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Investigaciones Regionales

The Location of ICT activities in EU regions. Implications for regional policies

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ABSTRACT: The location of ICT producing industries does matter for global competitiveness and long-run growth potential. For instance, the differing contribution of ICT to economic growth between the US and the EU is often mentioned as one of the main cause explaining the diverging growth performance of these two areas since the mid-1990s. In turn, since the mid-1990s, countries with especially dynamic economic growth have tended to be highly specialized in ICT-producing and ICT-using industries, see van Ark and Inkaar (2005). More generally, ICT producing sectors, tend to promote technological change and innovative capability which are seen to be at the core of economic growth and competitiveness. When considering the EU economy, ICT industries appear to be concentrated in a limited number of regions, see Koski et al. (2002) for empirical evidence. A first objective of the present paper is to document the location of ICT producing industries in European regions in order to map existing EU clusters as well as to analyze recent changes in these industries using recent data on employment and firm location, especially in relation to the EU enlargement that has taken place in May 2004. The location of the ICT-producing sectors is not the end of the story however. A crucial aspect concerns the nature of activities that are being undertaken in different regions. Importantly, ICT industries do have different characteristics in terms of human capital, skill requirement, and knowledge content. In particular, because of the positive association between human capital, knowledge and long-run growth, it is important to analyze to what extent EU regional ICT clusters differ in according to these characteristics. The second question addressed in the paper concerns the nature of ICT activities undertaken in EU regions. Finally, the paper provides econometric estimates of the location of firms in ICT industries across EU regions. The paper considers more specifically the case of multinationals' location. Results on the determinants of firms' location appear to differ widely depending on

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the ICT sector considered as well as the type of companies considered. A number of policy implications are derived from these results.

JEL classification: R11, 033.

Key words: ICT activities, EU regions, regional policies.

La localización de las actividades TIC en las regiones europeas. Implicaciones para las políticas regionales

RESUMEN: La localización de las industrias productoras de las TIC importa para la competitividad global y el potencial de crecimiento de largo plazo. Por ejemplo, la contribución diferencial de las TIC al crecimiento económico entre los EE.UU. y la UE se menciona a menudo como una de la causas principales que explica la divergencia en el funcionamiento del crecimiento de estas dos áreas desde mediados de los 90. A su vez, desde mediados de los 90, los países con especial dinámica en el crecimiento económico han tendido a ser sumamente especializados en industrias productoras y usuarias de TIC, véase Van Ark e Inkaar (2005). Más generalmente, los sectores productores de las TIC, tienden a promover el cambio tecnológico y la capacidad innovadora que se consideran ser la base del crecimiento económico y de la competitividad. Cuando se considera la economía de la UE, las industrias TIC aparecen concentradas en un número limitado de regiones, véase Koski *et al*., (2002) para la evidencia empírica. Un primer objetivo del documento es documentar la localización de las industrias productoras de las TIC en regiones europeas para analizar los cluster existentes de la UE así como los cambios recientes en estas industrias usando datos actualizados de empleo y localización de la empresa, especialmente con relación a la ampliación de la UE en mayo de 2004. Sin embargo, la localización de los sectores productores de TIC no es el único objetivo. Un aspecto crucial se refiere a la naturaleza de las actividades que se están emprendiendo en diversas regiones. Las industrias de las TIC sobre todo tienen diversas características en términos de capital humano, requerimientos de formación y contenido del conocimiento. En particular, debido a la asociación positiva entre el capital humano, conocimiento y crecimiento de largo plazo, es importante analizar en qué medida los cluster regionales de las TIC en la UE se diferencian según estas características. La segunda cuestión abordada se refiere a la naturaleza de las actividades TIC emprendidas en las regiones de la UE. Por último, el trabajo proporciona estimaciones econométricas sobre la localización de las empresas en la industria de las TIC a través de las regiones de la UE. El trabajo considera específicamente el caso de la localización de las multinacionales. Los resultados de los determinantes de la localización de las empresas parece diferir ampliamente dependiendo del sector de las TIC considerado, como del tipo de empresa considerada. A partir de estos resultados se deriva un número de implicaciones de política.

Clasificación JEL: R11, 033.

Palabras clave: Actividades TIC, regiones UE, políticas regionales.

1. Introducción

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, see Barrios and Burgelman (2008). The second issue concerns the key role played by ICT producing sectors 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. Both ICT-diffusion and ICT-production are, therefore, believed to play a key role in the future of EU economy competitiveness.

