Mapping the ICT in EU Regions:
Location, Employment, Factors of Attractiveness and Economic Impact

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Foreword

The present study is based on two premises: On the one hand, the renewed Lisbon strategy has emphasised the need to boost growth, competitiveness and cohesion throughout the EU. On the other hand, Information and Communication Technologies (ICT) have been shown to be at the core of growth and productivity dynamics over the past decade.

There is also a growing perception of the fact that ICT strongly determine the way EU regions keep pace with, and possibly benefit from, the globalization process. However, when looking at the existing literature on the location of ICT industries in EU regions and on the impact of ICT investment on regional growth and cohesion, there is very little evidence available.

This study therefore aims to <u>bridge the gap between policy concerns and existing empirical evidence at regional level</u> by:

- mapping the regional location and related recent dynamics of the ICT industry,

- analysing the regional employment of the European ICT industry,

- assessing the attractiveness of European regions for ICT-related FDI, and

- providing empirical evidence on the impact of ICT on regional growth and convergence.

This study has greatly benefited from discussions and inputs received at different stages of its inception. In particular, the discussions and presentations made at a Workshop organised by IPTS and the University Pablo de Olavide of Seville in June 2006 on "ICT and Regional Development" have greatly encouraged the authors to undertake further research in the area. The study has also benefited from comments received from the participants in an IPTS internal workshop organised in June 2007. The authors wish to thank in particular Marc Bogdanowicz (IPTS) for his active support during this research.

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Executive Summary

The advent of Information and Communication Technologies (ICT) has engendered intense public discussions over the past few years, in both policy and academic circles. In particular, the renewed Lisbon strategy has emphasised the need to boost growth, competitiveness and cohesion throughout the EU. The differing contribution of ICT to economic growth between the US and the EU is often mentioned as one of the main causes of the diverging growth performance of these two areas since the mid-1990. Factual evidence suggests that ICT-led growth is strongly localised geographically. For instance, references in the press and media to the astonishing economic performance of Silicon Valley, Dresden and Bangalore, to name a few, have become common place. It follows that regions are increasingly considered to be the natural dimension in which the ongoing transformations and structural/technological changes enabled by ICT should be observed and understood.

From a policy perspective, the evolutions mentioned above raise important prospective issues of direct relevance for the European Union. In particular, there is an increasing awareness of the need to adopt, together with country-level initiatives, regional policies. As the nature of ongoing technological change and innovation dynamics has a strong local/regional component, public policies need to be designed at this level as well. However, little is known - if anything - of the regional impact of ICT.

The objective of the present study is to document the regional impact of ICT by mapping the location of the ICT industry in the EU25, analysing the volume and nature of ICT employment across European regions, identifying the determinants of EU regions' attractiveness for ICT business location and, finally, assessing the contribution of ICT investment to regional growth and convergence.

The main results can be summarised as follows:

The study shows that the ICT industry tends to be concentrated geographically in an arc that extends from the South of the UK, and continues through the Benelux countries, the North of Italy, South of Germany to the Île de France region. ICT activities have also tended to play a very important role in the industrial specialisation of these regions. Recent changes in employment and the rise in skilled employment in the ICT sector is strongly governed by the fast growing ICT Computing Services sub-sector (Nace 70). Interestingly, while this sector also tends to be located in the richest EU regions, the EU has also witnessed over the past decade the emergence of regional clusters in the Madrid region, in particular, but also in the South of Scotland, Ireland, the South of Finland and the Western regions of Sweden, as well as some regions in the EU10, generally located around the capital cities. In addition, the decrease in employment in the EU ICT manufacturing sub-sectors has translated into marked increases in the *proportion* of skilled workers in the richest EU regions. This difference has not been compensated by an equivalent increase in employment in the EU10, where, additionally the nature of employment also denotes a lower skill-content.

Since 2000, a growing number of multinationals have located subsidiaries in the EU10, whereas before then multinationals tended to favour locations in regions in the UK, Ireland, Holland and Germany. Here again, ICT evolutions are largely governed by the booming ICT Computing Services sub-sector. For this specific sector, the ICT poles identified earlier have been the most attractive for foreign investors. A number of factors appear to be especially influential for attracting multinationals such as the level of regional GDP, the degree of industrial specialisation, the level of

education and the density of ICT SMEs established in a particular region. The level of industrial specialisation appears to be particularly important in the case of the Computing Services industry while the presence of ICT SMEs appears to be more influential for ICT manufacturing. These results tend to reinforce the idea that the impressive growth of the ICT Computing Services sub-sector has, on the whole, been localised in regions already highly specialised in Computing Services.

Turning to the impact of ICT investment on regional convergence, the present study provides a number of novel and potentially important results by considering the specific case of Spanish regions. The reason why the study focuses on Spain is related to the fact that reliable data on ICT investment by region has recently been made available for this country while, to date, no such comparable data was available in other EU countries. The literature and existing evidence suggest that the economic benefits of ICT are more likely to take place in countries (and regions) highly specialised in ICT-producing industries. Given the predominance of the Madrid region in the Spanish ICT industry mentioned earlier, one would expect a much more pronounced impact of ICT diffusion on economic growth in this specific region and that ICT would not necessarily contribute to greater regional convergence in Spain. Despite this, our results show that ICT investment appears to have contributed significantly to regional convergence despite the great spatial concentration of the Spanish ICT industry around Madrid.

The results obtained in this study provide a number of important policy implications. The study has provided evidence for the role played by the Computing Services sector in recent employment and skills' changes in the ICT industry, as well as for the emergence of new regional growth poles in the EU. Departing from traditional business models, this sector of activity presents relatively low sunk costs, especially in terms of physical capital requirement while having strong innovative and skills content. Low sunk costs, in particular, tend to shift the allocation of available resources towards investment in human capital and innovative capability. In order to meet the challenges of improving productivity and competitiveness, Europe should play to its strengths. It should develop existing growth poles and favour the emergence of new ones as shown, for instance, by the emergence of new ICT-service poles such as Madrid, the South of Ireland and the North of Scotland. These regions are good examples of the potential offered by ICT service activities and also of the role played by labour skills in the emergence of growth poles.

Certainly, infrastructure remains a key point – specifically, telecommunication infrastructure – for promoting regional development of innovative ICT activities. However, future cohesion policy programmes should consider a shift in the relative importance and nature of measures to be taken. At the same time as they promote infrastructure, they should also promote ICT labour skills and the use of ICT by SMEs as these factors can improve the attractiveness of European regions, especially as regards foreign direct investment.

Finally, our results concerning the impact of ICT investment on regional convergence provides a number of novel results which are of direct relevance for policy making, especially as regards the EU cohesion policy. In particular, the study shows that ICT capital tends to promote regional economic convergence. Regional policies aiming to promote regional cohesion must therefore consider ICT diffusion as a potentially important tool for the promotion of convergence throughout the EU. However, policies promoting ICT diffusion cannot be considered as stand-alone policies. In particular, education and skills play a very important role. The study also shows that the absence of high ICT specialisation, as in the case of most regions analysed in the Spanish case study in this report, should not be seen as a major barrier to promoting the impact of ICT on regional development.

Introduction

The advent of Information and Communication Technologies (ICT) has engendered intense public discussions over the past few years both in policy and academic circles. These discussions have focused on two main issues. First, the differing contribution of ICT to economic growth between the US and the EU is often mentioned as one of the main causes explaining the diverging growth performance of these two areas since the mid-1990s. The second issue concerns the key role played by the ICT sector in promoting technological change and innovative capability. Here again, the EU appears, in general, to lag behind the US, and is also increasingly facing competition from other parts of the world, most noticeably from a growing number of Asian countries such as Japan, China and Korea, among others.

ICT determine the way economies position in the globalization process...

Both ICT-diffusion and ICT-production are, therefore, believed to play a key role in the future of EU economy competitiveness. More generally, there is growing perception of the fact that ICT strongly determine the way our economies and societies keep pace with, and possibly benefit from, the globalization process.

In turn, factual evidence suggests that ICT-led growth is strongly localised geographically. For instance, references in the press and media to the astonishing economic performance of the Silicon Valley, Dresden and Bangalore, to name a few, have become common places. They are depicted as success-stories of regions able to reap substantial benefits from ICT diffusion and globalisation. It follows naturally that regions are increasingly seen as a natural dimension to consider in order to observe and to understand the ongoing transformations and structural/technological changes being enabled by ICT. When considering the location of ICT industry in the EU more specifically, this sector appears to be highly concentrated, in most cases in the richest EU regions. However, because of the increased international competition, certain EU regions specialised in ICT activities do face external competition more directly, particularly in the case of regions specialised in tradable ICT goods, such as manufacturing ICT sub-sectors and a growing number of ICT service activities. Furthermore, the economic benefits of the rapid diffusion of ICT tend to be still largely localised in the EU. Indeed, ICT adoption and productivity impact has been especially vigorous in certain Member States (e.g. Ireland, Finland), while this effect has still not materialized in most EU countries, see van Ark and Inklaar (2005).

...and factual evidence suggests that ICT have a strong regional dimension

The policy challenge

From a policy perspective, the evolutions mentioned above raise important prospective issues of direct relevance for the European Union. In particular, there is an increasing awareness of the need to adopt, together with country-level initiatives, regional policies given that the nature of current technological change and innovation dynamics have a strong local/regional component such that public policies need to be designed at this level as well.

From a policy perspective, the regional dimension of ICT is becoming increasingly relevant...

In particular, following the i2010 Communication, information and communication technologies are seen a *"powerful driver of growth and employment and...differences in economic performances between industrialised countries are largely explained by the level of ICT investment, research, and use, and by the competitiveness of information society. ICT services, skills and content are a growing part of the economy and society."*

These objectives have been embedded into a wide range of EU policies. For instance, in the new Cohesion Policy programmes, Member States are increasingly encouraged to use structural and cohesion funds in pursuit of the Lisbon strategy in general and the promotion of Information Society, see, in particular, the Community Strategic Guidelines on Cohesion policy for 2007-2013, European Commission (2005). The inclusion of the i2010 objectives is also being made effective in the Integrated Guidelines used to monitor the implementation of the Lisbon strategy through the National Reform Programmes (NRPs). The recent assessment made by the European Commission on the i2010 initiative acknowledges that Europe is making sustained progresses in ICT diffusion. However, this assessment also suggests that ICT diffusion is far from having fulfilled its potential in terms of productivity and growth performance, see EC (2007).

...however, little is known about the impact of ICT on regional economies

Research questions

The Study deals with three research questions:

When considering existing empirical evidence, one must admit that little is known on the regional impact of ICT as well as on the location of ICT industries across EU regions. The opportunity to address these issues from a research viewpoint are, therefore, also highly relevant.

 A number of possible angles of research can provide valuable insights. As suggested above, the location of ICT-producing industries does matter for global competitiveness and long-run growth potential. Indeed, even when considering the world economy, ICT industries appear to be concentrated in a limited number of regions. A first objective of the present study will be therefore to document the location of ICT-producing industries in European regions in order to map existing EU clusters as well as to analyse recent changes in these industries. In particular, one question concerns the change in the geography of EU ICT industry after the 2004 enlargement. Furthermore, it is important to gather information about the nature of ICT activities undertaken across the EU regions, making the distinction for instance between R&D and lower-skilled types of activities. Qualified workers are also usually considered as more productive and better equipped to absorb fast technological changes which characterize ICT activities. In particular, ICT sub-sectors do have heterogeneous features in terms of human capital and knowledge content which are especially pronounced, for instance, in the case of the semi-conductors industry. Given the positive association between knowledge intensity, innovation and long-run growth, one may therefore expect that different types of ICT activities have different impacts in terms of regional development.

...Agglomeration economies: the study provides a mapping of ICT activities together with their skills-characteristics across EU regions...

As suggested earlier, the advent of ICT in the economy goes along with the globalisation process. Indeed, technological change and the increase in international trade and direct investment flows across countries are closely related. The case of the semi-conductors industry is, here again, illustrative of the international division

of labour which takes place at a global level with the off-shoring of large spans of the production process to low cost production sites and the (re-)distribution of R&D activities between multinationals' affiliates located in different countries. More specifically, multinationals, when considering alternative location choices, often compare alternative regions located in different countries in order to organise their production process. All regions do not share the same characteristics, for instance in terms of labour force qualification or access to markets.

It follows that the analysis of ICT industries location across EU regions should also aim to identify the determinants of the location of ICT multinationals in order to understand the determinants of regions' attractiveness for foreign investors. We will see that the availability of local providers, often represented by ICT SMEs, are particularly important to assess the relationship between multinationals' global choices and the regional dimension.

...Regional Attractiveness: the study assesses EU regions' attractiveness for ICT multinationals' location and its link with SMEs...

Finally, as noted above, the impact of ICT cannot be limited to the study of ICT sector only. What also matters from an economic viewpoint, is the impact of ICT diffusion on economic growth and productivity differentials, the latter being at the heart of global competitiveness. The report therefore considers the impact of ICT diffusion on growth and productivity at a regional level. Importantly, this type of study has only been undertaken in a limited number of countries and, to date, never been performed at the regional level. We will consider a case-study, namely the Spanish regions. Novel results are provided, which are potentially very valuable for EU regional policy given that it documents the role of ICT investment in promoting regional growth and convergence, alongside other factors such as infrastructures and labour skills.

...Economic Impact: the study provides evidence on the impact of ICT investment on regional growth and convergence

The report is organised as follows. Section 1 reviews the main theoretical arguments as regards to the impact of ICT on regional economies. Section 2 provides a description of the location of the ICT sector and the nature of ICT activities in the EU 25 regions. Section 3 explores the issues related to regional ICT employment and skills. Section 4 deals with the attractiveness of EU regions for ICT multinationals. Section 5 provides empirical evidence on the impact of ICT investment on regional growth and convergence. Section 6 summarises the main results and provides a number of policy implications as well as future research objectives.

1. ICT and regional development: main theoretical arguments

The present Section provides a review of the main theoretical arguments concerning the role played by the location of economic activities for regional development, taking into consideration the case of the ICT sector. The Section then considers the elements that influence the attractiveness of regions in terms of ICT business location. Finally it considers the impact of ICT from a user-side approach by looking at the influence of ICT investment on regional growth and convergence.

1.1.1. ICT industries, regional development and the knowledge economy: location (still) matters

It has been recognized for long that economic activity is unevenly distributed across space, see, for instance, Fujita and Thisse (2002). There is plenty of similar evidence for a diversity of regions in the world, for instance, the so-called Blue Banana in Europe,[1] the Manufacturing Belt in the US, industrial districts in Italy, see Pyke et al. (1990), Route 128 and Silicon Valley in the US, see Saxenian (1996). Understanding industrial concentration in Europe is of substantial importance for a number of reasons. In particular, over the past decade, European integration and the successive enlargements of the European Union have fostered the need to better understand production patterns across EU countries and regions and their geographical re-distribution together with the process of economic integration, see in particular Barry and Curran (2004) for a study concerning the impact of EU 2004 enlargement on the location of the ICT manufacturing industry. Additionally, this period has also witnessed a deepening of global economic integration with the emergence of a growing number of competing economies worldwide with direct consequences for the European economic structure and competitiveness, see in particular, the recent study by Belessiotis et al. (2006).

Common belief suggests that ICT is disrespectful of physical distance …

Common belief suggests that ICT is disrespectful of physical distance and geographical barriers and transportation costs are becoming less relevant, see Quah (2000). Some argue this might bring the *"death of distance"* as advocated by Cairncross (2001). But theoretical contributions in geographical as well as urban economics provide a number of explanations as to why agglomeration of economic activities still occurs. The main arguments can roughly be classified according to so-called Marshallian externalities.[2] More specifically, Marshall's first theory claims that the existence of scale economies in the inputs production could induce firms to locate close to their inputs. Elaborating on Marshall's concept, the New Economic Geography literature stipulates that also input-output linkages, alongside increasing returns, may give firms an incentive to locate near markets and suppliers in order to

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[1] The part of Europe concentrating most of the industrial activity is called in the literature the "blue-banana of Europe", i.e. the area going from the South of the UK, the Benelux and Denmark, the French region of Ile de France, the Western regions of Germany and the North of Italy.

[2] For a survey, see Duranton and Puga, 2004.

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save on transport costs, where market-size effects expand in a self-reinforcing process of agglomeration (see Fujita and Thisse, 2002). Labour market pooling may also be an agglomerative force because industrial agglomeration should encourage the formation of thick local labour markets so that employees' skills could match more easily employers' requirement and vice-versa (see Helsley and Strange, 1990, and Monfort and Ottaviano, 2000). Finally, knowledge spillovers could lead to agglomeration because they can generate externalities that are bounded geographically, increasing the productivity of firms in the region where the new economic knowledge is created. Firms may thus locate where they are likely to learn from other firms (see Henderson 1974, 1988, and Glaeser 1999).

Hence, the issues at stake are likely to be more complex than the mere vanishing of the influence of geographical distance on the location of economic activities in general and ICT industries in particular. More specifically, the implications of ICT diffusion on the location of economic activities are yet to be better understood. In fact, it is more likely that ICT diffusion is altering the very definition of *"distance"* from an economic viewpoint, shifting from an almost exclusively spatial/infrastructural dimension to a composite of conditioning factors including immaterial components such as human capital, innovative capabilities, etc. see in particular, Venables (2001).

The above discussion points at two major research questions: does agglomeration of economic activities still occur, and if so, do the dynamics of agglomeration change and why. The present report offers new insights into those questions.

1.2. What determines the attractiveness of regions for ICT business location?

The development of ICT is now in a phase where main technological inventions (micro-processors, software, internet…) have given rise to ever growing innovations and technological changes, characterizing the deployment phase of ICT, see Perez (2002). During this phase, the widespread use of ICT is likely to give rise to a growing and self-reinforcing number of applications, with direct incidence on economic activity both in terms of overall economic growth but also in terms of economic efficiency (productivity), see Varian et al. (2004). For this very reason, these authors ascertain that ICT-related innovations tend to spread much faster and allow creating new applications much quicker than during previous periods of intense technological change.

Although these characteristics were shared by previous technological revolutions, they are often considered as exacerbated in the case of ICT and tend to strongly influence the location of ICT businesses activities. In particular, intangible components such as knowledge and technological spillovers which go along ICT deployment, do not face the same constraints as traditional physical components such as intermediate products and capital, and can be thought as directly influencing economic efficiency and potentially change the determinants of the location of economic activities.

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ICT-related technological changes may involve production process and firm-organizational changes. These are likely to concern consumer and suppliers relationship and tend to blur traditional market organization both for intermediate and final products and services. For instance, Klier (1999) provides evidence for the fact that the introduction of just-in-time production methods in the automotive US industry has propitiated the agglomeration of intermediate suppliers close to production centres. One explanation put forward by the authors is that the implementation of just-in-time method made possible with the generalisation of ICT use has in turn provoked a relative rise in time costs. The reduction in time costs in turn legitimates the clustering of producers along the production chain.

Because of the specific characteristics of ICT industries, the determinants of business location in ICT industries are also likely to be strongly influenced by intangible assets.

Another ICT-led production location change is exemplified by the development of call-centres in EU countries, see for instance, Beekman et al. (2002) who look at the location of call-centres in the Netherlands and find that local labour market characteristics (in terms of skills) do interact with technological change and, in turn, influence the location of economic activities. In the case of ICT-producing industries and, more specifically, the manufacture of semi-conductors, the need for customized services and the ability to run cross-border production systems in real time, has led to off-shoring of large spans of the production process to low cost producers, leading in turn to substantial changes in business models and concentration of high-value added stages of production, generally in developed countries, see for instance, Sackett et al. (2005) and Hung et al. (2006).

Such examples illustrate that the ICT sector presents specific features that make business location a relevant research topic. In particular, the predominance of knowledge and other intangible assets over the value chain and production of goods and services, has important implications for the structure of production costs and regional attractiveness for ICT business location. In particular, many ICT service activities are intensive in human capital such that production costs are especially influenced by the availability of qualified workers rather than the need to undertake heavy (physical) investments. For instance, software development has spurred a type of business model that focuses mainly on offering consulting and client-tailored software services and require mainly highly qualified work force and relatively low sunk costs. This makes, on the other hand, ICT services relatively less intensive in physical capital such that human capital becomes the primary factor explaining the development of this type of activities. The latter characteristic in particular, makes the development of ICT activities a potentially good candidate for promoting regional development.

In particular, many ICT service activities are intensive in human capital such that production costs are especially influenced by the availability of qualified workers rather than the need to undertake heavy (physical) investments

More generally, the different intensity in human capital and physical capital between ICT services and manufacturing activities may have important implications for regional development. Indeed, economic research has provided empirical evidence concerning the fact that differences in access to capital (i.e., to finance private investment) is seen as an important element behind persisting regional differences in economic development, see in particular, Guiso et al. (2004). As ICT service activities depend very much on the availability of skilled workforce, one may expect that the constraint related to access to capital be less binding for these types of activities than in the case of manufacturing activities where physical capital intensity is higher.

Such views invite for investigating the changing factors of attractiveness for the location of ICT industry, in particular in the service activities. The present report addresses such questions.

1.3. The impact of ICT investment on regional growth and productivity differentials

Recent estimations data provided by the Groningen Growth and Development Centre (GGDC) suggest that, while the combined contribution of ICT assets to total output growth of the economy has been equal to 0.55 percentage point between 1995 and 2004 in the EU, this contribution has been approximately double in the US during the same period with a 1.1 percentage point contribution. These figures also appear to explain to a large extent the differing growth performance since 1995 between the US and the EU.

From a research perspective, the evidence on the role played by ICT diffusion on regional growth and development is still scant, not to say inexistent

There are a number of reasons to believe that ICT diffusion is likely to have different impact on productivity and growth depending on the region considered. Two main factors can be put forward. The first factor is represented by differences in industrial specialisation and takes as starting point the idea that technical progress takes place mainly if not only in the high tech sectors of the economy, see Barrios and Burgelman (2007). Here technological progress is embedded in ICT diffusion in economic activity. Accordingly, one should expect that the higher the share in regional output of ICT producing industries, the higher will be the impact on economic growth via multifactor productivity[3] improvements. The second factor is represented by ICT capital accumulation, the hypothesis being that not all forms of capital have the same impact on economic growth. In particular, recent empirical studies on economic growth have focused on the importance of distinguishing between ICT and non-ICT assets, see, for instance, Jorgenson (1995). Accordingly, those sectors with the largest shares of ICT on total capital should experience also the largest productivity gains. Regions hosting a relatively high proportion of such ICT-intensive industries[4] should then experience higher economic impact from ICT diffusion.

The present study provides new evidence on the impact of ICT investment on regional convergence by considering the specific case of Spain

From a research perspective, the evidence of the role played by ICT diffusion on regional growth and development is still scant, not to say inexistent. The main explanation for this is related to data availability. This issue was also, until recently, seen as the main impediment for cross-country studies on the impact of ICT on growth and productivity.

Recently, a number of countries has undertaken to gather data on ICT investment (including, in general, software, hardware and communication equipment), see Jorgenson (2005). In a recent research programme under the European commission Sixth Research Framework Programme, EU KLEMS, comparable data on ICT

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[3] Multifactor productivity: measures the changes in output per unit of combined inputs. Indexes of Multifactor productivity are produced for the private business, private non-farm business, and manufacturing sectors of the economy.

[4] ICT-intensive industries: those sectors, such as banking, telecommunications, wholesale and retail, etc.. that show to have important ICT investments, see Mas M., Quesada J. (2005 c) for a taxonomy

investment and productivity has been provided for a number of countries.[5] Unfortunately, however, no such data is available at the EU regional level.

Because of the lack of EU-wide comparable data at regional level, the focus of the present study is made on a specific case-study, namely the Spanish autonomous regions. As explained in Section 5 good-quality information is available on regional investments in ICT in Spain and this makes it a unique case-study at the European level in order to analyse the impact of ICT diffusion on regional growth and convergence. This also makes the report presented here the first one of its type to be undertaken at the regional level.

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[5] See http://www.euklems.net/ for more background information and data.

2. ICT industry location and regional specialisation in the EU

2.1. Main results

- The present Section shows that the ICT sector, and, in particular ICT services, is highly concentrated spatially. High-tech sectors are generally more concentrated spatially given the importance of knowledge and technological spillovers in shaping their spatial distribution. The fact that the ICT sector is more spatially concentrated than other sectors of activity then comes as no surprise. However, the fact that ICT services are even more concentrated spatially goes rather counter common belief given that services are generally found to be more spatially dispersed than manufacturing. This result suggests therefore that knowledge-related agglomeration economies could possibly be especially important in the case of ICT services. Further causality analysis is needed, however, in order to verify this assumption. Such analysis is undertaken in Section 4.

  ICT sectors, and, in particular ICT services, are highly concentrated in the richest EU regions.

- Employment in the ICT sector tends to be rather concentrated geographically around the so-called blue-banana of Europe, i.e. the area going from the South of the UK, the Benelux and Denmark, the French region of Ile-de-France, the Western regions of Germany and the North of Italy. The ICT sector appears to play a very important role in the specialisation of the richest regions which are also essentially located in Western EU countries (the so-called EU15 countries). The results also show that the emerging ICT-clusters in the EU10[6] still do not match EU15 specialisation levels.

- The regional dimension is the most important one when considering recent changes in ICT employment. This is especially true for the fast growing ICT computing services sector: some additional regions are emerging such as the Scottish and Irish regions, the Madrid region, the South of Finland and Western regions of Sweden as well as some regions located in the EU10 such as Malta, Kozep-Magyarorszag (HU), Mazowieckie (PL) and Praha (CZ).

  The regional dimension is the most important in order to describe recent employment changes in the EU ICT sector

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[6] EU10: in this report we will refer to the ten Member States that joined the European Union on May 1st, 2004 as EU10. Those countries are: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovenia and Slovakia. The EU15 are the other 15 Member States, composing the Union until that date. Together, EU10 and EU15 countries compose the EU25. Data on Romania and Bulgaria was not made available at the time of the study.

2.2. The location pattern of the ICT sector across EU regions

2.2.1. Location pattern: country-level evidence

We consider first national figures in order to get a broad overview of the structure of the ICT sector in the EU25. In particular, since the membership of the EU10 in May 2004, a number of interesting evolutions have come into play that are worth bearing in mind in order to understand regional features.

Table 1 below provides a first overview of the employment structure of ICT subsectors at country level for the years 1995 and 2004.[7] Overall, a substantial share of total ICT employment is created in the EU15 given that 88.3% of total employment is located in EU15. This proportion has also tended to increase slightly over the period 1995-2004. The share of ICT employment in the EU10 slightly decreased over the same period going from 12.6% in 1995 to 11.7% in 2004. Two observations are worth making when comparing the EU15 and the EU10. First, the decrease in the proportion of employment in the EU10 is a reflection of an overall decrease in the percentage of employment in the EU10 when considering all sectors of the economy. Indeed, the decrease in percentage experienced by the EU10 is less pronounced in the ICT sector compared to the rest of their economy. The period considered here indeed covers a period of intense economic restructuring in the EU10 and the ICT sector has been no exception to this process, although the ICT sector seems to have suffered less than the rest of the sectors. Interestingly also, the EU10 tend to have gained employment shares in the manufacturing ICT sub-sectors, with the exception of the sector Medical, precision and optical instruments (Nace 33) This applies above all for countries such as Hungary, which percentage in sub-sectors such as the manufacture of Office, Machinery and Computing has risen from 3.9% of total EU employment in 1995 to 9.4% in 2004. The same can be said also, to some extent, for countries such as the Czech Republic, Malta and Slovakia, among others. For the ICT service sub-sectors, employment is still largely located in the EU15 countries and countries such as the United Kingdom, the Netherlands, Germany and Spain have slightly increased their percentage of employment on these sub-sectors.

Above all, the figures displayed in Table 1 suggest that a number of important changes have come into play in the EU ICT industry. In particular, ICT manufacturing sectors have tended to lose weights in terms of total employment while the ICT service sub-sectors' employment has increased. These evolutions have not been shared by all countries though, in particular when considering the EU15 and the EU10, as some distinctive features between these two countries' group tend to emerge. As suggested in the introduction, it is worth analysing whether these changes have had distinctive features across EU regions given the nature of ICT activities.

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[7]   For details on data sources and/or methodological choices used in this section, see Appendix 2, Methodological Note 2.1, annexed to this report

Table 1: Share of EU25 employment across ICT sub-sectors, 1995-2004

	30. Office, Machinery, Computing		32. Radio, Television and comm.. equpt.		33. Medical, precision and optical instr.		64. Post & Telecom		72. Computer services		Total ICT sector		Total economy	
	1995	2004	1995	2004	1995	2004	1995	2004	1995	2004	1995	2004	1995	2004
Austria	0.6	0.7	3.5	3.0	1.7	1.7	2.2	1.9	1.0	1.5	2.0	1.8	2.0	2.0
Belgium	0.3	0.5	2.1	1.7	0.7	0.7	2.7	2.8	1.4	1.6	2.0	1.9	2.1	2.1
Cyprus			0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1
Czech Rep.	1.9	4.9	2.4	4.0	2.9	3.2	2.8	2.4	1.8	1.4	2.6	2.4	2.9	2.4
Denmark	0.9	0.8	1.3	1.1	1.6	1.6	1.5	1.8	1.6	1.8	1.5	1.7	1.5	1.5
Estonia	0.2	0.1	0.5	0.4	0.4	0.2	0.6	0.4	0.1	0.0	0.4	0.3	0.4	0.3
Finland	1.5	0.2	2.7	4.4	0.9	1.2	1.6	1.6	1.1	1.7	1.5	1.8	1.2	1.2
France	11.3	12.9	11.2	11.9	13.1	12.2	15.2	16.2	23.1	17.5	15.9	15.6	13.2	13.4
Germany	29.5	20.4	21.0	18.9	36.1	34.9	21.7	17.8	16.4	16.7	22.9	19.8	22.0	20.5
Greece	0.1	0.1	0.3	0.3	0.3	0.4	1.5	1.8	0.2	0.4	0.8	0.9	1.3	1.4
Hungary	0.6	3.9	2.1	9.4	2.0	2.0	2.6	2.2	0.8	1.2	2.0	2.6	1.9	2.0
Ireland	7.2	9.4	1.0	1.1	1.4	2.7	0.8	1.2	0.4	0.8	1.1	1.4	0.7	0.9
Italia	7.9	9.7	12.2	11.9	8.4	10.3	9.6	8.9	17.6	16.9	11.4	12.2	10.4	10.7
Latvia	0.0	0.1	0.7	0.2	0.1	0.2	0.6	0.6	0.1	0.2	0.4	0.3	0.5	0.5
Lithuania	0.3	0.2	1.2	1.2	0.4	0.4	0.6	0.7	0.3	0.3	0.6	0.5	0.8	0.7
Luxembourg			0.0	0.0	0.1	0.2	0.1	0.1	0.0	0.2	0.1	0.1	0.1	0.2
Malta	0.0	0.0	0.1	0.4	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1
Netherlands	2.0	2.6	5.0	4.4	4.5	3.7	3.4	4.0	3.5	4.6	3.8	4.1	3.9	4.2
Poland	1.9	2.9	5.9	3.4	4.8	4.3	6.4	5.9	1.5	2.0	4.8	4.0	6.6	5.5
Portugal	0.2	0.4	1.3	1.6	0.7	0.7	1.3	1.4	0.9	0.9	1.1	1.1	2.3	2.4
Slovakia	0.9	1.8	1.4	1.5	1.2	0.9	1.3	1.1	0.7	0.5	1.1	0.9	1.3	1.1
Slovenia	0.4	0.5	0.7	0.8	0.8	0.8	0.3	0.4	0.2	0.3	0.4	0.5	0.5	0.4
Spain	9.8	9.8	4.8	5.3	2.2	3.1	5.3	6.8	4.8	5.2	4.8	5.7	7.2	9.2
Sweden	1.9	1.5	4.5	3.5	2.8	2.6	2.9	3.0	3.4	3.5	3.2	3.1	2.5	2.4
UK	20.6	16.6	14.2	9.6	12.6	12.0	14.7	16.9	18.9	20.9	15.4	16.9	14.4	14.9
EU15	**93.8**	**85.4**	**85.1**	**78.7**	**87.3**	**87.9**	**84.6**	**86.2**	**94.3**	**94.1**	**87.4**	**88.3**	**84.9**	**86.9**
EU10	**6.2**	**14.6**	**14.9**	**21.3**	**12.7**	**12.1**	**15.4**	**13.8**	**5.7**	**5.9**	**12.6**	**11.7**	**15.1**	**13.1**
EU25	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Sources: EU KLEMS database and authors' computations

2.2.2. Location pattern: regional-level evidence

The Table 2 below provides a first idea about the degree of spatial concentration of ICT sub-sectors across EU regions. It offers two alternative measures of the spatial concentration of employment, namely the Gini index and the Theil index, where both indices allow for a comparison of the degree of spatial concentration of ICT employment across NUTS2 regions. For both indexes, the results support the hypothesis of high spatial concentration.[8]

Table 2: Spatial concentration of employment across EU25 NUTS2 regions and ICT sub-sectors, Gini and Theil indices, 1999-2004

	GINI INDEX		THEIL INDEX	
Sub-sectors	2000	2004	2000	2004
30. Manufacture of office machinery and computers	0.64	0.56	0.74	0.60
32. Manufacture of radio, television and comm..	0.54	0.55	0.52	0.56
33. Manufacture of medical, precision and instr.	0.54	0.53	0.52	0.49
64. Post and telecommunications	0.67	0.71	1.00	1.16
72. Computer and related activities	0.64	0.64	0.76	0.78
All ICT sub-sectors	0.60	0.61	0.77	0.81
All sectors of the economy (including ICT)	0.42	0.42	0.30	0.31

* Sources: Eurostat, Structural Business Statistics and Author's computation. Inequality measures are weighted by absolute levels of employment in each sector/region

The ICT sector appears to be more concentrated spatially than the rest of the sectors of the economy.[9] This result tends to support the fact that hi-tech sectors such as ICT tend to be more spatially concentrated than other more traditional types of activities, see in particular, Audretsch and Feldman (1996). The reason put forward by these authors is that agglomeration economies related to knowledge and technological spillovers are usually more pronounced in hi-tech sectors and therefore also likely to be more influential in order to determine the location of economic activities and to favour its concentration in very few locations.

The concentration of the ICT service sub-sectors runs counter common expectation as service sub-sectors in general do tend to be more spatially dispersed

The results of Table 2 show also that, among the ICT sub-sectors, the service sub-sectors (Nace 64 and 72) are the most concentrated, independently of the year considered. This result runs counter common expectation as service sub-sectors in general do tend to be more spatially dispersed, see for instance, Fujita et al. (1999). The reason to expect service sub-sectors to be more spatially dispersed is that

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[8] In our table, a Gini index close to 1 indicates high spatial concentration of ICT employment, while for the Theil index, the value can be slightly above 1 with the same interpretation. For a definition of the Gini and Theil indices, see Hale (2003). For the data, only two years are considered, i.e., 2000 and 2004, given that comprehensive data for the EU NUTS2 regions were available for these two years only.

[9] Strictly speaking though, one must consider this result as not really surprising given that we compare here the ICT sector with the overall aggregated total employment in the economy

services activities are generally non-tradable such that they tend to localise according to the spatial distribution of population which is also more dispersed than economic activity in general. The result shown here therefore suggest that agglomeration forces at play in shaping the geography of ICT activity mentioned above are likely to be more pronounced in the case of ICT services.

Map 1 below provides a visual overview concerning the spatial concentration of ICT activities in the EU25. This map shows the share of total employment in ICT industries as distributed among all NUTS2 regions for the year 2004 (the latest available year in the regional SBS (Eurostat)).

Map 1: Share in percentage of total EU ICT employment, by NUTS2 regions, 2004.

Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations

As can be seen from this map, the ICT industries are rather concentrated geographically around the so-called blue-banana of Europe, i.e., the area going from the South of the UK, the Benelux and Denmark, the French region Ile de France, the Western regions of Germany and the North of Italy. This broad picture is in line with the one put forward in an earlier study by Koski et al. (2002) and also ESPON (2005). More generally, these results are aligned with the evidence based on the economic geography literature concerning the location of hi-tech industries in Europe and GDP differentials across EU regions, see Combes and Overman (2004). There are some differences, however, compared to these previous works. First of all, the so-called blue-banana, when considering location of ICT industries, extends to other parts of the EU, including Scottish regions, the Madrid region and Central Italian regions, the South of Finland and Western regions of Sweden as well as regions located in EU10 such as Kozep-Magyarorszag (HU), Mazowieckie (PL) and Praha (CZ).

