a new challenge for Europe. The European Commission in its 2005 Annual Report has emphasized that modern ICT allows not only creating faster digital networks but that it also represents new options for international outsourcing, including services; part of services represent well-paid jobs. Extra-EU outsourcing could cost jobs in the Community. At the same time one should emphasize that insourcing is also a relevant phenomenon; e.g. many firms in Asia have outsourced knowledge-intensive elements of the value-added chain to the EU where firms in many countries are well positioned in the relevant fields. Measuring relative sectoral export positions one may thus expect that EU countries improve their so-called revealed comparative advantage in ICT services, a trend that is clearly visible in the data.

The pervasive (general-purpose) nature of ICT affects productivity growth and structural change in all sectors – hence ICT is of broad economic significance. ICT expansion can be expected to accelerate structural change, but also to stimulate trade and foreign

direct investment. It will not only affect broad sectors but so-called “fragmentation-crucial subsectors” in particular. Fragmentation means that a product is internationally sliced up according to elements in the value-added chain, and production of components will take place in several countries as the overall product goes through the typical product cycle: high prices and pure quality competition in the first stage, lower prices and increasing price competition in the standardization stage and full price competition in the saturation stage of production or service provision. This new wave of international fragmentation raises particular challenges in terms of flexibility of firms and workforces as well as adjustments of institutions in modern economic systems.

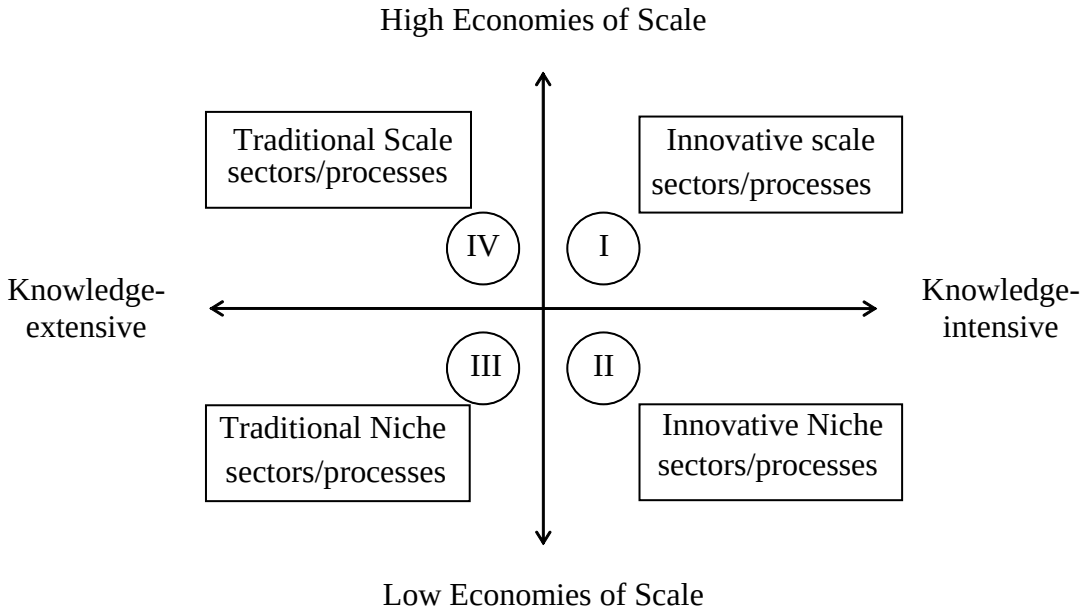
To a large extent ICT sectors are knowledge-intensive. ICT expansion is expected to raise the demand for skilled labour, while the relative demand for unskilled labour is reduced. The latter implies new challenges for EU countries with high unemployment (typically the share of unskilled labour unemployment is already relatively high).

If one is to understand the impact of ICT expansion more deeply, it is useful to analytically split ICT –beyond the standard distinction of ICT goods vs. ICT services– into subsectors, namely in accordance to the relevance of economies of scale and of knowledge-intensity. This distinction is relevant with respect to the ease with which sectoral value-added can be relocated abroad. In competitive sectors with high knowledge intensity, there is pressure for recovering costs in international markets; and offshoring (involving FDI) is naturally favoured over outsourcing – that is international sub-contracting – by firms that consider maintaining ownership-specific knowledge advantages as a sensitive issue. As regards economies of scale, one may emphasize that ICT-induced reductions of fixed transportation and transaction costs stimulate internationalization through both offshoring and international outsourcing. In certain cases governments of countries with large markets, in particular China, require offshoring/outsourcing. Moreover, ICT goods often involve outsourcing/offshoring of intermediate products of low transportation intensity (e.g. in the production of chips which are characterized by both static and dynamic economies of scale), since sharp competition in final goods markets forces firms to exploit these economies of scale by internationalization of production. Against this background, the following distinction is useful:

- Innovative scale sectors: production is scale intensive and knowledge-intensive; here global relocation is very difficult except for the locational competition between the EU and the US (e.g. a software lab in Europe might lose projects and contracts to competitors in the US; software indeed is scale intensive in the sense that marginal costs of production effectively is zero).
- Traditional scale sectors: production is scale intensive and knowledge-extensive; such activity can be relocated rather easily to non-EU countries – and within EU25 from high wage to low wage countries.
- Traditional Niche Products (including commoditised services): provision of such products is not scale intensive and characterized by low knowledge-intensity. This field of value-added is difficult to relocate in most cases as the respective service involves immobile service providers and local service users.

- Innovative Niche Products: production is not scale intensive but is knowledge intensive so that relocation from Europe to Asia is not easy as factor endowments in most countries in Asia – with the particular exception of Japan, Korea, Hong Kong and Singapore – are not characterized by high shares of skilled workers which are required in knowledge-intensive production.

Figure 1 Types of Goods and Internationalization



The subsequent diagram gives an assignment of some sub sectors of ICT to the categories chosen. For instance, we can distinguish customized high knowledge intensity ICT goods (medical/precision/optical instruments), telecommunications plus IT services, electronic products and software. Within advanced software we can distinguish packaged software, customized software and own account software. Packaged software is both characterized by economies of scale and by high knowledge intensity whereas economies of scale are less present in the customized software and absent in the production of own account software. Moreover, one should note that even within packaged software, some processes or functions are knowledge intensive, like software design and system design, whereas actual coding is less knowledge intensive. Electronic products are mainly defined by high relevance of economies of scale in production; knowledge intensity plays a role in the initial stage of product design, while strategic cooperation may enhance positive scale effects. Customized high technology ICT goods are characterized by high knowledge intensity, like telecommunications with additional IT services.

The dichotomy of knowledge and scale is attractive for its clarity and is very useful because of the type of competition that prevails: The higher knowledge intensity, the less footloose is the respective activity, in the sense that e.g. relocation from the EU towards

Asia cannot easily take place. Telecommunications and IT services also are largely knowledge-intensive, but economies of scale do not play a big role – rather network effects on the demand side are important so that the size of the market is an advantage. From this perspective the creation of the single EU market and the EU-inspired sectoral opening up after 1998 is a crucial advantage for Europe.

Figure 2 Selected Sub-ICT Sectors (position in terms of knowledge intensiveness/relevance of scale economies)

Knowledge-Intensity / Economics of Scale	
Packaged Software* +/++ Customized software +/+ Own account software +/0	Electronic Products: with Respect to Design ++/0 in Production 0/++
Customized High technology ICT Goods ++/0	IT services +/0 telecommunications* +/+

* also has network effects = endogenous growth of demand

In knowledge-intensive industries quality competition plays a considerable role. This does, of course, not rule out that prices could fall over time, in particular if there is a high rate of process innovations or if there are network effects in combination with economies of scale. By contrast, knowledge-extensive products with high economies of scale will be subject to strong international price competition where rapidly falling prices imply potential downward pressure on wages in the respective sector. Electronic products with strong economies of scale in production will be subject to globalization in the sense that at each stage of the product cycle there will be pressure to move production to those countries which have production cost advantages, in particular labour cost advantages. Packaged software – and standardized digital goods in general – have certain special aspects: software stands for a combination of huge economies of scale plus knowledge-intensive "production" plus on top positive network effects, i.e. that the usefulness to the first users rises as others also adopt the respective software. So this sub-sector faces both supply and demand economies of scale.

These macroeconomic considerations are strongly related to the management theories of internationalization. Important theories are the Monopolistic Advantage Theory, the Oligopolistic Reaction Theory, the Product Life Cycle Theory, the Step Model of Internationalisation, the Theory of Internalisation, the Network Approach and the New Venture Theory. These management theories shed light on different functions of a company which are related to the products offered. Thus the two pivotal dimensions economies of scale and knowledge-intensity also determine management decisions.

2.2 Theoretical Framework

Internationalization is carried by trade, foreign direct investment and licensing (including cross licensing). There is a potential for rising trade to the extent that ICT facilitates product differentiation and to the extent that ICT contributes to productivity growth and higher per capita income: the demand for differentiated products will increase – so there could be a virtuous circle for ICT. Foreign direct investment should play a particular role in technology-intensive and knowledge-intensive sectors as is argued in the standard literature. In a networked world-economy outsourcing and offshoring potentially affects elements of the value-added-chain; this fragmentation phenomenon has become increasingly important in some sectors in the 1990s. Moreover, we have to take into account life-cycle theory in the sense that product innovations imply absence of economies of scale and hence emphasis on quality competition: with standardization progressing in the life cycle and hence marginal knowledge requirements falling the scope for internationalization will increase. To the extent that there is intra-EU outsourcing/offshoring there should be no major problems from the perspective of the Union. It is clear that value-added in sectors of low knowledge-intensity is likely to be relocated to extra-EU countries in many cases – often this will affect unskilled or less skilled labour in the EU. Consequently, retraining and education become key challenges in the digital age in Europe. As regards knowledge-intensive high-technology sectors, the EU could indeed be on the winning side since there is not only international outsourcing/offshoring (which could be to the US as a country richly endowed with human capital and R&D capital) but insourcing/inshoring, too.