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 producing sectors in the EU more specifically, these sectors appear 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 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, although ICT adoption and productivity impact has been especially vigorous in certain Member States (e.g. Ireland, Finland), this effect has still not materialized in most EU countries, see van Ark and Inklaar (2005).

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 going technological change and innovation dynamics have a strong local/regional component such that public policies need to be designed at this level as well. 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 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 European Commission (2007).

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, highly relevant. As stated earlier 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-intensive and low-skill 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 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 to have different impacts in terms of regional development.

As suggested earlier, the advent of ICT in the economy goes along with the globalisation process. Technological change and 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 factors contributing to regions'

attractiveness for foreign investors. In particular, the availability of local providers, often represented by SMEs, are particularly important to assess the relationship between multinationals' global choices and the regional dimension.

The rest of the paper is organised as follows. Section 2 provides descriptive results on the location of ICT employment in EU regions. Section 3 describes recent regional employment changes in ICT sectors. Section 4 describes the nature of skills and occupations of workers in EU regions. Section 5 makes use of micro data on creation of new ICT businesses in EU regions and focuses on the case of SMEs and multinationals. Section 5 provides econometric evidence on the determinants of ICT multinationals in EU regions. Section 6 concludes and provides a number of policy implications.

2. An overview of the location of ICT employment in EU countries and regions

The present paper uses the taxonomy of ICT-producing sectors as described in Annex 1. 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 by OECD (that requires Nace 4-digits level of aggregation). The main constraint is given by regional data availability, however. In the present study, Nomenclature of Statistical Territorial Units (NUTS 2003) is used as regional classification. 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.

Before turning to the regional analysis, we consider first national figures in order to get a broad overview of the structure of the ICT sectors in the EU25. In particular, since the membership of the ten New Member States in May 2004, a number of interesting evolutions have come into play which are worth having in mind in order to understand regional features. Table 1 provides a first overview of the employment structure of ICT subs-sectors at country level for the years 1995 and 2004. Overall, a substantial share of total ICT employment is created in the EU15 given that 88.3% of total employment is located in the so-called old Member States. This proportion has also tended to increase slightly over the period 1995-2004. The share of employment made in the new Member States 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 NMS. First, the decrease in the proportion of employment in the NMS is a reflection of an overall decrease in the percentage of employment in the NMS when considering all sectors of the economy. Indeed, the decrease in percentage experienced by the NMS is less pronounced in the ICT sectors compared to the rest of the economy. The period considered here indeed covers a period of intense

Table 1. Share of EU25 employment across ICT 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 sectors*		*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**
NMS	**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**
Gini index across EU25 countries	**0.71**	**0.65**	**0.61**	**0.58**	**0.70**	**0.69**	**0.62**	**0.61**	**0.72**	**0.69**	**0.65**	**0.64**	**0.62**	**0.62**

Sources: EU KLEMS database and authors' computations.

economic restructuring in the NMS and the ICT sectors have been no exception to this process, although the ICT sectors seem to have suffered less than the rest of sectors of the economy. Interestingly, the NMS tend to have increased employment shares in the manufacturing ICT sectors, with the exception of the sector Medical, precision and optical instruments. This applies above all for countries such as Hungary, which percentage in 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 sectors, employment is still largely made in the EU15 countries and countries such as United Kingdom, the Netherlands, Germany and Spain have slightly increased their percentage of employment on these sectors.

The figures displayed in Table 1 suggest that a number of important changes have come into play in the ICT EU industry. In particular, ICT manufacturing sectors have tended to lose weights in terms of total employment while the ICT service sectors' employment has increased. These evolutions have not been shared by all countries though, in particular when considering the old and new Member States of the EU, 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.

The Table 2 provides a first idea about the degree of spatial concentration of ICT sectors across EU regions.