The figures displayed in the Map 1 above need to be compared with the one concerning the regional distribution of total employment (i.e., including ICT and non-ICT sectors). Table 3 compares this by showing the percentage of ICT employment in the first ten EU regions (those in dark red in Map 1 above) to the share of these regions in total EU employment for all the sectors of the economy. The total employment of all sectors of the economy appear to be much more spread geographically compared to ICT industries. These regions are also among the most populated ones and represent also the largest share in total EU employment as, for instance, the region Ile-de-France (FR), the Lombardia region or even Denmark (which is considered a NUTS2 region on its own). However, the share of these regions in ICT employment outpaces by far their share in total employment. The ten largest regions in terms of ICT employment represent 29% of ICT employment while they represent *only* 13.4% of total employment. As shown by the last column of Table 3, these regions are also among the richest EU regions (in terms of GDP per capita). Interestingly also, none of the regions located in the EU10 appear among the ten first regions for employment in the ICT sector.

Table 3: Ten largest ICT regions as measured by percentage of EU ICT employment in 2004

region	ICT SECTOR			ALL SECTORS			GDP PER CAPITA 2004 (EU25=100)*
	Rank	Share of EU ICT employment	Cumulated Shares	Rank	Share of EU total employment	Cumulated shares	
Île de France (FR)	1	9.40%	9.40%	1	2.65%	2.65%	167.5 (6)
Lazio (IT)	2	3.64%	13.04%	11	1.20%	3.85%	126.5 (32)
Comunidad de Madrid (ES)	3	3.62%	16.65%	4	1.45%	5.30%	126.8 (31)
Lombardia (IT)	4	2.74%	19.39%	2	2.24%	7.54%	135.8 (22)
Danmark (DK)	5	1.76%	21.14%	5	1.36%	8.90%	119.5 (47)
Inner London (UK)	6	1.75%	22.90%	10	1.22%	10.12%	290.7 (1)
Berkshire, Buck. & Oxf. (UK)	7	1.66%	24.56%	44	0.64%	10.76%	166.8 (7)
Darmstadt (DE)	8	1.58%	26.14%	18	0.98%	11.74%	157.3 (11)
Oberbayern (DE)	9	1.49%	27.62%	13	1.15%	12.89%	162.5 (8)
Stockholm (SE)	10	1.41%	29.04%	64	0.51%	13.39%	159.0 (9)

Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations.
* EU Rank in parentheses

The employment pattern that is displayed in Map 1 tends to compare closely with regional differentials in terms of GDP per capita. One salient difference, however, concerns the relative importance of regions located in EU10. In particular regions such as Kozep-Magyarorszag (HU), Mazowieckie (PL), Praha (CZ), DolnoSlaskie (PL), among others, appears to be ranked relatively high in terms of EU employment shares of ICT industries.

Table 4: Ten largest ICT regions located in the EU10 as measured by percentage of EU employment in 2004

region	ICT SECTOR			ALL SECTORS			GDP PER CAPITA 2004 (EU25=100)*
	Rank	*Share of EU ICT employment*	*Cumulated Shares*	*Rank*	*Share of EU total employment*	*Cumulated shares*	
Kozep-Magyarorszag (HU)	12	1.29%	1.29%	40	0.65%	0.65%	97.5 (120)
Mazowieckie (PL)	14	1.24%	2.52%	13	1.04%	1.68%	73.7 (194)
Praha (CZ)	29	0.82%	3.34%	92	0.38%	2.06%	150.8 (12)
Slaskie (PL)	47	0.53%	3.87%	27	0.78%	2.84%	54.7 (227)
Lietuva (LT)	50	0.50%	4.37%	30	0.71%	3.56%	49.0 (235)
Slovenija (SI)	53	0.49%	4.86%	74	0.45%	4.01%	79.9 (179)
Severovychod (CZ)	57	0.46%	5.32%	106	0.35%	4.36%	61.1 (218)
Jihovychod (CZ)	66	0.41%	5.73%	88	0.38%	4.75%	64.7 (210)
Wielkopolskie (PL)	71	0.38%	6.11%	45	0.61%	5.36%	52.3 (231)
Dolnoslaskie (PL)	74	0.37%	6.48%	75	0.45%	5.81%	49.6 (234)

Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations
** EU Rank in parentheses*

Table 4 above displays the share in total ICT employment of the top ten regions located in the EU10 (in terms of share in EU ICT employment). This Table shows that, despite the fact that these regions present a relatively high share of ICT employment compared to their level of GDP per capita, the total share of the EU10' regions is relatively low since it represents only 6.5% of total ICT employment in the whole EU, a figure rather close to the share in total employment (i.e. for all sectors of the economy) of these ten regions (5.8%).

It follows that, while the ten largest ICT employing regions are located in the EU15 regions and show an ICT employment share largely above the corresponding total employment shares of these regions, the same cannot be said about the largest employing regions of the EU10 where, except for a few cases, regions hosting the largest shares of ICT employment do also tend to be the largest ones in terms of overall employment. Put differently, ICT employment tends to concentrate in the so-called blue-banana regions.

2.2.3. Specialisation pattern: regional-level evidence

The above discussion drives us to having a closer look at the role played by ICT employment in the industrial specialization of EU regions. Two questions are worth considering: the first one concerns the relative importance for each region of the employment in ICT in the overall economic activity in a particular region; the second one, concerns the spatial distribution of employment. In particular, regarding the second question, because EU regions are very different in size, it is important to take into account the spatial dimension of the regions considered. The map below shows the specialization of EU regions measured in terms of ICT employment by using the Balassa index of industrial specialisation.[10]

Map 2: Specialization in ICT activities by NUTS2 regions, 2004
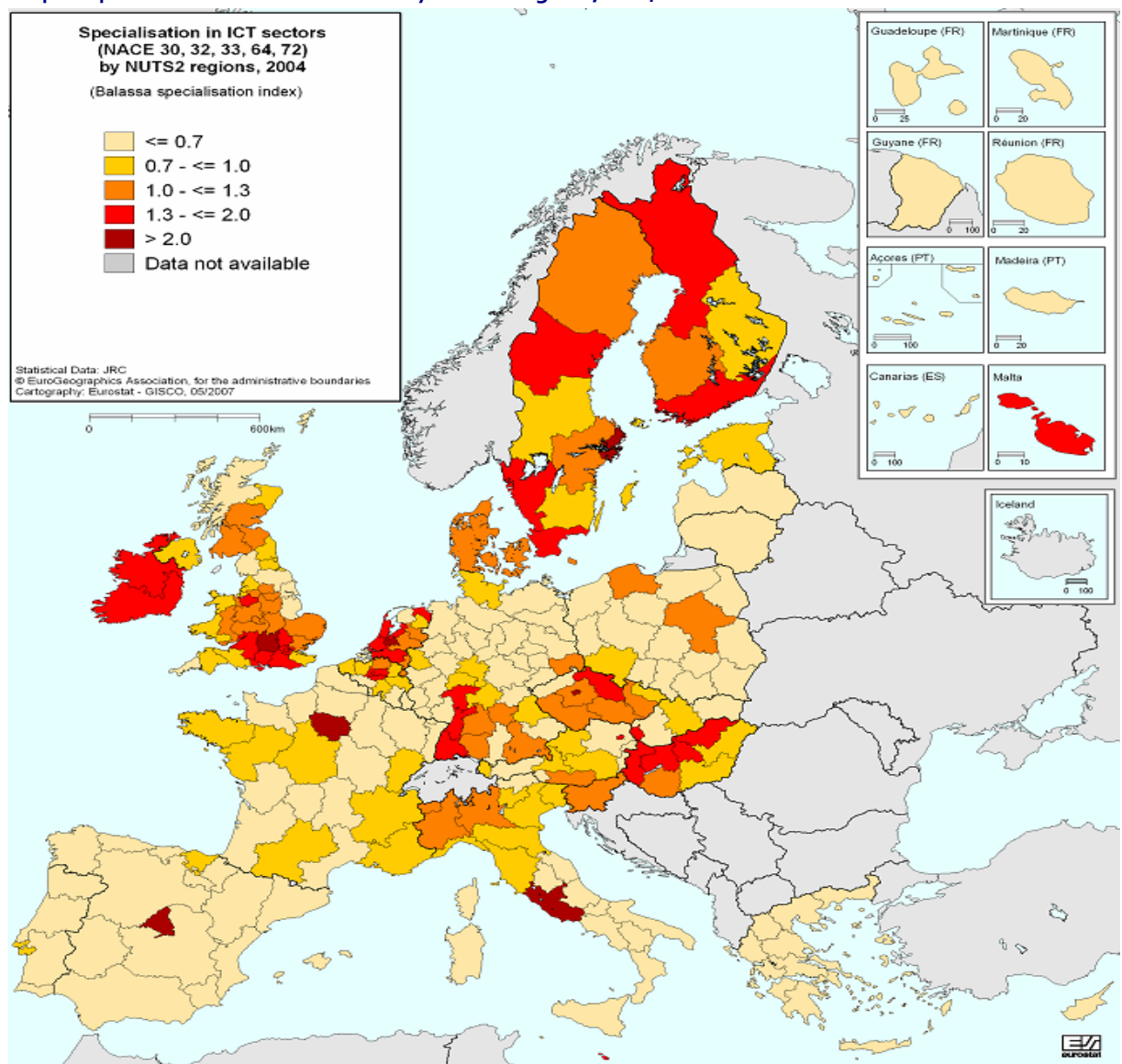
Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations

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[10] For details on data sources and/or methodological choices used in this section, see Appendix 2, Methodological Note 2.2, annexed to this report

The Balassa index compares the share of employment in ICT sector in a particular region with the same share for the whole EU. It follows that the value of an index greater to 1 for a specific region will denote a relatively high specialisation level of that region in ICT activities as measured by employment. The advantage of the Balassa index compared to the simple comparison of shares in total employment provided by Map 1 therefore is that the relative size (in terms of total employment) is taken into account here. Therefore Map 2 shows the regions where this share of ICT employment is the highest, indicating their relative specialisation as compared to other regions of Europe. When comparing Map 2 with Map 1, we observe also that the regions where EU ICT employment is the highest, are often the ones with the highest specialisation level in ICT activities.

The most specialised EU regions in ICT industries appear to be the Ile de France (FR) region, Lazio (IT), Stockholm (SE), the Berkshire, Buckinghamshire and Oxfordshire region (UK), the Madrid region (ES) and Utrecht (NL). Interestingly, while in most cases those regions are also located in countries considered as rather highly specialised in ICT industries (See also Table 1), the same cannot be said for the Madrid region which stands as the only Spanish region with a (well-) above specialisation index. This result, coupled with the picture provided for that country in Map 1, indicates probably that the role played by the ICT industry in the specialisation of Spain is essentially limited to the Madrid region.

The most specialised EU regions in ICT industries appear to be the Ile de France (FR) region, Lazio (IT), Stockholm (SE), the Berkshire, Buckinghamshire and Oxfordshire region (UK), the Madrid region (ES) and Utrecht (NL)

Here again, some exceptions are worth signalling. First, the Nordic EU regions of Finland and Sweden appear to be highly specialised in ICT activities. ICT tend also to play an important role in total employment in most of Irish regions together with Dutch, Belgian and Southern German regions. It is worth noticing also that some regions located in the EU10, most notably Praha (CZ), Kozep-Magyarorszag (HU), Nyugat-Dunantul (HU) and Malta, do appear to be relatively highly specialised in ICT activities. It follows that in those regions ICT industries can potentially play an important role in industrial specialisation and, thus, for regional development. On the other hand, in most Spanish (with the notable exception of the Madrid region) and Portuguese regions, South of Italy regions, France (with the notable exception of the Île-de-France region), a large part of German regions, the whole of Greece, and most Polish regions together with the Baltic States, ICT do appear to play a less decisive role for industrial specialisation

Up to now, the ICT industries have been considered together, i.e., including the five sub-sectors. The next maps (from) presented at the end of this section provide a more detailed sub-sector view on the relative specialisation of EU regions in each of the ICT sub-sectors. It must be noted first that a large number of regions tend to be relatively highly specialised in ICT manufacturing. In fact, it appears that EU employment in ICT manufacturing is located in a limited number of regions such as the Northern and Eastern European regions, with Hungarian, Czech Finnish regions being among the most specialised in manufacturing such as Office Machinery and Computers (Nace 30) and Radio and Television (Nace 32). In addition, Irish and UK regions (both in Scotland and the Southern part of the UK) appear to highly specialised in Manufacturing of Office Machinery and Computers (Nace 30). Regarding the specialisation in ICT services, it is worth noting that most Finish and UK regions tend to be highly specialised in these types of activities together with the capital regions Île de France (FR), Madrid (ES), Prague (CZ), Kozep-Magyarorszag (HU).

Map 3: Specialization in Office Machinery & Computers (Nace 30) by NUTS2 regions, 2004
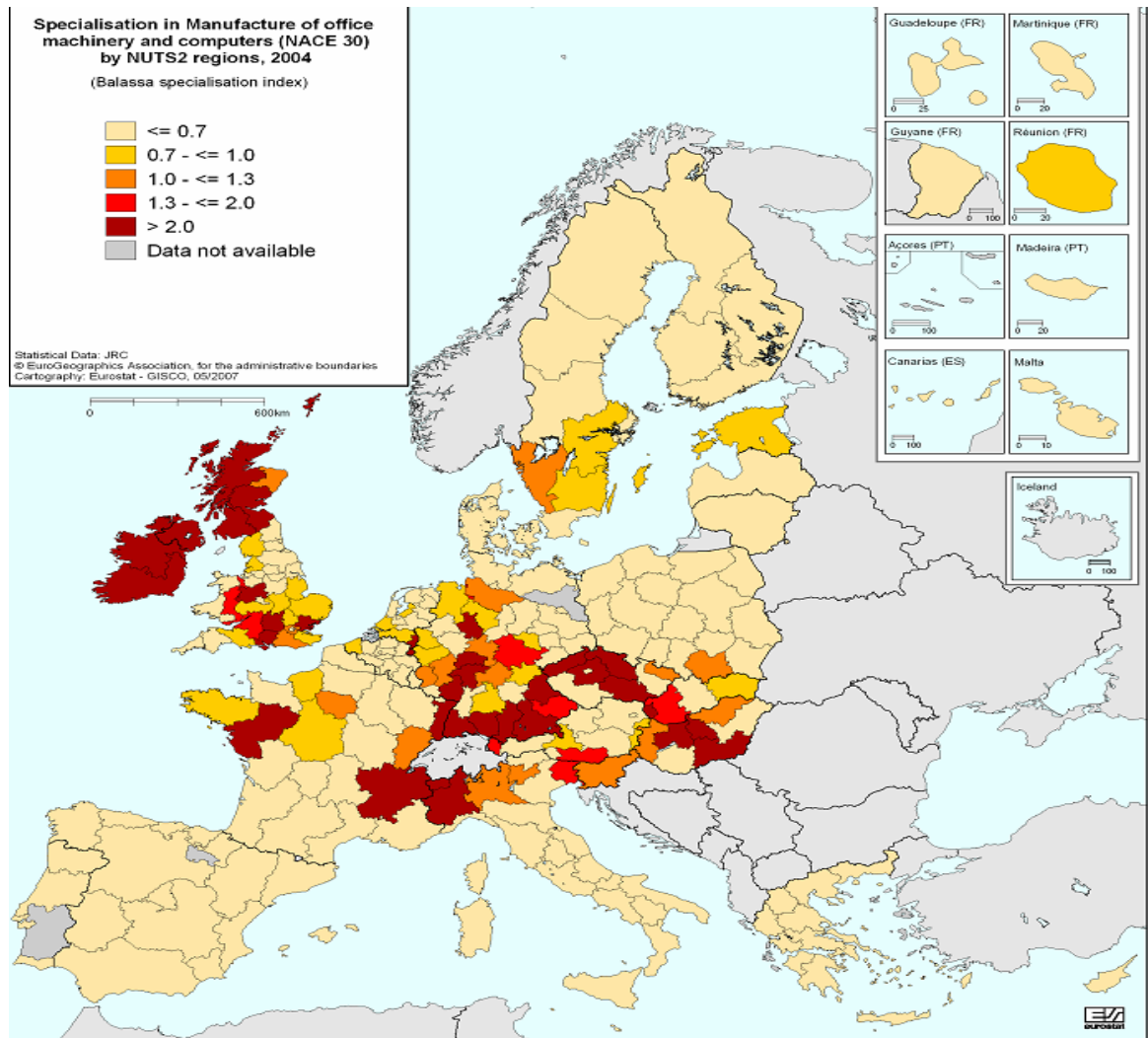
Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations
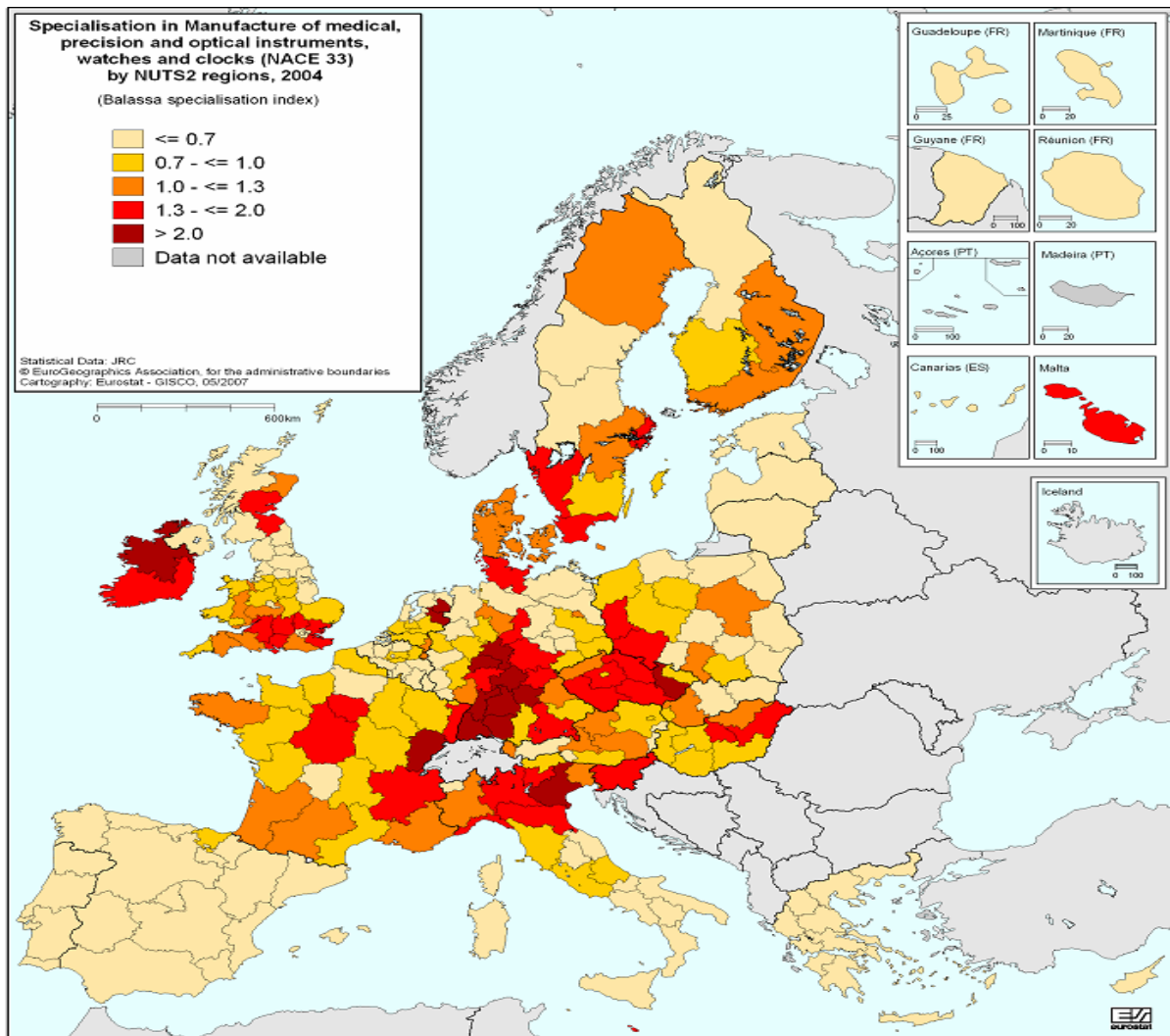
Map 4: Specialization in Television & Communication Equipment (Nace 32) by NUTS2 regions, 2004
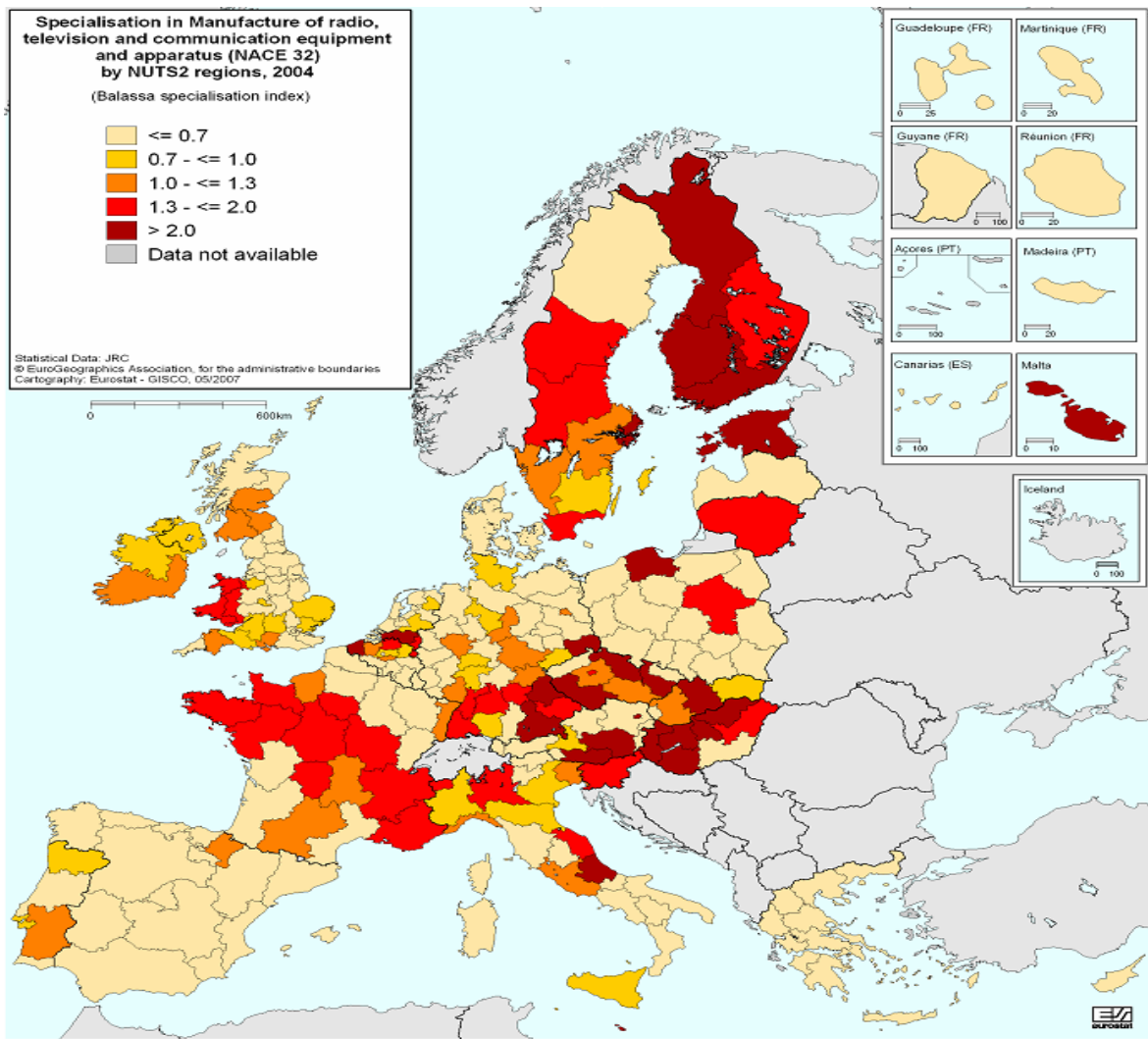
Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations

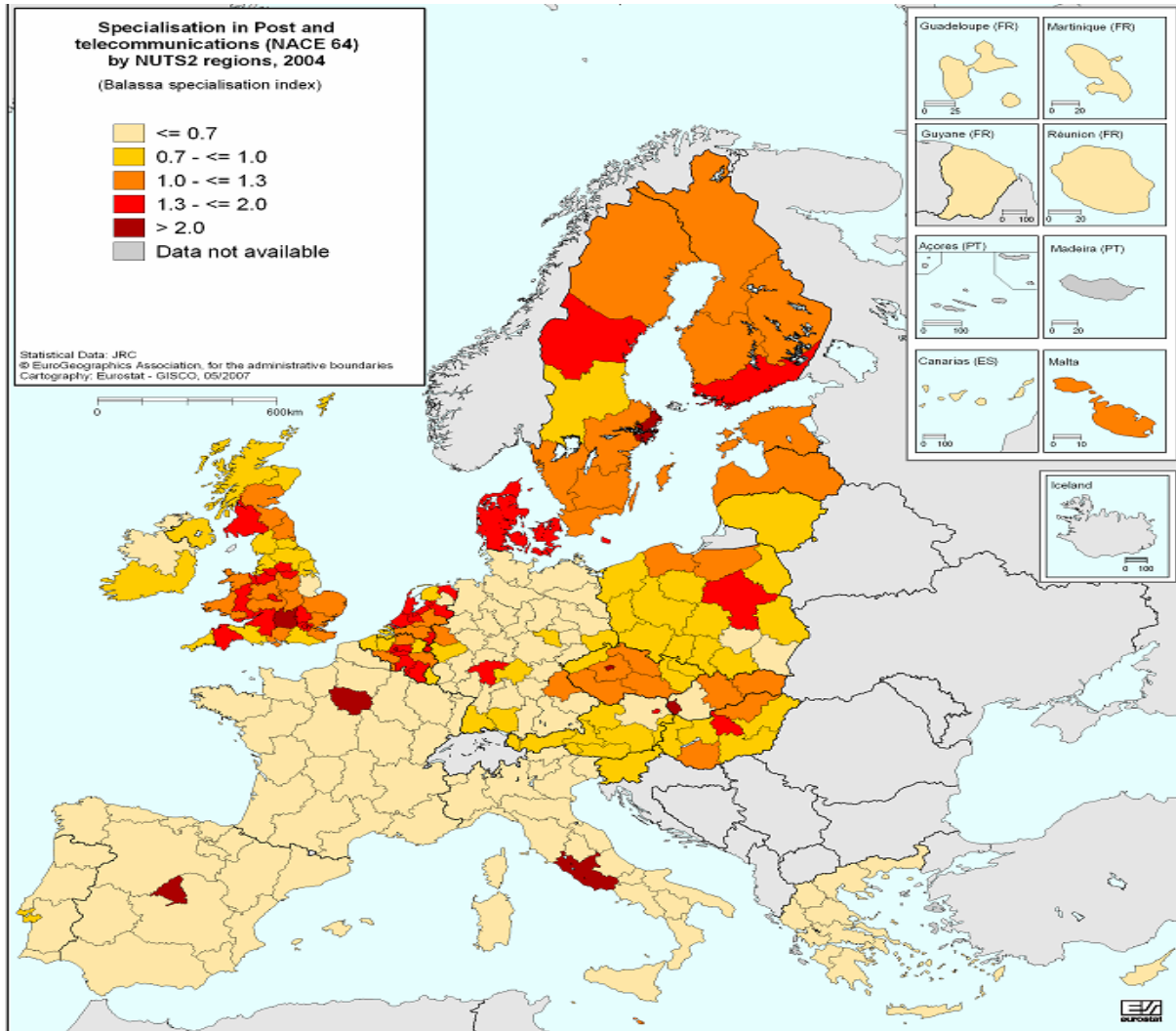**Map 5: Specialization in Medical, Precision & optical instruments (Nace 33) by NUTS2 regions, 2004**
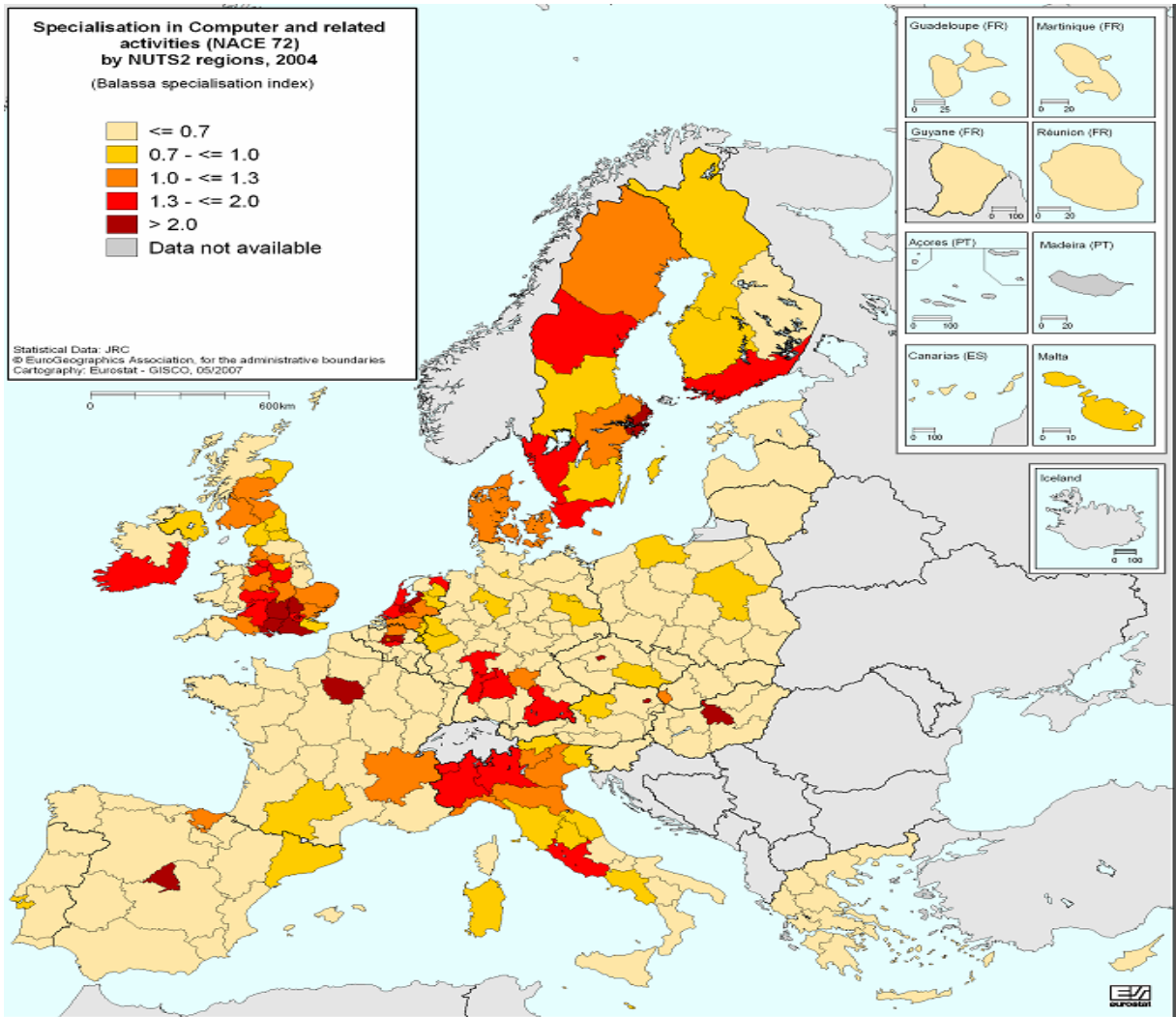

Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations

Map 6: Specialization in Post & Telecommunications (Nace 64) by NUTS2 regions, 2004

Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations

Map 7: Specialisation in Computer and related activities (Nace 72) by NUTS2 regions, 2004

Specialisation in Computer and related activities (NACE 72) by NUTS2 regions, 2004

(Balassa specialisation index)

- <= 0.7
- 0.7 - <= 1.0
- 1.0 - <= 1.3
- 1.3 - <= 2.0
- \> 2.0
- Data not available

Statistical Data: JRC
© EuroGeographics Association, for the administrative boundaries
Cartography: Eurostat - GISCO, 05/2007

0 — 600km

Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations

3. ICT employment in EU regions

Up to now, the report has provided a static overview of the location of ICT sub-sectors across EU regions in 2004. We will now consider ICT employment and its dynamics across EU regions over the period 1995-2004, which is the longest period for which data is available for a sufficiently large number of regions. In order to do so, we will proceed in three steps. First, we will establish the general trends in ICT employment for the period 1995-2004. Second we will analyse to what extent these trends in ICT employment are mainly related to the regional dimension. Finally, we will consider in closer details the nature of these changes and in particular the regions in which employment has changed most drastically over the past decade.

3.1. Main results

- Employment in the EU ICT industry has increased by 1.6% on an average annual basis during the whole period 1995-2004. In contrast, for the overall economy this rise has been rather less pronounced. The increase in employment has been essentially due to the evolution experienced in the EU15 countries. Second, regions and ICT sub-sectors have experimented very different evolutions over the period 1995-2004.

- For all ICT sub-sectors, and in particular, for the Manufacture of Medical, Precision and Optical Instruments (Nace 33), Post and Telecommunication Services (Nace 64) and Computer Services (Nace 72) sub-sectors, more than a 50% of employment change is due to trends specific to the regions and industries considered rather than sector performance or general overall employment changes at national level.

- The ICT sector presents a higher proportion of highly educated/professionals in its total employment as compared to the rest of the sectors of the economy. The proportion of highly skilled workers has been rising steadily over the past decade, in clear contrast with the rest of the sectors of the economy. The Computing Service sub-sector (Nace 72) is almost exclusively responsible for these evolutions, although it must be noted that this role has manifested itself through the rise in its total employment rather than the rise in proportion of skilled workers in the ICT service sector itself.

- Some regions do play a particularly active role in the above structure and recent evolutions, suggesting that national figures are strongly governed by regional features. The strong expansion in the Computing service sector has contributed to the concentration of highly-skilled employment in the largest EU ICT clusters, mainly located in the richest EU15 regions. In addition, the downturn in employment in the EU ICT manufacturing sub-sectors has translated into marked increases in the proportion of skilled workers in the

Employment in the EU ICT industry has increased by 1.6% on an average annual basis during the whole period 1995-2004

For all ICT sub-sectors, the combined regional/sector dimension is the most relevant one in order to explain recent employment changes in EU ICT sector.

The Computing Service sub-sector (Nace 72) is almost exclusively responsible for these employment changes in the EU ICT sector…

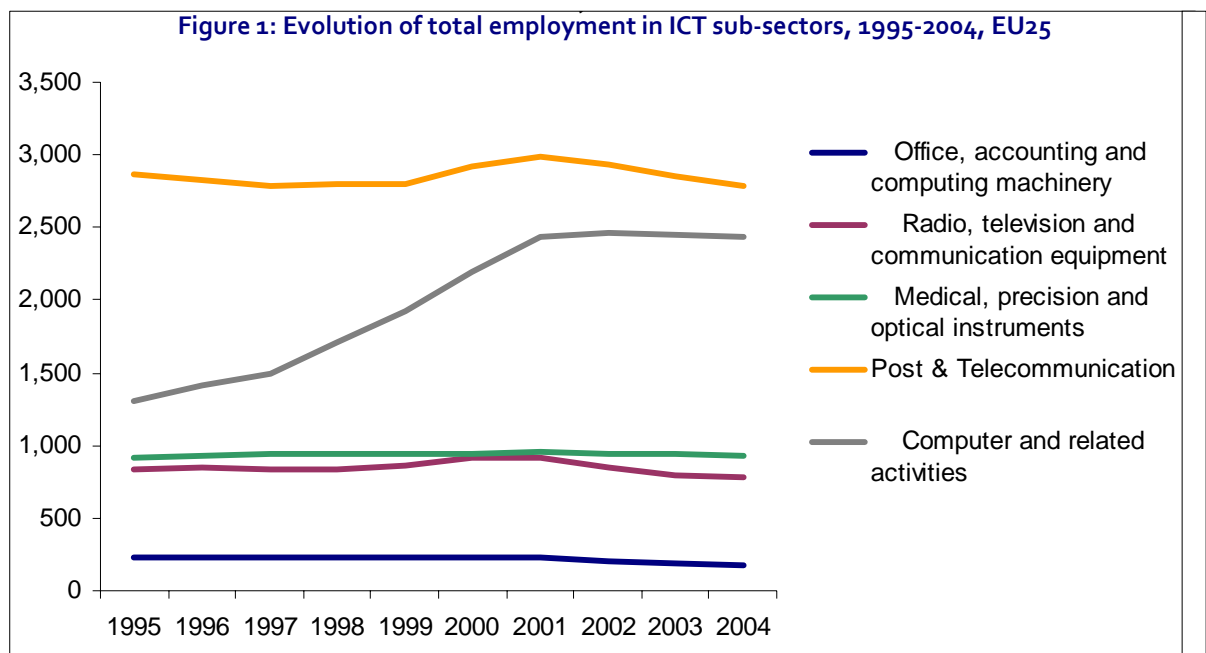*… and a small amount of regions do play a particularly active role in the recent evolutions*

richest EU15 regions. Such increase is not observable in EU10, where the nature of employment also denotes a lower skill-content.