The international division of labour in Europe and the world economy, respectively, naturally will show that the EU15 (or EU10 or EU25) has a positive revealed comparative advantage (RCA) – that is a sectoral strength in terms of the relative export position – in some sectors and a negative RCA in other sectors. Having advantages in high technology sectors is a special asset of a country since this amounts to high technology specialization, which in turn stimulates economic growth. A relatively large RCA in key ICT sectors is thus indeed desirable since ICT largely stands for high-technology goods and advanced services. Catching up in this respect means increasing one's RCAs, and several new member states show such improvements.

In terms of economic growth ICT trade can contribute both on the export side and the import side to growth. Exporting could mean impulses towards high-technology specialization, which supports economic growth. Importing ICT goods to some extent could reinforce the high technology specialization. At the same time one should consider that growing imports of certain ICT-intensive goods imply that knowledge from abroad – embedded in the intermediate products imported – is flowing into the economy and effectively adding to the growth rate of technological progress. International technology transfer can also take place in a two-way direction through international alliances among ICT firms. Considering technology dynamics and specialization it thus is important to focus on RCAs and on patenting patterns – the latter also has implications for potential cross licensing. Since international technology transfer is also strongly linked to foreign direct investment it is important to analyze the relative inflow of such investment in EU countries. As regards EU offshor-

ing dynamics it is interesting to look at also on foreign direct investment outflows. According to standard approaches in Economics high outflows should reflect ownership specific (technological) advantages of the respective firms on the one hand, and on the other hand relatively attractive locational conditions for foreign firms abroad; and advantages for organizing international transactions within the multinational firm. As ICT is largely technology-intensive high foreign direct investment dynamics should be expected in this sector.

ICT generally facilitates international outsourcing and offshoring (the latter involving foreign investment): digital international networking within multinational firms and further fragmentation of the value chain via international outsourcing are crucial elements of economic integration and globalization. In a dynamic perspective there will be a change in the intra-EU international division of labour and also the global division of labour. ICT affects trade, foreign direct investment and the building of international alliances. In those sub sectors where ICT is high technology-intensive, international alliances play a considerable role (patent citation analysis can reveal some of the international knowledge flows which largely are not revealed by patent analysis).

ICT is characterized in both the field of hardware and software through declining relative prices, which implies that the share of ICT investment in overall investment will increase. This aspect in combination with static and dynamic economies of scale effects in ICT production and network effects imply considerable opportunities for (endogenous) growth: Technological dynamics and growth dynamics create opportunities for sustained growth; hence innovation policy and growth policy stand for a very important challenge in the EU.

Not all ICT is high technology in the traditional sense, i.e. that R&D expenditures exceed 8.5% of sales. One may distinguish between electronic products which are largely high-technology intensive; telecommunications which is medium-technology plus human-capital intensive; software, which is mainly knowledge-intensive; and IT services which are knowledge intensive, too. As regards the potential for international relocation of industry, the value-added chain of electronic products could almost fully be subject to globalization in the sense of offshoring - producing in subsidiaries abroad - and outsourcing (buying intermediate inputs from firms abroad). Relocation of manufacturing is rather common in the electronics industry; strong competition in mobile telecommunications markets forces US and EU firms to subcontract manufacturing of mobile handsets to Asian countries. Only R&D cannot easily be relocated globally – relocation will mainly occur within OECD countries. However, one should not overlook the fact that ICT facilitates internationally networked R&D, so that an important challenge for EU countries is that part of R&D activities might be relocated outside the EU. European firms undertaking R&D in the US – involving asset-seeking foreign direct investment – are a standard phenomenon but there are new tendencies that part of R&D is relocated to Asia, in particular to China (e.g. SAP Labs in Bangalore and Shanghai; Nokia reducing R&D activities in the EU and establishing a new R&D facility in China).

2.3 Internationalisation and Foreign Direct Investment

As mentioned above, foreign direct investment (FDI) is one of the main channels to internationalise economic activities. According to the OLI paradigm[1] a firm will engage in FDI if ownership, locational and internalisation advantages coincide. Particularly, FDI is the first choice of means to supply a foreign market with services, which are often considered as non-tradable goods. In this case, FDI can replace the exports that are not possible because of the necessary double coincidence, which means that transactions of services in most cases require the spatial and temporal proximity of buyers and sellers simultaneously. For tradable goods, there can be trade barriers or high transport costs (generally spoken: very high transaction costs that discourage exports) which prompt firms to substitute exports by FDI. On the other hand, a complementary relationship can also exist between FDI and exports. Thus subsidiaries can be established abroad that provide direct contacts with the customers and additional services while the firm headquarters can provide the digitalized basic services, such as databases or software. Furthermore, FDI can be a driving force of the fragmentation of production, which means the splitting-up of the value added chain allowing for a more in-depth specialisation. The reason for this is that different stages of production correspond to different production functions, so that a country may have a comparative advantage in one stage of production and a comparative disadvantage in other stages. Today, the ICT industry has one of the most globally fragmented production in the manufacturing sector.

Furthermore, in the modern literature on the motives and effects of FDI we find the differentiation between horizontal and vertical FDI. The notion of horizontal FDI is closely linked to the substitution type of FDI and means that firms produce the same goods and services in their home country and in the host countries, which is – as already mentioned – often motivated by high transaction costs. Since this type of FDI is often driven by market considerations, it is also labelled as market-seeking FDI. Vertical FDI, on the other hand, is a means of geographical production fragmentation. Since this FDI is driven by cost considerations, it is often labelled as efficiency-seeking FDI.

2.4 Internationalisation of R&D activities

Internationalisation in ICT is not only restricted to production and sales; multinational enterprises (MNEs) also increasingly perform innovative activities like research, development, design or testing outside of their home countries. However, as already indicated by the analysis of FDI data in the R&D sector, the intensity of internationalisation in R&D is still well below the intensity of the internationalisation we can observe in sales or production. Even the most internationalised companies are still strongly rooted in the innovation systems of their home countries.

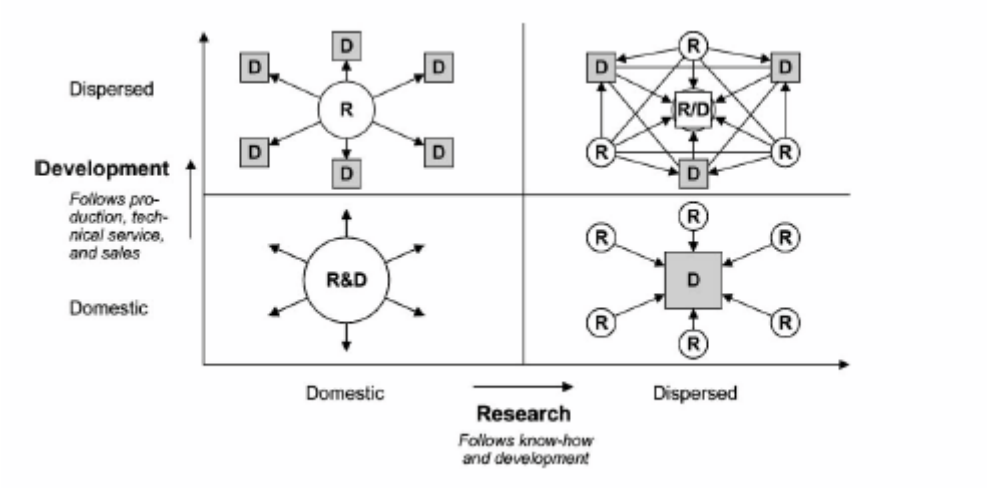
[1] OLI or Ownership, Location and Internalisation (of local knowledge) as the most important drivers of internationalisation. (see section 4.2)

The theoretical literature has identified two main motives for enterprises to perform innovative activities overseas. The first motive is the need to adjust products to the local needs of foreign markets and to provide global development services for customers. The second one is the wish to access superior knowledge or locate research and development units where systems of innovation provide superior framework conditions. Empirical evidence shows that the first motive is prevailing; however, it is always a melange of reasons and motives that determine firms to go abroad with innovative activities.

The internationalisation of innovative activities allows companies to better adjust products to local markets and tap into new sources of knowledge. Internationalising their innovative activities, however, is not costless for firms. MNEs have to organize the internal transfer and distribution of knowledge between various locations, central R&D may loose some scale advantages, and they may face the problem of keeping important knowledge secret. The individual strategy a company pursues results from these advantages and disadvantages. The literature has identified four different archetypes of these strategies (Figure 3):

- “National treasure R&D”, where both research and development is located at the home base. The main reason for this strategy is to keep core technologies more easily under control.
- “Technology-driven R&D”, where research is more internationalised than development activities. Companies do R&D abroad to access local knowledge and react to scarcities of scientific personnel at home.
- “Market-driven R&D”, where R&D abroad mainly monitors technologies and is driven by customer demands and not scientific exploration. In particular, this strategy is found in industries that are rather driven by demand and clients’ requirements than by scientific advance. Companies concentrate their research at home to retain a critical mass, and decentralize their development efforts to provide capacities for clients in the main markets.
- “Global R&D”, where both scientific research and development are dispersed across countries. It is the organisational form that may require the highest coordination efforts and where the trade-offs described above may be largest. However, the benefits associated with sourcing knowledge, wherever excellence may be, seem to offset the cost.

Figure 3 Four different archetypes of R&D internationalisation



Source: Gassmann and von Zedtwitz (2002)

2.5 Digital Goods and Services

Digital goods and services are an important element of ICT. The existence of the internet as a worldwide computer network enables the digital exchange of goods and services. Examples for those are music files (digital goods) or consulting (digital services; software). From a theoretical point of view production and consumption of goods can be at different locations, however, with services there is a need that users and providers are in the same location – and with the Internet the effective mobility of both the supply side and the demand side has strongly increased in markets for digital services.