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

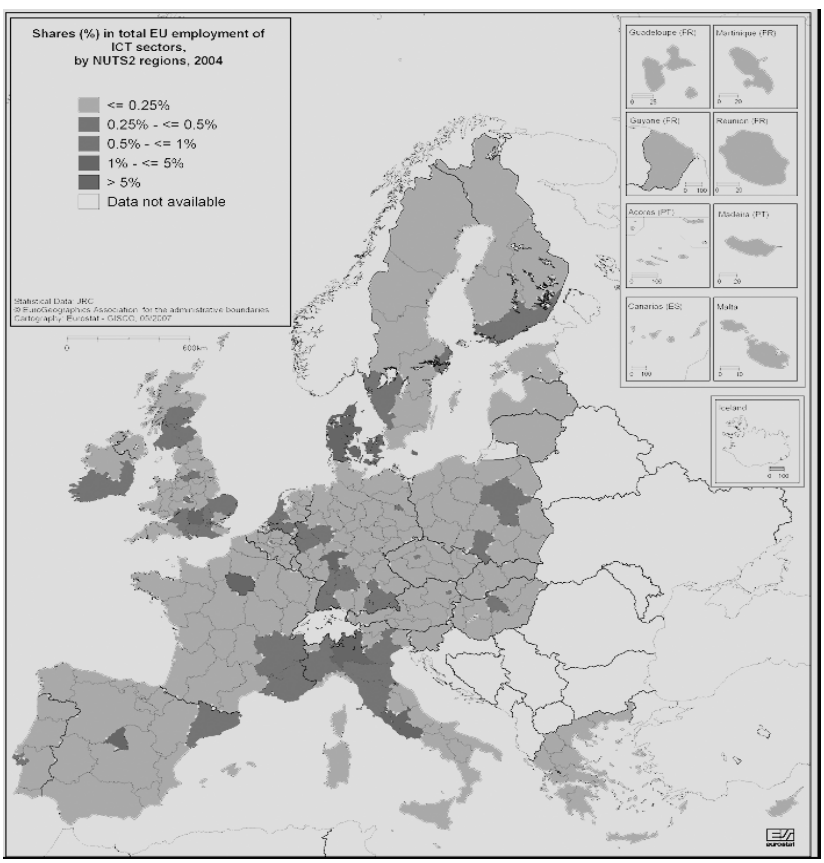
Sectors	*Gini index*		*Theil index*	
	2000	*2004*	*2000*	*2004*
30. Manufacture of office machinery and computers	0.64	0.56	0.74	0.60
32. Manufacture of radio, television and comm..	0.54	0.55	0.52	0.56
33. Manufacture of medical, precision and instr.	0.54	0.53	0.52	0.49
64. Post and telecommunications	0.67	0.71	1.00	1.16
72. Computer and related activities	0.64	0.64	0.76	0.78
All ICT 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 Joint Research Centre, Institute for Prospective Technological Studies. Inequality measures are weighted by absolute levels of employment in each sector/region

Table 2 provides two alternative measures of the spatial concentration of employment, namely the Gini index and the Theil index, where both indexes allow for a comparison of the degree of spatial concentration of ICT employment across NUTS2 regions. Only two years are considered, i.e., 2000 and 2004, given that comprehensive data for the EU NUTS2 regions were only available for these two years only. ICT sectors appear to be more concentrated spatially than the rest of sectors of the economy. Strictly speaking though, one must consider this result as not really surprising given that the rest of the economy in fact represents the total employment. This result tends to support the fact that hi-tech sectors such as ICT tend to be more spatially localised 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. Independently of the index used, the results of Table 2 shows that, among the ICT sectors, the service sectors are the most highly localised, independently of the year considered. This result runs counter common expectation as service sectors in general do tend to be more spatially dispersed, see for instance, Fujita *et al*. (1999). The reason to expect service sectors to be more spatially dispersed is that 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 suggests 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. The Map 1 below provides a visual overview concerning the spatial concentration of ICT activities in the EU25. This map shows the share of employment in ICT industries in each of the NUTS2 region for the year 2004 (the latest available year in the regional SBS (Eurostat).

Map 1. Share in percentage of total employment in ICT 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). More generally, these results are line 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, Madrid region and Central Italian regions, the South of Finland ad Western regions of Sweden as well as some regions located in the Member States that have entered the EU in 2004 such as Kozep-Magyarorszag (HU), Mazowieckie (PL) and Praha (CZ).

The figures displayed in the Map 1 above can be compared with those concerning the regional distribution of total employment (i.e., including ICT and non-ICT sectors). Table 3 makes this comparison by showing the percentage of ICT employment in the first ten EU regions to the share of these regions in total EU employment for all the sectors of the economy.

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

Region	*ICT SECTORS*			*ALL SECTORS*			*GDP PER CAPITA IN 2004 (EU25 = 100)**
	Rank	*Share ICT employ-ment*	*Cumulated Shares*	*Rank*	*Share 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)
Com. 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 total employment of all sectors of the economy appears 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 Iles 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 the share of these regions 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 5, these regions are also among the richest (in terms of GDP per capita) EU regions. Interestingly also, none of the regions located in the new Member States appear among the first ten regions for employment in ICT sectors.