3.2. Changes in ICT employment across the EU

3.2.1. Employment changes in the ICT industry: country-level evidence

The sub-sector Computer Services and related activities (Nace 72) clearly stands as the main driver of employment changes for the period 1995-2004

Figure 1 below provides an overview of ICT employment levels per sub-sector in the EU25 during the period 1995-2004. Overall, while in most sub-sectors employment levels have remained broadly stable or even have declined during the period, the sector Computer Services and related activities (Nace 72) clearly stands as the main driver of employment changes during the period. The end result is that total employment in the ICT industry has increased steadily during the period considered here.

Figure 1: Evolution of total employment in ICT sub-sectors, 1995-2004, EU25

Legend:
- Office, accounting and computing machinery
- Radio, television and communication equipment
- Medical, precision and optical instruments
- Post & Telecommunication
- Computer and related activities

Sources: Eurostat (SBS and LFS) and authors' computations
Y axis: 1000 of employees

Table 5 provides more details on employment changes in ICT sub-sectors by providing percentage figures in three groups of countries namely, the EU25, the EU15, and the EU10. Table 6 provides detailed results by country for the same time span.

Table 5: Employment changes in ICT sub-sectors during the period 1995-2004 (Average annual figures)

	Total ICT sectors	30. Office Machinery & computers	32. Radio, television & communication equt.	33. Medical, precision & optical equt.	64. Post & Telecommunications	72. computers services & related activities	Total economy
annual average % change 1995-2004							
EU25	1.6%	-3.1%	-0.8%	0.1%	-0.4%	7.2%	1.1%
EU15	1.7%	-4.1%	-1.6%	0.2%	-0.1%	7.1%	1.3%
NMS	0.8%	6.4%	3.2%	-0.5%	-1.6%	7.6%	-0.5%
annual average % change 1995-2000							
EU25	3.2%	0.3%	1.7%	0.6%	0.4%	10.9%	1.5%
EU15	3.4%	-0.9%	1.3%	0.9%	0.4%	11.0%	1.8%
NMS	1.7%	14.0%	4.2%	-1.7%	0.1%	8.0%	-0.4%
annual average % change 2000-2004							
EU25	-0.3%	-7.2%	-3.8%	-0.5%	-1.2%	2.7%	0.6%
EU15	-0.3%	-7.9%	-5.1%	-0.7%	-0.8%	2.5%	0.8%
NMS	-0.4%	-2.4%	2.0%	1.0%	-3.6%	7.0%	-0.7%

Sources: Eurostat (SBS and LFS) and authors' computations

Overall, employment in the EU ICT industry has increased by 1.6% on an average annual basis (or, alternatively, by 15.3% in accumulated terms) during the whole period 1995-2004. In contrast, for the overall economy this rise has been rather less pronounced as shown on the last column of Table 5 1.1% annually (or an accumulated change over 1995-2004 of 10.2%).

This overall figure also masks interesting, more detailed, patterns.

Three main remarks need to be made. First, the increase in ICT employment has been essentially due to the evolution experienced in the EU15 countries as employment in these countries has increased by 1.7% annually against 0.8% for the EU10. This statement is confirmed by a more detailed analysis of the individual countries' experience. Table 6 provides detailed results at national level, with the five countries that have represented the largest share in total EU25 employment in the ICT industry on the top.

Table 6: Percentage changes in employment in the ICT industry and percentage of EU25 change explained by country variations

country	% annual average change 1995-2004	% change 1995-2004	% of total EU25 change *
EU25	1.6%	15.3%	100.0%
United Kingdom	2.6%	26.0%	24.2%
Italy	2.3%	22.9%	15.8%
France	1.4%	13.0%	12.4%
Spain	3.4%	35.4%	10.3%
Hungary	4.9%	53.3%	6.4%
Netherlands	2.7%	27.1%	6.2%
Finland	3.8%	39.5%	3.6%
Ireland	5.0%	55.7%	3.6%
Sweden	1.5%	14.2%	2.7%
Denmark	2.8%	28.4%	2.6%
Poland	-0.6%	-5.6%	1.6%
Greece	3.2%	32.3%	1.6%
Belgium	1.3%	11.9%	1.4%
Portugal	2.1%	21.0%	1.4%
Czech Republic	0.9%	8.2%	1.3%
Austria	0.8%	7.1%	0.8%
Estonia	-4.1%	-31.5%	0.8%
Slovenia	3.0%	30.1%	0.7%
Slovakia	-1.0%	-8.7%	0.6%
Luxembourg	8.5%	107.7%	0.5%
Germany	0.0%	-0.4%	0.5%
Latvia	-1.8%	-14.8%	0.4%
Malta	5.3%	59.1%	0.3%
Lithuania	0.6%	5.3%	0.2%
Cyprus	3.4%	35.6%	0.1%

Sources: EU KLEMS Database, March 2007, http://www.euklems.net and authors' computations
* As measured in absolute values

When looking on a country-by-country basis, we find countries like the UK, Italy, France, Spain and Hungary, which, overall, have represented together around 70% of the total employment rise in ICT over the period 1995-2004. The case of Hungary is particularly salient given that this employment increase has mainly taken place in the sector Office Machinery and Computers (Nace 30).[11] The case of Germany is, on the other hand, rather surprising at first glance given the large size of this country in terms of ICT employment and the substantial employment changes that have taken place in this country recently. However the result is not so surprising, if one considers that Germany has experienced rather deep restructuring process of its ICT industries in this period.[12] In absolute terms, Germany appears to have largely

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[11] Table 7 provides detailed results for each ICT sector.
[12] Restructuring process in Germany: there has been a sharp fall in employment in manufacturing activities (the Office machinery & computers experiencing for instance an annual decrease of -7%) and Post and Telecommunication (-2.5%) and a steady rise in Computers services and related activities (+7.3%).

contributed to the overall rise in the computer services sector and related activities, representing 17% of the total EU25 employment changes in this sector and also to 40% of the overall decrease in the manufacturing of Office Machinery & Computers (Nace 30).

The second interesting result concerns the differing growth pattern between the two sub-periods 1995-2000 and 2000-2004. While the first period has been marked by a fast increase in employment in ICT sectors, amplifying the overall economic cycle as evidenced by the last column of Table 7, ICT sectors seem to have suffered more from the economic downturn following the year 2000. ICT employment during the latter period has decreased at an annual average growth rate of -0.3%, against a general annual increase in total employment of 0.6% in the total EU25 economy. The ICT manufacturing sub-sectors and the Post & Telecommunications (Nace 64) services have largely contributed to this overall unfavourable evolution. This was not fully compensated by the rise in employment in the Computer Services activities (Nace 72) which kept growing by 2.7% on average during the period 2000-2004.

Table 7: Percentage changes in employment in ICT sub-sectors and percentage of EU25 change explained by sub-sectors' variations: 1995-2004

Sectors	annual average change	total % change	% of the total ICT variation	% of total ICT empl. in 2004
30. Office Machinery & Computers	-3.1%	-24.5%	4.1%	2.4%
32. Radio, Television & communication equt.	-0.8%	-6.6%	4.1%	11.0%
33. Medical, precision & opital equt.	0.1%	1.1%	0.7%	13.1%
64. Post & telecoms	-0.4%	-3.1%	6.7%	39.1%
72. Computers services & related activities	7.2%	86.5%	84.3%	34.4%
ICT sectors	1.6%	15.3%	100.0%	100.0%
Total Economy	1.1%	10.2%	-	-

Sources: EU KLEMS Database, March 2007, http://www.euklems.net and Author's computation

The third and last remark concerns the different evolutions between EU15 and EU10, especially when considering separately the ICT services and ICT manufacturing sectors. It appears that in most of the period considered here, employment in ICT manufacturing has risen in EU10 during most of the period (excepting in the case of the Medical, Precision & Optical Equipment, Nace 33), while it has markedly declined in the EU15 countries. The decline of employment in the ICT manufacturing sub-sectors in the EU15 is especially pronounced in the Office Machinery and Computers (Nace 30) with an average annual decrease of -4.1% in the EU15 against an average annual increase of 6.4% in the NMS. Still, the favourable evolution in the EU10 has, not been enough to compensate the fall in employment in that sector (and in ICT manufacturing sectors in general) in the EU15. One possible explanation of these evolutions is related to the re-location of ICT manufacturing outside the EU.

3.2.2. Employment changes in the ICT industry: regional-level evidence

3.2.2.1 Does the regional dimension matter?

With the above general evolutions in mind, and before turning to a detailed analysis of regional evolutions it is worth considering whether, precisely, it makes sense to look at regions in order to understand the overall patterns of employment changes in the ICT industry. In particular, when considering employment changes in a specific ICT sub-sector in a given region one must consider a number of elements possibly influencing employment variations: the first point concerns the whole ICT sector which, as described above, has shown a tendency depending on the nature of activity considered. A number of elements are potentially at play here.

The first element concerns the issue regarding whether employment variations in a given sector/region are likely to be influenced by the overall sector's variation in employment across the whole EU. It follows that employment changes observed at the regional level for a given ICT sector may just be due to employment variation in the sector in the EU as a whole. For instance, in case a sector of activity faces a severe downturn due to increased global competition such as the Office Machinery and Computers sector (Nace 30) or, alternatively, in periods of fast expansion driving employment growth as in the case of the Medical, Precision and Optical Equipment sector (Nace 33) which has been shown to be particularly influenced by the overall macroeconomic cycle. These changes could possibly occur in a similar way across all EU regions or across all regions within a given country. In both cases, the regional component may not be (too) important in order to understand employment dynamics for the sector concerned.

Similarly, because ICT industry is itself possibly influenced by overall macroeconomic employment changes, one must consider to what extent the employment changes observed at sector level are in fact just the reflection of overall EU or national employment changes. In this latter case, analysing figures on employment changes without considering broader (including both ICT and non-ICT sectors) business cycle conditions may be misleading. These issues require considering to what extent the regional and sector dimensions are relevant when considering employment changes.

In order to provide a tentative answer to the questions risen above, we use here shift-share analysis,[13] a technique traditionally used in order to determine the relevance of the region and sector when addressing employment change analysis.

 Figure 2 provides a summary of the results obtained for each ICT sub-sector. The results presented here are weighted average of the regional results using as weight the share of country in total EU employment of the sub-sector considered.

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[13]   Methodological Note 3 of Appendix 2 provides more details on this methodology.

Figure 2: Shift-share decomposition in percentage points of total employment changes per ICT sub-sector, 2000-2004, EU25

*y-axis: % of total employment variation*
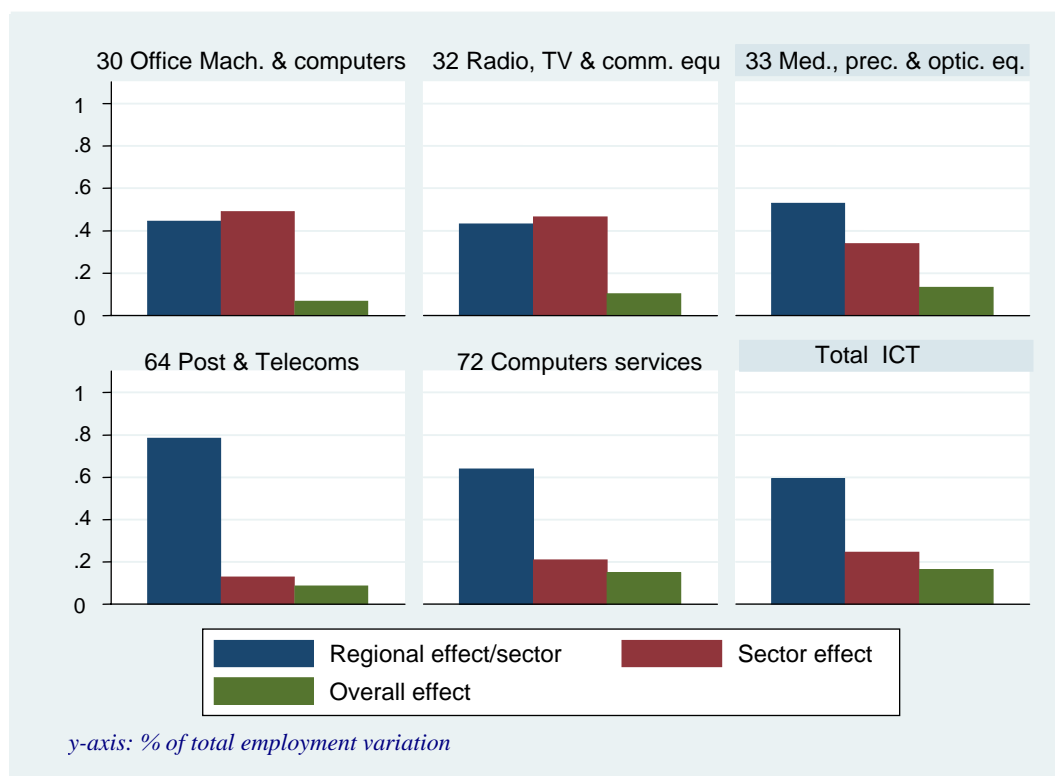
Sources: Eurostat (SBS and LFS) and authors' computations

The results displayed in Figure 2 show that for all ICT sub-sectors, the combined regional/sector dimension (the shift term in our analysis) is the most relevant one in order to explain recent employment changes in the EU ICT sector. In particular, for sub-sectors NACE 33, 64 and 72, more than a 50% of employment change is due to trends specific to the regions and industries considered (shift term) rather than sectoral performance (mix term) or general overall employment changes (share term) at national level. These three sub-sectors have also been shown earlier in Figure 1 (Section 3.1), to be the ones driving the largest part of recent employment changes in the whole ICT industry. Interestingly, in the manufacturing ICT sub-sectors, the combined regional/sector dimension effect is comparable to the nationwide sector effect on employment, suggesting that in those sub-sectors, overall industrial trends play an important role in explaining recent evolutions. All in all, the results depicted in Figure 2 suggest that the regional/sector dimension is the most important one in order to understand recent employment dynamics in ICT EU industry.

In order to check whether the results depicted in Figure 2 are specific to the ICT industry, the shift-share analysis has been replicated for the broad sectors of the economy, namely Mining and Quarrying, the Manufacturing Industry, Electricity Gas and Water Supply, Construction, Wholesale and Retail Trade, Hotels and Restaurant, Transport and Communication and Real Estate and other business services activities. The regions considered in replicating the shift-share analysis for these broad sectors are the same regions and the same period (i.e. 2000-20004) as those considered for the ICT sector in Figure 2. The results indicate that, in general terms, the sector dimension (mix term) is the most important one, explaining between 30% and 60% of overall employment change. The regional/sector dimension comes second and

explains between 20% and 50% of overall employment changes. These results therefore suggest that recent employment changes in the ICT industry are more characterized by their regional/sector dynamics than the rest of the economy.[14]

Figure 3: Shift-share decomposition in percentage points of total employment changes in aggregated sectors, 2000-2004, EU25

y-axis: % of total employment variation
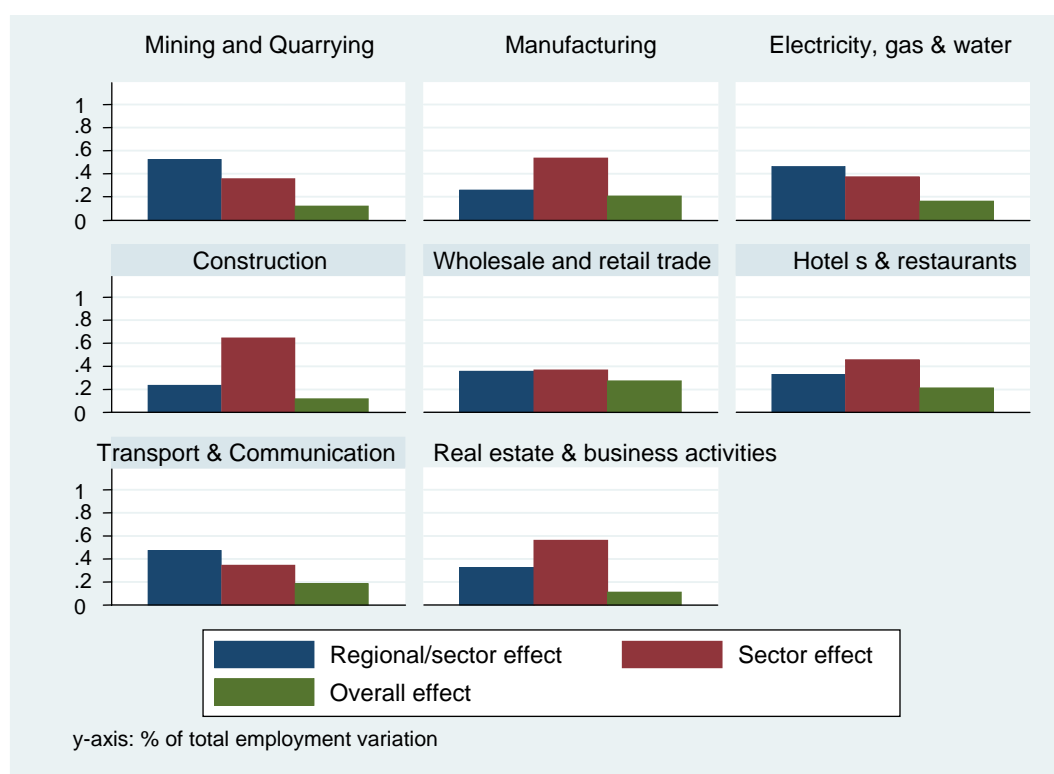
Sources: Eurostat (SBS) and authors' computations

3.2.2.2 Regional employment changes in the ICT industry (2000-2004)

The evidence provided above suggests that recent employment dynamics in the EU ICT industry do have a strong regional component. In what follows we consider specifically the EU regions where these changes have been more pronounced. In the sequel, we will also relate the observed changes with the level of specialisation as well as the relative importance (measured as share of ICT total employment) of the regions considered at the level of the EU ICT industry.

Table 8 and 9 provide a summary of the employment changes for a number of selected regions. Table 8 provides the ranking of the five regions with the largest contribution to EU ICT employment change. Accordingly, a region is included in this

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[14] One should note though that this result does not take into account the fact that the broad sectors considered are often larger in terms of total employment than the whole ICT industry. The consequence of this is that the sector dimension tends to be inflated, the broader the sectors considered are. Despite this, the result for the overall ICT industry depicted by Figure 2 indicates that the regional dimension clearly dominates for the ICT industry employment changes. This, of course, does not exclude that in other comparable (in terms of employment) sectors, the regional dimension is also the dominant one.

ranking if it has had a high contribution to the whole EU ICT industry employment change during the period 2000-2004, independently of whether this contribution was positive or negative. In line with the Table 7 presented previously, Table 8 shows that the manufacturing ICT sub-sectors have experienced, overall, a decline in employment, this decline being logically more pronounced in the regions presented here.

Considering the ICT manufacturing sub-sectors, Table 8 shows that the overall decline in employment has taken place in UK regions mostly. Considering more specifically the sector Office Machinery and Computers (Nace 30), the negative evolutions of employment are also mostly located in the UK together with the region Île de France, which has also experienced a decline in its employment. A very similar picture emerges for the manufacture of Radio, Television and Communication Equipment (Nace 32) as well as for the Medical, Precision and Optical Equipment Manufacturing sector (Nace 33) where, almost all regions that have experienced a marked decline in their employment during the period 2000-2004 were located in the UK. Also, according to the figures shown in parentheses, the employment variations of these regions have represented a substantial share of the overall EU ICT employment variation. For instance, the decline in employment in Office, Machinery and Computers (Nace 30) in the UK region South Western Scotland (-32,7% on average per year), has represented 17.7% of the total EU ICT employment change in that sub-sector which represents a quite substantial figure.

Table 8: Regional changes in Employment by ICT sub-sectors, 2000-2004

Five regions with the largest contribution to EU ICT employment change				
30. Office, Machinery & Computers	32. Radio, Television & Comm. Equt.	33. Medical, precision & optical equt.	64. Post & Telecoms	72. Computers services
South Western Scotland (uk) -32.7% (17.7%)	Eastern Scotland (uk) -32.8% (8.2%)	Berksh, Buck. and Oxford (uk) -13.9% (6.1%)	Lazio (it) 33.3% (14.1%)	Outer London (uk) -18.3% (10.2%)
Shropshire and Staffordshire (uk) -31.3% (13.2%)	Île de France (fr) -5.9% (4.4%)	West Midlands (uk) -21.1% (5.7%)	Madrid (es) 23.3% (9.0%)	Inner London (uk) -13.0% (9.7%)
East Wales (uk) -44.2% (8.6%)	Northumberland, Tyne and Wear (uk) -40.2% (4.3%)	Essex (uk) -15.8% (4.7%)	Köln (de) -3.1% (5.6%)	Madrid (es) 12.2% (7.3%)
Hampshire and Isle of Wight (uk) -21.4% (4.5)	Östra Mellansverige (se) -29.4% (4.0%)	Surrey, East and West Sussex (uk) -11.4% (4.2%)	Düsseldorf (de) 50.6% (3.4%)	Berksh, Buck. and Oxford (uk) -9.9% (6.5%)
Île de France (fr) -12.8% (4.4%)	Gloucestershire, Wiltshire and North Somerset (uk) -23.2% (3.6%)	East Anglia (uk) -15.8% (4.2%)	Lombardia (it) -16.4% (2.8%)	Île de France (fr) 4.3% (6.3%)

Sources: Eurostat (SBS and LFS) and authors' computations.
The first figure indicates the % of change in ICT employment in that sub-sector and in that region
The figure in parentheses indicates the contribution to total EU ICT employment variation in that sub-sector and of that region

Rather opposite to the evolutions in the ICT manufacturing sub-sectors, the recent employment changes in the ICT service sub-sectors are characterized by an overall increase throughout the EU, although the figures included in Table 8a show that the experience of the most salient EU regions are rather mixed. For instance, if one considers the sub-sector Post and Telecommunication Services (Nace 64) the first region in terms of contribution to the overall EU employment change is the Italian region Lazio which has had a marked increase in employment between 2000 and 2004 (+33.3% on average per year), representing 14.1% of the overall employment change in that sub-sector in the EU. However, within the same sub-sector of activity, one finds the German region of Köln, which has experienced a decline in employment (-3.1% on average) representing a substantial share of the overall EU

ICT employment change in that sub-sector (5.6%). There is also a large variety of evolutions in the Computing Services sector (Nace 72), which has been marked by a relatively large decline in the UK regions, especially in London and around London and a marked increase in other regions of Europe, in particular in the Spanish region of Madrid (+12.2% employment increase on average) and the region Île de France (+4.3% on average).

Table 9 provides rankings of regions according to their growth rate of ICT employment. The first panel provides a ranking for the highest growing regions while the second provides a ranking for the regions that have experienced on average, during the period 2000-2004, the highest decline in ICT employment. Logically, the employment change rates are much higher in absolute terms than the ones for Table 8. It must be noted, however, that the contribution of the employment changes in these regions are rather low with respect to the overall EU employment changes. However, in the cases of the Radio, Television and Communication Equipment sector (Nace 32) and the Medical, Precision and Optical Equipment (Nace 33), the regions that have experienced the highest decline in employment, mostly UK regions, have represented a relatively high share in total EU ICT employment.

Table 9: Regional changes in Employment by ICT sub-sectors, 2000-2004

30. Office, Machinery & Computers	32. Radio, Television & Comm. Equt.	33. Medical, precision & optical equt.	64. Post & Telecoms	72. Computers services
Five regions with the highest regional growth rates in ICT employment by sub-sectors				
Basilicata (it) 165.9% (0.1%)	Auvergne (fr) 53.3% (0.8%)	Castilla-la Mancha (es) 32.8% (0.3%)	Devon (uk) 911.6% (1.2%)	Burgenland (at) 24.5% (2.1%)
Prov. Hainaut (be) 157.3% (0.3%)	Itä-Suomi (fi) 26.2% (0.5%)	Övre Norrland (se) 20.3% (0.5%)	East Riding and North Lincolnshire (uk) 706.3% (0.3%)	Castilla-la Mancha (es) 18.9% (0.1%)
Molise (it) 134.0 % (0.0%)	Merseyside (uk) 21.4% (0.3%)	Extremadura (es) 18% (0.2%)	Cornwall and Isles of Scilly (uk) 612.9% (0.3%)	Halle (de) 17.1% (0.1%)
Castilla-la Mancha (es) 50.2% (0.1%)	Niederösterreich (at) 15.6% (0.1%)	Västsverige (se) 17.8% (3.2%)	Halle (de) 106.9% (0.4%)	Düsseldorf (de) 14.9% (2.3%)
Prov. Luxembourg (be) 33.5% (0.0%)	Andalucia (es) 14% (0.5%)	Galicia (es) 13.9% (0.4%)	North Yorkshire (uk) 84.9% (0.4%)	Niederösterreich (at) 13.0% (0.4%)
Five regions with the highest regional decline rates in ICT employment by sub-sectors				
Västsverige (se) -82.3% (1.4%)	Northumberland, Tyne and Wear (uk) -40.2% (4.3%)	South Western Scotland (uk) -16.8 (3.0%)	Castilla-la Mancha (es) -40.9% (0.5%)	Merseyside (uk) -21.1% (1.4%)
Stockholm (se) -81.0% (1.1%)	Eastern Scotland (uk) -32.8% (8.2%)	Auvergne (fr) -16.7% (3.2%)	Extremadura (es) -33.6% (0.2%)	North Yorkshire (uk) -21.1% (0.9%)
Östra Mellansverige (se) -81.0% (1.1%)	Outer London (uk) 30.5% (4.0%)	Outer London (uk) -16.1% (1.5%)	Galicia (es) -33.0% (0.9%)	Essex (uk) -19.3% (2.9%)
Småland med öarna (se) -78.5% (0.6%)	Östra Mellansverige (se) -29.4% (4.0%)	Northumberland, Tyne and Wear (uk) -16.1% (1.5%)	Calabria (it) -32.6% (0.7%)	Outer London (uk) -18.3% (10.2%)
Norra Mellansverige (se) -71.1% (0.2%)	South Yorkshire (uk) -28.5% (0.5%)	East Anglia (uk) -15.8% (4.2%)	Andalucia (es) -32.3% (2.1%)	West Wales and The Valleys (uk) -15.2% (0.8%)

Sources: Eurostat (SBS and LFS) and authors' computations.
The first figure indicates the % of change in ICT employment in that sub-sector and in that region
The figure in parentheses indicates the contribution to total EU ICT employment variation in that sub-sector and of that region

Table 10 provides additional information regarding the spatial concentration of regional employment changes in the ICT industry during the period 2000-2004. This Table shows that the employment changes in the manufacturing sector Office, Machinery and Computers (Nace 30) and the Computer Services (Nace 72) sub-sectors are the ones most spatially concentrated in the EU. The ten largest contributing regions in terms of overall employment changes have represented more than half of the total employment changes in the EU in these sub-sectors (61% for the Office Machinery and Computers sector and 58.6% for the Computer Services sub-sector).[15] The Gini indices computed on the absolute employment change of each region also denote that the two sub-sectors mentioned above, Office Machinery and Computers (Nace 30) and Computer Services (Nace 72) are also the ones where employment changes have been spatially more concentrated. Looking back at the data presented above in Table 7 and Figure 1, these two sub-sectors are also the ones that have experienced the most important changes during the recent years in the ICT industry.

Table 10: Spatial concentration of Regional changes in Employment by ICT sub-sectors, 2000-2004

	30. OFFICE, MACHINERY & COMPUTERS	32. RADIO, TELEVISION & COMM. EQUT.	33. MEDICAL, PRECISION & OPTICAL EQUT.	64. POST & TELECOMS	72. COMPUTERS SERVICES
Cumulated % of five largest contributors to employment change	48.4%	24.6%	24.8%	34.9%	40.0%
Cumulated % of Ten largest contributors to employment change	61.0%	40.8%	41.7%	46.7%	58.6%
Gini index of absolute variations in employment	0.76	0.64	0.62	0.65	0.73

Sources: Eurostat (SBS and LFS) and authors' computations

3.3. Nature of ICT employment across the EU: skills and occupation characteristics

While the previous results provide interesting insights concerning the structure and dynamics of ICT employment across EU regions, little has been said up to now regarding the nature of this employment.

The nature of employment matters in first place given that the expected output of employment will strongly depend on the qualification of employees and their productivity level. In particular, what really matters in the end from an economic viewpoint, especially with regard to regional development, is, together with the level of education, the nature of occupation of the workers considered. In particular, elements such as research and innovation, which, as mentioned in the Introduction of this report are at the core of long-run productivity and growth, are necessarily tied to certain levels of education and types of occupation. Thus, two dimensions

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[15] Note that these figures, corresponding also to those in Table 10, are obtained considering the first 10 regions in terms of their contribution to ICT employment while Table 8 only displays the 5 first ones. More details can be made available from the authors.

reflecting the nature of ICT employment are considered for this analysis: on the one hand, the level of education of employees and, on the other hand, the nature of their occupation. The effort to characterise the ICT sector and its sub-sectors together with regions in terms of knowledge intensiveness drives the analysis over the rest of this Section. It also provides further empirical evidence that may help better understand to what extent human capital is determinant for the economic performance of regions.

3.3.1. The nature of employment in ICT: country-level evidence

As already suggested in Section 2.2, before undertaking a regional analysis it is important to get an idea of the overall nature of European ICT industry, here in terms of occupation and level of education as well as the changes occurred during the last decade. Table 11 below provides an overview, for the EU25, of the level of education and nature of occupation of employees in the ICT sub-sectors as well as for the remaining sectors of the EU economy.

Table 11: Percentage of employees with university degree and professional occupation[16]

	30. Office, Machinery & Computers	32. Radio, Television & Communication equt.	33. Medical, precision & optical equt.	64. Post & Telecommunications	72. Computer services & related activities	Rest of Sectors (non ICT)
Share of employees with University degree (% of total employment)						
EU25	50.2%	32.7%	32.2%	23.9%	56.1%	25.2%
EU15	52.1%	36.9%	32.7%	23.9%	55.7%	26.1%
NMS	25.2%	14.8%	25.7%	24.0%	61.3%	20.5%
Share of Professionals (% of total employment)						
EU25	34.8%	22.3%	18.0%	12.2%	47.7%	13.4%
EU15	35.7%	25.7%	18.3%	12.3%	47.0%	13.4%
NMS	23.0%	7.8%	14.1%	11.6%	55.5%	13.6%
Share of Professionals with University degree (% of total employment)						
EU25	28.6%	18.1%	15.2%	8.9%	35.1%	11.2%
EU15	29.2%	20.9%	15.3%	8.7%	34.2%	11.2%
NMS	20.9%	6.2%	13.7%	10.5%	45.3%	11.1%

Sources: Eurostat (Labour force Survey) and authors' calculations

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[16] Professionals are those considered in Major Group 2 of the ISCO88 occupational taxonomy which includes for instance Computer professionals, Engineers, Mathematicians, etc......

Looking at the percentages concerning the EU25, the table above shows that, on the one hand, ICT sub-sectors do have a higher proportion of highly-educated workers compared to the remaining sectors of the economy. The same applies to the percentage of employees with professional occupation for most sectors of the economy, except for the Post and Telecommunication sector where this percentage does not appear to be very different (slightly lower) when compared to the rest of the economy.

When looking at differences between the EU15 and the EU10, in all sub-sectors the EU15 countries tend to have a higher share of highly-educated/professionals in their total employment, with the exception of the Computer Services sub-sector (Nace 70). The contribution of the EU10 to the EU25 percentages is relatively low, however, given that almost all EU employment in that sub-sector is located in the EU15 as shown previously in Table 5. When comparing the percentages displayed in Table 11 with those displayed previously in Table 5 the relative shift in ICT manufacturing employment from the EU15 to the EU10 appears therefore to be made in lower-skilled, manufacturing activities. For those ICT sub-sectors, especially in the ICT service sub-sector, where the EU10 tend to employ a higher proportion of skilled workers, almost 90% of employment is still located in the EU15 and the evolution of the past decade seem to indicate that these differences are likely to persist.

Figure 4 provides a dynamic overview of the share of highly-educated employees in total employment for the EU15.[17] This figure shows first that there is a large difference in levels between ICT sectors and non-ICT sectors in the proportion of highly educated workers in total employment. Second, this difference has steadily increased between 1995 and 2005.[18] The proportion of people with higher-education degree employed in the ICT industry has risen over the past decade going from 27% to 37% of total employment, i.e., 10 percentage points. While an increase in the proportion of high-skilled labour can also be observed in the rest of the economy as depicted by the blue-curve in Figure 4, this increase is clearly less pronounced compared to the ICT industry as the proportion of high-skilled employment rose from 21 to 26%, i.e., half of the percentage point increase experienced by the ICT sectors.

Furthermore, in both ICT and non-ICT sectors, clearly two inflexion points emerge. The first one happens around the years 1999 and 2000, where the past evolution of the years 1995-1999 slows down and the curve of skilled labour becomes much flatter. This evolution could possibly be related to the bubble burst of the year 2000 which affected mostly the Telecommunication sector. More specifically, companies belonging to this sector had invested heavily in dot.com companies, see, for instance, Bradford DeLong and Magin (2006).

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[17] Data for EU10 were not available for almost all years considered in Figure 4 when using the Eurostat Labour Force Survey so that the EU15 country group was considered instead. However, reporting figures for the EU25 for the years in which the same information is available would provide very similar evolutions.

[18] Note that Figure 4 includes all regions using interpolation for the missing values. These interpolations were negligible compared to the non-interpolated employment figures as the latter represents 96% of total employment over the period 1995-2005. Note that we also elaborated Figure 4 for continuous regions only, i.e., regions for which observations were available for all years from 1995 to 2005. These continuous regions included all regions of Austria, Belgium, Spain, Finland, France, Greece, Portugal and Sweden.