Digital goods can be reproduced at very low costs, which means that the costs of producing one additional unit (marginal costs) are close to zero. Taking into account fixed costs for research & development and marketing, the implications are considerable scale effects and thus more extensive pricing power for the market leader. From the demand side lock-in and network effects - e.g. the rising attractiveness of a widely used product - reinforce economies of scale. Due to low transport costs of digital products these effects are working worldwide so that achieving or maintaining the global leadership position in the particular market segment will be the natural goal of digital goods producers; existing language barriers imply that there will be some subgroups in global markets.

Yet, global scale effects are only one part of the story. Customers have a 'love for variety' and cultural diversity which leads to differentiated goods, services and prices. Especially in the B2B-segment software services are often tailored for specific customers. Furthermore, the markets of digitally delivered goods and services are contestable, that means that innovative competitors can gain considerable market shares in a short time provided that there are no high sunk costs (typically R&D costs and marketing costs). Last but not least Open Source Software projects set the path for a new model of international cooperation which transparency and cooperation rather than international dominance.

Internationalization happens through worldwide acquiring of new customers directly, through multinational (traditional) companies or by fragmenting the value-added chain of a specific product. The first strategy emphasizes digital goods as final goods. The second strategy is related to the character of ICT as a general purpose technology where software and other knowledge-intensive services play an important role: multinationalisation in the digital sector in the sense of setting up R&D labs or marketing centres abroad is rather easy. Finally, outsourcing and offshoring are part of global relocation processes, which are stimulated by communication costs, and the a-spatial character of digitally delivered products.

Faced with key characteristics such as economies-of-scale intensity and knowledge-intensity, internationalisation strategies differ. To the extent that one can exploit massive scale economies in a knowledge-intensive sector – see e.g. the case of SAP – the respective country/the EU will benefit from highly paid jobs and positive technology spillover-effects. Sub-sectors with knowledge-intensity can be easily served from almost all countries on the globe provided there is adequate broadband density. When networks will finally modernize in all OECD countries and in many Newly Industrializing Countries, the ability to create profitable digital content will be a major potential field of high-wage EU economies.

The sector of digitally delivered goods and services is heterogeneous. From a theoretical point of view a political framework favouring innovations and human capital formation is crucial; a stimulating environment for creation of new digital service providers is a difficult challenge.

2.6 Differential Market Dynamics

With respect to IT services one typically observes that major source countries of foreign direct investment are net exporters of IT services, since subsidiaries abroad mostly rely on the same IT service providers as the parent company – and intra-company headquarter services are sold to subsidiaries abroad. While standardized software and services are rather price-sensitive, specialized IT providers will emphasize both price and quality aspects.

Emphasizing quality competition naturally seems to be important for high-wage countries in Western Europe, while firms in Eastern Europe should be particularly strong in price competitive segments. In a dynamic perspective, accession countries in some sectors can be expected to upgrade product quality and the sophistication of services. The factor endowments of the EU15 countries are characterized by relatively high stocks of human capita, R&D capital – and advanced innovation systems. Therefore, knowledge-intensive production shapes ICT dynamics in our view. To the extent that ICT expansion leads to a general increase in international trade the typical adjustment patterns of trade dynamics must be considered. Here, some recent models (e.g. the Feenstra-Hanson approach) suggest that analyzing trade in a simple two-country setup will lead to skilled labour benefiting in both countries while unskilled labour is losing in both countries. From a Community

perspective such potential dynamics risk undermining economic cohesion in the EU and in the world economy could become a critical challenge.

3. Data Analysis

As introduced above, the standard literature is clear on the particular role of trade and foreign direct investment in the internationalisation of ICT activities in technology/knowledge-intensive sectors. Moreover, the specific role of R&D as the most important driver for innovation and new technologies is well understood. However, in a networked global economy, internationalisation affects all elements of the value-added-chain. This fragmentation phenomenon is hard to confirm directly because the myriad of inter-firm exchanges of goods and services hides fragmentation. Thus from the theory presented in this study we borrow a life-cycle theory as a point of departure. Therefore, we arrive quite naturally at the differentiated products in the sense that products of different qualities carry different prices. Examples of these different qualities are the sequence of generations' chips and microprocessors, and in different appearance telecommunication equipment such as base stations vs. mobile handsets. It might be clear that value-added in sectors of low knowledge-intensity as in the low-priced intermediate goods, is more prone to relocation than others are. On the other hand, knowledge-intensive high technology sectors may remain where they are because of locational advantages such as a rich endowment of human capital and R&D capital, including strong contextual factors such as good governance, efficient markets and tolerance towards deviating opinion and ideas.

This study focuses mainly on the ICT sector from a production point of view, whereas data on trade is product oriented. Table 1 shows the relevant markets for further analysis. While the first two sectors belong to the manufacturing industries, the remaining sectors belong to the service industries.

Table 1 Sectors of industry used in the analysis

Description	ISIC code
Office, accounting & computing machinery	30
Radio and television & communication equipment	32
Post & Telecommunication	64
Telecommunication	6420
Computer & related services	72
Research and Development	73
(parts of) Business Services n.e.c.	74

What will become clear in the next sections is that not all data are available for all sectors and not for all countries of interest. This implies that in some cases one has to deal with e.g. Post and Telecommunication as an aggregate sector, whereas in other cases further disaggregating is possible. Data on trade in ICT goods are readily available at a disag-

gregated level in Eurostat's COMEXT database, but not for services. Moreover, data on e.g. comparable skill levels or foreign direct investment and wage rates shows uneven coverage over time, over countries and over sectors. This implies that different modes of internationalisation (trade, FDI and R&D) are studied using different approaches and do not cover the same countries, sectors and time periods.

3.1 Trade in ICT Goods and Services

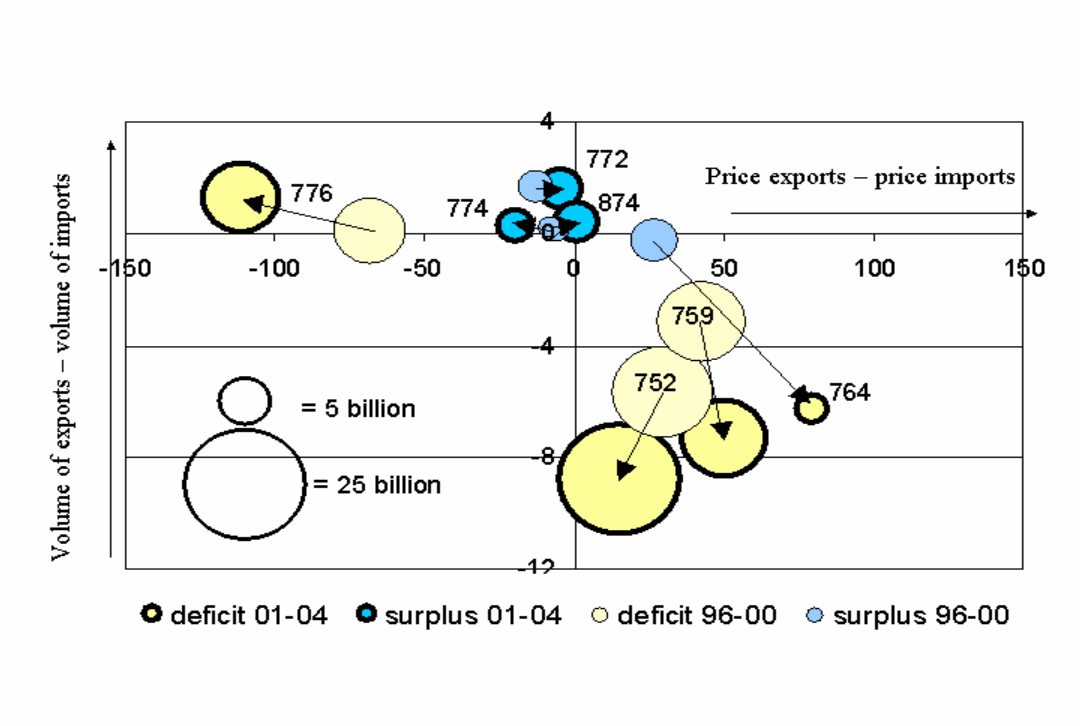
EU25's international trade position with regard to ICT goods vis-à-vis the rest of the world is characterised by a trade deficit of about 0.5% of GDP while the trade in ICT services yields a growing trade surplus of 0.25% of GDP. The ICT sector is very exposed to the world market: ICT goods exports accounts for more than 50% of the sector's GDP and imports of ICT good more than 75%. The ICT services sector is less exposed, with 20% of its GDP exported and 10% imported. This does not mean that the competitiveness of EU25 is low in ICT goods production and higher in ICT services. The development for ICT goods is simply different from ICT services, as the evidence over the period 1996-2004 shows.

Before we discuss the findings with regard to trade in ICT goods and services we like to stress a rather remarkable point: inter EU trade in ICT goods did not increase very much at least in a relative sense. Despite the run-up to the enlargement of the EU15 into EU25, inter EU25 trade in office, accounting & computing machinery, computers (ISIC30), which was 46% of total imports in 1993, still stood at 47% in 2003. Inter EU25 trade's share in radio and television & communication equipment (ISIC32) actually diminished, while inter EU25 trade in medical, precision and optical instruments (ISIC33) rose slightly: from 50% in 1993 to 52% in 2003.

3.1.1 Trade in Goods

The main characteristics of the developments in EU25 trade in ICT goods vis-à-vis the rest of the world are visualised in Figure 4. In this figure the horizontal axis represents the difference between the price of exports and the price of imports of the same good. The vertical axis shows the difference between volume of exports and volume of imports. The general idea is that when goods are homogenous and when markets are elastic the north-west and south-east quadrant will be populated by the data points representing a certain ICT good with regard to price and volume acres, the size of the bubble represents the contribution (deficit or surplus) to the trade balance. What we see is not the expected pattern; on the contrary, the centre is densely populated with relative small surpluses of EU25 while the outskirts are populated by the much larger trade deficits of EU25 in ICT goods trade.