The employment pattern that is displayed in Map 1 tends to follow closely regional differentials in terms of GDP per capita. One salient difference, however, concerns the relative importance of regions located in the countries that entered the EU in 2004 (the so-called New Member States). In particular regions such as Kozep-Magyarorszag (HU), Mazowieckie (PL), Praha (CZ), Slaskie (PL), among others, appear to be ranked relatively high in terms of EU employment shares of ICT industries.

Table 4. Ten largest ICT regions located in the New Member States as measured by percentage of EU employment in 2004

Region	*ICT SECTORS*			*ALL SECTORS*			*GDP PER CAPITA IN 2004 (EU25 = 100)**
	Rank	*Share ICT employment*	*Cumulated Shares*	*Rank*	*Share 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 first ten regions located in the NMS. 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 NMS' regions are relatively low since they represent 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, which is equal to 5.8%. It follows that, while the ten largest ICT employers are located in the EU15

regions, this share is largely above the corresponding total employment shares of these regions while the same cannot be said about the largest employing regions of the NMS 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. With some exceptions, though, these regions tend also to be highly specialised in ICT industries.

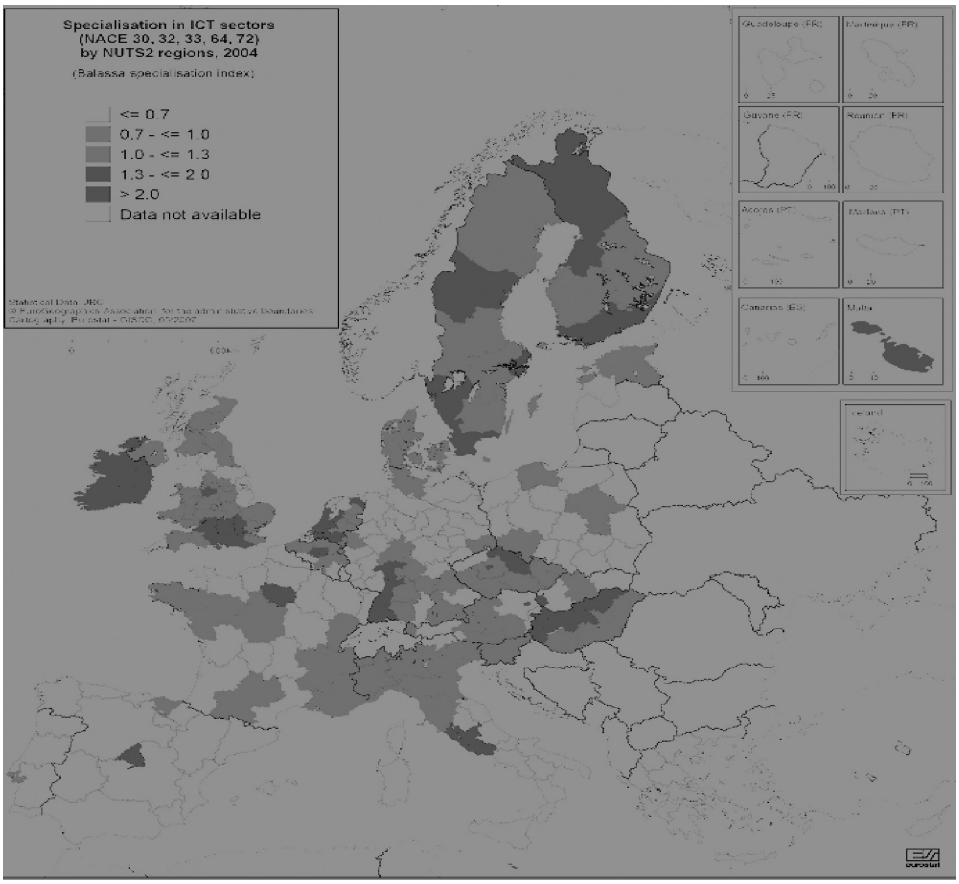
The previous discussion drives us to having a closer look at the role played by ICT employment in the industrial specialization of EU regions. Two questions are worth considering: the first one concerns the relative importance for each region of the employment in ICT in the overall economic activity 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 2 below shows the specialization of EU regions in ICT employment by using the Balassa index of industrial specialisation. This index provides the following measure:

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

where E^{T}_{ICT} denotes the level of employment in ICT sectors 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^{r}_{ICT} 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.