Figure 4: Percentage of highly-skilled employees in ICT and non ICT sectors, EU15, 1995-2005
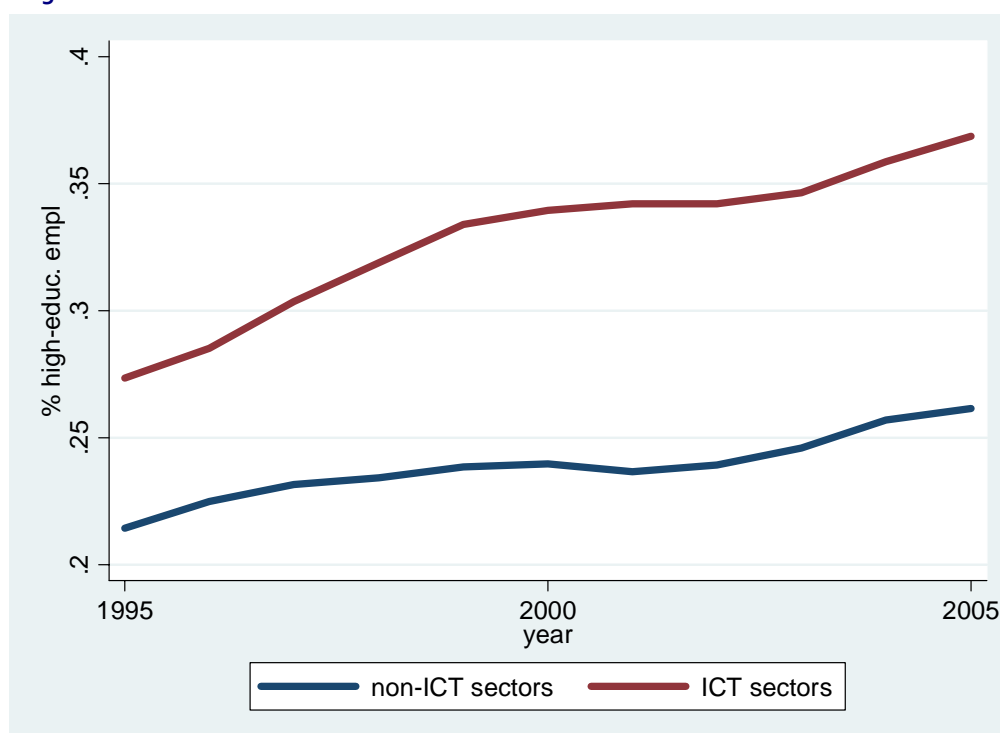
Sources: Eurostat, LFS and Authors' computation

The rise in the proportion of highly-skilled workers in total ICT employment experienced a rebound from 2003 onward. Here again, the evolution of the share of skilled workers in total ICT employment can be related to more general business cycles features in the ICT sector. For instance, when considering the major OECD economies (i.e., Japan, the US and the EU25), total employment in the ICT industry has fallen by 3% on average between 2001 and 2003 while overall employment in all sectors of the economy had slightly increased by 0.3% on an annual basis. The economic downturn was even more pronounced in certain ICT sub-sectors of activity though, with the Office, Machinery and Computers (Nace 30) falling annually by -8.8% on average by year over the same period. The decrease in employment was the least pronounced (-0.9% on average per year) in the Computers Services and Related activities sub-sector (Nace 72).

The blue curve in Figure 4 shows that the evolution described for the ICT industry can be observed also, to some extent, for the rest of the economy meaning that some of the sector-specific evolutions of the ICT sectors' employment were also shared by the rest of the economy and, more generally, influenced by the overall business cycle.

A closer look at the sector-level data in fact reveals that the differences in shares of skilled workers between the ICT and non-ICT sectors can be again explained essentially by the dynamics of two sub-sectors belonging to the ICT industry: the rise of *Computer and related services* (Nace 72) and the decline of *Manufacturing of Office Machinery and computers* (Nace 30). Given that the relative proportion of skilled employment in these two sub-sectors also changed very little, it follows that the

evolutions depicted in Figure 4 were in fact driven by the changing weight of these two sub-sectors in the overall ICT employment.

These overall evolutions are summarized in Figure 5 which depicts the role played by each sub-sector in the overall evolution of the high-skill intensity of the ICT industry. Figure 5 shows the contribution of each ICT sub-sector to the overall evolution of high-skilled ICT labour.[19]

Figure 5: Decomposing the evolution of high-skilled labour by ICT sub-sector, EU15, 1994-2005*
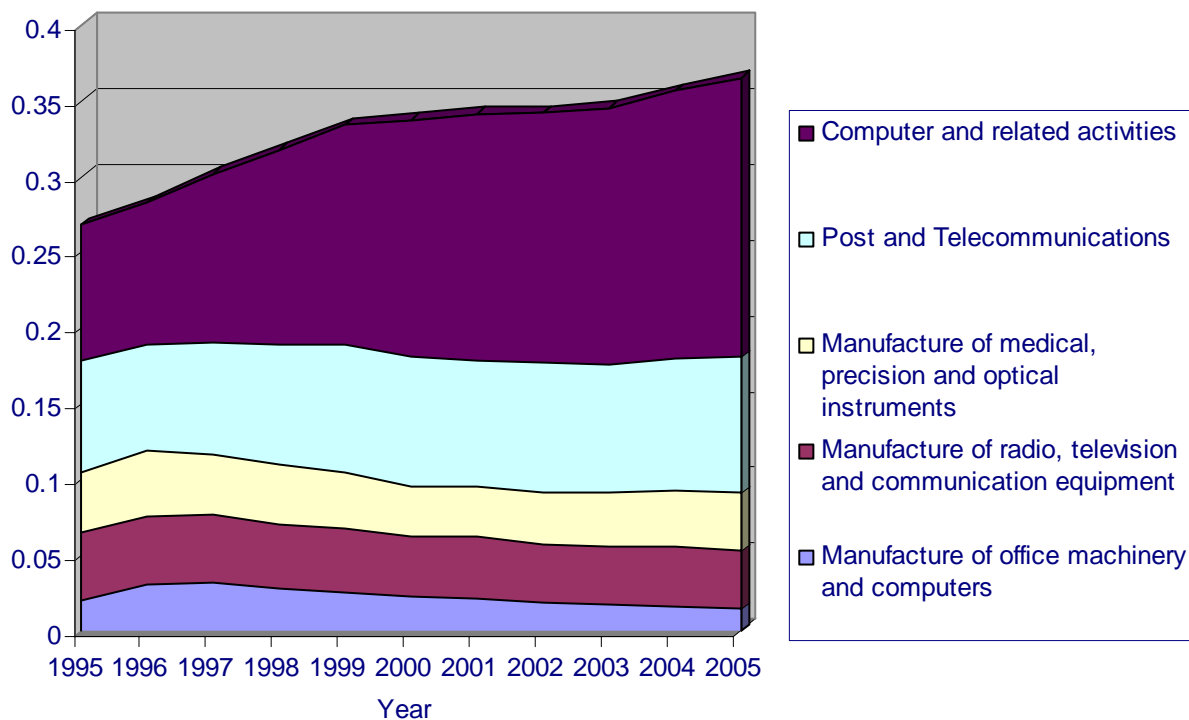
Sources: Eurostat, LFS and authors' computation
* The graph displays the evolution of the decomposition of high skilled labour share in total

ICT employment (Sh$_{ICT}$) into its sub-sector component such that $Sh_{ICT} = \sum_i w_i \, Sh_i$

where w$_i$ is the employment share of sub-sector i in total ICT employment and Sh $_i$ is the share of high skilled labour in sub-sector i total employment for a given year.

Most notably, the sector Computer Services and related services (Nace 70) appears to explain most of the increase of high-skilled labour intensity of the ICT sector. The evolution observed for the rest of ICT sub-sector is rather stable by comparison. Moreover, the Manufacturing of Office Machinery and Computers (Nace 30) appears to experience a slight but steady decline in both its proportion of high-skilled workers and relative weight in total ICT employment.

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[19]   Calculated as the product between the weight of each sub-sector in total employment of the whole ICT industry and the high skilled workers proportion in each sub-sector For more details, see formula attached to the Figure 5.

A similar analysis could be also undertaken considering the proportion of workers with occupations classified as Researchers following the definition provided in the Frascati manual, see OECD(2002b)[20] (See Appendix 2, Methodological Note 2.4) . Figure 6 provides an overview of the evolution of the proportion of workers that can be classified into this category in both the ICT and non-ICT sectors of the economy in the same way as in Figure 4.

Figure 6: Percentage of professionals with Tertiary education level in ICT and non ICT sectors, EU15, 1999-2005
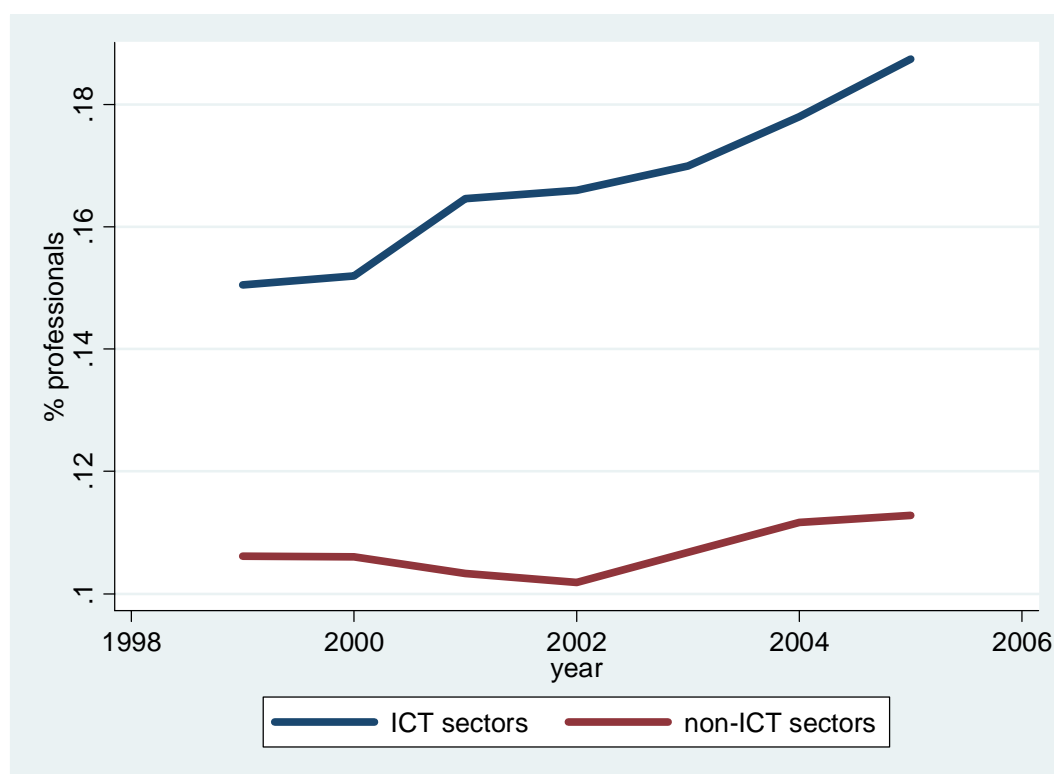
Sources: Eurostat, LFS and Authors' computation

The proportion of highly-education workers who also have professional occupations according to the definition above is clearly much lower than the proportion of workers with tertiary education level. This reflects the fact that not all highly-educated workers do have a professional occupation. What is more interesting, though, is the fact that the difference between ICT and non-ICT sectors is relatively larger in this case and it has grown even faster than when considering education levels only. This has two implications. First, the ICT industry has increased the share of employment of highly-educated workers at a much faster rate than the rest of the sectors of the economy. Second, these workers have been occupying professional positions which are also potentially correlated with a higher number of researchers according to the discussion undertaken in Appendix 2, Methodological Note 2.4. A more detailed analysis by ICT sub-sectors would also reveal that the Computing Services sector (Nace 70) explains again almost completely the whole evolution depicted in Figure 6. Thus, it is worth considering this sector more specifically in order to analyse in details regional evolutions.

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[20] For details, see Appendix 2, Methodological Note 2.4

3.3.2. The nature of employment in ICT: regional-level evidence

This section provides evidence on the nature of employment, represented by occupation and education levels of employees, in ICT sub-sectors across EU regions. The first question to be addressed concerns the spatial distribution of employees with the above characteristics in order to see whether the regional structure - Blue Banana and richest EU15 regions - depicted previously in Section 2.2 is reflected also through differences in skills and qualifications. Another question to be addressed is whether the changes described above do have (or do not have) specific regional components and to identify regions where most of those changes have been taking place.

In line with the observations made in 2.2, we check whether the European regions with most ICT employment (See Map 1 in 2.2.2) are those where skilled workers in ICT are mostly concentrated and are also the richest regions. More specifically, we consider the link between the proportion of high-education/professionals and the GDP per capita of each region for the year 2004.

Figure 7: Percentage of highly-educated/professionals in total ICT employees vs. GDP per capita in 2004. ICT Sub-sectors. Five largest EU regions (in terms of % of total ICT employment) only.
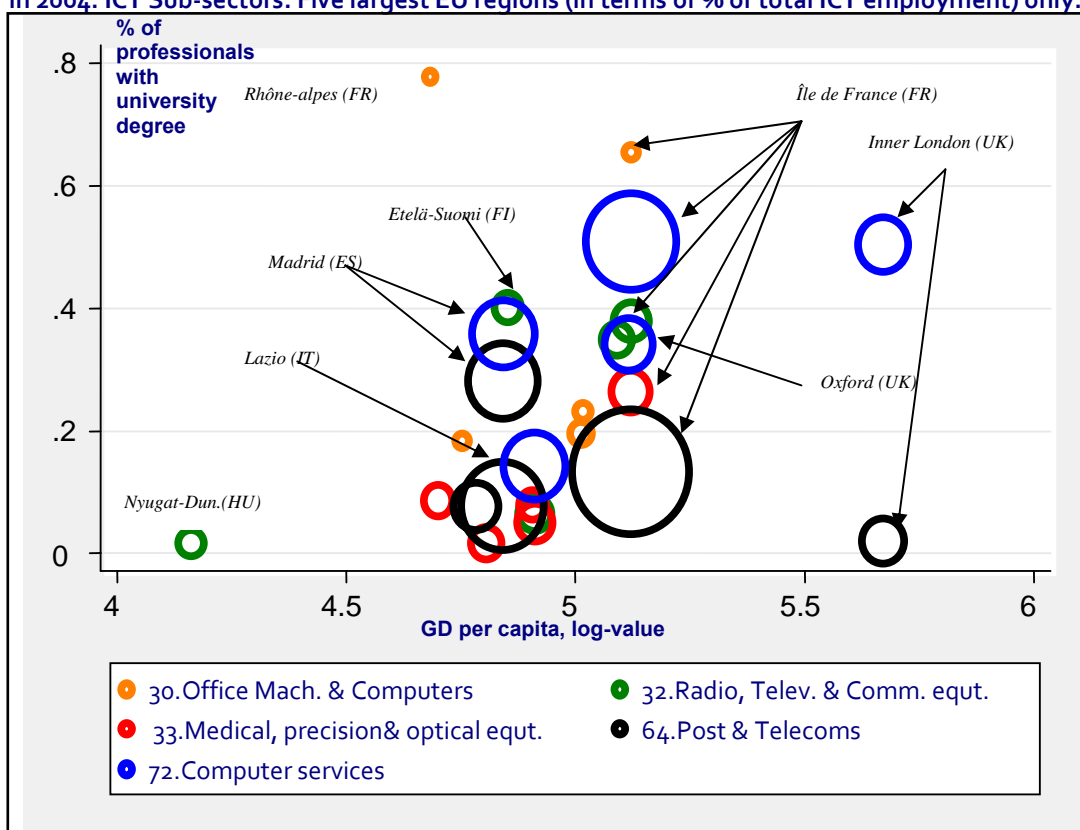
Sources: Eurostat, LFS and Authors' computation
Note: Circles' size correspond to the initial criteria of choice for the regions: the size of the region in terms of share of total European ICT employment in that sub-sector

Figure 7 provides information by sub-sector, selecting the five largest EU regions for each ICT sub-sector, as measured by their share in total European ICT employment,[21] in order to facilitate the interpretation of the results.[22]

Overall, the positive relationship between the level of GDP per capita and the percentage of highly educated professionals holds. One can observe that the aforementioned positive relationship gets stronger for larger regions (i.e., big circles).

Three ICT-sub-sectors, the Radio, Television & Communication Equipment (Nace 32), the Medical, precision and optical equipment (Nace 33) and the Post and Telecommunication (Nace 64), have, overall, lower percentage of employees with university degree and professional occupations. The Office Machinery and Computers (Nace 30) and the Computer services sub-sectors (Nace 72), in turn, have the highest percentage. This higher proportion of highly educated/professionals in these regions is also much higher than in the other ICT sub-sectors as evidenced previously in Table 11.

Some regions are especially present, in particular the Île de France region stands out prominently in all ICT sub-sectors in terms of total employment and, in addition, the percentage of professionals with higher-education degree in total employment is high, independently of the sub-sector considered. More generally, it is worth noting that regions with a high proportion of university-educated professionals in a specific ICT sub-sector tend to have also relatively high proportion of such professionals in the rest of their ICT sub-sectors.

Overall, there is a positive relationship between the share of high-educated/professionals and the wealthier region. This relationship does not seem to hold in the case of the Post and Telecommunication sector (Nace 64) which could be due to the fact that this sector encompasses activities related to Postal services. These have a much more spread regional distribution. This latter result is likely to be due to the fact that in a large number of EU countries this activity is still dominated by state-owned public companies. As noted earlier also, in most cases the largest regions in terms of ICT employment are located in the richest regions which are, in most cases, also located in the EU15. This is especially true for the Computer Services sub-sector (Nace 72) which is concentrated in a limited number of regions such as Île de France (FR), Madrid (ES), Lombardia (IT), Inner London (UK) and Berkshire, Buckinghamshire and Oxfordshire (UK).

Figures (a) 1 to (a) 5 presented in the Appendix 1 provide separate results for each of the ICT sub-sectors.[23]

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[21]   The same methodology has been used at ICT sector level in section 2.2.2

[22]   Our choice is guided by feasibility issues. The total number of NUTS regions is 254. The exhaustive presentation of all regions for each ICT sub-sector is evidently unsustainable.

[23]   7a to 7e, in Appendix 1, do have the same x-values and y-values together with the same weighting schemes to determine the relative size of each circle. These figures are, as a consequence, directly comparable to Figure 7.

4. Assessing the attractiveness of EU regions for ICT firms' location: a closer look at multinationals and SMEs

The present Section starts with describing the location patterns of ICT multinationals and ICT SMEs. The reasons for focusing on these firms-types are twofold: on the one hand SMEs do play a particularly important role for regional development; on the other hand multinationals location choices usually reflect the degree of attractiveness of each region especially with regards to globalisation.

We then make special emphasis on analysing the determinants of the location of ICT multinationals and, in particular, their link to local/regional economic characteristics such as the density of ICT activities, ICT-specialisation and the qualification of the workforce at regional level.

In order to do so, this Section makes use of firm-level data. The advantage of using firm-level rather than aggregated employment data is that inference can be made regarding the determinants of the location choices of ICT firms. In particular, if we consider the location of newly created companies, inference can be made about the factors influencing the location choices made by these companies. Because such inference is made here using discrete choice modelling techniques,[24] one must assume that when multinational firms make their location choice, they do compare the characteristics of all EU regions.

4.1. Main results

- When considering the evolution of the location patterns of multinationals over time one observes a rather different geographical location pattern of foreign companies in the manufacturing ICT sub-sectors, especially the manufacture of Office Machinery and Computers (Nace 30). In particular, since the early 200s, Poland and also to some extent Slovakia, Slovenia and the Check Republic have attracted a growing number of multinationals while before the 200s, multinationals tended to favour location in UK, Irish, Dutch and German regions.

- Concerning the ICT service sub-sector, the core ICT EU regions from Ireland, UK, the Netherland, South of Germany, Austria, the Madrid region Finland and Sweden have been the most attractive for FDI. Nevertheless, a growing

The link between ICT multinationals' location choices and local ICT SMEs and workers' skills is especially relevant when observing the way regions position themselves in a globalising world

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[24] See appendix 2: Methodological Note 2.5 attached to Section 5 provides full details on the methodology.

number of multinationals has tended to locate in the EU10 although locating their ICT services affiliates mainly in the capital town regions.

- When considering the location of SMEs, the location pattern of new SMEs is broadly similar to the case of multinationals described earlier although it is worth pointing out that SMEs tend to be much more dispersed geographically than multinationals. New SMEs in ICT manufacturing sub-sectors have been particularly numerous in the regions located in the EU10, in particular in Polish and Czech regions.

- This Section further investigates the attractiveness of EU regions by considering the special case of multinationals' location choices and its determinants. These determinants are represented by the level of regional GDP measuring local market access, the degree of industrial specialisation which is used to measure ICT-specific sector's agglomeration economies, the level of education and the density of SMEs of the EU25 regions. All these variables appear to have positive and significant influence on the probability for a given EU region to be chosen as location site by a multinational, independently of the ICT sector considered. By contrast, the fact that a region is located in a new Member State seems to be relevant only in the cases of the manufacture of Radio, Television and Communication Equipment (Nace 32) and Post and Telecommunications (Nace 64).

- The level of industrial specialisation appears to be especially important in the case of the Computing Service Industry (Nace 70). Given the descriptive evidence provided in Section 3, this result tends to support the idea that the impressive growth of this sector of activity has tended to be localised in regions already highly specialised in Computing Services tending to reinforce existing clusters. To the extent that the level of specialisation also reflects the existence of potential agglomeration economies related to knowledge and technological spillovers, then the location of the Computing Service sub-sector tends to be greatly influenced by these factors as well.

- The density of ICT SMEs in a given region is especially more relevant in the case of the ICT manufacturing sub-sectors compared to the ICT services. Given the dynamism in SMEs creation in the EU10 regions, one can therefore consider that this feature represent a growing advantage of the regions located in the EU10 for improving their attractiveness for FDI in ICT manufacturing activities.

4.2. Considering the location of ICT SMEs and multinationals: underlying assumptions

On the one hand, the location of SMEs is particularly relevant in the context of the present study, as SMEs are often recognised as being a crucial component of regional development, see for instance, Santinha and Soares (2004). SMEs often rely on local/regional productive capabilities, especially in terms of workforce qualification and access to capital. Also, SMEs are usually more closely connected to the local markets of products and services. Importantly, SMEs are seen to be less footloose than large multinational companies and rely more on local networks which are a key dimension for understanding firms' response to changing market conditions, especially in relation to globalization. Therefore, SMEs are key for regional development. In particular, from a policy perspective, many EU and national programmes foster the creation and development of SMEs to promote regional development.

On the other hand, the analysis of the location pattern of multinationals proves to be especially useful to understand how the benefits of the internationalisation of EU economies spread across regions, see the study by Barrios et al. (2005) and Lopez-Bazo et al. (2006). Besides the obvious implications in terms of regional economic inequalities, adopting a regional rather than a national approach to foreign direct investment (FDI) may also prove useful in order to understand a number of interesting features regarding the determinants of FDI. For instance, EU regions appear to have very unequal access to the most prosperous markets both within and between countries. Additionally, while multinational firms tend to locate in regions with better market access, they increase in turn the attractiveness of these regions such that firms' new location patterns are also good indicator of their development potential in a globalizing world, see Head and Mayer (2004).

It is also interesting to analyse the way SMEs and multinational location decisions are connected to each other. In particular, SMEs are tied to local entrepreneurs' and regions' characteristics while multinationals tend to chose between alternative locations which are often located in different countries. For instance, the availability of local providers which are usually SMEs is often believed to represent and important determinant of multinational location see Barrios et al. (2005). Following the analysis of geographical distribution of SMEs and multinationals, we will therefore also study the way multinationals' location decisions may be influenced by the regional density of SMEs in ICT industries.

4.3. Descriptive evidence on the location of ICT firms in the EU

As noted above here we focus on the location of SMEs and multinationals. We consider SMEs as firms with less than 250 employees, following Eurostat's definition.[25]

As noted in the introduction, the location dynamics of firms is in general highly correlated with development prospects of the regions concerned. However, the determinants of location are not necessarily the same depending on the type of companies considered as well as their sector of activity. Here we consider two cases where these determinants are potentially different, namely SMEs and multinationals.

Map (a) 1 toMap (a) 5 (Multinationals) and **Error! Reference source not found.**(SMEs), in Appendix 1.a, provide the plot of new multinationals' affiliates and new SMEs' location in the EU. Each dot in these maps represents a new firm created during the corresponding period where the black dots concern the period 1995-2000 and the green dots the period 2001-2004. Importantly also, these two periods do correspond to different phases in the European integration process, namely the preparation for the accession of the EU10. The year 2000 in particular set out the new rules with regard to make the EU fit for enlargement through the Treaty of Nice. This year incidentally coincides with the turning point in new firm creations as evidenced later in this Section. In particular, the prospective for the entry of the EU10 can be considered as consolidated as of 2000, such that one could expect for instance that multinational companies willing to take advantage of the new opportunities offered both in terms of being present in new markets integrated to the EU and also, possibly, in order to take advantage of lower production costs and high level of labour qualification.

4.3.1. Location patterns of ICT multinationals

Map (a) 1 to Map (a) 5 (See Appendix 1) provide evidence on the location pattern of new Multinationals affiliates in ICT European sub-sectors during the period 1994-2004. The data for the Manufacture of Office Machinery and Computers (Nace 30) show that very few new production sites appear to have been opened by multinationals during the period considered here. For the first period (i.e., the black dots), foreign investment was mainly done in the EU Member States such as the UK, Ireland, the Netherlands and Germany. During the second period, i.e., the period

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[25] A definition of SMEs can be found at:
http://ec.europa.eu/enterprise/entrepreneurship/facts_figures.htm.
Accordingly, " *Companies classified as small and medium-sized enterprises (SMEs) are defined officially by the EU as those with fewer than 250 employees and which are independent from larger companies. Furthermore, their annual turnover may not exceed €50 million, or their annual balance sheet total exceed €43 million. This definition is critical in establishing which companies may benefit from EU programmes aimed at SMEs, and from certain policies such as SME-specific competition rules.* " Here the definition on employment is retained instead.

immediately preceding the accession of the ten countries from Eastern and Central Europe, one observes a rather different geographical location pattern of foreign companies in this sector of activity. In particular Poland and also to some extent Slovakia, Slovenia and the Check Republic have attracted a growing number of foreign investors. Spain also has tended to attract foreign investors together with a number of French and Dutch regions.

The picture is slightly different for the two other manufacturing ICT sub-sectors considered, namely Television and Communication Equipment (Nace 32) and Medical, Precision and Optical Instruments (Nace 33). Generally speaking, foreign investments in these two sub-sectors have tended to concentrate in the areas going from the UK, the Netherlands till the South of Germany. A relatively large number of investments have been taking place in the Île de France, the Centre and Bretagne regions (FR). Interestingly also, a rather large number of investments have also taken place in Poland, Eastern Germany and the Czech Republic during the whole period. All in all, foreign multinationals' location have displayed a rather dispersed pattern in the ICT manufacturing sub-sectors, with a relative re-orientation towards the EU10 although in absolute terms, the EU15 still do dominate for the very last years for which data is available.

The correlation coefficients displayed in the tables appended to each of the Maps show that the two periods considered here are rather different in terms of location pattern of multinationals' affiliates. This reflects in the relatively low values of the correlation coefficients.

The Maps concerning the two ICT services sub-sectors Post & Telecom (Nace 64) and Computing Services (Nace 72) tend to display a relatively more concentrated pattern of location of multinational companies. Here foreign affiliates are much more numerous than in the manufacturing sub-sectors and tend to concentrate massively in the core ICT EU regions already identified in Section 2, namely the area going from Ireland, UK, the Netherland and South of Germany and, for the Computing Service sector (Nace 70), Austria as well. In this latter sub-sector Finland and Sweden are also relatively more present than in the case of the ICT manufacturing sub-sectors. The Spanish regions Madrid and Cataluña have also been rather attractive for FDI, especially Madrid in both service sub-sectors.

All in all, multinationals of the ICT service sub-sectors have tended to invest in regions that were already relatively highly specialised in ICT activities: this is observable when one compares the evidence presented here with the one provided in the Maps of Section 2 (with exception of the Italian region Lazio which, despite its relatively high density of ICT service employment, has attracted little foreign direct investment during the period 1995-2004).The previous statement is further confirmed by the high value of the correlation coefficients[26] computed to compare the location patterns of multinationals during the periods 1995-2000 and 2001-2005. The values of these coefficients indicate indeed that the concentration of FDI in the richest EU regions have tended to reinforce during the recent period.

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[26] Those correlation coefficients are displayed in Maps A.2.1 to A.3.5 in Appendix 1

4.3.2. Location patterns of ICT SMEs

Maps (a) 6 to (a) 10 (See Appendix 1) provide evidence on the location pattern of new SMEs in ICT European sub-sectors during the period 1994-2004. As one would naturally expect, the number of new firms created is much larger than in the case of multinationals. A first look at the case concerning the Office Machinery and Computers sector (Nace30) indicates that the location pattern of new SMEs is broadly similar to the case of multinationals described earlier although it is worth pointing out that SMEs tend to be much widely distributed geographically than multinationals. New SMEs in ICT manufacturing have been particularly numerous in the regions located in the EU10, in particular in Polish and Czech regions. Interestingly, if one compares the Office Machinery and Computers sector (Nace 30) with the other two ICT manufacturing sub-sectors, namely the Television & Communication Equipment (Nace 32) and the Medical, Precision and Optical Instruments (Nace 33) sub-sectors, these latter two sub-sectors appear to have a much more stable location pattern of new SMEs over time as evidenced by the higher values of the correlation coefficients. This feature becomes even more pronounced when comparing the manufacturing and the service ICT sub-sectors as shown by **Error! Reference source not found.**. Here new location of SMEs displays a stronger tendency to persist over time than in the manufacturing sub-sectors.

While Map (a) 1 Map (a) 10 provide a first useful visual representation of the location pattern of ICT SMEs and ICT multinationals' affiliates across European regions, a more systematic analysis of these results is called for.

First of all, it is necessary to analyse to what extent the location of new firms is made *within* existing ICT clusters or whether, location is made *outside* existing clusters. The answer to this question should allow one to say something about the possible emergence of new ICT clusters and possibly, future growth prospect of the regions concerned. In addition, the description of the location pattern of new multinational companies has been made up to now independently of that of other firms, SMEs in particular. The existing literature of FDI has largely documented the fact that firms' location choice and productivity dynamics may be strongly influenced by linkages between multinationals and local providers which are, in general, local SMEs, see Görg and Strobl (2001) and Peri and Urban (2006) for instance.

Table 12 provides first evidence on the correlation in location choices between multinationals and SME. This table displays the correlation coefficients of the number of new SMEs and multinationals' affiliates for each NUTS region. Accordingly, a positive and high coefficient would tend to indicate that both firms' types tend to locate in the same regions. The results shown here tend to suggest that the previous assumption is especially true for the ICT service sub-sectors compared to the ICT manufacturing sub-sectors. Second, in all sub-sectors considered here, the correlation in location choices between SMEs and multinationals has tended to decrease with time, possibly indicating that the location pattern of each firm-type has tended to change during the period considered here.

Table 12: Correlation in location choices: Multinationals vs. SMEs

	1995-2000	2001-2004
30. Office, Machinery & Computers	0.63	0.35
32. Radio, Tel. & Comm. Equt.	0.57	0.53
33. Medical, precision & opt. equpt	0.65	0.43
64. Post & Telecom	0.91	0.87
72. Computers services & related activities	0.85	0.70

Sources: Bureau van Dijk (Amadeus database) and authors' computations

The rest of this Section provides a more in-depth analysis of the location determinants of ICT firms in the EU with a special attention given to multinationals and the links existing between multinationals' location and SMEs.

4.4. An econometric analysis of the location choices of multinationals in the ICT industry

This section provides econometric results concerning the determinants of multinationals' location choices in the ICT industry. In order to do so, we rely on an econometric model in order to estimate empirically the variables that do influence the location choices of multinationals.[27] The study focuses on the location choices of multinationals rather than considering the location choices of SMEs because of the specific bias affecting SMEs location choices: SMEs will tend to locate in the regions where the entrepreneurs actually reside. While this feature makes the choice of location of SMEs interesting, it tends to reflect mainly the inner regional entrepreneurial activity rather than the attractiveness of each region as compared to other regions. In order to be able to compare regions' attractiveness for the location of ICT activities, one therefore needs to consider firms which potentially compare the characteristics of regions located in different countries. For these reasons, it is preferable to consider only the location of multinationals as, by definition, these firms do locate their activity in different countries and are therefore more likely to undertake cross-border comparisons of regions' characteristics.

4.4.1. The determinants of multinationals' location choices in ICT industry

The empirical modelling strategy used here assumes that regional characteristics can be compared by a given multinational. These characteristics will in turn determine the location probability of a given firm assuming that regions can be assigned a given level of *"profitability"*. For instance, highly urbanised regions located in rich countries will most likely host a higher proportion of educated workers compared to rural area located in less developed countries. By observing both the frequency of location choices and the characteristics of the set of regions considered on can say something about the potential influence exerted by each of these characteristics on the attractiveness of each region using discrete choice modelling tools. Appendix 2, Note 2.6 provides further details on the econometric

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[27] For methodological details about the econometric model, see Appendix 2, Methodological Note 2.6

technique used in order to link location choices observed with the regions' characteristics.

In order to make the estimated model easily tractable we have restricted the exercise to a limited number of regional characteristics for the econometric analysis. Table 13 below provides the definition of the explanatory variables and the data source used for their construction. These variables reflect the characteristics of all the EU NUTS2 regions.

First, because of the potential role played by ICT SMEs in regional development, the first variable to be considered is represented by the density of ICT SMEs which is represented by the number of ICT SMEs per square kilometre. According to this variable, a high density of ICT SMEs in a given ICT sector will attract ICT multinationals if, for instance, those multinationals require the presence of intermediate providers. Given the relatively high level of sector aggregation used here, i.e., NACE two digits, one may expect that intermediate providers are included in the same NACE category.

Table 13: Definition of explanatory variables used and data sources

VARIABLE NAME	DEFINITION	STATISTICAL SOURCE
Market Size	Ln(GDPs) where Y_s is the GDP in *PPP* for region s	Eurostat and authors' computations
Education	% of Labour force with at tertiary education level for each ICT sub-sector and each region	Labour force Survey (Eurostat) and authors' computations
Specialisation	Balassa Index	Eurostat and authors' computations
EU10	Dummy variable equal to 1 if NUTS2 region located in one of the EU10	nr
Density SMEs	Log of the number of SMEs per sq. km in the ICT sector considered	Bureau van Dijk, Eurostat and authors' computations

Another variable to be considered is a measure of market access represented by the regional GDP level. This variable represents the influence of market access. Accordingly, the size of the local market is likely to exert a strong influence of business location choices. In particular, market access can magnify the influence of local demand on production structure and business location in presence of increasing returns to scale in production and network externalities as this is likely to be the case in some of the ICT industries considered here. It s worth noting that here we consider separately manufacturing and services industries. Generally speaking, services industries are believed to be more oriented towards the local market which may explaining why, in general, service activities tend to be more spread geographically. However, in the case of ICT services, many services location may not be primarily determined by market access as some services (for instance, in the case of a web-based company) do not require physical proximity between the provider and the consumer. In the case of manufacturing, ICT market access is likely to govern location choices as well if firms need to get access to local providers or are tied to local purchasers of their products as for instance an electronic component

company may need to locate close to its main clients in order to save on transport costs. In the context of multinationals' location choices also, market access would thus exert a strong attraction for foreign firms producing on a large scale and seeking to export their products to the rest of the EU.

Another factor to be considered in our empirical model is a measure of agglomeration economies. The existing empirical literature shows that firms tend to make the same location choice where other firms with similar characteristics, such as nationality of ownership and the sector of activity, are already established, see for instance, Head et al. (1995) and Crozet et al. (2004). Furthermore, in presence of sector-specific agglomeration economies, for instance linked to knowledge externalities of sector-specific labour skills, multinational companies will tend to locate in regions which are already specialised in similar types of activities. The location of industries may thus follow a cumulative causation process if agglomeration economies do exert a significant influence since start-up firms may tend to locate in existing industrial centres, increasing in turn the relative attractiveness of these through a circular process, see Fujita and Thisse (2002). In order to capture the influence of industrial specialisation we also include the Balassa index of industrial specialisation already used in Section 2.

Similarly, we also include a sector-specific measure of labour skills which is represented by the percentage of workforce with higher education degree for each ICT sub-sector and region. According to this latter variable, one may expect ICT multinationals to be attracted by regions with a highly qualified workforce in cases where the nature of activities to be undertaken is skills-intensive.

Finally, in order to investigate whether potential differences exist between the EU15 and EU10, we also include a dummy variable that takes a value equal to one when a region is located in one of the EU10. This variable will be equal to zero for the rest of regions.

Table 14 below provides the results of our estimation of the location choice model represented by equation (3) of Appendix 2, Methodological Note 2.6 including the explanatory variables described above.