Figure 4 Assignment of shift in the main products involved in extra EU25 trade in ICT goods according to price and volume differentials as well as the contribution to the trade balance (shifts between averages of 1996-2000 and 2001-2004)



The blue/darker bubbles in Figure 4 represent the SITC product groups electrical apparatus etc. (SITC772), electrodiagnostic apparatus for medical, surgical, dental or veterinary purposes and radiological apparatus (SITC774) and measuring, checking analysing and controlling instruments etc (SITC 874), in which EU25 has a surplus position that increased somewhat during the period under consideration. Dark blue bubbles represents trade surplus in 2000-2004, light blue a trade surplus in 1996-2000. EU25's exports of electrical apparatus etc. (SITC 772) and measuring, checking analysing and controlling instruments etc (SITC 874) became relatively more expensive and at the same time its trade surplus rose, but volumes hardly changed. On the other hand electrodiagnostic apparatus for medical, surgical, dental or veterinary purposes became relatively cheaper while trade surplus rose also. These two examples give a good impression of the position of EU25: it is mainly quality competition (as in the case of SITC 772 and 874), but price competition is also a reality.

Comparing the periods 1996-2000 and 2001-2004 (see also Figure 4) leads to the conclusion that the firmament became larger, especially in the price dimension. The expansion means that the difference in prices of exports and imports became larger. This is the contribution of cathodes (SITC776), optical instruments and apparatus, n.e.c. (SITC 871), parts and accessories for computers (SITC759) and telecommunications equipment (SITC 764). The trade surplus of the latter product group turned even into a trade deficit in the more recent years, due to a surge in the imported volumes of relatively cheap telecommunication equipment from abroad. Despite a relative price decrease in the exports of automatic data-processing machines and units thereof, etc (SITC 752) imported volumes surged leading to a slight increase in the trade deficit.

Our conclusion here is that on the one hand the EU25 ICT trade balance deficit is mainly caused by automatic data processing machines etc. (SITC 752), parts and accessories for computers (SITC759) and cathodes (SITC776) while in more recent years telecommunication equipment (SITC 764) can be added to this group. On the other hand the EU25 holds a relatively strong position in electrical apparatus etc (SITC 772), electrodiagnostic apparatus for medical, surgical, dental or veterinary purposes and radiological apparatus (SITC 774) and measuring, checking, analyzing and controlling instruments and apparatus (SITC, 874), but also in consumer electronics.

Illustrative in this respect is the EU25's trade in ICT goods vis-à-vis China that differs from the trade with Japan especially with regard to prices. Average price (unit value[2]) of imports from China is 12 € per kilo while EU 25's exports to China buys a price of 43 €/kg. EU25's imports from Japan are valued at 44.5 €/kg while EU25's export to Japan are valued at 144 €/kg.[3] According to the theory two conclusions are possible: either EU25 exports consists of goods of higher quality compared to the imports of these goods, or EU25 exports are final goods and imports are components or intermediate goods to produce these exports. The latter interpretation implies an indirect confirmation of the central hypothesis of this study: the fragmentation of production of ICT goods. Therefore, competitiveness has at least two dimensions, and quality as well as price competition plays a major role in ICT goods trade.

3.1.2 Inter EU25 trade in ICT goods

Despite the relative stagnation of inter EU25 trade in ICT goods, there has been a considerable shift in global market shares in recent years. China is clearly the big winner while US, UK and Japan are the losers that lost on all ICT (import) markets. EU25 as a whole won on all markets mainly thanks to the European Tigers (Czech Republic, Hungary, Ireland and Poland). Therefore, the conclusion is that EU25 has a competitive edge especially in electrical apparatus (SITC 772) and in medical, precision and optical instruments (ISIC 33) and there are ample possibilities to enhance this advantage, by intensifying R&D outlays in ICT goods producing enterprises and by relaxation of national product market regulations.

3.1.3 Trade in Services

The performance and perspectives for ICT services are different from those for ICT goods. The service trade surplus of EU25 is surging at 20% per year (over the period 1993-2003). However, not every EU country gains from this trade; in fact, it is the specialisation of a few countries. Belgium, Ireland, Germany Sweden, UK (and the US) are the countries specialised in the exports of computer and related services. These services embrace a rich variety of services: computer data and news-related service, transactions between residents

[2] Defines as the value of the trade goods divided by their weight.
[3] Average of unit values in €/kg during 1993-2003.

and non-residents, data bases, data processing, provision of processing services on a time-share or specific (hourly) basis. But also management of facilities of others on a continuing basis; hardware consultancy; software implementation–including design, development, and programming of customized systems; maintenance and repair of computers and peripheral equipment; news agency services–including provision of news, photographs, and feature articles to the media; and direct, non-bulk subscriptions to newspapers and periodicals are included in these services. In this rich variety, some services are scale intensive like database services and news provision, while others are scale extensive like software implementation; the same can be said on knowledge intensity. Consequently, there are large unleashed potentials for all countries in these services, because these services cover the whole range from scale and knowledge intensive to scale and knowledge extensive. Although the current levels of production are quite low these services are surging in Poland and the Czech Republic, but also in France and Germany. More growth is possible if these kinds of services become more liberalised and regulation harmonised in EU25. But this may take some time to materialise, because it is well known that traditionally these locally provided services are subject to local regulation, which favours local provision and discourages standardisation, packaging and provision from elsewhere or abroad. Elimination of this locally-inspired regulation will open up the possibilities to provide these services either from a local affiliation in a customised form, or from a distance using the possibilities of networking when it comes to packaged services.

Need for better data

The competitive position of a country on the global market regarding a certain product or service is measured by several indicators like revealed competitive advantage, R&D expenditures, FDI etc. In using these data to express a country's competitive edge in a certain market we met severe data limitations, which prevented us from using much of the detailed and specific data on ICT activities we intended to use at the start of this project. The actual use of databases in empirical research is very often disappointing because of 'holes' and uneven coverage of periods of time and other inconveniences. An exceptional good statistical source on trade in goods is EUROSTAT's COMEXT trade database. Volume and value of traded goods between 28 European reporting countries and 263 partner countries is available for each month from January 1993 onwards on a very detailed level (5 digit level). Another example of a useful database is the 60-industry database of the Groningen Growth Centre. However, when it comes to e.g. wages this database does not cover all the countries it contains, and when it comes to foreign direct investment and educational attainment or skill levels of the labour force – emphasised as important factors in the theoretical part of this study - databases become a nightmare. The data sources indeed show here a large number of 'holes': foreign direct investment of the ICT sectors and costs like wages in the sectors of activity are often only available for a small selection of countries, too small to base robust calculations on. The same applies to sectoral skills data which is available for only a handful of countries thanks to the laborious work of others using data supplied by the national CSO's instead of direct provision by EUROSTAT. Although trade with countries like China and India is certainly taken into account, it was not possible to explain these developments by investigation of underlying forces, also because of severe

data limitations. India as an important ICT service provider is absent in the Balance of Payment Statistics of the IMF when it comes to ICT and information services. Therefore, the choice of the indicators and countries is necessarily also determined by data availability. Better data would be a great help for high quality empirical research.

3.2 Trends in Foreign Direct Investment

Next to trade in ICT goods and services, foreign direct investment is one of the main channels to internationalize economic activities. As mentioned above, data limitations do not allow for a comprehensive EU25 analysis and is thus limited to a few European countries. In the main final report we present the results of a variance analysis by means of a regression model with dummy variables to explain the degree of internationalisation by FDI, but we will only briefly summarise it here. Since the interaction effects between countries and sectors are particularly important with respect to FDI, we use here again the two dimensions as presented above to analyse patterns of internationalization by means of FDI data. Knowledge intensity is approximated by country and sector specific R&D-intensity and scale is measured by employment per enterprise. These data are used to assign the sectors of those countries for which the necessary data is available to the four fields of our classification: innovative scale sectors, innovative niche sectors, traditional niche sectors and traditional scale sectors. Next we present the general findings of the analysis of outward and inward FDI, followed by an analysis on the importance of scale and knowledge intensity of inward and outward FDI.

3.2.1 Inward and Outward FDI stocks

Due to severe data limitations sectoral outward FDI stock-to-value added ratios are available only for Austria, France, Germany, the Netherlands and the UK. Inward figures are also available for Portugal. From our analysis presented in the full report in more detail, some general conclusions can be drawn with regard to the degree of the internationalisation of the ICT sectors by means of FDI, which we measured by the ratios of FDI stocks to value added. Firstly, there is generally an increase of both the inward and outward FDI-to-value-added ratios from the first period (1995-1998) to the second period (1999-2002): the ratios in the second period are on average twice as high as in the first period. Secondly, this pattern holds true for almost all countries, except for the Netherlands, which have generally higher inward and outward FDI ratios than the other countries. Thirdly, we find significant differences between sectors meaning that there are sectors –over all five/six countries included in the analysis– which have especially high or low inward or outward FDI ratios. More concretely, the sector “research and development” has on average lower outward FDI ratios than the first sector “office, accounting & computing machinery”, while the sector “business services n.e.c.” has on average higher outward FDI ratios. The same holds true for inward FDI ratios.

3.2.2 FDI, knowledge intensity and economies of scale

The assignment of the sector-country-combinations can be done on the basis of knowledge intensity and the importance of economies of scale. Contrary to the previous section on trade in specific ICT goods, FDI data do not allow for a highly detailed analysis. Sectors are broadly defined and several different activities are aggregated. This obviously reduces somewhat the accuracy of the analysis. Bearing this remark in mind we assigned all sectors presented above to the four quadrants presented earlier in this report. In order to do so, we used the R&D intensity relative to value added as a measure of knowledge intensity and the average firm size as a (raw) measure of the importance of economies of scale. We also included country effects and sector effects in the analysis. Using this subdivision, we can aggregate inward and outward FDI stocks for four countries.[4] Table 2 shows the resulting "FDI trade balance".