Table 14: The Determinants of Multinationals' location choice in ICT: results from the Conditional Logit estimations

SECTOR	OFFICE, MACH. & COMPUTERS	RADIO, TEL. & COMM. EQU	MEDICAL, PRECISION & OPT. EQU	POST & TELECOM	COMPUTER SERVICES
Regional GDP	0.814**	0.900**	0.791**	1.199**	0.855**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Specialisation	0.293**	0.204**	0.408**	0.165**	0.683**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
High education	2.696*	3.290**	2.875**	4.401**	1.438**
	(0.021)	(0.000)	(0.000)	(0.000)	(0.000)
EU10	0.293	1.507**	0.401	0.781**	0.116
	(0.656)	(0.000)	(0.191)	(0.000)	(0.418)
Density SME	0.561*	0.476**	0.445**	0.037**	0.012**
	(0.034)	(0.000)	(0.001)	(0.000)	(0.000)
Observations	8895	36224	40667	110747	331813
Pseudo R²	*0.15*	*0.09*	*0.08*	*0.27*	*0.23*
Log Likelihood	-267.4	-891.9	-1014.9	-1888.7	-6710.8

*Note: ***, ** and * signify statistical significance at the 1, 5 and 10 per cent levels, respectively. Standard errors in parentheses.*

Overall the sign of the coefficients displayed by the different explanatory variables are according to our prior expectations. In particular the level of regional GDP measuring local market access, the degree of industrial specialisation, the level of education and the density of SMEs of the EU25 regions all have positive and significant influence on the probability for a region to be chosen as location site by a given multinational, independently of the ICT sector considered. By contrast, the fact that a region is located in EU10 seems to be relevant only in the cases of the manufacture of Radio, Television and Communication Equipment (Nace 32) and Post and Telecommunications (Nace 64) where regions located in the EU10 have, on average, tended to be more attractive for multinationals' location.

While the results depicted by Table 14 appear to be relatively homogenous across the different ICT sub-sectors, some interesting differences do emerge, however. In particular the level of industrial specialisation appears to be especially important in the case of the Computing Service sub-sector (Nace 70). Given the descriptive evidence provided in all the previous sections, this result tends to support the idea that the impressive growth of this sector of activity, which has mostly driven the whole ICT industry growth over the past decade, has tended to be localised in regions already highly specialised in this type of activity. Sector-specific agglomeration economies therefore are likely to be at play in this sector of activity with an important attraction of existing clusters for the location of new multinationals' affiliates. The level of education of the workforce and the density of SMEs tend to play a lesser role in the Computing service sector as compared to the other ICT sub-sectors, although this role is still positive and highly significant. Probably, the density of SMEs is less relevant in the case of the two ICT service sub-sectors where the potential role played by this type of firms as intermediate providers of multinational firms is likely to be less relevant than it might be in the case of ICT manufacturing activities.

4.4.2. Assessing the attractiveness of EU regions for multinationals' location

One advantage of the estimation results described in Table 14 is that one can calculate the estimated probability of each and every EU region of being chosen by a multinational of the ICT sector. In particular, by calculating such estimated probabilities, one takes into account the influence exerted by the explanatory variables considered. The big difference therefore with the simple descriptive statistics counting the frequency of a given region to be chosen by a multinational is that with an econometric model at hand one controls for the observed characteristics of the regions concerned. Accordingly, the estimated probability can be thought as representing the estimated frequency (or probability) of a region to be chosen by a multinational *given* a set of regional characteristics. In order to do this we therefore use the estimation provided in Table 14 to compute for each sector/region the following statistics:

$$\Pr\left(y_r = 1\right) = \frac{\exp\left(b\, X_r\right)}{1 + \exp\left(b\, X_r\right)}$$

where y_r is the probability of a given region r at time t to be chosen as location site by a multinational and X are the regions' characteristics which estimated elasticities are given by the econometric results. With the estimates of b provided by Table 14, one can therefore easily calculate the values of the above estimated probabilities when the observed location is actually taking place. The average location probability is then calculated for each EU region such that regions can be classified according to this estimated probability. In order to ensure that results are comparable across ICT sub-sectors we use the same classification criteria.[28]

These groups are shown in the Maps 8 to Map 12: 12 presented in the following pages, They display the results obtained after calculating the expression above. They provide a picture of how attractive European regions have been for the location of new multinational activities during the period 1995-2004. As noted above, these Maps do provide more complete information than the simple count of new affiliates locations as they take into account the characteristics considered in Table 14. According to these maps, the most attractive regions for FDI were mainly located in the EU15 regions in most sub-sectors considered. In particular, the South-East of Ireland, the French region Île de France, the Madrid region (ES), the French region Rhône Alpes, the Stockholm region, Denmark, Oberbayern and Darmstadt (DE), the Brussels region and the Noor Halland region, London, Eastern Scotland and Berkshire, Buckinghamshire and Oxfordshire (UK), are usually ranked relatively high in terms of attractiveness for FDI. The EU10 regions that have been most attractive for FDI during the period considered here are Mazowieckie (PL), the Kozep-Magyarorszag region (HU), the Prague region (CZ) and Estonia. In these latter case, attractiveness has been especially high in the ICT manufacturing sub-sectors although even for these sub-sectors the most attractive EU10 regions appear to lag behind the most highly specialised EU15 regions mentioned before.

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[28] It is important to note that because the probabilities calculated after estimating equation (3) are conditional on observed explanatory variables, the values obtained cannot be directly interpreted such that one can only classify regions according to the same classification criteria across the different ICT sectors.
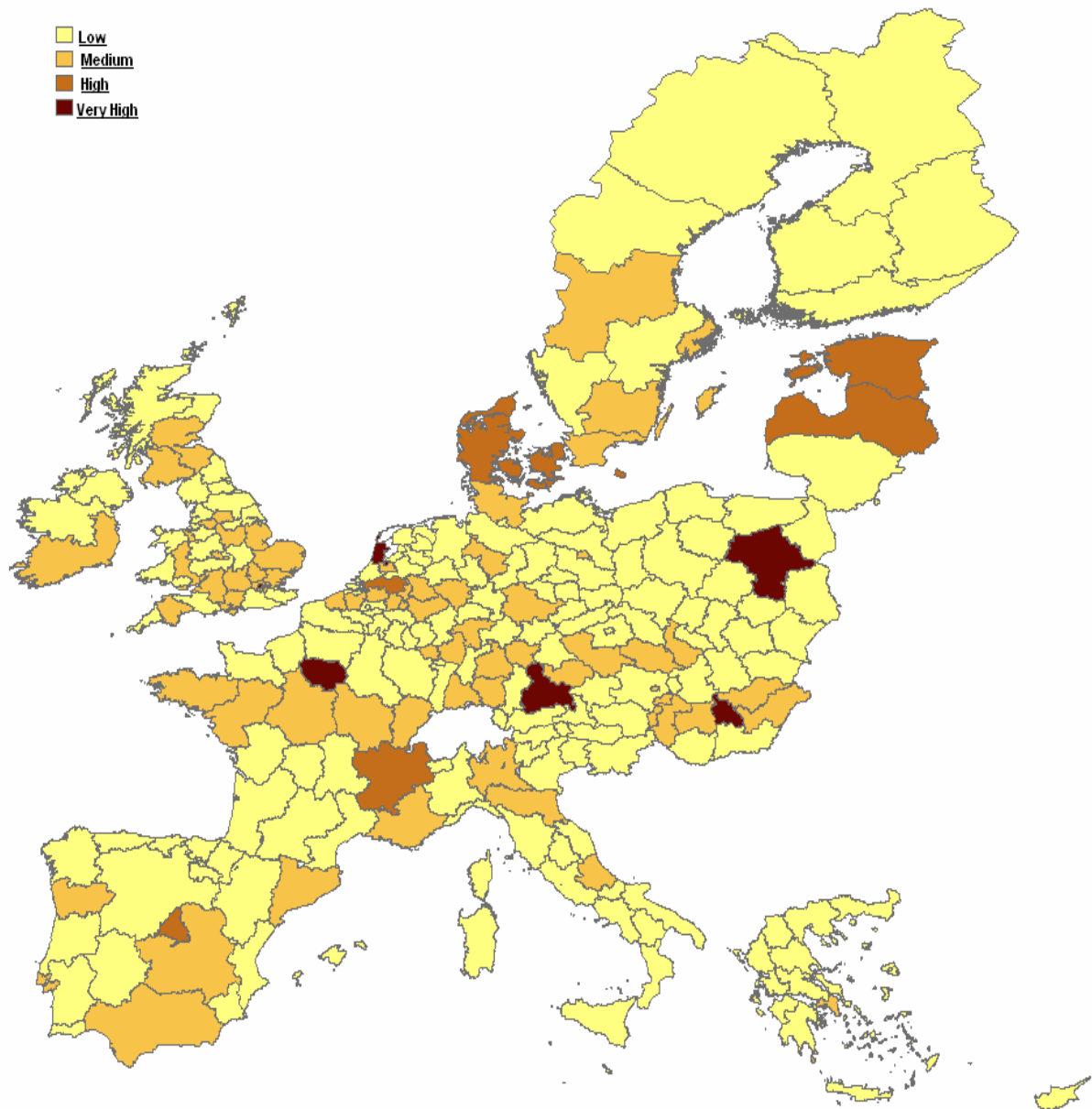
Map 8: Probability of a European region for being chosen by a multinational, based on estimation results for the period 1995-2004

Office Machinery & Computers (Nace 30)
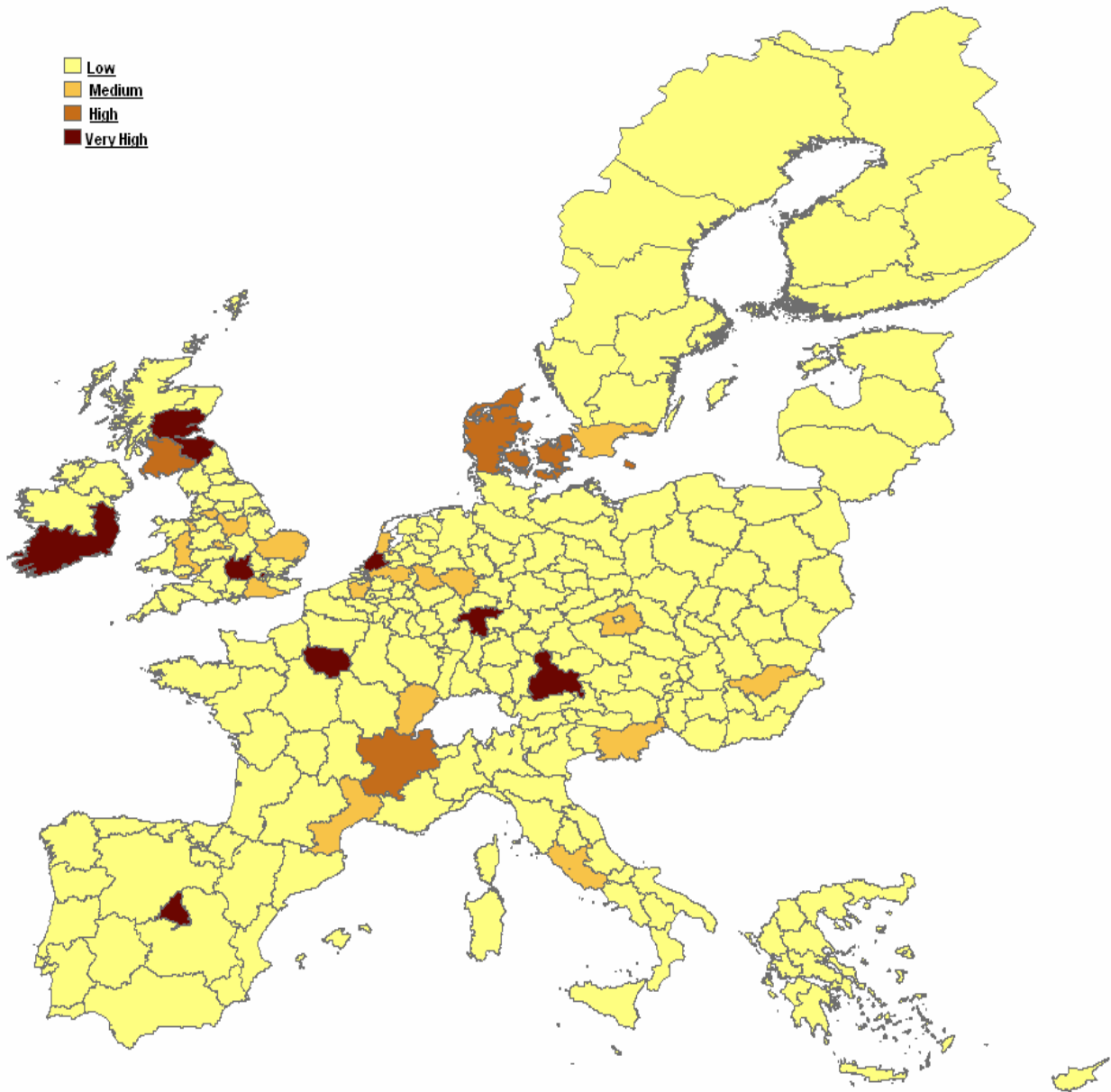
Sources: Data from Amadeus database, Bureau van Dijk. Estimation based on Equation (3) (Appendix 2, Note 2.6) and result of Column (1) of Table 14. Predicted probabilities computed according to Equation (2) (Appendix 2, Note 2.6)
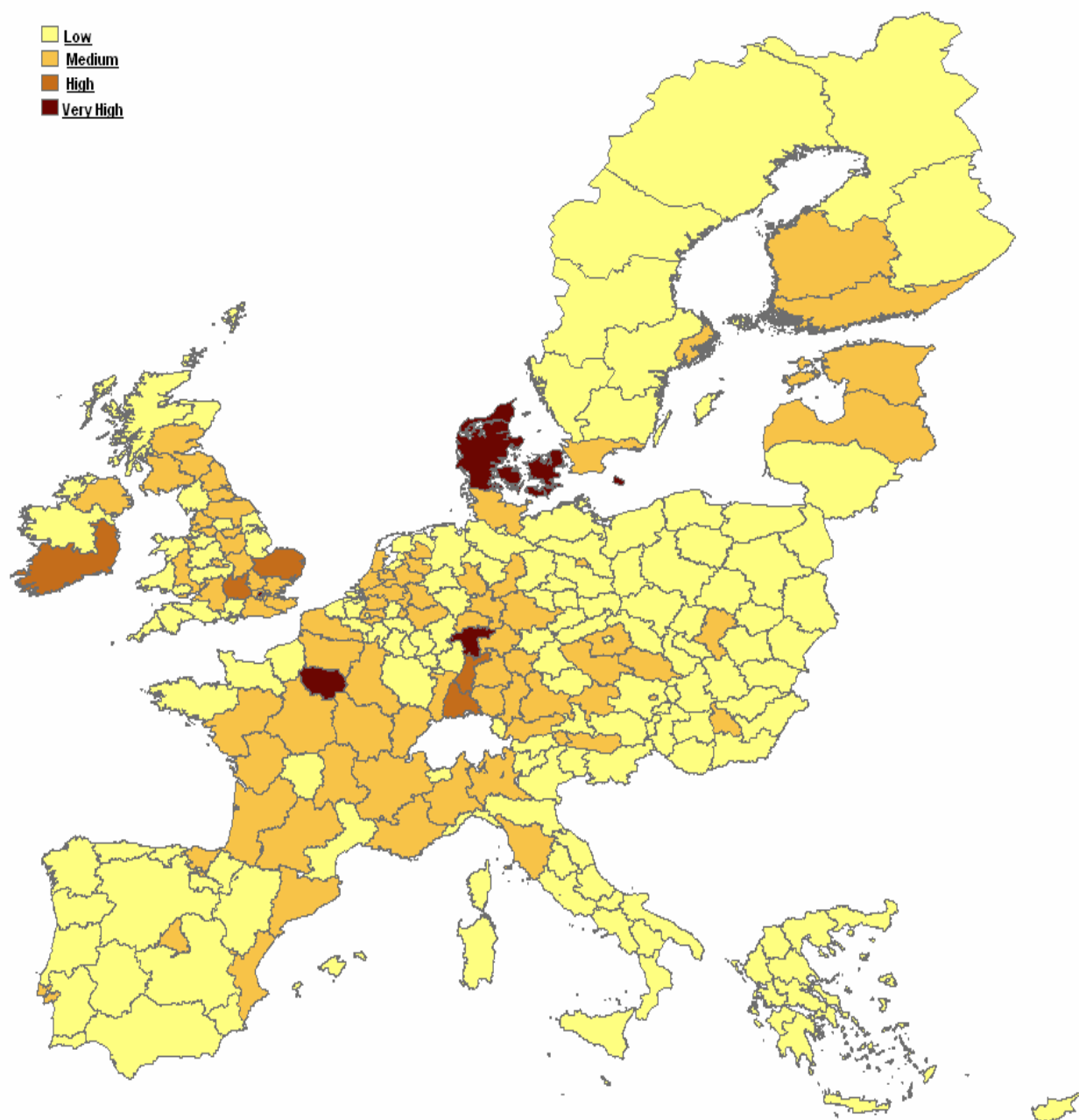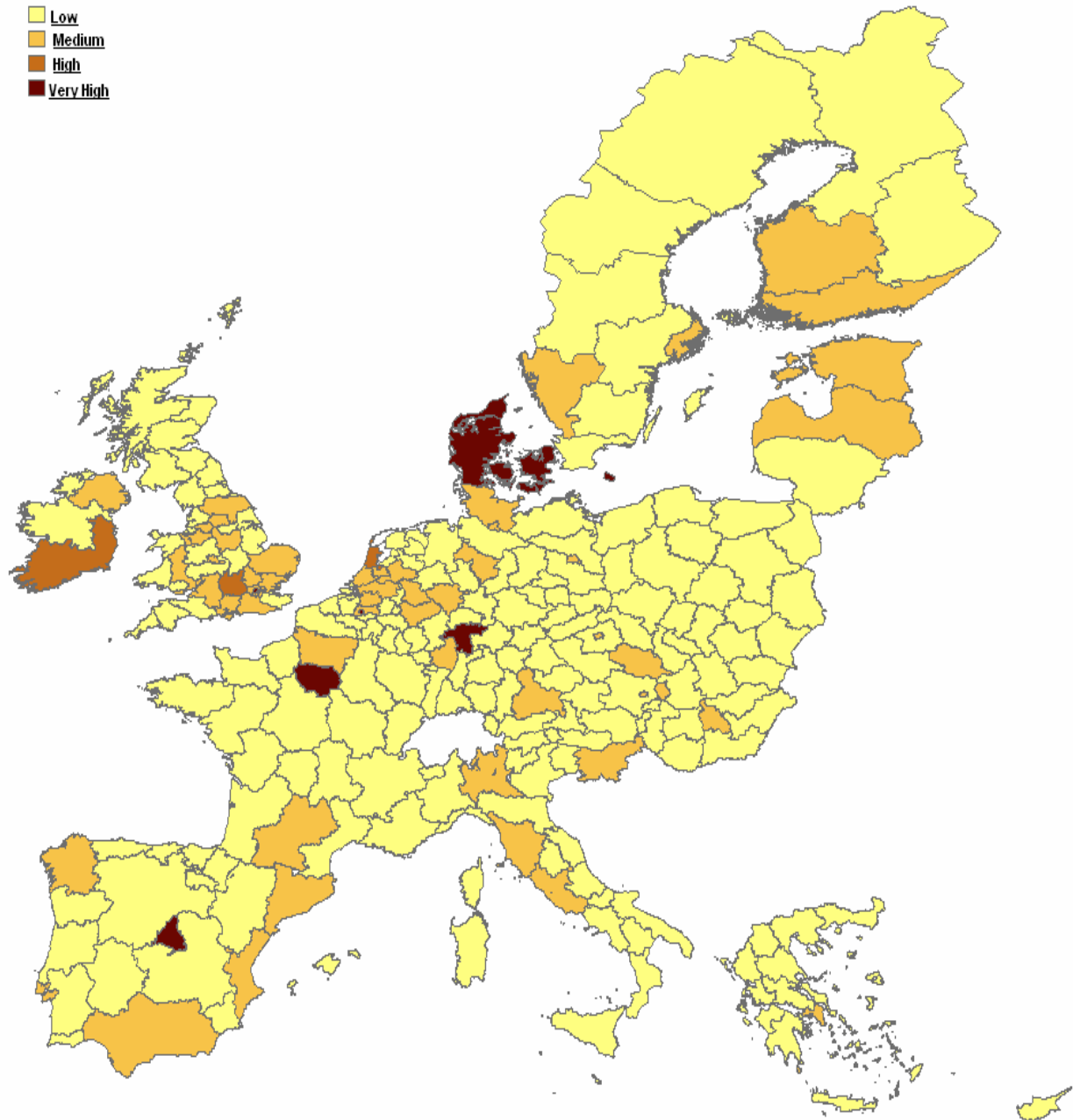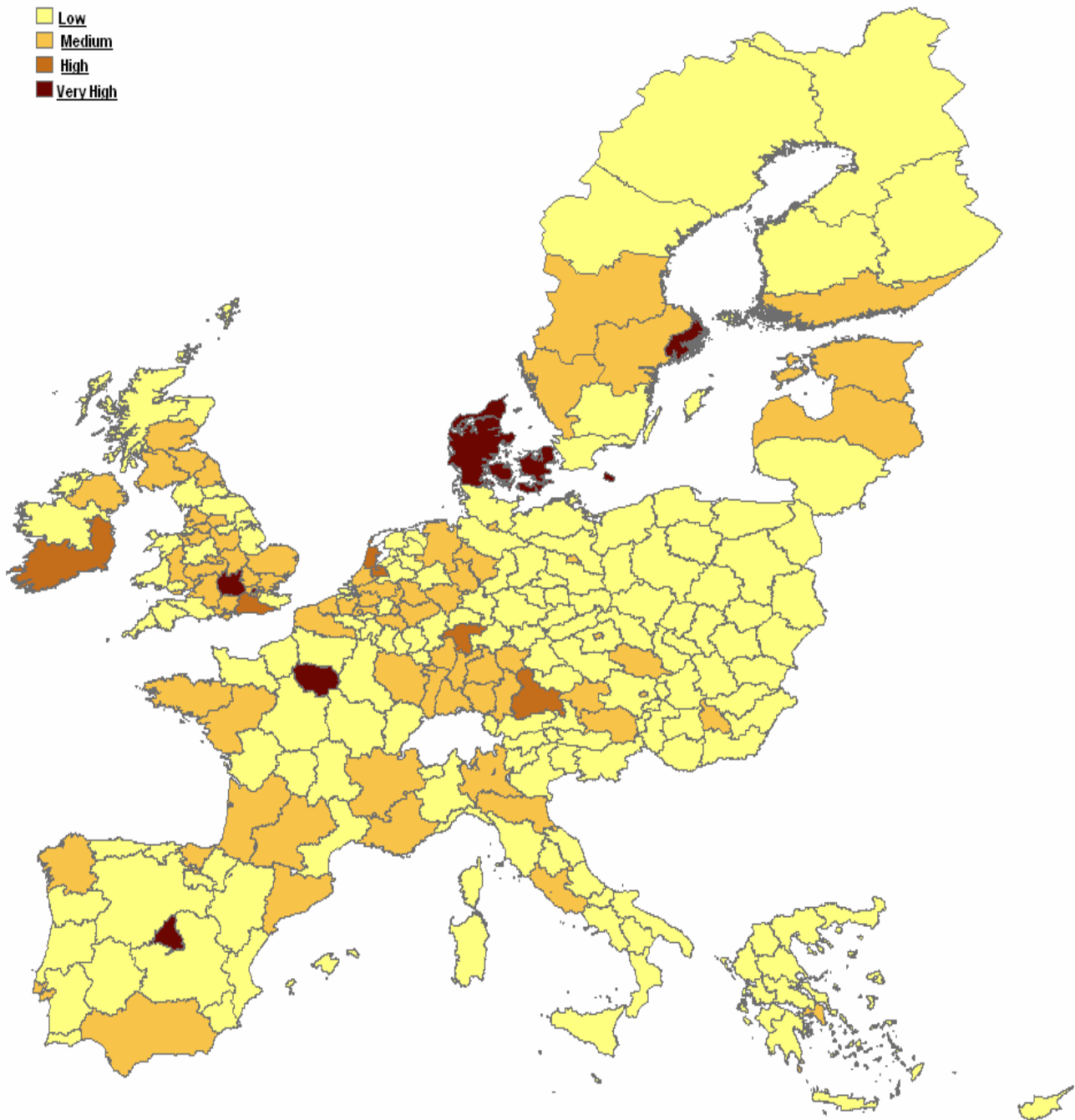
Radio, Television & Communication Equipment (Nace 32)

Sources: Data from Amadeus database, Bureau van Dijk. Estimation based on Equation (3) (Appendix 2, Note 2.6) and result of Column (2) of Table 14. Predicted probabilities computed according to Equation (2) (Appendix 2, Note 2.6)

Medical, Precision & Optical Equipment (Nace 33)

Sources: Data from Amadeus database, Bureau van Dijk. Estimation based on Equation (3) (Appendix 2, Note 2.6) and result of Column (3) of Table 14. Predicted probabilities computed according to Equation (2) (Appendix 2, Note 2.6)

Map 11: Probability of a European region for being chosen by a multinational, based on estimation results for the period 1995-2004

Post & Telecommunications (Nace 64)

Legend:
- Low
- Medium
- High
- Very High

Sources: Data from Amadeus database, Bureau van Dijk. Estimation based on Equation (3) (Appendix 2, Note 2.6) and result of Column (4) of Table 14. Predicted probabilities computed according to Equation (2) (Appendix 2, Note 2.6)

Low
Medium
High
Very High

Sources: Data from Amadeus database, Bureua van Dijk. Estimation based on Equation (3) (Appendix 2, Note 2.6) and result of Column (5) of Table 14. Predicted probabilities computed according to Equation (2) (Appendix 2, Note 2.6)

5. The impact of ICT investment on regional growth and productivity differentials

5.1. Main results

- The recent slow path of EU productivity, as compared to that of the USA, has worried the EU authorities, raising the prospect of a long term loss in EU competitiveness. Existing studies show that the EU deficit in ICT investment is a primary candidate for explaining this state of affairs. Up to now, these issues have been studied at the country/sector level such that regional studies have, to date, not been performed. The main reason for this is related to the lack of reliable regional data.

  Up to recently, studies on the impact of ICT on regional development had not been undertaken, due to the lack of reliable data.

- Since the mid-nineties, data on ICT investment and other types of capital stocks at regional level, including public capital, have been assembled for Spanish regions by the Fundación Banco Bilbao Vizcaya Argentaria (FBBVA) and the Instituto Valenciano de Investigaciones Económicas (Ivie). Importantly, the FBBVA-Ivie database has been updated using the most recent OECD methodology. The database splits total capital into 18 different asset types: six of these are infrastructures and three of them are ICT capital assets (hardware, software and communication). Importantly, this data allows the analysis of the contribution of ICT capital investment to regional GDP and productivity growth and, by the same token, regional convergence.

  The present Section provides novel evidence by considering the special case of Spanish regions

- The data used here show that, during the period 1985-2004, capital endowments have differed substantially by region and that almost 60% of total investments in ICT are done by the four largest regions. Despite this, ICT capital appears to be more evenly distributed among regions than infrastructures while ICT capital services have grown at more than twice the speed of total capital during the period under scrutiny. The growth accounting exercise undertaken here shows that the contribution of ICT to GDP and productivity growth has been noticeable across Spanish regions during the period 1985-2004.

  ICT capital investment appears to have grown markedly, although the bulk of it has been concentrated in a limited number of regions...

- Except for infrastructures capital, the results reported here show a strong convergence process among Spanish regions for labour productivity, total capital deepening (ICT and non ICT capital) and average years of studies. A measure of regional dispersion diminishes along the period (σ-convergence) and the poorest regions grow quicker than the richest ones (β-convergence).

  ...however, ICT investment appears to have contributed significantly to regional income and productivity convergence and even more so than other types of capital and infrastructures

- The results also show that ICT has contributed positively to regional convergence in Spanish regions during the period. What is more, ICT appear to be the item that has contributed most to regional convergence denoting a

widespread positive effect of ICT on convergence despite large inequalities in ICT investment. Despite this, the results obtained here also show that the full benefits of ICT on productivity and growth are not yet visible in Spain as a whole such that it may be expected that, in the future, regional effect become even more pronounced as ICT tend to diffuse throughout the Spanish economy. A later start and a lower intensity of ICT investment than those of its trade partners can explain this delay. Additional elements can also be responsible for this gap like a low presence of an ICT producing sector, a reduced household use of ICT, a weak presence of ICT in schools, a high relative cost of internet, etc. More structural factors can also be mentioned like the industry specialization of the economy with a low presence of high tech sectors and low R&D investment rates.

5.2. The impact of ICT investment on growth and productivity: rationale and data used

As previously argued, Information and Communication Technologies (ICT) may affect regional development through different avenues. While these transmission channels are not different from those followed by national economies, it is interesting to see whether, even within the same country, the economic benefits of ICT investment can differ across regions within the same country. Three different channels can be put forward:

- The first channel operates through the output composition of industries. The presumption here is that technical progress takes place only in the high tech sectors of the economy. Therefore, the higher the weight of ICT producing industries in total output, the higher will be the impact on economic growth via multifactor productivity improvements.

- The second channel operates through ICT capital accumulation. The presumption is that not all forms of capital have the same impact on economic growth. Most recent contributions have stressed the importance of distinguishing between ICT and non-ICT assets as it had previously done with qualified and unqualified workers. The conjecture was that those industries with the largest shares of ICT on total capital should experience also the largest productivity gains. Importantly, this argument shifts the emphasis from industries that produce ICT on to industries that use ICT.

- The third way in which ICT can affect the growth rate of a given economy is by accelerating the general technological progress. ICT capital incorporates a completely horizontal set of technologies, so that all sectors can potentially benefit from their use. Accordingly, ICT investments should bring about a general improvement in the technical progress component of productivity growth.

The three different channels summarized above rely on the importance of ICT capital accumulation for economic growth. Therefore, this Section will focus on capital inputs rather than ICT employment figures.

The availability of capital stock data, and information on ICT capital in particular, represents the main issue to be considered here. In terms of requisite, this data should display a minimum level of disaggregation by type of assets, in particular regarding the distinction between ICT and non-ICT capital. A number of initiatives have been taken at the country-level to gather ICT reliable investment data. The first one was promoted by the OECD –under the sponsorship of the United Nations - and produced two Manuals (2001a, b) designed to serve as guidance for all member countries. A common methodology has been developed that is suited to deal with different types of assets: more specifically, with short lived assets that experience falling prices and strong quality improvements, such as ICT.[29] This very important initiative called for practical implementation. Using the new methodology a first set of aggregate results is provided by the OECD Productivity database. The second initiative is the EU KLEMS project within the 6th Framework Programme of the EU, with 18 institutions and 14 countries participating in it. From our perspective three key features are worth highlighting: 1. the international coverage (EU-25, USA, Japan); 2. A homogeneous methodology used for capital stock estimates that include ICT and non-ICT assets disaggregation; and 3. A fairly detailed sectoral breakdown (62 industries).

However, a very limited number of countries consider the regional dimension of capital accumulation. Spain, together with Canada, are the most prominent exceptions. In the Spanish case, the Fundación Banco Bilbao Vizcaya Argentaria (FBBVA) and the Instituto Valenciano de Investigaciones Económicas (IVIE) have started to publish the first capital stock estimates as early as 1995, following the OECD (1992) methodology. Two features stand out prominently. First, the rich level of regional disaggregation, covering the 17 regions (NUTS-2) and 50 provinces (NUTS-3).[30] Second, the emphasis put on public capital, and more especially in infrastructures.

The FBBVA-Ivie database has undergone a continuous process of updating. It benefited from all methodological improvements already mentioned in three different ways. Namely, *i)* through an active participation in the elaboration of the OECD (2001a) *Measuring Capital Manual* as well as in its current revision; *ii)* with the provision of Spanish data to the OECD Productivity and STAN databases; *iii)* becoming the Spanish counterpart of the EU KLEMS project. Its main characteristics are as follow (Mas, Pérez and Uriel, 2006b):

Coverage: Nationwide; regions (17 NUTS-2); and provinces (50 NUTS-3 plus the two autonomous cities of Ceuta and Melilla).

Period: 1964-2004 (the update to 2005 will be available before the end of 2007)
Asset types: 18 of which:

   – 3 ICT assets (hardware, software and communications)

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[29] This is probably not the right moment to get into methodological issues. Interested readers should address the two OCDE *Manuals* for details. A short overview can be found in Mas, Pérez and Uriel (2006). Presently, August 2007, a revision of the *Measuring Capital* Manual is underway.
[30] Mas, Pérez and Uriel (1998)

– 6 Infrastructures (roads, railways, ports, airports, urban and water infrastructures).

5.3. The impact of ICT investment on regional growth and productivity: Evidence from Spanish regions

In this section we present the main results derived from the use of the data described above.[31] We start making a general presentation of ICT endowments from the regional perspective. Then, we proceed to analyse the contribution of ICT to regional growth and convergence using a growth accounting approach. Finally, we provide some concluding remarks.

5.3.1. ICT capital endowments in Spanish regions

The OECD published in 2002 two Manuals devoted to the clarification of the concepts and definitions of ICT (2002a) and Information Economy (2002c). Two main outputs came out from this effort. First, a consensus was reached among member countries on the most important ICT indicators. Second, for the first time, the use of this first array of indicators placed every country in the international context.

From the ICT point of view, one indicator stood as the most prominent one: spending on ICT assets, that is Gross Fixed Capital Formation (GFCF) on ICT, as a percentage of either Gross Domestic Product (GDP) or of total GFCF. This latter indicator for the whole country as well as for each of the 17 regions appears in Figure 8 for two selected years 1985 and 2004. The initial year of 1985 illustrates the position of Spain one year before joining the EU and 2004 is the last year with available information.

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[31] A similar analysis could be carried out for the 52 Spanish provinces.

Figure 8: ICT GFCF / Total GFCF (dwellings excluded). Spanish regions. Current prices (percentages)
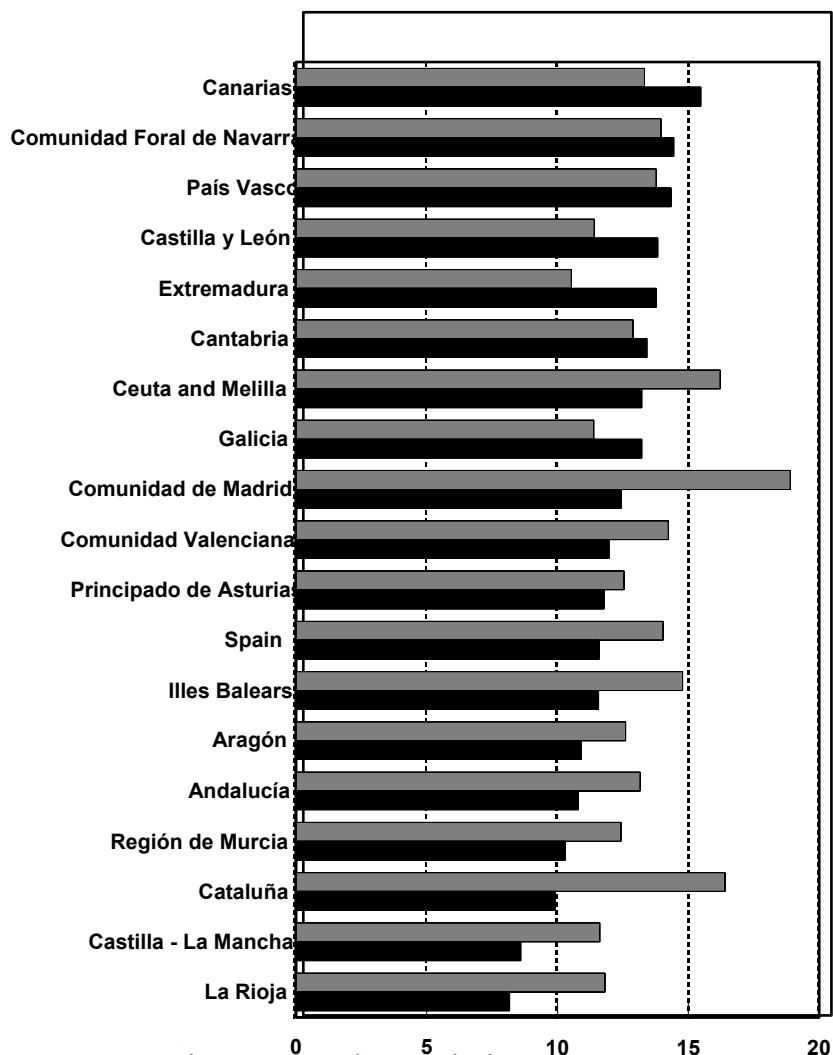
Source: BBVA Foundation-Ivie and own calculations

GFCF = Gross Fixed Capital Formation   ■ 1985 ■ 2004

Although investment spending is the most prominent indicator of ICT penetration in the economies, from a growth perspective, estimates on regional capital endowments are preferable.[32] The position of each region in terms of their ICT endowments in relation to total capital appears in Figure 9. In this second case we find smaller regional differences[33] than before and in all but two of the regions, the

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[32]   Technically, what is needed is information on the capital services provided by ICT capital. For that, it is required to build estimates on *productive* capital as well as for the price of the services provided. The latter is called user cost of capital. For Spain this information is provided by the FBBVA-Ivie database (Mas, Pérez, and Uriel (2006b)). The methodological details can be found in Mas, Pérez and Uriel (2006a)

[33]   This is not unusual since investment fluctuates more than productive capital.

services of ICT capital exceed the threshold of 15% of the total capital services in 2004. Remarkably, Madrid stands in the first place of the Spanish regions.