Table 2 FDI stocks of Germany, France, Netherlands and UK (Million Euro) in 2002

Field of Classification	Outward FDI Stocks	Inward FDI Stocks
Innovative Scale Sectors	30807	33116
Innovative Niche Sectors	5470	3076
Traditional Niche Sectors	540431	569059
Traditional Scale Sectors	245329	73441

Both inward and outward FDI ratios can be explained by scale and knowledge intensity. A remarkable result is that the country effect is significant for outward FDI whereas it is not for inward FDI. This suggests that some countries are more inclined to outward FDI, irrespective of the scale and knowledge intensity, whereas foreign investors seem not to have preferences for certain host countries.

It is obvious from Table 2 that in 2002 the overwhelming amount of outward as well as inward FDI stocks of the four countries which could be considered is in the field of traditional niche sectors, where these positions are rather well-balanced with a small surplus of inward FDI stocks. For the outward FDI stocks in business services it can be assumed that they are of the market-seeking type and replace the exports that are not possible because of the necessary double coincidence (meaning that transactions of services in most cases require the spatial and temporal proximity of buyers and sellers simultaneously). Thus, these foreign activities are no threat to growth and employment in the home countries. For the outward FDI stocks of computer and related services, the second important sector in this field, the situation might be a little bit different. Here, further research is necessary. However, the large inward FDI stocks in both sectors increases competition on domestic markets. One possibility for domestic firms to react to this competitive pressure is to increase innovation activities. It is usually assumed that product innovations allow fetching higher prices, while process innovations lead to cost reductions.

[4] Since sector R&D intensity, which we used as an approximation for knowledge intensity, is not available for Austria at all as well as for telecommunications for Germany and France and for the sector "research and development" for France, we dropped these observations.

The second largest amount of outward and inward FDI stocks can be found in the field of traditional scale sectors, where the outward FDI stocks are three times higher than the inward FDI stocks. Since only the sector telecommunications is located in this field, it can be assumed that outward FDI stocks are largely market seeking and no threat for growth and employment in the home countries. The only exception might be the offshoring of some low skill activities – like call centres –, which implies a certain degree of fragmentation of production and a certain threat for low skilled employees. For the inward FDI stocks the same argument applies as for the field of traditional niche goods.

In the field of innovative scale sectors the outward and inward FDI stocks are also rather well balanced with a small surplus of the inward FDI stocks. Here, we can safely assume that outward FDI is a means of production fragmentation. If this fragmentation of the value added chain increases overall competitiveness of the sectors in the home countries, we might expect an overall positive impact on growth and employment in those countries. However, at the same time, it might intensify pressure on relative wages and impair employment opportunities for low skilled employees.

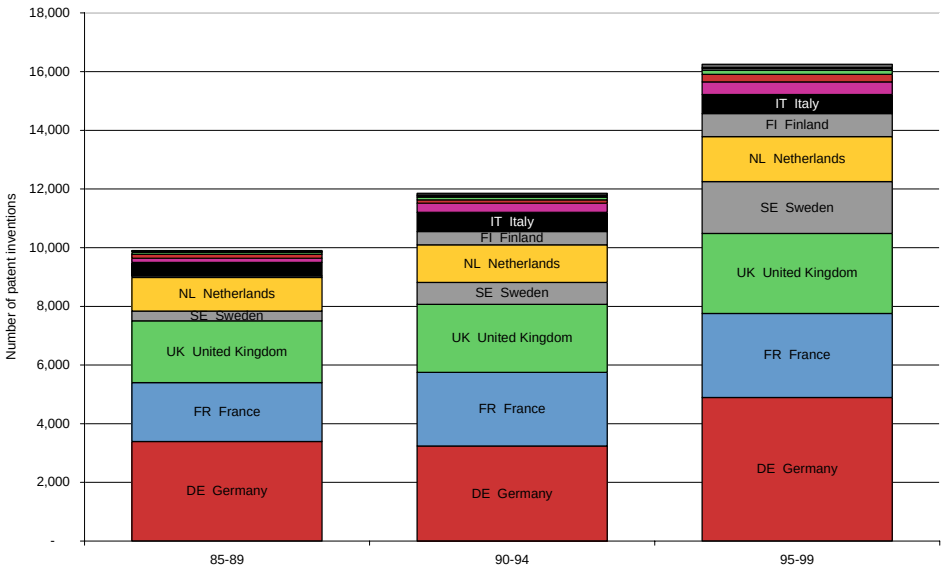
Finally, in the innovative niche sector, which shows the smallest amount of outward as well as inward FDI stocks and a clear surplus of outward FDI stocks, the economic effects obviously might depend on the individual sub-sector. While we can assume quite legitimately that outward FDI stocks of the sector “office, accounting & computing machinery” are at least partly a means of production fragmentation with effects similar to those just mentioned for the innovative scale sectors, outward FDI stocks of the sector “research and development” are largely market-seeking.

The general pattern shows that FDI is much more present in the traditional, less knowledge intensive sectors and that inward and outward FDI is rather well balanced, with the exception of outward FDI in the traditional, scale extensive sector. This again points into the direction of offshoring of more standardized, more mature products and services, which would mean that the production of innovative products and services remains in the home countries. One way to verify this hypothesis is to analyse the internationalisation of R&D activities.

3.3 Internationalisation of R&D activities

We used for this part of our analysis the triadic patent data set on granted patents and the classification of information and communication technologies (ICT), both provided by the OECD. While the absolute number of patent applications has increased in all sub-technologies of ICT and in all EU member countries (Figure 5), the dynamics of this growth differs. The highest growth rates in terms of technologies can be found in Telecommunications, where the number of patents more than tripled from the period 85/89 to 95/99.

Figure 5 ICT patent inventions in the EU25 member states, priority years 1985-1999



Source: OECD Triadic Patents database, own calculations

If we look at EU member states, Sweden and Finland experienced the most dynamic growth; the three largest R&D performing countries in Europe, Germany, France, and the UK grew slower. However, they still account for more than 60% of all ICT patents within the EU. As a result of different growth rates, the geographical concentration of research and development in ICT has decreased in the 1990s in the EU25. Today, R&D in ICT is more equally distributed across Europe than 10 or 20 years before.

The geographical concentration did not only change over time but also differs among the five sub sectors of ICT. We found the highest concentration within semiconductors, which is also the only sub sector without a de-concentration trend over time. The lowest concentration for the period ‘95/99 (as well as the strongest de-concentration) can be found in telecommunications, which is largely due to the rise of the Nordic telecommunications industry.

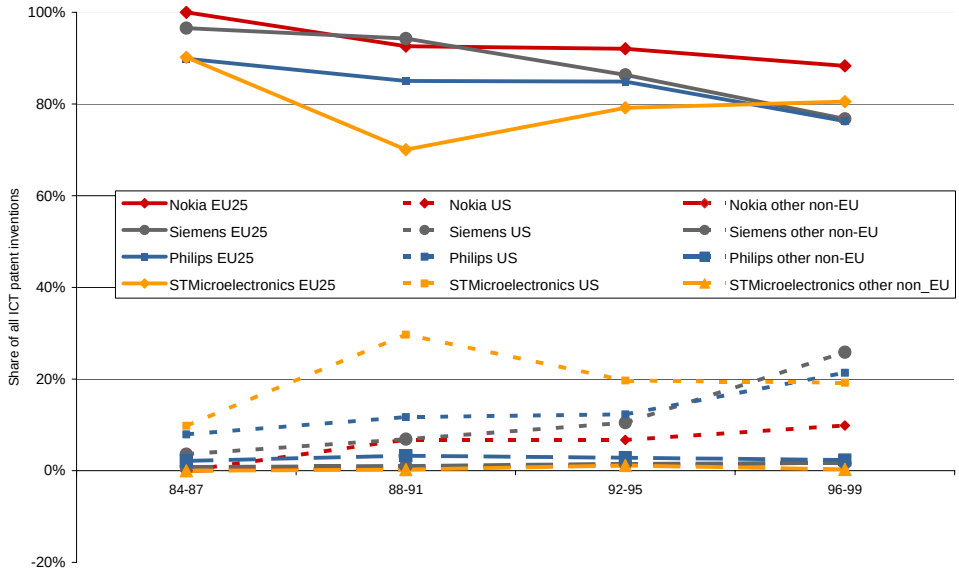
A second important de-centralisation trend is overseas research in the US. We analyzed the geographical patterns of patenting activity of eight companies, four of them (Nokia, Philips, Siemens and STMicroelectronics) European (Figure 6). All European companies increased the share of ICT patents invented in the US as well as in other European countries. The degree of concentration in ICT research has decreased in all cases. However, more than 75% of all research is still located in the EU. Figure 6 also indicates that other non-EU locations remain unimportant for all enterprises. The share of locations outside the EU25 (except the US) is below 3% for the period 1995/99 in all four European cases.

For comparison, we also included two US (IBM and Hewlett Packard) and two Japanese companies (Sony and Toshiba) in the analysis. We found a similar pattern for the US and Japanese companies; while the home country is in all cases the dominating location for R&D (more than 75% of all patents in all four firms), the EU is becoming more important as an location for R&D for US and, to a smaller extent, for Japanese companies. This con-

firms the finding that the internationalisation of R&D is still mainly an Intra-Triad phenomenon.

Despite large investments of European and US companies, locations outside the Triad, e.g. China or India, but also the EU10 countries, have so far yielded only few ICT patents. We argue that overseas R&D in these countries is mainly 'market driven', concentrated on developments for local markets, instead of 'technology driven'. Strategic R&D is still concentrated in the home countries of the enterprises.