Figure 9: ICT capital services / Total capital services (dwellings excluded). Spanish regions (percentages)
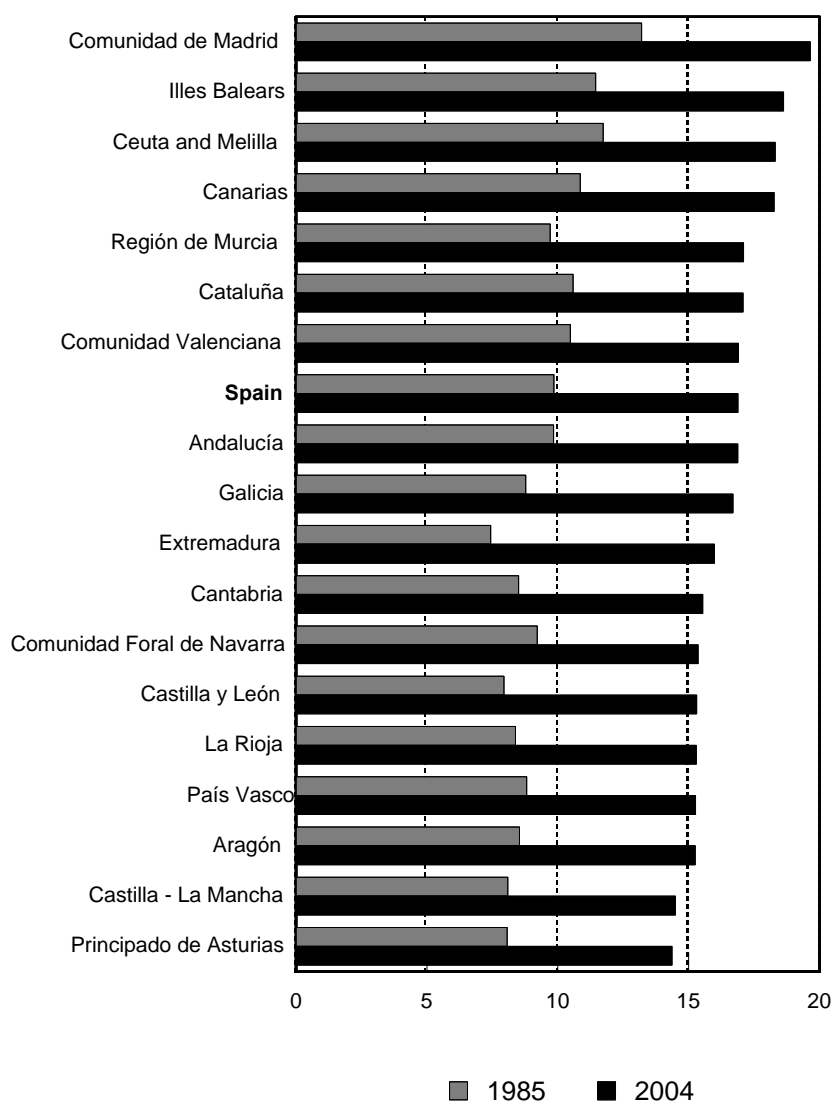
Source: BBVA Foundation-Ivie and own calculations

The dynamics of the accumulation of productive capital appears in Table 15. It shows the annual rate of growth of productive capital for the period 1985-2004. This table breaks up productive capital into a non-ICT and an ICT component and this latter one, in turn, into three assets: hardware, software and communications.

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Table 15: Capital services (dwellings excluded). 1985-2004

	Total	ICT				Non-ICT
		Total	Software	Commu-nications	Hardware	
Andalucía	5.46	10.68	10.86	6.29	17.45	4.67
Aragón	5.01	10.83	10.63	6.36	16.86	4.23
Principado de Asturias	3.36	8.80	10.44	3.88	16.63	2.66
Illes Balears	6.17	10.64	11.52	6.42	18.77	5.37
Canarias	6.36	11.07	11.91	7.08	19.15	5.56
Cantabria	3.82	9.96	10.18	4.96	16.65	3.00
Castilla y León	4.01	10.26	10.38	5.49	16.71	3.20
Castilla - La Mancha	4.95	10.68	10.55	6.48	16.78	4.24
Cataluña	5.39	10.51	10.36	6.17	16.84	4.58
Comunidad Valenciana	5.77	10.81	10.39	6.49	17.52	4.98
Extremadura	3.94	11.19	11.59	5.73	17.82	3.01
Galicia	4.76	10.70	10.77	5.74	17.71	3.90
Comunidad de Madrid	7.05	11.66	11.21	7.38	17.37	6.16
Región de Murcia	6.44	11.51	11.95	6.64	18.93	5.65
Comunidad Foral de Navarra	5.67	11.35	11.42	7.07	16.87	4.88
País Vasco	3.95	9.69	10.82	4.71	16.18	3.17
La Rioja	5.31	11.52	11.22	6.97	17.21	4.50
Ceuta and Melilla	5.36	9.78	11.28	5.63	18.73	4.58
Spain	5.32	10.72	10.82	6.22	17.24	4.50

Source: BBVA Foundation-Ivie and own calculations
* Annual rates of growth in %

Spain's annual rate of accumulation of total capital reached 5.32% over the period. This substantial real rate of increase was, in turn, the combination of a 4.5% rate of increase of Non-ICT capital and a much higher growth rate of ICT capital of 10.72%. Similarly, the components of ICT capital rise at very different speeds. The fastest growing ICT capital component is hardware with a 17.24% annual rate, whereas software's rate is 10.82% and Communications' 6.22%. Notice again that Madrid was the region showing the highest growth rate.

5.4. The impact of ICT capital on growth and convergence: results from growth accounting

The available information allowed us to perform a growth accounting exercise distinguishing among different types of capital.[34] Even though we are mainly interested on ICT, it is worth to consider at least two other forms of capital that have deserved a great deal of attention in the literature: infrastructures and human capital.

Prior to the interest on distinguishing between ICT and non-ICT assets, another distinction had received a great deal of attention in the literature. It was the break down between private and public productive capital. This innovative approach was received with great interest in Europe and probably even more in Spain where the birth of the new Autonomous Communities gave a regional dimension to the debate on infrastructures. Furthermore, also the regional policy of the EU reinforced the key role of public infrastructures on regional growth and convergence.

The growth accounting methodology is based on the decomposition of the output growth of an economy into the contributions of the factors of production used and a residual. This residual is called multifactor productivity and, under certain conditions, is interpreted as the technical progress or efficiency improvement term which contributes to output growth without apparently consuming any resources.

The information available for Spain also considers five different factors of production: three types of capital (infrastructures, ICT and non-ICT capital) and two components of labour (worked hours and labour qualification). The latter is especially relevant for Spain since the labour qualification index improved dramatically over the period of analysis.

The growth accounting results for the Spanish regions over the period 1985-2004 appear in Table 16. Spain's average annual rate of growth was 3.14%. Capital services contributed to this growth with 1.49 pp, hours worked with 1.61 pp and labour force qualification with 0.61 pp. Consequently, the residual was negative (-0.56 pp.)

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[34] In a series of papers Mas and Quesada (2005a,b,c and 2006)) have addressed similar issues but from a national perspective. These papers also describe the growth accounting approach used here.

Table 16: Growth accounting. VA (Value Added). Total market economy. 1985-2004

	VA	Capital services				Hours worked	Labour force qualifi-cations	TFP
		Total	ICT	Infras-tructures	Rest of capital			
Andalucía	3.32	1.65	0.42	0.19	1.03	2.06	0.58	-0.97
Aragón	2.63	1.53	0.39	0.19	0.95	1.17	0.60	-0.66
Principado de Asturias	1.62	1.07	0.32	0.19	0.56	0.17	0.36	0.01
Illes Balears	2.75	1.68	0.44	0.10	1.15	1.96	1.00	-1.89
Canarias	3.56	1.93	0.49	0.16	1.28	2.48	0.80	-1.65
Cantabria	2.88	1.24	0.38	0.19	0.67	1.24	0.05	0.36
Castilla y León	2.22	1.26	0.37	0.17	0.72	0.52	0.63	-0.19
Castilla - La Mancha	2.90	1.67	0.40	0.21	1.06	1.03	0.80	-0.61
Cataluña	3.34	1.40	0.37	0.10	0.93	1.89	0.58	-0.53
Comunidad Valenciana	2.99	1.65	0.42	0.14	1.09	1.92	0.52	-1.10
Extremadura	2.85	1.46	0.48	0.22	0.76	0.89	0.65	-0.15
Galicia	2.44	1.33	0.39	0.15	0.80	0.14	0.40	0.57
Comunidad de Madrid	3.89	1.53	0.41	0.12	1.00	2.28	1.07	-0.99
Región de Murcia	3.71	2.03	0.48	0.16	1.39	2.32	0.52	-1.16
Comunidad Foral de Navarra	3.08	1.62	0.39	0.10	1.12	1.42	0.67	-0.63
País Vasco	2.70	1.20	0.35	0.11	0.74	1.33	0.23	-0.07
La Rioja	2.48	1.61	0.41	0.10	1.10	0.93	1.18	-1.24
Ceuta and Melilla	4.31	1.76	0.49	0.21	1.06	2.05	0.37	0.13
Spain	**3.14**	**1.49**	**0.40**	**0.14**	**0.95**	**1.61**	**0.61**	**-0.56**
Coefficient of variation	0.21	0.16	0.12	0.28	0.23	0.51	0.47	-1.14

Sources: Own calculations.
* Annual rates of growth in % and absolute contributions to VA growth.

With respect to regional growth accounting exercise described in Table 16, interesting results do emerge. In particular, looking at the coefficient of variation of each of the contributing factors to output growth (see the last row in Table 16) we find the highest dispersion in TFP, followed by hours worked, labour force qualification, infrastructures, rest of capital and ICT capital. In other words, the Spanish regional growth pattern is more homogeneous in the growth contributions made by ICT capital than in those made by infrastructures. Interestingly, the regions which show a positive contribution of TFP (such as Asturias, Cantabria and Galicia) exhibit a relatively poor VA growth performance. However in terms of labour productivity, PTF contribution appears to be the most relevant source of growth.

Turning to regional convergence issues, the data used here allows us to study the contribution of ICT capital and other types of inputs to regional convergence. In order to do so, we use the analytical tool traditionally used in the growth literature to analyse the convergence of GDP per capita issues, see in particular Barro and Sala-i-Martin (2005). Two concepts of convergence are commonly used: σ and β-convergence. According to the first concept, there is σ-convergence in regional growth if, as time elapses, regions look more alike in terms of GDP per capita. In our case, there is σ-convergence if the coefficient of variation (a popular measure of dispersion) of the regional per capita income (or labour productivity) falls over a period of time.[35] The second concept relates to the notion of β-convergence. Accordingly, there is absolute β-convergence when poor regions grow faster than rich ones.[36] The main explanatory variable of the growth rate of a region would be its starting point. Thus, the higher the relative position of a region at the initial time the lesser should be the growth rate of the variable being considered.

Table 17 summarizes the results obtained for the σ-convergence of six different variables at five different points in time. According to these figures it is clear, first, that there has been a general reduction in regional differences in Spain over the period. Second, although the convergence in labour productivity levelled off in the mid-nineties, the total capital-labour ratio and the labour qualification continued their convergence processes. Third, if one compares the degree of dispersion among the different regions of labour productivity and capital deepening, one finds a reversal in their relative values between the initial and the final point in time. There is a higher regional disparity of resources than of output at the beginning of the period that gives way to a lower disparity at the end of the period. Fourth, if we look at the break down of total capital into ICT, non-ICT and infrastructures, we find convergence in the endowments of the first two components but an absence of convergence in infrastructures.[37] In other words, regions have become more alike in non infrastructures capital endowments but slighter more distinct in infrastructures related to employment. Hence, apparently, public infrastructures policies have not corrected the initial regional differences in public capital and have not contributed to regional convergence. Also we find that the dispersion among regions in ICT capital is lower than in non-ICT capital. Thus the effort made in ICT investment has been more homogeneous among regions than in the rest of capital goods.

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[35] In this definition two assumptions are implicit: all regions are equally important regardless of their relative size, and no attention is paid to the distribution of income among citizens within each region.

[36] This definition is called non-conditioned, or absolute, β-convergence. In contrast, conditioned β-convergence would introduce additional explanatory variables (to the initial value) in the determination of the long term regional equilibrium.

[37] All capital variables are scaled to employment. Alternative variables for scaling infrastructures have been considered in the literature -like GVA, population or the size in km^2 of the region- with somehow different results.

Table 17: σ-convergence. Labour productivity, capital services and labour force qualification (percentages)

	Labour productivity	Capital services / employment				Labour force qualification
		Total (dwellings excluded)/ employment	ICT/ employment	Infras- tructures/ employment	Rest of capital/ employment	
1985	0.1470	0.1608	0.1496	0.2738	0.1747	-
1990	0.1408	0.1549	0.1258	0.2897	0.1745	0.1157
1995	0.1191	0.1258	0.0827	0.3024	0.1347	0.0994
2000	0.1073	0.1119	0.0571	0.3088	0.1193	0.0766
2004	0.1056	0.0945	0.0696	0.2863	0.0926	0.0601

Sources: BBVA Foundation-Ivie, INE and own calculations

We now turn to the alternative method of computing convergence. Figure 10 clearly shows the existence of β-convergence[38] in five of the six variables considered. All the estimated convergence equations have a negative slope and a coefficient which is statistically significant in five of the six cases. Regions with a backward initial position are situated on the left hand side of the diagram. These regions are also on the upper part, meaning that they have enjoyed a high rate of growth of the respective variable. Note that in all the six cases presented, the Region of Galicia appears as the least advanced region in 1985. But the good news is that it is also the region that has improved its position at the quickest pace. So, there is convergence.

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[38] This method relies completely on the initial and the final observation values. So, it takes them as good indicators of the true information and it ignores all intermediate values.

Figure 10: β-convergence (percentages)

a) Labour productivity . Total market economy

$y=0,307-0,029x$
$(-5,527)$
$R^2=0,66$

Annual rate of growth 1985-2004

Galicia
Castilla y León
Extremadura
Castilla-La Mancha · P. de Asturias
Ceuta and Melilla
La Rioja
Navarra
Cantabria
C. de Madrid
Cataluña
Aragón
País Vasco
Andalucía
C. Valenciana
R. de Murcia
Illes Balears
Canarias

Labour productivity (total market economy) neper logarithm 1985

b) Total capital services (dwellings excluded)/total market employment

$y=0,296-0,030x$
$(-5,167)$
$R^2=0,63$

Annual rate of growth 1985-2004

Galicia
La Rioja
C. de Madrid
Castilla y León
Castilla-La Mancha
C. F. de Navarra
Aragón
Illes Balears
C. Valenciana
Canarias
P. de Asturias
R. de Murcia
Extremadura
Cataluña
Ceuta and Melilla
Andalucía
País Vasco
Cantabria

Total capital services (dwellings excluded) / total market employemnte neper logarithm 1985

c) ICT capital services / total market employment

$y=0,281-0,034x$
$(-6,912)$
$R^2=0,75$

Annual rate of growth 1985-2004

Galicia
La Rioja
Castilla y León
Extremadura
Castilla-La Mancha
C. F. de Navarra
P. de Asturias
Illes Balears
C. de Madrid
R. de Murcia
Canarias
C. Valenciana
Andalucía
Cataluña
Cantabria
País Vasco
Ceuta and Melilla

ICT capital services / total market employment neper logarithm 1985

d) Infrastructures capital services/total market employment

$y=0,124-0,011x$
$(-1,586)$
$R^2=0,14$

Annual rate of growth 1985-2004

Galicia
P. de Asturias
Cantabria
Castilla-La Mancha
C. de Madrid
Castilla y León
Extremadura
País Vasco
Illes Balears
C. Valenciana
R. de Murcia
Andalucía
Aragón
Cataluña
C. F. de Navarra
La Rioja
Canarias
Ceuta and Melilla

Infrastructures capital services /total market employment neper logarithm 1985

e) Rest of capital services / total market employment

$y=0,317-0,034x$
$(-6,347)$
$R^2=0,72$

Annual rate of growth 1985-2004

Galicia
La Rioja
C. de Madrid
C. F. de Navarra
Illes Balears
Castilla-La Mancha
Castilla y León
C. Valenciana
Canarias
P. de Asturias
Cataluña
Ceuta and Melilla
R. de Murcia
Extremadura
Andalucía
País Vasco
Cantabria

Rest of capital services / total market employment neper logarithm 1985

f) Labour force average years of schooling (16-64 years)

$y=0,086-0,032x$
$(-8,379)$
$R^2=0,81$

Annual rate of growth 1988-2004

Galicia
Extremadura
Castilla-La Mancha
Andalucía
C. Valenciana
R. de Murcia
Cataluña
Aragón
Canarias
Ceuta and Melilla
P. de Asturias
Castilla y León
Illes Balears
País Vasco
Cantabria
La Rioja
C. F. de Navarra
C. de Madrid

Labour force average years of schooling neper logarithm 1988

ation

Sources: BBVA-Ivie Foundation, INE and own calculations
* t-statistics in parenthesis

The β-convergence analysis confirms the previous σ-convergence results. Thus, we find a lack of convergence in the same variable as before, infrastructures (panel e), over the entire period. Also we find regional convergence in the rest of the variables. The estimated equations allow the computation of the speed of convergence. This is shown in Table 18. There we find a rank of the different variables according to their speed of convergence. Correspondingly to the earlier results, the fastest convergence variable is ICT capital and the slowest one is infrastructures capital.[39]

Table 18: β-convergence. Speed of convergence. 1985-2004** (percentages)

	Speed	Ranking
Labour productivity	4.22	5
Total capital	4.42	4
Labour force qualification	4.58	3
ICT capital	5.59	1
Infrastructures capital	1.25	6
Rest of capital	5.49	2

Sources: BBVA Foundation-Ivie, INE and own calculations
*** 1988-2004 for labour force qualification*

From this analysis of convergence one can derive some policy implications, either for evaluating implemented Programmes of regional policy or for the identification of the actual needs prior to the writing of new Programmes. With the results concerning the specific case of Spain at hand, it appears that the contribution of infrastructures to convergence is not visible, which is not the case with other types of capital and, in particular, of ICT capital. The above result should be interpreted with caution. In particular, given the analytical framework used here, i.e., a growth accounting exercise based on a production function approach, all production factors are deemed to play a role in GDP (and productivity) growth. Differences between production factors arise, however, in terms of variations of quantity (and quality) of the inputs used and their corresponding contribution to overall output. It follows that while ICT and other types of capital have contributed to a great extent to regional convergence in income per capita, and even more so than infrastructures for instance, the approach used here does not allow us to say anything about the significance of these effects. The results obtained here tend to show, therefore, that from a growth perspective, ICT accumulation has played a more substantial role than infrastructures in the Spanish regional performance.

From a regional policy perspective the above interpretation of our results tend to suggest that, while free markets play a more decisive role in assigning ICT capital than in providing infrastructures, the under-provision of public infrastructures may also represent a major impediment for growth and the Spanish case is a good example of this. On the positive contribution of public infrastructure on regional growth in Spain, see for instance, Mas, Maudos, Pérez and Uriel (1996, 1998) and Herce and Sosvilla (2007).

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[39] As the table indicates, 5.59% of the gap between actual labour productivity and its long run equilibrium vanishes in one year. At this speed it would take 12 years for half the gap to be eliminated. In the case of infrastructures, the corresponding figures are 1.25% for the speed of convergence and 55 years for the half-life convergence (see Barro and Sala-i-Martin (1995) for details)

6. Summary and policy implications

Regions are increasingly seen as the natural areas in which to observe the ongoing transformations and structural/technological changes enabled by ICT. In particular, ICT appear as an important element conditioning the way regions position themselves in a globalising world. Little is still known, however, about the consequences of the advent of ICT on regional economies. In particular, the technological change propitiated by ICT is likely to affect the EU industrial structure and growth dynamics. The present study has attempted to document the above trends, putting emphasis on three specific questions. The first concerns the location and nature of ICT employment and activities in EU regions. A comprehensive mapping of ICT industry location is provided in this study. The second question concerns the attractiveness of EU regions, with a special focus on employment skills and the role played by SMEs. The third question concerns the economic impact of ICT diffusion on regional growth and convergence. For this last question and given the lack of comprehensive data at the EU level, a special case-study was considered, namely Spain, which allowed us to provide new evidence on the topic.

This section summarizes the main results of the study and provides a number of policy implications related to these results, as well as future research questions.

6.1. Main results of the study

Main results of the study

- The Study shows that the ICT industry tends to be concentrated geographically around the so-called 'blue banana' of Europe, i.e. the area going from the South of the UK, the Benelux and Denmark, the French region of Ile de France, the Western regions of Germany and the North of Italy. The ICT industry appears to play a very important role in the specialisation of the richest regions which are also essentially located in Western EU countries (the EU15 countries). The regional dimension appears to be an especially important one when considering employment changes. In particular, this is true for the fast growing ICT Computer Services sub-sector (Nace 70) which has witnessed the emergence of regional clusters in the Madrid region in particular, but also in the South of Scotland, Ireland, the South of Finland and Western regions of Sweden as well as some regions in the EU10, generally located around the capital cities.

  The Study shows that ICT sectors tends to be concentrated around the blue-banana of Europe, although fast growing ICT cluster have emerged over the past decade

- When considering the nature of ICT activities, the ICT industry sectors appear to present a higher proportion of highly educated/professionals in their total employment as compared to the rest of the sectors of the economy. The proportion of highly skilled workers has also been rising steadily over the past decade, in clear contrast with the rest of the sectors of the economy. The Computer Services sub-sector is almost exclusively

  ICT sectors have a relatively high proportion of skilled workers....

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responsible for these evolutions. The strong expansion in the Computer Services sub-sector has contributed to the concentration of high-skilled employment in the largest EU ICT clusters, also mainly located in the richest EU regions. In addition, the downturn in employment in the EU ICT manufacturing sub-sectors has translated into marked increases in the proportion of skilled workers in the richest EU regions which has not been compensated by the increase in employment in the EU10, where the nature of employment also denote a lower skill-content. A possible explanation for these evolutions could be found in the fast de-location of ICT manufacturing/low-skills activities outside the EU25.

- Since 2005, a growing number of multinationals have located subsidiaries in the EU10, whereas before, multinationals tended to favour location in UK, Irish, Dutch and German regions. Here again, overall ICT evolutions are largely governed by the booming ICT Computer Services sub-sector. For this specific sub-sector, the core ICT EU regions from Ireland, the UK, the Netherlands, the South of Germany, Austria, the Madrid region and the South of Finland and Sweden have been the most attractive for foreign investors.

- A number of factors appear to be especially influential for attracting multinationals such as the level of regional GDP measuring local market access, the degree of industrial specialisation, the level of education and the density of SMEs established in a particular region. The level of industrial specialisation appears to be especially important in the case of the computer services industry while the presence of ICT SMEs appears to be more influential for ICT manufacturing. This result tends to support the idea that the impressive growth of the Computer Services sub-sector has tended to be localised in regions already highly specialised in this type of activity tending to reinforce existing clusters. This result, in particular, is suggestive of the role played by potential agglomeration economies related to knowledge and technological spillovers.

- Turning to the impact of ICT investment on regional convergence, this study provides a number of new and potentially important results. It considers a case study on the Spanish regions during the period 1985-2004 (as robust data on ICT capital investment has become recently available for this country). The analysis is undertaken using a growth accounting approach to estimate the role played by ICT capital investment in regional growth and convergence. Importantly, the literature and existing evidence suggest that the economic benefits of ICT are more likely to take place in countries and regions which are highly specialised in ICT-producing industries. Given the predominance in the Spanish ICT industry of the Madrid region and also, to some extent of the Catalonia region, evidenced in this study, one would therefore expect a much more pronounced impact of ICT diffusion on economic growth in these regions.

- Our results show that ICT investment, despite being still low in Spain, especially compared to its main trading partners, appears to have contributed more to regional convergence and growth than other types of capital investment, labour force qualification or infrastructures. These results suggest that ICT investment has had a widespread positive effect on Spanish regions despite large inequalities in ICT investment. Given the fact that ICT investment in Spain is still low, it can be expected that, in the future, regional effects may become even more pronounced as ICT tend to diffuse throughout the Spanish economy. It is also important that the high concentration of both ICT investment and ICT industries in Spain does not prevent the significantly positive effects of ICT investment on regional convergence.

... the results provided here suggest that the benefit of ICT-use are much more widespread across regions, providing support for the role played by ICT for convergence

6.2. Policy implications

- The study has provided evidence for the role played by the Computer Services sub-sector in recent employment and skills changes in the ICT industry. The computing service sector focuses mainly on offering consulting and client-tailored software development services. Departing from traditional business models, this activity presents relatively low sunk costs – indeed, many of these companies own nominal offices – most of the time, their employees are meant to carry out their work on the contractors' premises. Thus, access to capital has been partly replaced as an entry barrier by access to clients and high skills requirement. Low sunk costs in particular tend to shift the allocation of available resources towards investment in human capital and innovative capability. The study shows in particular that ICT services are especially characterised by these elements and concern a limited number of highly specialised (and usually rich) EU regions. In order to meet the challenges of improving productivity and competitiveness, Europe should play to its strengths and develop existing growth poles and also favour the emergence of new ones. For instance, the emergence of new ICT-services poles such as Madrid, the South of Ireland and the North of Scotland are good examples of the potential offered by these types of activities.

The Computing service sector offers great potentials for promoting regional development given in particular its low-physical capital requirement...

...although it shifts requirements towards labour skills and innovative capability which are still predominantly present in the richest EU regions despite the emergence of new ICT poles

- Despite the rising importance of human capital and intangibles assets, infrastructures remain a key point – specifically, telecommunication infrastructures – for promoting the development of those activities. Existing studies show that, in the EU, IT equipment and networks structure have represented the largest share of ICT investment since the early 1990, meanwhile in the US, investment in new technologies has been mainly devoted to software and, more generally to ICT use in the private business sector (Ahmad et. al, 2004). Future Cohesion policy programmes could consider this shift in the relative importance and nature of basic infrastructures and the need to promote ICT use by private businesses, when designing future investment plans. Furthermore, given the importance of the human factor and the strong emergence of ICT services in the EU economy, investment plans could aim at favouring the attractiveness of EU regions, especially when considering ICT businesses' location. Given the low-

Infrastructures and, in particular, IT infrastructures remain keys for regional development...

...however, regional policy makers should ensure that infrastructure effectively contribute to improve the attractiveness of backward regions for business location and that ICT effectively diffuse in the private sector

(physical) capital requirement that characterises ICT services, these sub-sectors offer great potential for regional development.

- The results presented here concerning the impact of ICT investment on regional convergence provide a number of novel results which are of direct relevance for policy making, especially concerning EU cohesion policy. The study shows that ICT capital tends to promote regional economic convergence. Regional policies aiming to promote regional cohesion could then consider ICT diffusion as a potentially important tool to promote convergence throughout the EU. From a regional perspective, public investment in infrastructure is generally the main spending line of regional government. However, the bulk of investment still goes to traditional infrastructures such as Transport and, to a lesser extent, Environment, Planning and Public health.[40] While a low specialisation in ICT-producing industries should not be considered as an impediment, public authorities might aim to promote the use of ICT by the private sector and by SMEs in particular and ensure that IT infrastructures meet high coverage and quality standards.

One-size-fits-all approaches should be avoided, however, and region-specific barriers to ICT diffusion should be well identified when designing regional policies

- These policy implications do not necessary call for a one-size-fits-all approach, however. Indeed the nature and importance of barriers and drivers (including financial, regulatory, but also institutional, educational and cultural factors) to new technology adoption need to be taken into account when designing public policies favouring a widespread use of ICT. The previous argument calls for differentiated policies given that, even when considering regions within the same countries, important differences emerge as shown in the present study. Policies promoting ICT diffusion cannot therefore be considered as stand-alone policies. In particular, education can play a very important role at all levels.

6.3. Future research

A number of research questions have been left untouched in the present study. The possible venues for future research provided below are certainly not exhaustive. Indeed, the results provided in the present study represent a good starting point for dealing with these other research questions.

- First, there is great need to better understand how the regional context contributes to setting appropriate framework conditions for the diffusion of ICT and their interaction with regional innovative capability. In particular future research should consider the way ICT are being used to improve local learning capacity and give rise to greater economic efficiency, innovation (innovation creation and/or use), entrepreneurship

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[40] Indeed, during the programming period 2000-2006, EU co-financed investments in basic infrastructures represented around 50% of all spending in the Objective 1 regions (i.e., regions with a GDP per capita below 75% of the EU average level) and only 9% of these funds were used for Telecommunications and Information Society infrastructures (i.e. totalling only 2.5% of total EU structural funds in Objective 1 regions)Source: DG REGIO, 17th Annual Report on the Implementation of Structural Funds, 2006.

and competitiveness. More specifically, from a regional policy perspective, more is needed to be known on the way the availability and use of ICT infrastructure and, in particular, broadband penetration, can favour the emergence of new types of activities or contribute to innovation and modernise existing activities.

- Second, there is also a great need to better understand the role played by ICT in promoting regional competitiveness within a globalisation context. In particular, while the present study has provided novel evidence on the role played by regional characteristics to attract ICT activities, more needs to be known concerning the way ICT is changing the nature of the determinants of regions' attractiveness for business location for instance through clusters/networking effects.

- Third, the results of the impact of ICT investment on regional growth and convergence provide evidence that is potentially important for policy making. In particular, the identification of the contribution of ICT capital investment together with other types of factor such as infrastructure and labour skills, allow for a better understanding of the dynamics of regional growth and the influence of technological changes on it. The positive effect of ICT on regional convergence documented here calls for further studies concerning other EU countries. Future research should also aim to identify what are the best framework conditions for promoting such positive effect of ICT on regional convergence.

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Appendices

Appendix 1: Additional tables and maps

Appendix 1.a:

Additional tables on the regional nature of ICT employment

Figure (a) 1: % of highly-educated/professionals in total ICT employees vs. GDP per capita in 2004 (Nace 30). Five largest EU regions only:
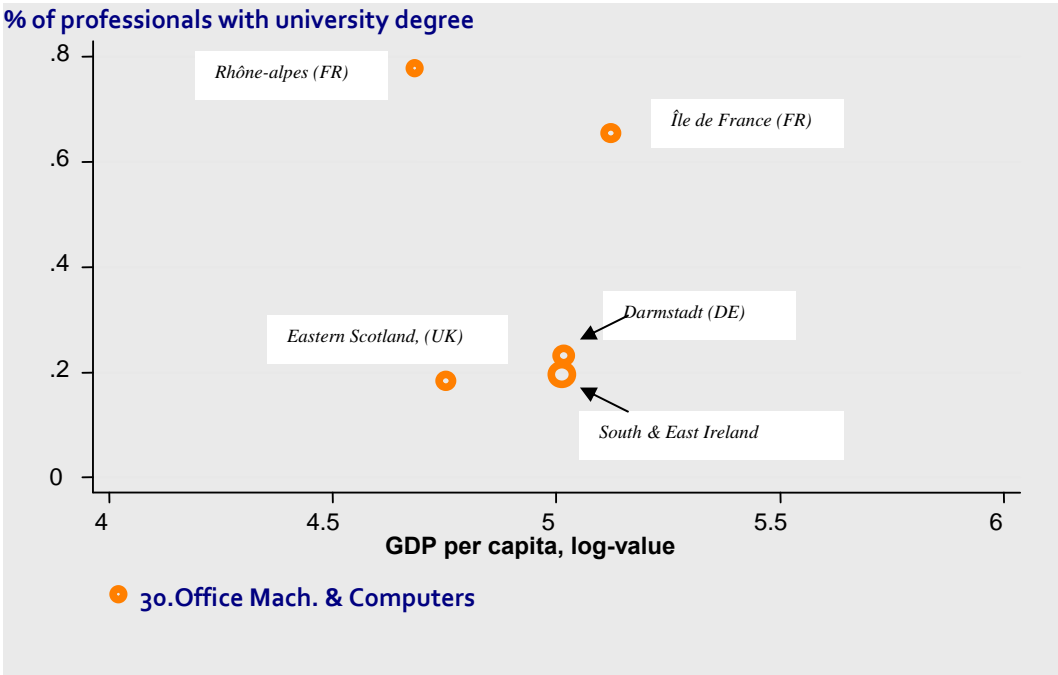
% of professionals with university degree

- *Rhône-alpes (FR)*
- *Île de France (FR)*
- *Darmstadt (DE)*
- *Eastern Scotland, (UK)*
- *South & East Ireland*

GDP per capita, log-value

● **30.Office Mach. & Computers**

Sources: Eurostat, LFS and Authors' computation
Note: Circles' size given by regions' sub-sector employment

Note: Considering the Office Machinery and Computers (Nace 30) sector, the presence of the semi-conductor industry is to a large extent responsible for the picture depicted in this Figure. There are also large differences between the regions with the highest proportions of professionals with university degree between the two French regions the Rhône-Alpes and Île de France regions and the South and East of Ireland, Darmstadt (DE) and Eastern Scotland (UK). Overall though, all these regions are among the highest employers (in relative terms) of professionals with university degree.

Figure (a) 2: % of highly-educated/professionals in total ICT employees vs. GDP per capita in 2004 (Nace 32). Five largest EU regions only.