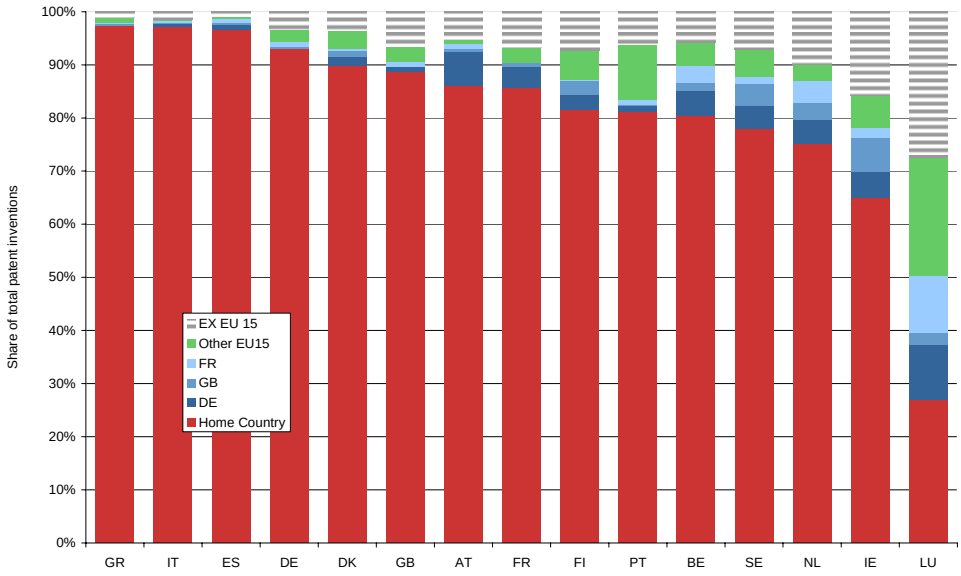
Figure 6 Location of ICT patent inventions of Nokia, Philips, Siemens and STMicroelectronics, priority years 1984/87, 1988/91, 1992/95, 1996/99



Source: OECD Triadic Patents database, own calculations

To get insights into the most recent developments we additionally analyzed data on applications at the European Patent Office (EPO) for the time period 2000 to 2005. Like in the Triadic data, there is a clear trend towards R&D internationalisation among EU15 members in EPO data, although the majority of inventions still originate from the home country (Figure 7). We find the largest shares of applications based on inventions from outside the EU15 among some small member countries like Luxemburg, Ireland and the Netherlands. With the exception of Luxemburg, there is no country where Ex-EU15 inventions accounted for more than 15% between 2000 and 2005. If we leave home country inventions out of the picture, then there is no country that has more patent applications outside of the European Union than inside. This indicates a high integration of corporate R&D within the EU.

Figure 7 Origin of invention of EU15 patent applications, 2000-2005, European Patent Office



Source: European Patent Office, own calculations

Patent inventions from outside of the EU15 applied for by EU15 companies predominantly originate from North America. Inventions from European countries outside the EU25 predominantly originate from Switzerland and Norway. EPO patent data also indicates that the share of Asian locations is rising. This supports the observation that European companies have been locating R&D in this region in recent years. However, if we relate the number of patents from Asian countries and Japan to the total number of EU15 patent inventions, it becomes obvious that their share does not exceed 1% in any year between 2000 and 2005. EU15 patents invented in the EU10 (new member) countries have an even smaller share.

This picture changes only slightly if we move to the level of technologies: 93% of all EU15 patent applications at EPO in information and communication technologies were based on inventions from within the EU15. We see a certain decrease of the EU15 share between 2000 and 2005; this shift, however, is mainly in favour of North America and cannot be ascribed to Asian countries. Countries outside the EU15 states gain the highest shares as inventors of EU15 ICT patents in consumer electronics, where they account for 11% of all ICT patents applied for by the EU15. However, the deviations from the average value for all ICT patent applications reported above are quite small.

R&D activities of European companies in ICT are still concentrated in the home country and other EU15 countries. However, this does not mean that European companies have no ongoing R&D activities in Asia or the EU10 countries. What we can conclude is that strategic R&D where results are protected with EPO patents is still located in Europe. Overseas activities in Asian countries and the EU10 are still mainly concentrated on the markets in the target countries.

4. From the case studies: The place of the EU in the international division of activities within ICT companies

4.1 Business case-studies, objective and methodology

Eighteen business case studies complement both the theoretical and the other empirical work by providing detailed and recent insights into the adopted internationalisation strategies and the implications for the international division of labour at the level of individual EU-based ICT companies. The objective of the case studies is to illustrate and complement the theoretical and practical understanding developed in this study. The analyses mentioned above lead to insights mostly at the macro- and meso-level of countries, sectors, or to insights focussing on R&D as one business function indicated by patent applications. With the case studies we have adopted a qualitative methodology to address geographical fragmentation (and organisational integration) of ICT activities at the micro-level, that is, the company level, and even below the level of a MNE, because some of the case studies involve specific EU-based subsidiaries of multinational corporations. A two-stage work plan had been adopted to perform case studies. In the first stage eighteen business cases have been reviewed in an explorative way to get a broad view of the emerging key issues. These eighteen companies have been selected to reveal different models of internationalisation, since these differences may have different policy implications. In order to get this desired diversity we have included small and large companies from all EU regions; companies in each of the three ICT sub-sectors of hardware, software and services; some companies with R&D activities in New Member States; and some companies with FDI-subsidiaries outside the EU.

In the second stage we have focused on a smaller selection of cases in order to get a more detailed and in-depth view on the internationalisation of five ICT companies located in Europe, namely: AT&S, LogicaCMG CEE, SAP, Océ and FreeSoft.

4.2 Motives and models of internationalisation

A horizontal analysis across the case studies has resulted in the conclusion that an internationalisation decision is almost always a ‘multiple-motivated’ decision, combining mainly low-cost arguments, market development arguments and strategic arguments. This observation accords with the OLI paradigm (combining Ownership-, Location-, and Internalisation-advantages), which is basically an eclectic conceptual model to address this multiple motivated nature of internationalisation decisions. Another clear message from the case studies is that for ICT industries, too, the individual internationalisation decisions are clearly influenced by former decisions, and this shows up in path-dependency and trajectories in time and space. For instance, when asked for the reasons to start or increase R&D activities at a certain location, many interviewees have referred to former experiences of some kind, e.g. an existing sales office. In this respect the case studies also confirm theories that emphasize the evolutionary nature within the process-models of interna-

tionalisation. However, the internationalisation process seems to be more dynamic for the ICT sector than for other sectors, especially for software companies (see the cases of F-secure and SAP). The 'digital goods' characteristics presented in the theoretical discussion fit with the observed internationalisation strategies of companies in the ICT software sector. Not only are these companies more foot-loose, but there also are less limitations to implement fast internationalisation trajectories in time. Since Dunning originally presented his OLI framework in a static way, the more recent applications adopting a more dynamic approach are therefore more relevant regarding the ICT sector.

Especially some cases of Foreign Direct Investments in New Member States have also pointed to the fact that asset-seeking and asset-exploiting are not mutually exclusive motives for internationalisation. The cases of Tumbleweed in Bulgaria and LogicaCMG in Czech Republic illustrate that for global networked companies the motives and opportunities for growth 'abroad' are dynamic and systemic. Such co-evolution of explanations blurs the boundaries between the originally expected Ownership-, Location- and Internalisation-advantages. When applied to ICT industries the OLI-framework has therefore to be put in a dynamic, networked perspective. Concerning the **Ownership-advantages** we have witnessed a decreasing importance of the nationality of ownership, e.g. in the case of SAP, LogicaCMG, and Delta Singular. The terms 'home' and 'host' seem to become less relevant for many of the case-study companies, not only for the large globally networked companies, but also for small companies like Kring and ITprovision, two companies which have developed a specific international business model in which they have integrated offshoring and near-shoring possibilities. Concepts like 'home-base-augmenting R&D' and 'home-base exploiting R&D' seem rather out-dated for such international corporate networks of software and service providers. For instance, the R&D activities at LogicaCMG in Prague could perhaps be referred to as either network-exploiting or network-augmenting, depending on the specific project. The cases involving ICT hardware show more traditional patterns that accord with the observation that most R&D is still concentrated in the home-country near its headquarters.

Location-advantages remain very important in many case studies although they change over time and we have seen many cases where there is a constant 'competition between locations' within corporate networks, e.g. between Bangalore and Sofia or between PaloAlto and Walldorf.

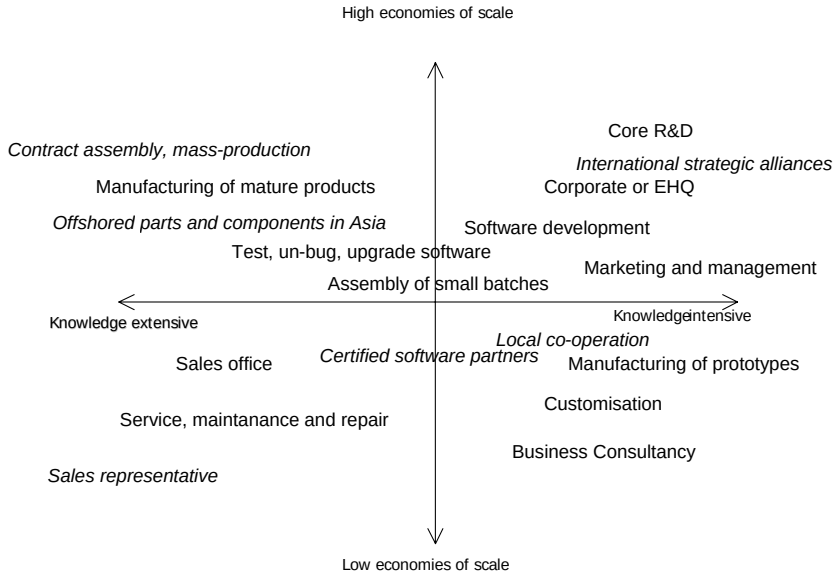
Concerning the **Internalisation advantages** of the OLI framework the ICT case-studies highlight the role of global networks and partnerships especially for software companies.The case studies also point at the increase of (external) offshoring of the more standardised, codified, and less strategic tasks in software development; and they point at the increased importance of contract manufacturing. Large ICT service companies such as Delta Singular and LogicaCMG prefer internalised networking, whereas small and medium ICT service companies more often adopt external networking strategies.