% of professionals with university degree
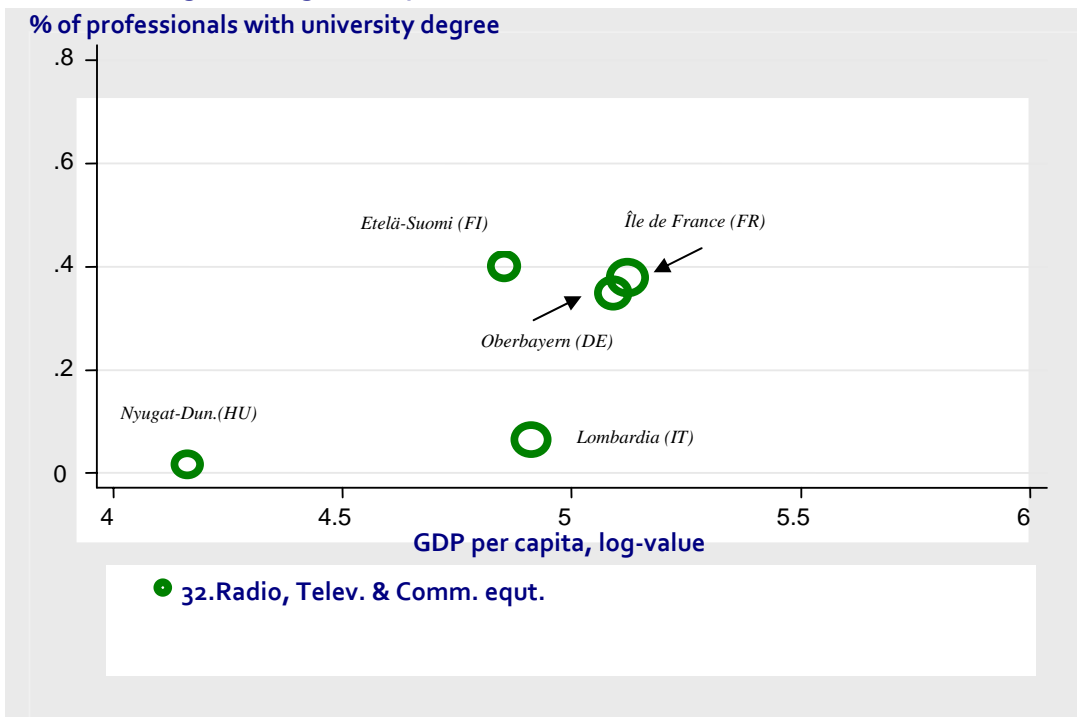
Sources: Eurostat, LFS and IPTS, Authors' computation
Note: Circles' size given by regions' sub-sector employment

Figure (a) 3: % of highly-educated/professionals in total ICT employees vs. GDP per capita in 2004 (Nace 33) Five largest EU regions only
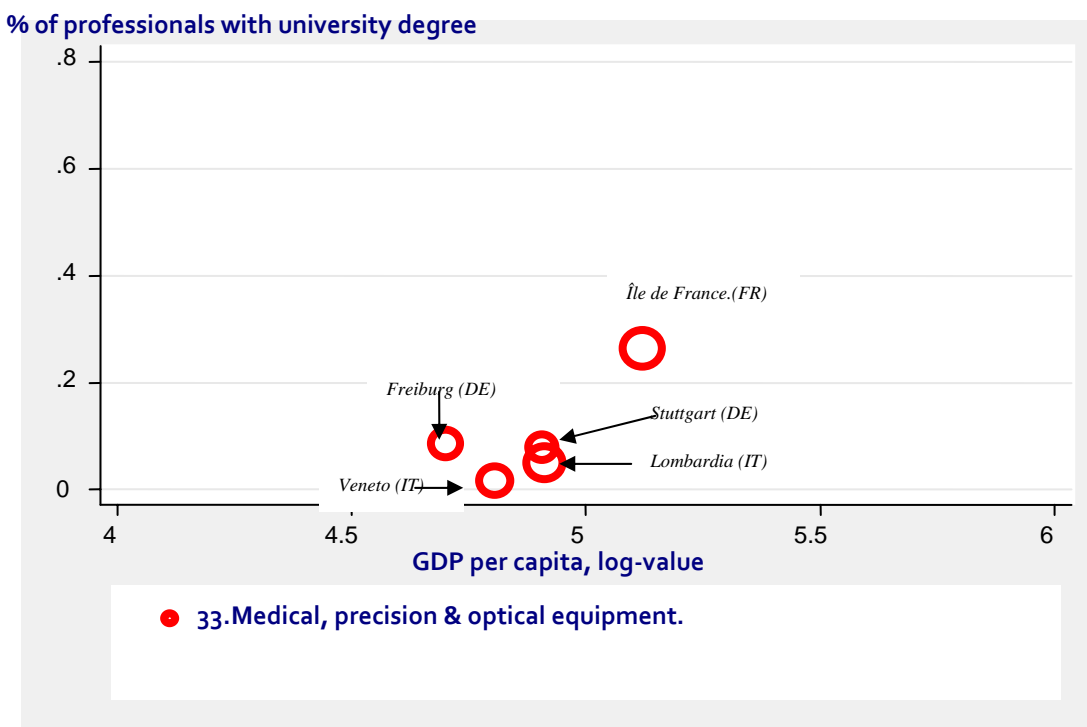
% of professionals with university degree

Sources: Eurostat, LFS and Authors' computation
Note: Circles' size given by regions' total ICT employmentFigure 7d: % of highly-educated/professionals in total ICT employees vs. GDP per capita in 2004 (Nace 64) Five largest EU regions only

Figure (a) 4: % of highly educated/professionals in total ICT employees vs. GDP per capita in 2004 (Nace 64) *Five largest EU regions only*

% of professionals with university degree

● **64. Post & Telecoms**
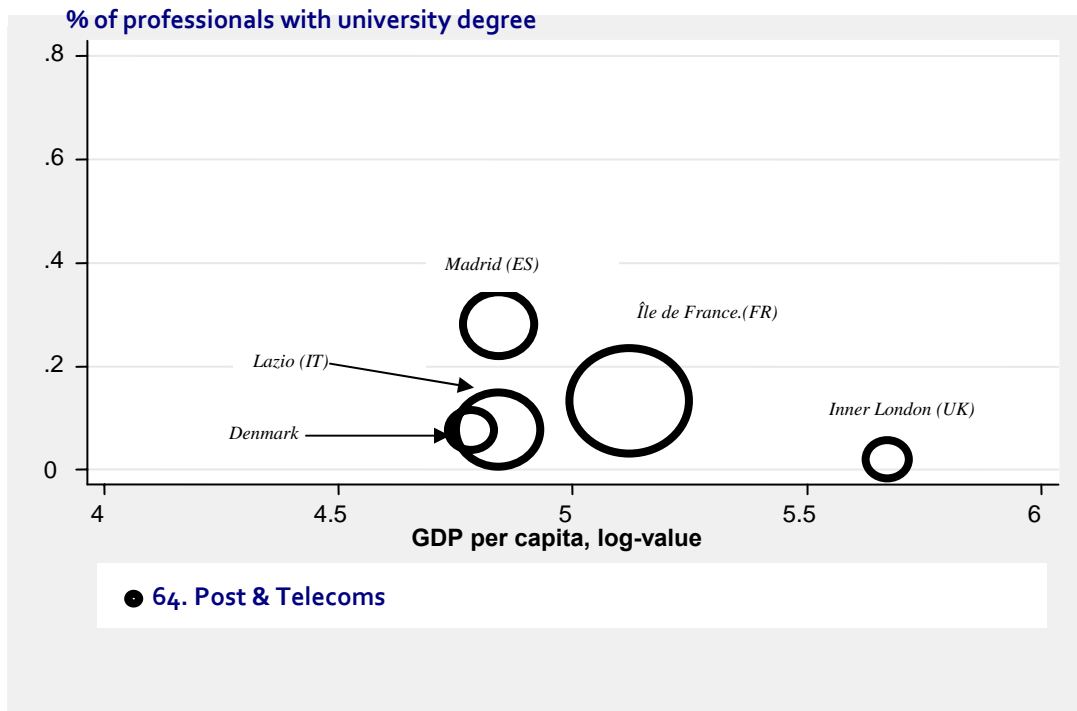
Sources: Eurostat, LFS and Authors' computation.
Note: Circles' size given by regions' sub-sector employment

Figure (a) 5: % of highly-educated/professionals in total ICT employees vs. GDP per capita in 2004 (Nace 72) *Five largest EU regions only*

% of professionals with university degree

● **72.Computer services**
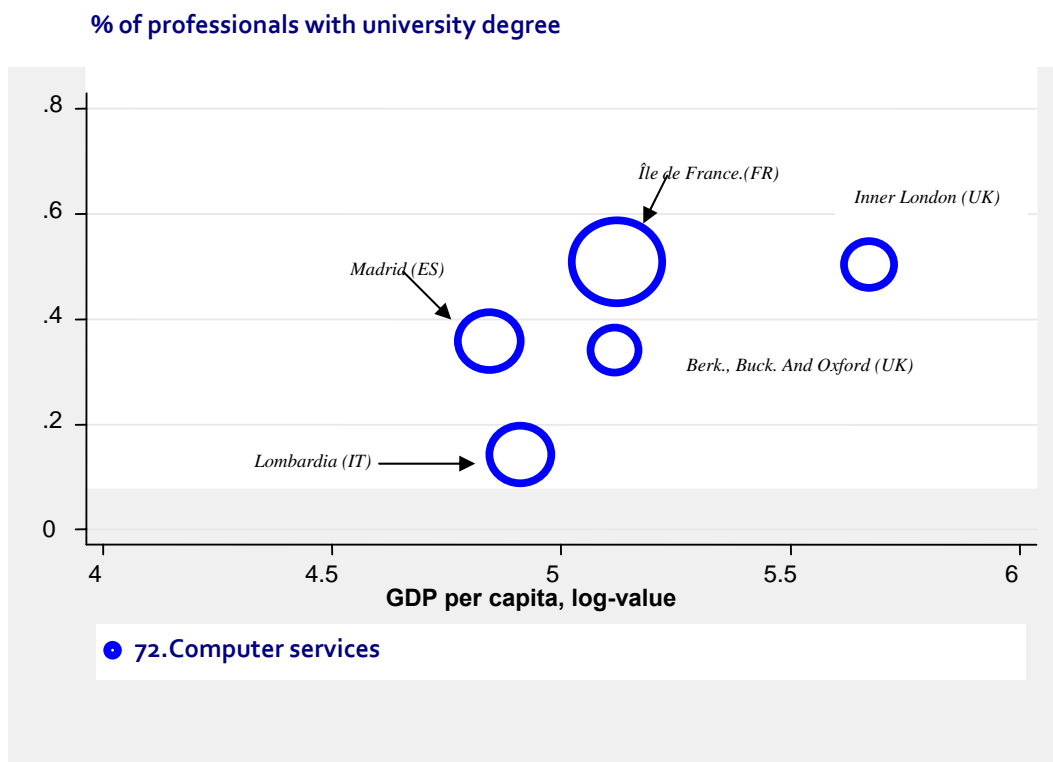
Sources: Eurostat, LFS and Authors' computation.
Note: Circle size given by regions' total ICT employment

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Appendix 1.b:

Location of new multinationals affiliates

Map (a) 1: The Location of new Multinationals' affiliates: Office Machinery & Computers (Nace 30)
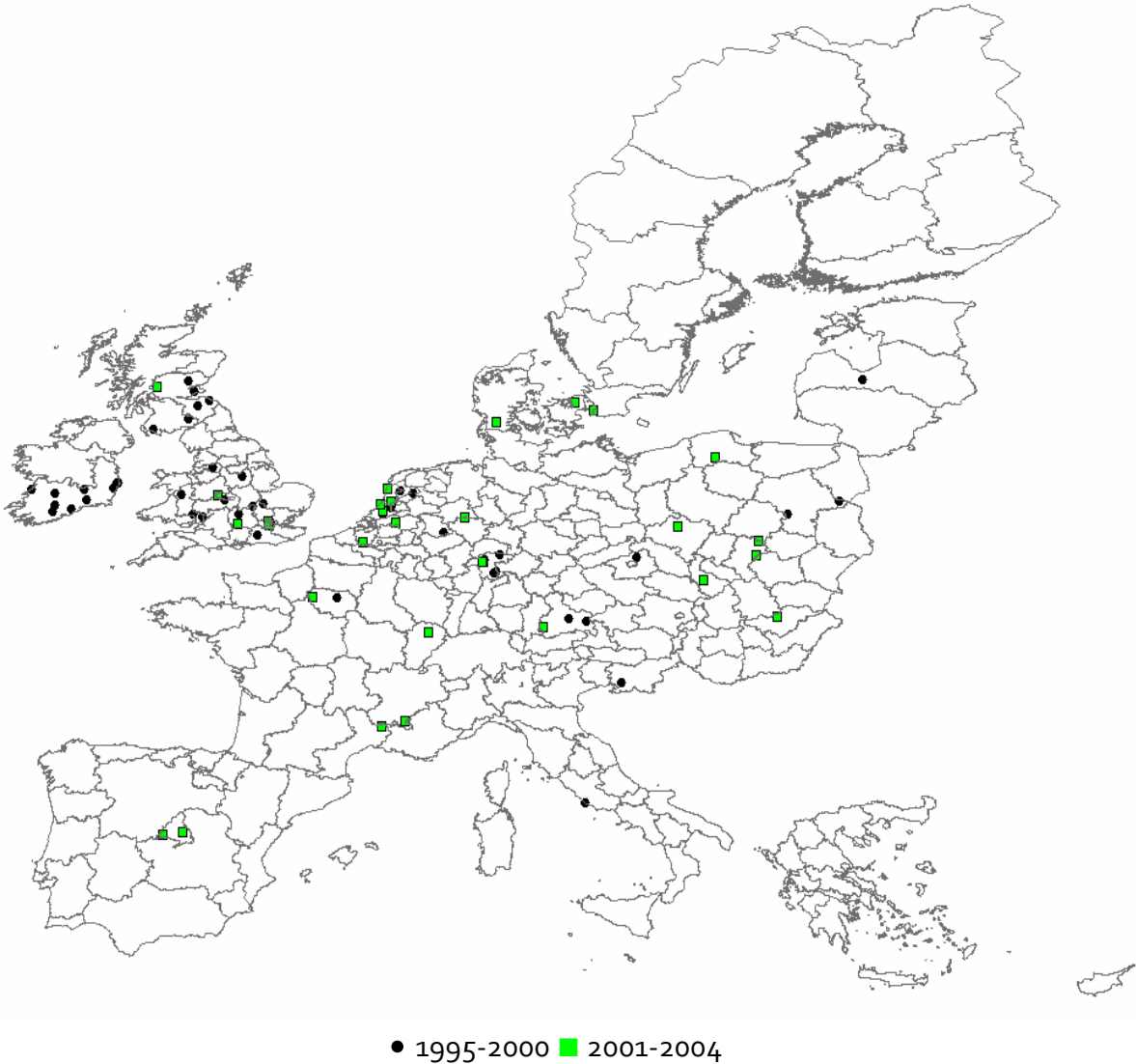
● 1995-2000 ■ 2001-2004

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.32	0.23

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots concerns the period 1995-2000 and the green dots the period 2001-2004

Map (a) 2: The Location of new Multinationals' affiliates: Television & Communication Equipment (Nace 32)
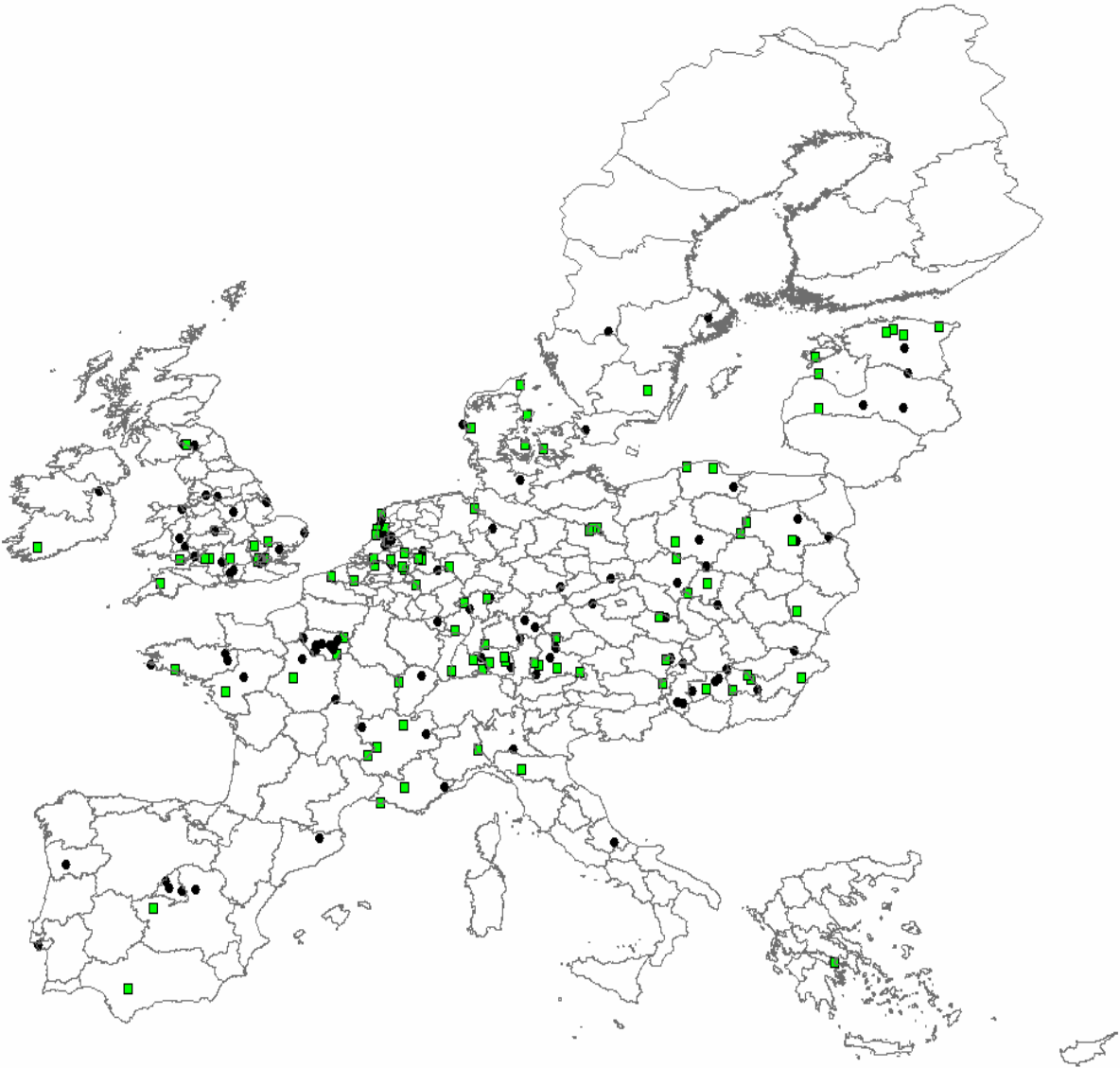
● **1995-2000** ■ **2001-2004**

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.47	**0.55**

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots concerns the period 1995-2000 and the green dots the period 2001-2004

Map (a) 3: The Location of new Multinationals' affiliates Medical, precision and optical instruments (Nace 33)
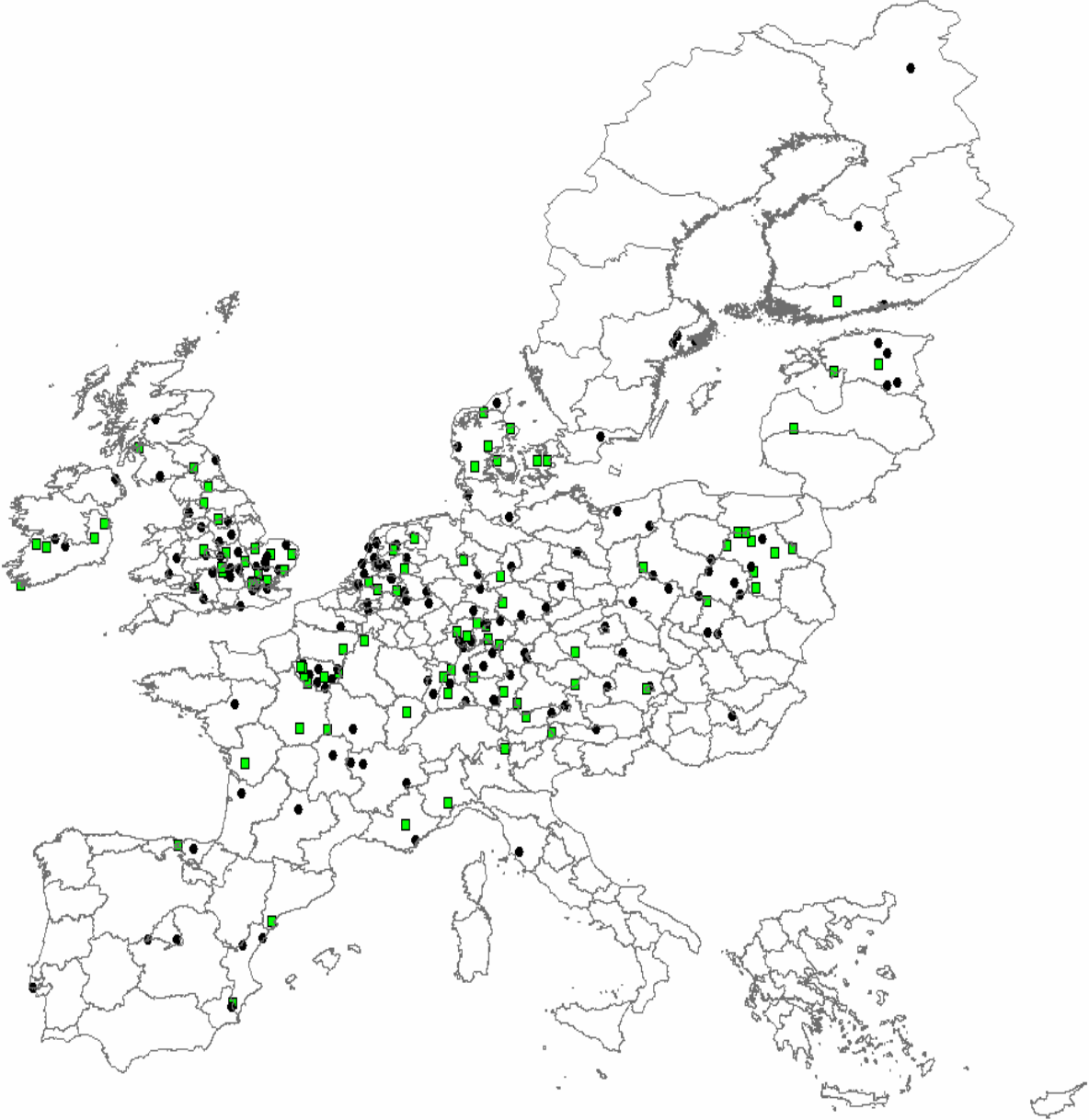
● 1995-2000 ■ 2001-2004

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.39	**0.51**

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots concerns the period 1995-2000 and the green dots the period 2001-2004

Map (a) 4: The Location of new Multinationals' affiliates Post & Telecommunications (Nace 64)
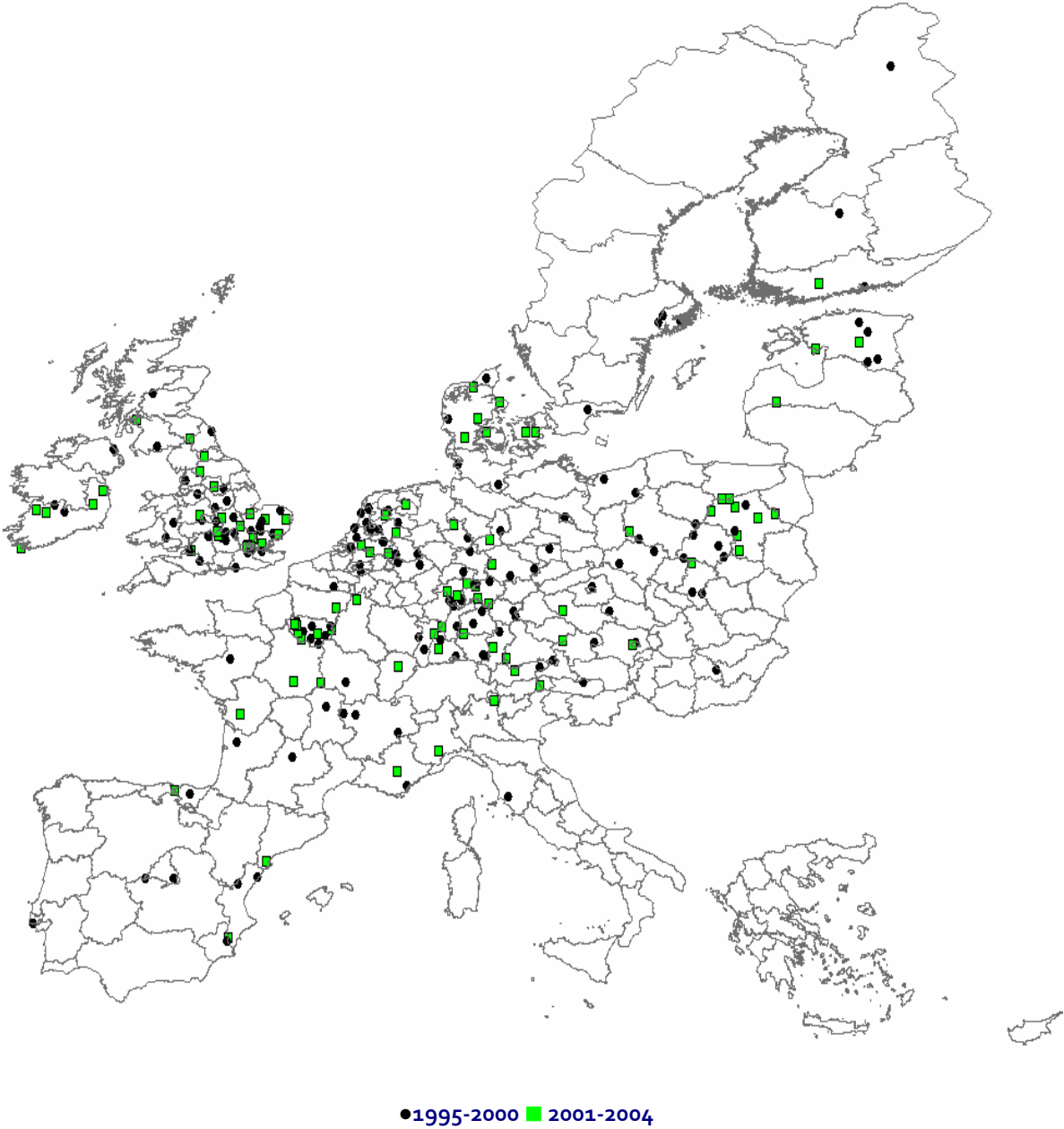
●1995-2000 ■ 2001-2004

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.66	**0.95**

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots
concerns the period 1995-2000 and the green dots the period 2001-2004

Map (a) 5: The Location of new Multinationals' affiliates Computing Services & Related Activities (Nace 72)
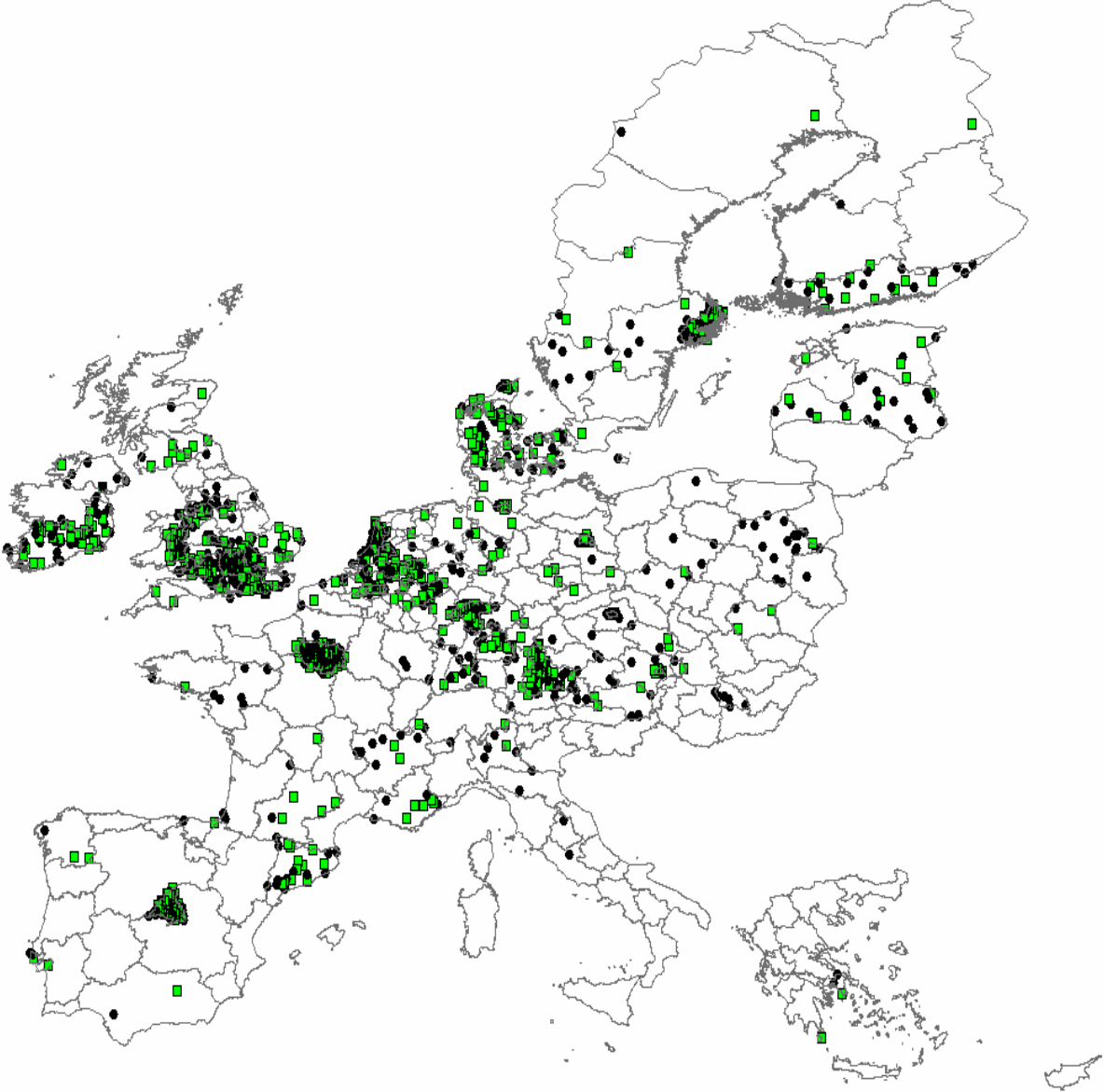
● **1995-2000** ■ **2001-2004**

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.69	**0.96**

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots concerns the period 1995-2000 and the green dots the period 2001-2004

Location of new SMEs

Map (a) 6: The Location of new SMEs: Office Machinery & Computers (Nace 30)
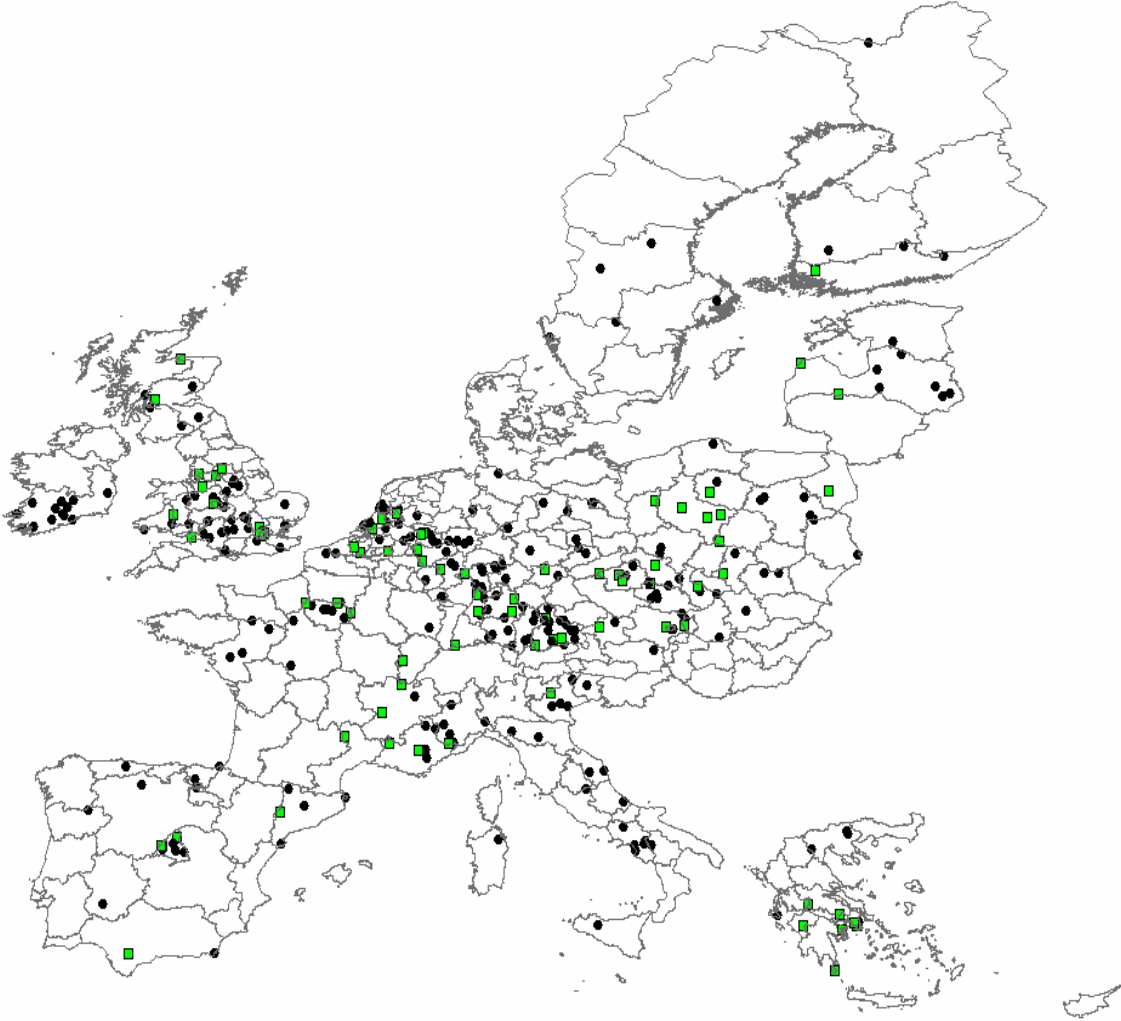
● 1995-2000 ■ 2001-2004

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.37	**0.42**

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots
concerns the period 1995-2000 and the green dots the period 2001-2004

Map (a) 7: The Location of new SMEs Television & Communication Equipment (Nace 32)

● 1995-2000 ■ 2001-2004

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.54	**0.68**

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots concerns the period 1995-2000 and the green dots the period 2001-2004

Map (a) 8: The Location of new SMEs Medical, precision and optical instruments (Nace 33)
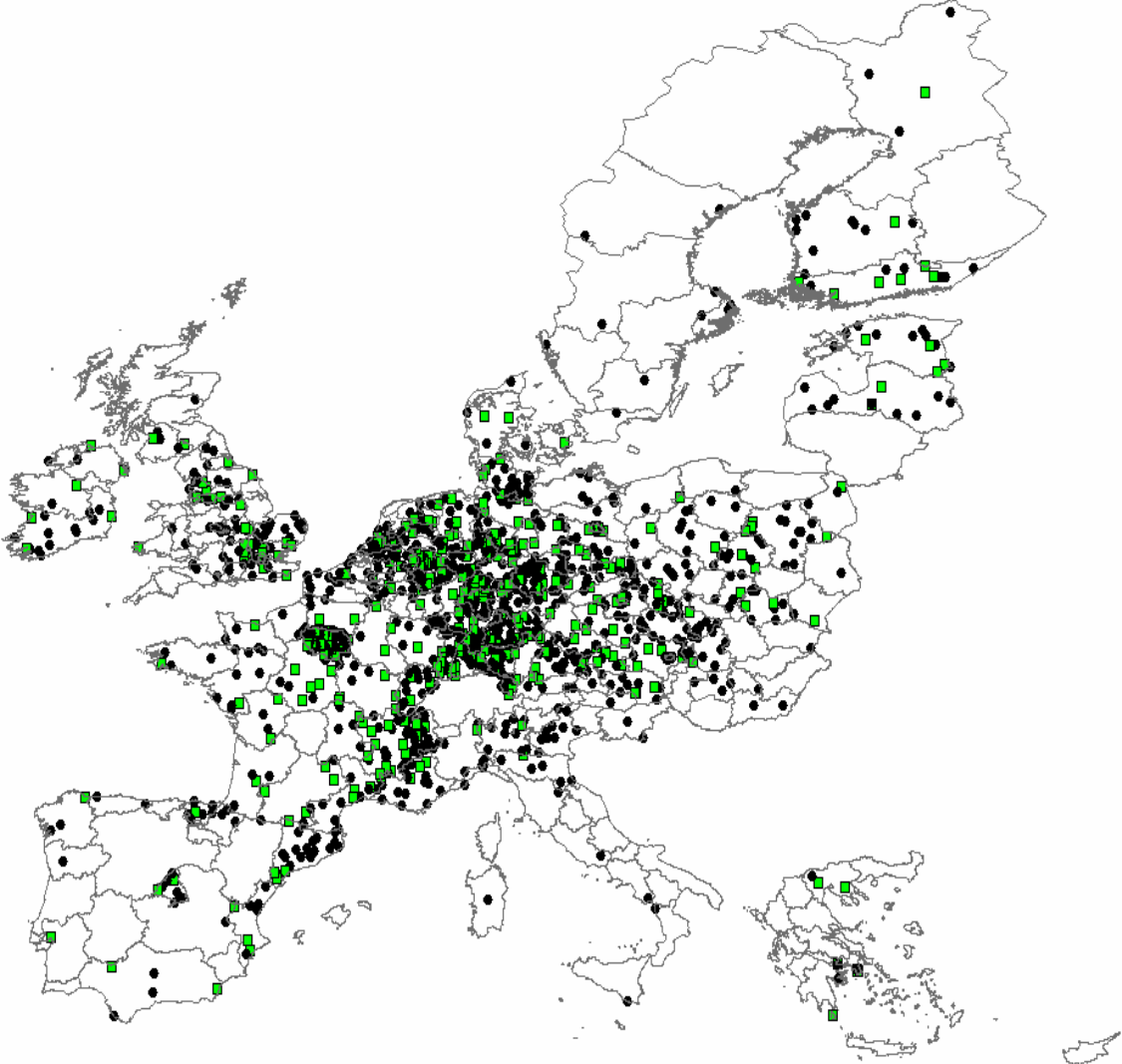
● **1995-2000** ■ **2001-2004**