4.3 International division of ICT business functions

Fragmentation of production has been defined as splitting-up or decoupling of the value added chain allowing for a more in-depth specialisation and broader international networking. The reason for these developments is that different stages of production correspond to different production functions so that a country may have a comparative advantage in one stage of production and a comparative disadvantage in other stages or functions. In the past, when the Marshallion 'single-plant-family-firm' dominated the economy, international trade has lead to specialisations of countries in certain products. In the business case-studies we have focussed on the geographical splitting-up of activities within ICT companies, in order to identify geographical specialisation in certain business functions.

Our main conclusion is that the case-studies support the evidence based on the analysis of international trade at the level of sectors and products. Within international ICT companies we have found evidence for this geographical splitting up of functions in ICT industries. Concerning the place of the EU in the international division of activities within ICT companies our main conclusion is that the activities in the EU15 tend to be the relatively knowledge intensive, focussing on customisation and high quality. The functions and activities located in Asia tend to be the more standardised and codifiable activities. New Member States take a middle position in this international division of ICT functions.

Figure 8 Business functions along scale/knowledge dimensions



Source: based on the case-studies;
Note: functions in italics are external, not performed under full ownership

Summarizing the case-study evidence, we have plotted the geographically fragmented business functions along the dimensions of scale and knowledge (Figure 8). We can associate several of the plotted functions with the three ICT sub-sectors of hardware, software and services. ICT hardware and digital goods are more standardised and codified and therefore more scale-intensive and with more globalised markets than for ICT services. For ICT services companies the scale of production (that is the cost-efficient advantage of geographical concentration) is less important. Small service providers can therefore be very productive. For ICT service industries economies of scope are very important, which can be obtained through international, but often decentralised networks. However, the evidence from the case-studies extends this conclusion beyond the sector level, since we have observed the trend at company level across the three ICT sub-sectors. The typical slogan or mission of our case-study companies therefore does not refer to a specific product or service, but to solutions.

In almost all case-studies we have seen that the companies have included several elements of the value chain, most notably by extending or expanding into service activities, but there is also hardly any company that is not engaged in software development somehow. Internationalisation facilitates both geographical fragmentation and corporate integration of business functions.

Within this international fragmentation and integration the EU has specialised as a location for the more knowledge intensive business functions, ranging from core R&D to design and marketing & management, and from innovative software development to customisation and business consultancy. This specialisation can not be maintained without internationalisation.

Concerning the fear for losing ICT jobs in the EU we can not draw firm conclusions based on the 18 case-studies, but at least our findings do not confirm such fears.

5. Conclusions and policy insights into the internationalisation of European ICT activities

ICT is different from other technologies

This report has explicitly dealt with the Internationalisation of European ICT industries because ICT is different in many respects from other technologies. Technological change is proceeding very fast in ICT, which provides new technological opportunities at a faster pace than in other areas. More than in other technologies, innovation and production in ICT exploit its possibilities through operations of networks, thus enabling an extensive division of labour along the production chain. ICT-related applications may often be characterised by their intangible character and reproducibility. In contrast to other physical goods (either ICT goods or other industrial products), digital goods and services can be easily transferred electronically.

ICT is also a general purpose technology with potential application in all sectors and activities of the economy. Moreover, the application of ICT is not restricted to new goods and services; ICT also changes the way firms are organized and goods are produced, allowing a more volatile, networked, or "virtual" way of doing business. This is an important precondition for an intensified international division of labour. It should be the goal of EU policy to exploit this intensified division of labour. This, however, implies focusing on knowledge-intensive and customized activities in Europe.

Internationalisation as a key feature of ICT

The specific characteristics of ICT have a number of implications with respect to internationalisation. Innovation and production activities in ICT can be highly fragmented and be located each where the best conditions for conducting them are offered. On the one hand, this entails the risk that production activities are easily re-located if better conditions are offered elsewhere. On the other hand, the division of labour allows concentrating on those segments of the production chain where a country or a region offers particularly good conditions. For Europe, this implies that knowledge-intensive activities (i.e. quadrants I and II) have the potential to remain in Europe and European firms may even improve their competitive position in these areas, even if large-scale production in later phases of a product life-cycle moves elsewhere. Large-scale production and less knowledge-intensive activities (quadrants III and IV), in contrast, may be shifted to locations with cost advantages to the benefit of both sides. This could also be, of course to the EU10 member states. A prerequisite for this intensified division of labour, however, is that Europe pushes further its knowledge intensity to maintain the potential for innovation.

Firms' motivations to internationalize R&D, innovation & production

The opportunities of ICT for a more flexible, geographically dispersed organisational structure meet with the strategies of many firms to enlarge their business to locations abroad. Firms are attracted by various motives, which often are of a market exploiting nature, but may also reflect cost differences. The motive to expand markets is arguably the most important reason for firms to go abroad with their activities. This motive is often driven by the wish to exploit firm-specific assets like technology, business ideas, management skills etc. on foreign markets. Firms may also follow their domestic customers, or use the advantages of international production by internal and external outsourcing. R&D has, so far, been an activity where firms maintained a strong home base. This observation applies most strongly to Asian firms, whereas both European firms and even more so US firms are increasingly tapping into foreign knowledge by forming alliances or making R&D investments abroad. Patent analysis has shown that this is done to date predominantly in the US.

Unjustified fears and major benefits of internationalisation

The advance of Asian economies like China, India or the South-East Asian "Tiger" states, as well as the growing gap between Europe and the US in terms of ICT diffusion, has raised fears that Europe's losses from the internationalisation will outweigh potential benefits of the process. Based on the analysis of the project, we can say that these fears can be confirmed neither on theoretical grounds nor by the empirical evidence analysed.

EU has stabilised its position in ICT, and improved in some areas

Direct effects from production and foreign trade in ICT have to be differentiated from the indirect effects arising from the use of ICT. The analysis of trade flows showed that Europe has a structural deficit in ICT products. Higher unit values for European ICT exports than for imports, however, indicate that Europe predominantly exports finished goods and/or goods of higher quality than it imports. Moreover, we also find a surplus in foreign trade with ICT services. Both results indicate that Europe is increasingly specializing in higher-valued ICT goods. In the most advanced areas of ICT, i.e. those that are characterised by a high degree of research and knowledge-intensity (Quadrant I and II), the best locations in Europe are competing in the first instance with those in the US. This applies to both inter-firm competition and for intra-firm competition. An example that may further illustrate this is the case study on SAP where competition is fierce between the Palo Alto and Walldorf locations of the enterprise. The perception that the US offer in many respects better and more attractive conditions for innovation (for instance in terms of regulations, but also access to excellence in research) is perceived as a threat in the medium term for keeping the cutting-edge activities of leading companies in Europe.

Pure price competition in trade in ICT goods is not an option for the EU25; the focus should be on quality competition. We see signs that such a process is already under way. Moreover, the EU10 (new) member states have gained momentum in ICT foreign trade in recent years. The analysis of FDI flows in ICT also supports the finding that an intensified division of labour between Europe and other parts of the world is currently emerging. Active as well as passive foreign direct investments have increased in all ICT sectors and countries where data is available, with ICT hardware producers and business services being the most internationalised sectors. European firms maintain strategic R&D activities mainly in their home country, despite cost advantages in other parts of the world; these activities are strongly rooted in the innovation systems of the firms' home countries. However, there is a growing tendency to set up R&D facilities abroad, mainly to support local production and market expansion.

A second argument why fears may be unjustified refers to the indirect effects of ICT on the economy. These indirect effects arise from the use of ICT in different sectors of the economy, regardless of whether imported goods or goods originating from the EU have been employed. One could even argue that foreign ICT goods may have a better cost/performance ratio or embody superior knowledge which may lead to spill-over effects to European industries.

Europe needs to continue moving up towards higher knowledge-intensity, quality, and the development of skills

Opportunities for Europe reside mainly in higher demand for advanced services and goods, R&D intensive activities, and quality competition rather than price competition. This requires a stronger orientation towards R&D. Major attention should be laid on skills and HR development. Firstly, because a further specialisation of EU members states on high-valued goods can only be a promising strategy if it is accompanied by constant skill improvements. This is also true for the EU10 countries, which – for the moment – still benefit from lower labour costs which allow them to compete with Asian locations for production. However, in the medium-term, the picture is likely to change.

A second argument in favour of skills development is the absorptive capacity. Major effects of ICT do not only arise in industries that produce ICT, but also downstream in user industries. To employ these technologies, however, firms need a certain level of technological expertise, also referred to as absorptive capacity. Therefore, it is important to invest in ICT related education and R&D. Skills development should also be accompanied by employees' flexibility and ability to learn throughout their entire working life.

Internationalisation of ICT facilitates the internationalisation of other sectors

Due to its general-purpose character, the widespread use of ICT in other sectors is likely to facilitate a move towards internationalisation and fragmentation of other production, too. However, for physical goods this will not reach the same level as for digital goods and services that can be easily transferred electronically. Due to the growing importance of digital goods and services, this mechanism is much more relevant in ICT than in other industries. Nonetheless, the increasing use of ICT and digitalised information along the value chain in most industries facilitates similar processes of relocation and fragmentation as we have observed in the ICT sector. Whether this development will turn into a real challenge for European industry remains to be seen, but it should be monitored closely.

5.1 Policy options and requirements

Based on these findings, we will now discuss some key issues and options for European and Member States policies that are likely to determine whether Europe will be able to maximise the benefits from the internationalisation of ICT.

Coping with the next phase of restructuring of European ICT industries …

Over the coming years, a new wave of restructuring in Europe's ICT industries is expected. Major production facilities, for instance in microelectronics, will have to be replaced by a new generation of plants, and the decisions on future production locations are open. It is unclear whether locations in Europe will still be able to win these large-scale

investments in ICT production facilities, and under which conditions they may be in a position to win them. In more general terms, this raises the question whether Europe, in recognition of global fragmentation, should concentrate on moving towards "Quadrants I & II", i.e. towards the provision of highly knowledge-intensive goods and services and give up on scale-intensive, but less knowledge-intensive production activities, or whether it should try to maintain production in Europe.