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.69	**0.83**

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots
concerns the period 1995-2000 and the green dots the period 2001-2004

Map (a) 9: The Location of new SMEs Post & Telecommunications (Nace 64)
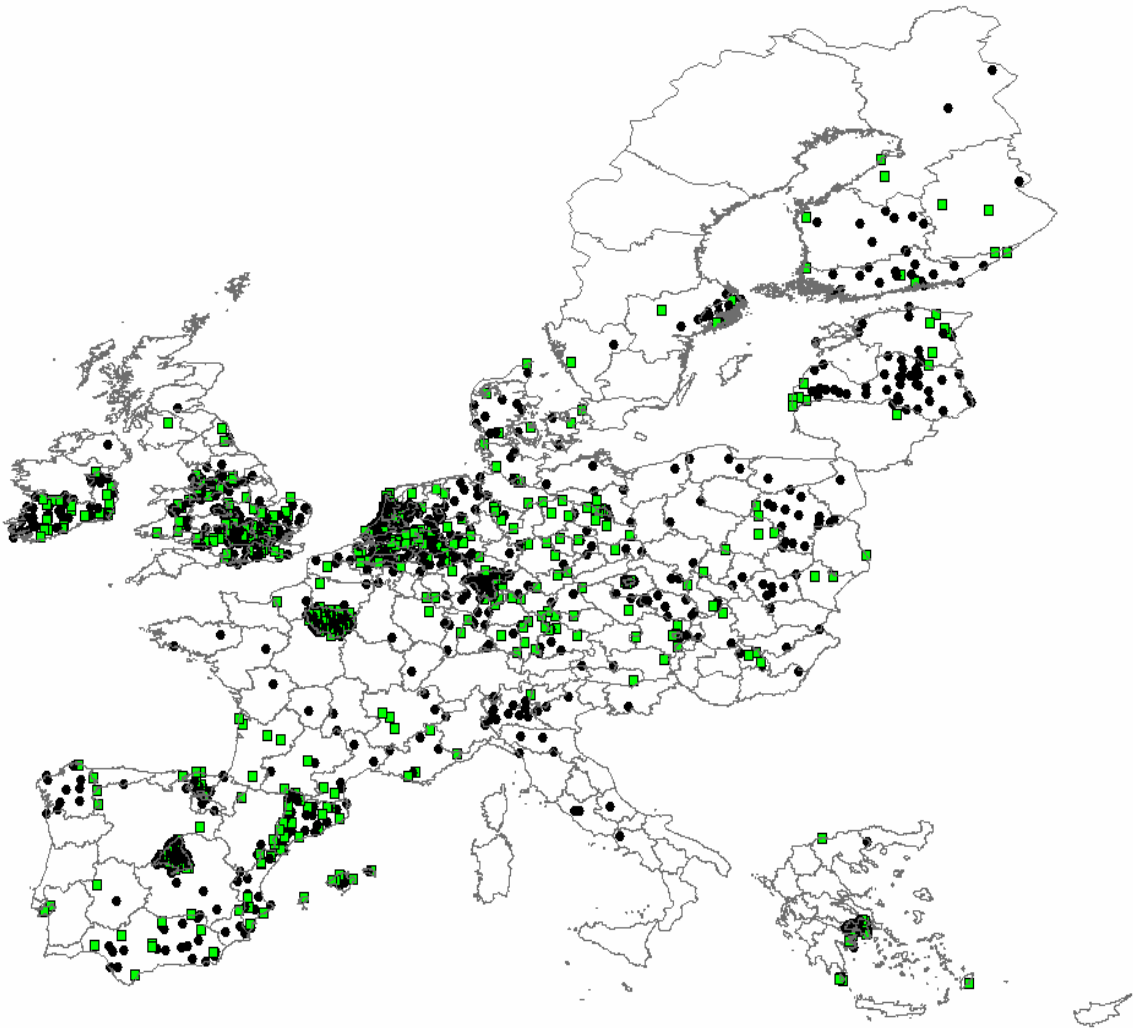
● 1995-2000 ■ 2001-2004

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.59	0.93

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots
concerns the period 1995-2000 and the green dots the period 2001-2004

Map (a) 10: The Location of new SMEs Computing services & related activities (Nace 72)
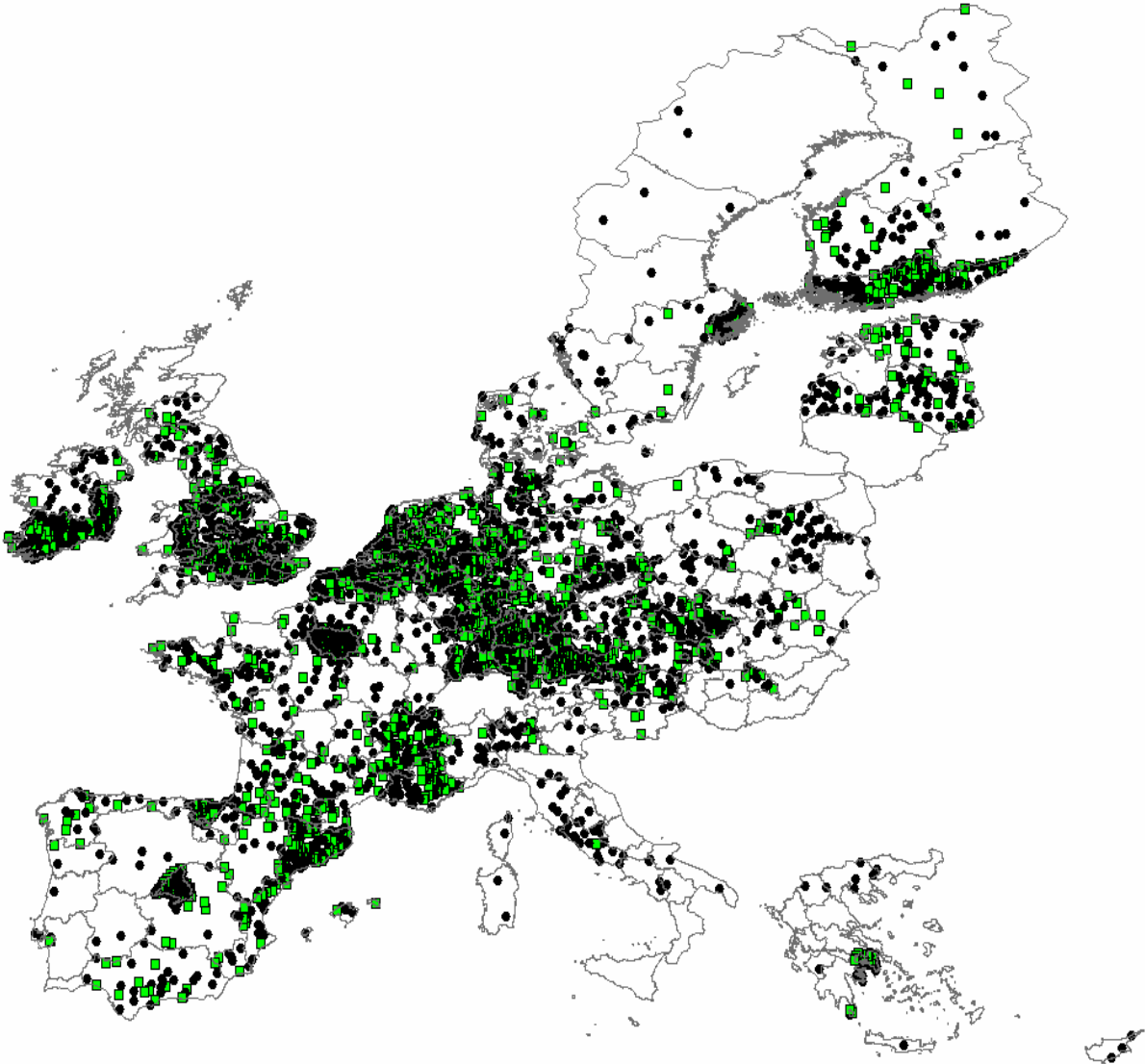
● 1995-2000 ■ 2001-2004

Spearman rank correlation	Coefficient of correlation
1995-2000 vs 2001-2004	*1995-2000 vs 2001-2004*
0.85	0.97

Sources: Bureau van Dijk (Amadeus database) and authors' computations
Each dot in these maps represents a new firm created during the corresponding period where the black dots
concerns the period 1995-2000 and the green dots the period 2001-2004

Appendix 2: Methodological notes

Appendix 2: Methodological note 2.1 attached to Section 3.2

Definition of ICT-producing sector

The Table below provides a definition of the ICT-producing sector (or ICT Industry) for the manufacturing and services industries. This definition is based on the definition proposed by the OECD (2002a).

Table (a) 1: Definition of the ICT sector following the Nace Rev. 1 classification

NACE 30	MANUFACTURE OF OFFICE MACHINERY AND COMPUTERS	
NACE 32	**MANUFACTURE OF RADIO, TELEVISION AND COMMUNICATION EQUIPMENT AND APPARATUS**	
	32.1	MANUFACTURE OF ELECTRONIC VALVES AND TUBES AND OTHER ELECTRONIC COMPONENTS
	32.2	MANUFACTURE OF TELEVISION AND RADIO TRANSMITTERS AND APPARATUS FOR LINE TELEPHONY AND LINE TELEGRAPHY
	32.3	MANUFACTURE OF TELEVISION AND RADIO RECEIVERS, SOUND OR VIDEO RECORDING OR REPRODUCING APPARATUS AND ASSOCIATED GOODS
NACE 33	**MANUFACTURE OF MEDICAL, PRECISION AND OPTICAL INSTRUMENTS, WATCHES AND CLOCKS**	
	33.1	MANUFACTURE OF MEDICAL AND SURGICAL EQUIPMENT AND ORTHOPAEDIC APPLIANCES
	33.2	MANUFACTURE OF INSTRUMENTS AND APPLIANCES FOR MEASURING, CHECKING, TESTING, NAVIGATING AND OTHER PURPOSES, EXCEPT INDUSTRIAL PROCESS CONTROL EQUIPMENT
	33.3	MANUFACTURE OF INDUSTRIAL PROCESS CONTROL EQUIPMENT
	33.4	MANUFACTURE OF OPTICAL INSTRUMENTS AND PHOTOGRAPHIC EQUIPMENT
	33.5	MANUFACTURE OF WATCHES AND CLOCKS
NACE 64	**POST AND TELECOMMUNICATIONS**	
	64.1	POST AND COURIER ACTIVITIES
	64.2	TELECOMMUNICATIONS
NACE 72	**COMPUTER AND RELATED ACTIVITIES**	
	72.1	HARDWARE CONSULTANCY
	72.2	SOFTWARE CONSULTANCY AND SUPPLY
	72.3	DATA PROCESSING
	72.4	DATABASE ACTIVITIES
	72.5	MAINTENANCE AND REPAIR OF OFFICE, ACCOUNTING AND COMPUTING MACHINERY
	72.6	OTHER COMPUTER RELATED ACTIVITIES

The above taxonomy is used throughout the Report. Importantly, it must be noted that the sectoral aggregation used here, i.e., Nace 2-digits, is quite high. As a consequence, each ICT sub-sector may, in some cases, encompass rather heterogeneous activities. However, lack of data availability at a more detailed level of activity breakdown prevented the use of the narrower definition determined by the OECD (that requires Nace 4-digits level of aggregation). Regarding services industries, thus, sub-sectors such as Wholesale of machinery, equipment and supplies (Nace 51.20) and Renting of office machinery and equipment (Nace 71.23) have not been included in the classification used here.

Regional Data

However, the main constraint is given by regional data availability. In the present study, Nomenclature of Statistical Territorial Units (NUTS 2003) is used as regional classification.[41] The NUTS nomenclature is the reference for socio-economic analysis of regions at European level as well as for the framing of Community regional policies. In spite of the fact that this classification is somewhat biased towards a normative criteria rather than a strictly functional definition, the well-established character of this classification and the comparability of the data provided justifies the choice of the NUTS regional breakdown for the purposes of this report. All 254 NUTS 2 level regions are considered unless explicitly stated.

The two main databases used for the mapping of ICT activity undertaken here are taken from the Eurostat databases Structural Business Statistics (SBS) and the Labour Force Survey (LFS). Both the SBS and the LFS provide data at NUTS 2 level and allow for a sectoral breakdown up to Nace 2-digits. The SBS will be used for mapping the location of ICT activities in Europe, using employment data. In turn, the LFS will be used for analysing the nature of employment in EU regions, focusing on education levels and the category of occupation of people employed in ICT industries. Before analysing these figures it is important first to consider to what extent the data from the Labour Force Survey is comparable to the Structural Business Statistics. Indeed, the LFS and SBS datasets used here are not directly comparable given that the SBS is designed in order to reflect the structure (by sector) of economic activity while the LFS is designed to analyse labour market features, among which levels of education are a prominent part. Given these differences, the LFS can still provide valuable information as regarding the level of qualification of employees across the ICT sector and can also be used, to some extent, to say something about the regional structure of employment. Table (a) 2 below provides an indication of the degree of comparability of these two data sources by, on the on hand, comparing share in total employment of each ICT sub-sectors in the EU 25 and, on the other hand, by ranking regions in terms of their total employment using the Labour Force Survey and the Structural Business Statistics.

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[41] Reference for the definition of the economic territory of the EU: Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May 2003on the establishment of a common classification of territorial units for statistics (NUTS) (Official Journal L 154, 21/06/2003). For the latest status of NUTS, please see the RAMON classifications server on the Eurostat website: http://ec.europa.eu/comm/eurostat/ramon/nuts/home_regions_en.html

Table (a) 2: Comparing SBS ad LFS data for the ICT sub-sectors: employment shares and regional employment ranking across NUTS2 regions (2004 data)

ICT SUB-SECTORS	PERCENTAGE OF TOTAL BUSINESS SECTOR EMPLOYMENT, AGGREGATE VALUES FOR THE EU25*		SPEARMAN RANK CORRELATION BETWEEN REGIONAL RANKINGS: *LFS* AND *SBS*	
	SBS	*LFS*	*Ranks using absolute levels of employment*	*Ranks using percentage of total employment*
30. Manufacture of office machinery and computers	0.12	0.21	0.75 (0.00)	0.60 (0.00)
32. Manufacture of radio, television and communication equipment and apparatus	0.64	0.78	0.83 (0.00)	0.74 (0.00)
33. Manufacture of medical, precision and optical instruments, watches and clocks	0.87	0.79	0.86 (0.00)	0.81 (0.00)
64. Post and telecommunications	2.55	2.62	0.74 (0.00)	0.70 (0.00)
72. Computer and related activities	2.31	2.12	0.94 (0.00)	0.82 (0.00)
All ICT sector	6.49	6.51	0.85 (0.00)	0.84 (0.00)

Sources: Eurostat Structural Business Statistics and Labour Force Survey and DG JRC, IPTS
* Data exclude CZ, GR, IE, LU, MT, NL, PT and SK due to lack of data availability. Total employment excludes Agriculture and Fisheries (Nace Sections A& B), Financial Services sector (Nace code J) and Public sector, Community services and Private households (Nace codes L, M, N, O, P, Q)
** p-values in parenthesis

The first two columns in Table (a) 2 provide the figures concerning the percentage of total employment for each ICT sub-sector in the EU25 using the Structural Business Statistics and the Labour Force Survey, respectively. The percentage for the overall ICT sector is very close in each case, i.e., according to the SBS, the total employment in ICT represents 6.49% if total EU employment, whereas according to the LFS, it is equal to 6.51%. These two percentages can be considered fairly close. A closer look at these percentages for each sub-sector denotes, however, some differences between the two databases. In particular, regarding the manufacturing sub-sectors, these differences can in some case, such as in the Manufacture of Office Machinery and Computing, be rather pronounced. In the other sub-sectors, and particularly for Computer and related activities, the percentages are fairly similar.

Additionally, for the purpose of the regional analysis carried out here, it is important to assess whether the two databases provide comparable information regarding the spatial distribution of the employment. In order to do so, the regional ranking according to level of employment for each of the ICT sub-sectors is considered for each database. The degree of similarity can be thus estimated by means of calculating the correlation coefficients between the two rankings. Columns 3 and 4 of Table (a) 2 provide the values of the Spearman rank correlation together with their p-value denoting the significance level of these correlations.[42] In all cases, the Spearman correlation coefficients are positive and above 0.5 and in most cases close or above 0.75. These values validate the assumption on the comparability of the data provided by each source (the SBS and the LFS).

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[42] The Spearman rank correlation coefficient is a non-parametric measure of correlation – that is, it assesses how well an arbitrary monotonic function could describe the relationship between two variables, without making any assumptions about the frequency distribution of the variables. The values taken by this statistics are between -1 and +1 such that a value close to +1 (and in general, above 0.5) would translate a high correlation in ranks between two variables.

Appendix 2: Methodological note 2.2 attached to Section 3.2.3

Note on the Balassa Index

The specialization of EU regions in ICT employment is calculated by using the Balassa index of industrial specialisation. This index provides the following measure:

$$\text{Balassa index of industrial specialisation} = \frac{E_{ICT}^{r} \big/ E^{r}}{E_{ICT}^{EU} \big/ E^{EU}}$$

where E_{ICT}^{r} denotes the level of employment in the ICT sector in a given region r, E^{r} is the total employment in this particular region, including both ICT and non-ICT sectors. The terms E_{ICT}^{r} and E^{r} denote the same variables for the EU as a whole.

The Balassa index therefore compares the share of employment in ICT sector in a particular region with the same share for the whole EU. It follows that the value of an index greater to 1 for a specific region will denote a relatively high specialisation level of that region in ICT activities as measured by employment. The advantage of the Balassa index compared to the simple comparison of shares in total employment provided by Map 1 therefore is that the relative size (in terms of total employment) is taken into account here.

Appendix 2: Methodological note 2.3 attached to Section 4.1.2

Note on the Shift-share analysis

The present study uses the classic shift-share technique, instead of more sophisticated formulations (such as dynamic shift-share or hybrid approaches) for the sake of neatness and simplicity. Particularly, any endeavour to reach further conclusions (such as forecasting) would be seriously flawed by the large number of the regions considered, the limited availability of data (employment by region and sector, according to NUTS2 and NACE code classifications) and the theoretical constrains of the shift-share method. Therefore, the aim of this analysis is to find empirical evidence of the existence of a relevant regional dimension of ICT industry across Europe.

The shift-share analysis is a purely algebraic method that breaks down employment change for a given region and sector into three components, effectively identifying the share of employment growth due to the national general business cycle (the *Share* term), the overall sectoral behaviour at national level (Industrial *Mix* term) and the specific behaviour of that industry in the region (the Regional *Shift* term). This method was first developed by Dunn (1960) and is mainly used in regional studies to ascertain local patterns of employment evolution, as well as to introduce a sectoral perspective into the analysis [43] Let e_n^i represent the employment in a sector i for a given region at time n, E_n account for total (i.e. including all sectors) national employment and E_n^i stand for the total employment nationwide for sector i at time n:

$$\frac{e_{n+1}^i - e_n^i}{e_n^i} = \frac{E_{n+1} - E_n}{E_n} - \left(\frac{E_{n+1} - E_n}{E_n}\right) + \frac{e_{n+1}^i - e_n^i}{e_n^i} + \frac{E_{n+1}^i}{E_n^i} - \frac{E_{n+1}^i}{E_n^i} \quad [1]$$

Equation [1] simply adds to the right and left hand-side three extra-components, namely the overall (national) employment growth rate $\frac{E_{n+1} - E_n}{E_n}$ and the nation-wide employment change in a given sector i represented by $\frac{E_{n+1}^i}{E_n^i}$. By rearranging terms in [1], one can easily obtain the following expression:

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[43]   Developments of the Shift-Share method have been proposed following the footsteps of Dunn (1960) See, for example, Esteban-Marquillas (1972), Arcelus (1984) or Rigby and Anderson (1993). For a review of the shift-share literature, see Loveridge and Selting (1998). providing more insight into the conclusions that can be drawn out of the shift-share analysis by incorporating further mathematical complexity in the classical formulation. However, it must be noted that this analysis lacks theoretical basis. One must note in particular that, in this sense, shift-share analysis does not attempt to identify the reasons explaining the relative performance of a given industry. Moreover, it only uses data from the beginning and end of the period considered, therefore measuring the change between two points in time, rather than exploiting all the information available throughout the period.

$$\frac{e_{n+1}^{i} - e_{n}^{i}}{e_{n}^{i}} = \frac{E_{n+1} - E_{n}}{E_{n}} + \left[\frac{E_{n+1}^{i}}{E_{n}^{i}} - \frac{E_{n+1}}{E_{n}} \right] + \left[\frac{e_{n+1}^{i}}{e_{n}^{i}} - \frac{E_{n+1}^{i}}{E_{n}^{i}} \right] \qquad [2]$$

Equation [2] can be used in order to identify the different dynamics at stake in regional employment variation for a particular sector. The following table provides an overview of these different components along with their economic interpretation:

Table (a) 3: Shift-Share analysis terms

SHARE TERM	$\dfrac{E_{n+1} - E_{n}}{E_{n}}$	Growth of total employment at national level	This term assumes that employment in the region and sector considered (e^{i}) grows at the same rate than total national employment
MIX TERM	$\dfrac{E_{n+1}^{i}}{E_{n}^{i}} - \dfrac{E_{n+1}}{E_{n}}$	Differential of employment growth rate between the industry and the national overall	This term depicts the relative performance nationwide of sector i (E^{i}) as compared to the overall national economy
SHIFT TERM	$\dfrac{e_{n+1}^{i}}{e_{n}^{i}} - \dfrac{E_{n+1}^{i}}{E_{n}^{i}}$	Regional growth rate of employment in sector i compared to the sector's employment growth rate nationwide	This term shows the relative performance of sector i in a given region as relative to the country's industry behaviour

Therefore, the employment growth can be broken down into the sum of the Mix Term (or sector component) and the Regional Shift (or sector/regional component) plus a Share Term which represents the national overall growth rate of employment. The Mix and Regional Terms are therefore calculated as residuals, after assuming that regional employment for the sector considered would increase (or decrease) at the same rate employment evolves in the country as a whole, as the Share terms captures the share of employment change due to the general business cycle. Once the Mix and Shift terms are calculated, the employment performance of a given region and sector can be compared to the national behaviour of the sector in order to identify particular employment dynamics in that region for the sector under analysis.

The Shift-Share analysis carried out here suffers from the fact that only two years, i.e., 2000 and 2004, are considered. Despite this shortcoming, this method proves to be very valuable in empirically assessing to what extent regional industrial performance differs from national and industrial overall behaviour regarding employment growth. The Shift-share analysis is used here in order to evaluate the importance of regional patterns in the European ICT industry. The Shift-share analysis has been applied here to the ICT sub-sectors, i.e. "Manufacture of Office Machinery and Computers" (Nace 33), "Manufacture of Radio, Television and Communication Equipment and Apparatus"(Nace 32), "Manufacture of Medical, Precision and Optical Instruments, Watches and Clocks"(Nace 33), "Post and Telecommunications"(Nace 64) and "Computer and Related Activities"(Nace 72).

The regions under scrutiny are those belonging to NUTS level 2 for all EU 25.[44] Due to the lack of available employment data[45] for some of these regions for the sub-sectors and years considered, a further selection was made, rendering the total number of regions used equal to 120 out of the total 254 regions at NUTS level 2 in the EU25. These regions are located in the following countries: Austria, Belgium, Germany, Spain, Finland, France, Italy, Poland, Sweden and the UK. Overall, the results described here can be thought as being fairly representative of employment changes in the EU given that, for 2004, the countries considered here represent 83% of total ICT employment and 80% of total employment changes (i.e., -1.3%) in ICT industries during the period 2000-2004.

For each region and each sector i (NACE codes 30, 32, 33, 64 and 72), we applied shift-share analysis. The results support the significance of the regional component with respect to the overall industrial employment changes. By comparing the shift term and the mix term (in absolute values), we can conclude that the shift term is greater than the industrial mix factor in most of the regions and sub-sectors analysed, thus showing a distinctive regional pattern of employment growth for the ICT industry.

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[44] Reference for the definition of the economic territory of the EU: Council regulation 2223/1996 on ESA 1995 (European System of Accounts) points 2.05, 13.07, published in Official Journal L 310, 30.11.1996. For the latest status of NUTS, please see the RAMON classifications server on the Eurostat website: http://ec.europa.eu/comm/eurostat/ramon/nuts/home_regions_en.html

[45] Data from the Structural Business Statistics (EUROSTAT), providing employment figures by regions and sectors, have been used in this analysis, along with national and sectoral employment data from EU-KLEMS.

Appendix 2: Methodological note 2.4 attached to Section 4.2

Analysing the nature of employment using the Labour Force Survey (LFS)

In the context of the present study, education is considered as a proxy for the level of qualification of workers as traditionally done in the economic literature, see, for instance, OECD (1998) for a review. The level of education is only one dimension of the qualification of workers, though, given that it is only an indication of the formal level of qualification of workers, without considering their actual occupation. The Frascati manual of the OECD (2002b) provides definition of R&D workers based on their occupation according to the standard classification used in labour force surveys. Here we follow this classification in order to identify for each ICT sub-sector the proportion of employees that can be considered as *Researchers* according to the Frascati manual. However, it must be noted that this category of occupation is only indicative of the proportion of researchers in total employment according to the figures given in the Eurostat Labour Force Survey since figures on headcount R&D workers can only be obtained through specific surveys. It follows that, despite the fact that the figures presented here cannot be considered as measures of the number of R&D workers, they can be used nevertheless as convenient proxy in order to measure differences across sectors (both within the ICT broad sector and between ICT and non-ICT sectors) as well as in order to measure changes over time and spatial distribution of this particular category of workers. The Box 1 below provides more details on the Frascati (OECD, 2002b) definition and the interpretation of figures on the occupations included in the *Researchers* category.

A particularly important point of the OECD classification of Researchers as indicated in Box 1 above is that a good approach is to consider together the nature of occupation together with the level of education in order to define groups of workers who have potential R&D occupation. Therefore, we proceed now to perform an analysis based on this classification for the ICT sub-sectors.

Box 1: Note on the classification of workers by occupation and education levels.

The Frascati manual (see OECD, 2002b, Section 5), states that "Researchers are professionals engaged in the conception of creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned". To this end, "Researchers are classified in ISCO88 Major group 2, Professionals, and in Research and Development Department Managers, ISCO-88, 1237". This information essentially requires the use of Labour force surveys. However, the group of workers with the above mentioned occupations should only be viewed as the categories in which R&D workers are classified such that "Population censuses, labour force surveys or population registers are useful complementary data sources but cannot be used systematically to obtain R&D personnel data". According to the OECD, "R&D surveys are the most appropriate instrument for collecting headcount data".

In the present study, the group of Researchers is defined following the criteria of the Frascati manual set out above including, in addition to this group, the category 1236 "Computing services managers" in order to reflect ICT-specific occupations.

Still according to the OECD, "both occupation and education series are important in the context of studying human resources in science and technology". However, the approach by occupation is preferable for identifying number of personnel employed in Research activities. The best approach though, according to the OECD, is to consider the two dimensions together, i.e., formal education and occupation.

The international classification ISCED provides the basis for this by breaking down formal education levels into six categories ranging from Holders of university degrees at PhD level (ISCED level 6) to Primary education or first stage of basic education (ISCED level 1). The use of formal education levels in order to identify R&D workers poses problems of international comparison, however, given that levels and structures of national education systems are sometimes very heterogeneous.

Appendix 2: Methodological note 2.5 attached to Section 5.3

Analysing firms' location patterns

The data used for analysing firms' location patterns is taken from the Amadeus database collected by the Bureau van Dijk (www.bvdep.com). The database consists of company accounts reported to National statistical offices concerning European companies with total turnover or assets at least equal to $12 millions or total employment of at least 150 employees. For each company the database provides the year of creation, the country/region as well as the ownership structure by nationality. Companies were selected when they were newly created during the period considered, i.e., 1996-2005 and when the percentage of assets owned by non-residents was superior to 50%. SMEs are defined as those firms with less than 250 employees, see European commission (2005b). The data includes information about the region where the creation of the firm has taken place as well as the main sector of activity given by a Nace code of 4 digits and for which the ICT sub-sectors Nace 30, Nace 32 Nace 33 Nace 64 and Nace 72 used in this report. The information used concerns the EU25 countries. A limitation of this data for studying the location pattern of multinationals is that the data contains firm-level rather than plant-level information which would be needed in order to study the exact geographical location of each foreign affiliate. This can potentially bias location in favour of regions where headquarters tend to locate, typically capital-regions cities. The results presented here, however, suggest that this bias is likely to be minor in the Amadeus database, especially given that for the EU10, the geographical pattern of multinationals' locations appears to be quite dispersed. Another issue with the data is skewed towards medium to large companies. If these companies tend to concentrate in some particular regions, these regions will in turn tend to be over-represented. When considering all the ICT sub-sectors together, the total number of companies covered is 44392, among which 40527 provide the year of creation of the company which is later used for analysing new firms locations.

Given that the Amadeus database provides data at firm-level, this data may entail problems when considering regional issues. As suggested above, firms do generally declare the location of their headquarters as location for the whole of their production activity, independently of the number of production sites in which they actually perform this production. This clearly poses a problem as the exact location of plants would be needed rather than the location of the firm's headquarter. Considering SMEs more specifically is therefore self-justified from a regional perspective as SMEs are less likely to own several production sites, at least when compared to large companies.

One problem when considering the location of SMEs, however, is that inferences with regard to the causes of the location of those companies is limited by the fact that, usually, SMEs locate where the entrepreneurs actually reside. For instance, Figueiredo et al. (2002) show that small companies tend to locate where their owner was actually born in Portugal. The main explanation given by these authors is that SMEs tend to chose location for reasons related to social capital and imperfect information about other alternative (to their region of residence) location choice. Importantly, these authors show that, non-home location choices are strongly governed by agglomeration economies in order to save on search costs while home-entrepreneurs do usually prefer to stay put, despite potential related costs both in terms of competition and labour costs.

Before undertaking a more specific analysis of the location of SMEs and multinationals it is important to consider to what extent the firm-level database used here provides a reasonably good description of the regional location pattern of firms in the European ICT sector. Following the same approach as in Section 3.1, one way to assess the regional coverage of the Amadeus data used here is to compare ranking of regions according to their level of employment for each for the ICT sub-sectors using ranking analysis via the calculation of the Spearman correlation index and its corresponding p-value, see Section 3 for more details. Table (a) 4 provides details of the calculations of the Spearman index for each ICT sub-sector of activity.

Table (a) 4: Comparing Amadeus database with the Eurostat Structural Business Statistics: Rank analysis

	SHARE OF TOTAL ICT EMPLOYMENT		SPEARMAN RANK CORRELATION*
	SBS, Eurostat	Amadeus	
30. Manufacture of office machinery and computers	2.0%	3.4%	0.80 (0.00)
32. Manufacture of radio, television and communication equipment and apparatus	10.3%	16.6%	0.75 (0.00)
33. Manufacture of medical, precision and optical instruments, watches and clocks	12.7%	10.8%	0.82 (0.00)
64. Post and telecommunications	39.5%	43.5%	0.65 (0.00)
72. Computer and related activities	35.6%	25.7%	0.86 (0.00)
Total	100%	100%	0.84 (0.00)

p-values are indicated in parentheses

The first two columns of Table (a) 4 compare the relative share of each ICT sub-sectors between the Amadeus and SBS database. While the overall structure of the ICT sector tends to be similar, especially with regards to the relative important of the ICT service sub-sectors (which represents 76% of total ICT employment when using the SBS and 68% when using the Amadeus database), some important differences emerge. These differences are somewhat natural given that one database, Amadeus, provides firm-level data, which is not exhaustive in terms of total employment in the sectors considered, while the other is especially designed to be exhaustive and to reflect the industrial structure of the EU economy. These differences are not necessarily problematic, however, given that our objective is to know which regions are the most important in terms of firms' location. Accordingly, the ranking of regions is therefore preferable to look at in order to know, in relative terms, whether the two databases provide similar information. This information is displayed in the third column of Table (a) 4 which shows that the two databases provide regional ranking that are indeed very similar and highly significant.

Appendix 2: Methodological note 2.6 attached to Section 5.4

Empirical modelling of the location choice of new firms

In the location choice model presented here, firms' location choices are mainly determined by region-specific production costs and market access. Each location decision is thus treated as a discrete choice made among several alternatives. Let consider that   is the profit level obtained by a given company if it chooses to locate in a particular region r against potential alternative location choices. Each alternative (or region) is characterized by an expected profit level linked to the region's specific characteristics such as its market access and all factors potentially affecting its production costs in this particular location including the size of the local market, qualification level of the workforce and so on. Location choices are assumed to be the result of profit maximization behaviour. The model therefore amounts to estimate the revealed profitability of each location site. Location decisions are derived from the maximization of a function of a number of regional characteristics represented by a group of variables X. Let P_r be the probability of choosing region r as location site:

$$P_r \equiv prob(\pi_r \rangle \pi_k) = prob(\varepsilon_k \langle \varepsilon_r + b(X_r - X_k)), \quad \forall r \neq k \qquad (1)$$

The profit potentially derived from choosing a given region to locate production in a region r against alterative regions k will thus depend on the characteristics of that region given by X_r compared to the characteristics of the regions k, X_k. The ε term represents the error term and b is the elasticity associated with each of the variables X which measure how sensitive the location choice of an average firm will be according to a change in a particular characteristic of a region. Assuming that the ε are iii according to a type I extreme-value distribution, the probability of choosing location r becomes

$$P_r = \frac{e^{bX_r}}{\sum_{k=1}^{n} e^{bX_k}} \qquad (2)$$

The profit function of each firm k locating in a particular region j can be written as follows:

Πkjt = β Xjit + Ekjt   (3)

Where X is the set of covariates characterizing each region and E is the error term. This profit maximisation problem is a variant of McFadden (1974) random utility maximisation model as shown by Carlton (1983). Assuming that the E component are independently distributed across k and j and that they follow a Weibull distribution, the model can thus be estimated as in McFadden (1974) using the conditional logit approach.

The coefficients of (3) can be estimated by maximum likelihood procedures under the independence of irrelevant alternatives (iia) assumption: the probability of choosing a region r compared to another alternative j, given by P_r/P_j depends only on the characteristics of the two alternative regions and not on any other third choice. This implies that all alternatives should be comparable in terms of substitution patterns. If this does not hold, an alternative model can be the nested logit model where location choices are made as a sequence of choices where subsets of regions meet the iia hypothesis. Typically, regions within countries where first the choice of the country is made and, in a second step, companies are assumed to choose between regions within one single country. Alternatively, the iia is not met when similar alternatives appear to be correlated within country for instance. One could in this case use alternatively the nested logit structure developed by McFadden (1978) in order to specifically control for the fact that alternative location choices are likely to be correlated between regions belonging to the same country.

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Abstract

Factual evidence suggests that ICT-led growth and ICT-producing sectors are strongly localised geographically. Given that the nature of ongoing technological change and innovation dynamics has a strong local/regional component, public policies need to be designed at this level as well. However, little is known - if anything - of the regional impact of ICT. The present study documents the regional impact of ICT by mapping the location of the ICT industry in the EU25, analysing the volume and nature of ICT employment across European regions, identifying the determinants of EU regions' attractiveness for ICT business location and, finally, assessing the contribution of ICT investment to regional growth and convergence. The study provides evidence for the prominent role played by the Computing Services sector in recent employment and skills' changes in the ICT industry, as well as for the emergence of new regional growth poles in the EU. Departing from traditional business models, this sector of activity presents relatively low sunk costs, especially in terms of physical capital requirement while having strong innovative and skills content, opening-up new opportunities for regional development in the EU. These factors also seem to explain much of the recent trends in ICT multinationals firms' location over the past decade. The study also shows that ICT capital investment tends to promote regional economic convergence. Regional policies aiming to promote regional cohesion must therefore consider ICT diffusion as a potentially important tool for the promotion of convergence throughout the EU. Importantly, ICT diffusion should also be accompanied by other policies and, in particular, policies aiming at improving education and skills levels. The study also shows that the absence of high ICT specialisation should not be seen as a major barrier to promoting the impact of ICT on regional development.

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