In this context, it is important to take a look at the possible division of labour between different locations in Europe along the production chain. The member states of the European Union play very different roles in the process of internationalisation. Some of them, i.e. the new member states of the EU10, offer considerable cost advantages to investors. It is also reported in the literature that manufacturing unit labour cost are only a third or a fourth in the Czech Republic, Poland or Hungary compared to France or the UK. The difference to Germany, Finland or Belgium is even higher. Compared to South-east Asia, however, unit labour costs are quite similar in the EU10, while the EU10 countries enjoy some other locational advantages, like a more favourable business environment as compared to Eastern Asia. The key concern with respect to the EU10 countries must be seen in the temporary character of their labour cost advantages, assuming – and hoping – that they will catch up with the EU 15 in GDP/capita and wage levels in the foreseeable future. However, the wage gap has been closing only slowly over the past ten years, and it is likely to continue to be like that for several years to come.

There seems to be little doubt that in view of the fragmentation and life-cycle considerations along the value chains in ICT, Europe must concentrate on highly knowledge-intensive activities in particular on services. The global division of labour along these value chains implies that high-tech ICT manufacturing is not a pre-condition any more for providing corresponding knowledge-intensive services. There may still be certain niches where production facilities in Europe are economically viable, for instance due to their high knowledge-intensity, their specialised character or the need for close collaboration with users. With respect to scale-intensive production (which are located in Quadrant IV), the exploitation of wage differentials in Europe, which are likely to persist for at least one generation of ICT production facilities, offers an opportunity to maintain also some of these production activities in Europe. For RTD policy this implies that it should pay much stronger attention to research and innovation in services, and that it should seek a new balance with funding opportunities directed to innovation in production.

Inward and outward foreign direct investment – a matter of general economic conditions rather than of specific incentives

Measures to improve the attractiveness for foreign direct investments in ICT are a key issue in ICT policy-making, and there is a controversial debate on the need (or not) for specific incentives. If successful, public subsidies for FDI promise a high return on investment. However, as a guiding principle, there is only little justification for an active policy that tries to attract foreign investment by means of financial incentives. The theoretical literature comes to the conclusion that, in the absence of externalities and market failure, a division of labour not affected by distortions from public policy is likely to en-

sure the highest welfare for both host and home countries. Moreover, since there is no clear empirical proof that FDI incentives work, such measures may rather be a transfer of taxpayer's money to MNEs than an effective instrument to promote growth. A third concern against active policies of this kind is that they may lead to prisoners dilemma-like situations between EU governments competing against each other for investments.

There seems to be no need for specific measures to attract foreign R&D, either. First, empirical evidence as well as theoretical insights suggests that overseas R&D investments follow FDI to a large extent. Second, we know that R&D is attracted by scientific excellence and stable framework conditions. Measures to foster domestic R&D and innovation in Europe mentioned above will therefore also attract foreign R&D units. A special policy designed at foreign firms or other "positive" discrimination does not appear to be appropriate and may even not be possible due to international agreements and EU treaties. Instead of special FDI incentives, governments should rather concentrate on improving business conditions for all, foreign and domestic enterprises. The literature highlights the importance of a healthy business environment, social cohesion, macroeconomic stability and the access to large unified and growing markets for attracting FDI. In the competition with the most knowledge-intensive locations for FDI, especially the US, soft factors (e.g. flexible labour regulations, low administrative burdens, etc.) seem to play an important role next to the access to scientific excellence in institutional and human resource terms. Only countries that offer such favourable conditions are also attractive to foreign enterprises. Such framework conditions are one of the locational advantages of European countries like Ireland, Hungary, or the Czech Republic as compared to Asia. And compared to the US they are offered by some leading locations in Europe, for instance in the Scandinavian countries, in Germany, the Netherlands, France or Belgium. Measures aiming at improving these general conditions for doing business will benefit both foreign and domestic enterprises.

Past experiences have also shown that foreign investment is not necessarily bound to stay. The next generation of investments may easily go elsewhere if better conditions are offered. The key issue for making foreign investments sustainable is thus whether mechanisms can be devised to ensure that these investments can be "rooted" in the local innovation and production system. This is also an important pre-condition for enabling benefits from spill-over effects.

Excellent conditions for conducting research and knowledge-intensive services

A key factor not only with respect to foreign investments and their rooting in the local innovation and production system, but also to support a general strategy of moving towards Quadrant I, consists of the provision of excellent conditions for research and knowledge-intensive ICT-services.

Attention should be paid to the supply of creative science and engineering staff and to the promotion of research, technology development and innovation. This is crucial in several respects; first, R&D can create new comparative advantages for Europe; second, we know that the scientific and technological capabilities and capacities of a country are an

important determinant for FDI inflows. Ensuring attractive conditions in these two respects is a key responsibility of governments in the context of internationalisation processes. The European Commission contributes to the development of Europe's creative potential by the Framework Programmes, by its efforts to create a common European Research Area and by the benefits of the Structural Funds. Since private investment in – mainly applied – ICT R&D considerably exceeds public expenditures, government funding should be concentrated on well-defined target areas where the market or system failure arguments apply. This holds in particular for basic research and education in ICT (i.e. two functions associated with universities and certain research organisations in most European countries), but also for R&D activities that are geared towards the creation of new, knowledge-intensive services.

Government R&D funding could also be justified in R&D areas where government exerts a strong influence through its demand and procurement function, i.e. as a "leading user" and customer of ICT-products and services. Supporting the creation of markets in Europe by means of innovation-oriented public procurement is also one of the inroads that have been highlighted in a recent report of an EC expert group.

Excellence is more than a matter of funding and skills; it also concerns the institutional conditions in the research and innovation system. As shown by the current situation of the EU 10 countries, investment in ICT must be "locally embedded" and "rooted" in the local economic and institutional tissue. The availability and continuous upgrading of skills and capabilities of the local labour force, as well as the promotion of excellence in research are conducive for ensuring the local embeddedness of investments in ICT. It can be further strengthened by the provision of products and services that are tailored to local demand, or when an interesting combination of factors coincide (like e.g. in the cluster approach). Otherwise, there is a risk of offshoring of investments after a few years, for instance when labour costs in the EU10 have increased in comparison with Asian locations. Policy should thus pursue a system-oriented approach that supports the embedding of ICT investments by a range of instruments: R&D policy, institutional framework conditions, labour market policies, human resource development, etc.

Ensuring access to and exploitation of knowledge worldwide

Of particular importance to avoid offshoring of highly knowledge-intensive ICT activities is the strengthening of ties between domestic firms and research organisations and the best sources of knowledge worldwide. This is not only important for keeping foreign firms in the country, but also to enable spill-over effects from foreign firms (which tend to perform better in many respects than domestic ones) to the local economy. As shown by the patent analysis, the ties in ICT R&D are increasingly strengthened between the US and Europe, whereas the activities in Asia seem to be less interlinked with the main knowledge sources in the US and Europe. This indicates that the global R&D hotspots are still in Europe and the US, and they are characterised by a high degree of complementarity. European firms tend to rely strongly on their local knowledge sources, whereas US firms are better at tapping knowledge sources outside the US.

However, access alone is not enough; it is the economic exploitation of global knowledge that matters for growth and employment. In this respect, US firms still seem to have an advantage. Alliances between EU and US firms at the leading end of R&D are thus a double-edge sword: both sides benefit from the access to the best knowledge sources in the world, but they don't equally exploit this access. For policy this implies that measures at least should not hinder the linkages between European organisations and knowledge sources outside of Europe. In addition, measures should be taken to increase the absorptive capacity for new knowledge and hence the probability of spillovers from knowledge acquisition in order to benefit from R&D alliances or from the presence of foreign firms in a country.

Fostering the responsiveness of institutions and innovation systems to the dynamics of ICT

The analysis in this report has shown that ICT is a highly dynamic area of techno-economic development, characterised by a fast pace of change and highly mobile enterprises and investors. If Europe is to keep pace with these dynamics, it will have to ensure that its institutions and key organisations in the area of ICT are sufficiently flexible to adjust to fast-changing circumstances. This implies that they need to frame the development towards Quadrant I and II type of activities and be more open to ICT-based knowledge-intensive service activities.

This argument applies first of all to universities, higher education institutes and research organisations which are central for both R&D and the training/skills development in line with the re-orientation of ICT in Europe. Moreover, well-functioning labour markets are essential for adjustments of the industrial structure. The benefits from an increasing division of labour can only be gained when structural change can happen fast, and workers smoothly move from one sector to the other (stressing once again the training and re-training issue).

Policy, however, will also have to provide some safety nets and a redistribution of factor incomes resulting from internationalisation to compensate for losses from internationalisation. Although the majority of studies finds no or a complementary relationship between home country employment and international activities, it is almost certain that there will be losers of the restructuring process. Upskilling and retraining will undoubtedly turn into a major issue in the course of this process, and policy will have to support this process by enhancing flexibility in labour markets and implement education and training schemes.

However, not all ICT jobs in Europe will be highly knowledge-intensive, and there need to be perspectives for the less skilled, too. Although there will continue to be Quadrant III and IV jobs in Europe in the future, these areas are not likely to turn into major “job-machines”. Even so, the remaining jobs of this kind will be essential for offering an employment perspectives to those who will not be able to follow the inevitable upskilling process towards high levels of knowledge-intensity.

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Abstract

This report provides a synthesis of the results of a research project on the Internationalisation of European ICT Activities. It starts by overviewing the theoretical frameworks applicable, then proceeds to evaluate available evidence based on trade, foreign direct investment and patent data. This macro-data is followed by micro-data supplied by case studies. Finally, the report draws conclusions and makes suggestions for policy.

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