Map 2 shows that the regions where EU ICT employment is highest, are also, in general, the ones with a highest specialisation level in ICT activities. Here again, some exceptions are worth signalling. First, the Nordic EU regions of Finland and Sweden appear to be highly specialised in ICT activities. The most specialised EU regions in ICT industries appear to be, by decreasing order of the Balassa index, the Île 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 themselves highly specialised in ICT industries, the same cannot be said for the Madrid region which stands as the only Spanish region with (well-) above specialisation index. This result, coupled with the picture provided for that country in Map 1, suggests that the role played by ICT industries in the specialisation of Spain in ICT industries is essen-

Map 2. Specialization in ICT activities by NUTS2 regions, 2004



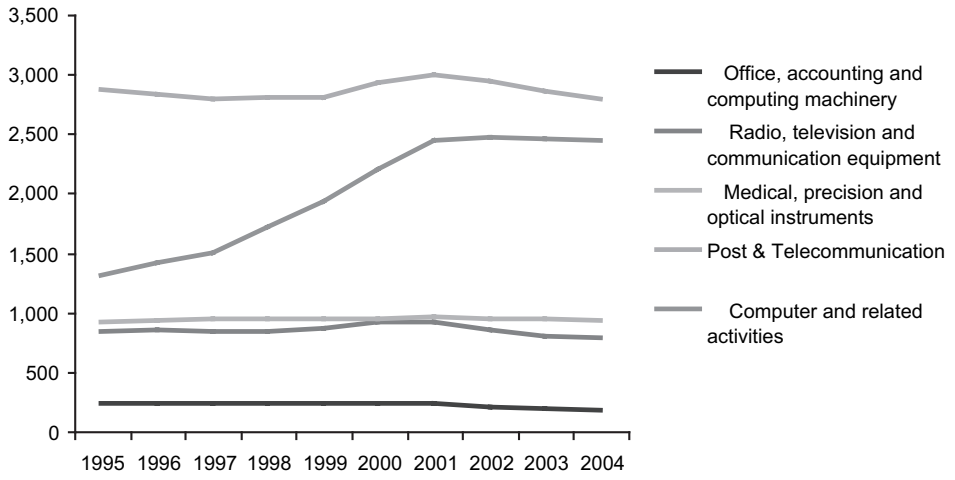
Sources: Eurostat (Structural Business Statistics and Labour Force Survey) and authors' computations.

tially limited to the Madrid region. Beside the regions aforementioned, ICT tend to play an important role in total employment in most of Irish regions together with Dutch, Belgian and Southern German regions, also appear to be relatively highly specialised in ICT industries. It is worth noticing also that some regions located in the NMS, 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, potentially, for regional development. On the other hand, in most Spanish 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 Greece, and most Polish regions together with the Baltic States, ICT do not appear to play a decisive role for industrial specialisation.

3. Regional employment change in ICT sectors, 1995-2004

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

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



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

Table 5 provides more details on employment changes in ICT sectors by providing percentage figures in three groups of countries namely, the EU25, the EU15, and the New Member States (NMS), i.e., those countries that have joined the EU in May 2004.

Overall, employment in ICT sectors 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. Over the same period, overall employment has increased by 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 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 new Member States. This statement is indeed confirmed by a more detailed analysis of the individual countries' experience[1].

[1] See Barrios *et al*. (2007) for more detailed country-level analysis.

Table 5. Employment changes in ICT 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 (Labour force Survey) and authors' calculations.

4. The nature of ICT employment across EU regions: skills and occupation characteristics

While the previous results provide interesting insights concerning the structure of ICT employment across EU regions, we now focus on the nature of employment in ICT sub-sectors by considering two aspects: occupation and formal levels of education of workers. 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 paper are at the core of log-run productivity and growth, are necessarily tied to certain levels of education and types of occupation. Thus, two dimensions 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. This effort to characterise ICT sub-sectors together with regions in terms of knowledge intensiveness enhances the analysis carried out over the rest of this Section. It also provides further empirical evidence that may help better understanding to what extent human capital is determinant for the economic performance of regions. The present paper makes use of data from the Eurostat annual Labor force Survey which can be considered as fairly representative at regional level for the two-digits aggregation level considered here. Importantly, we follow the definition provided in the Frascati Manual to build-up our measure of ICT-skills at the EU regional level. Annex 2 provides more details on this point.

As previously, before undertaking a regional analysis it is important to get an idea of the overall nature of European ICT industry both in terms of occupation and level of education as well as the changes occurred during the last decade. Table 6 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 rest of sectors of the EU economy.

Table 6. Percentage of employees with university degree and professional occupation

	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 (SBS and LFS) and authors' computations.

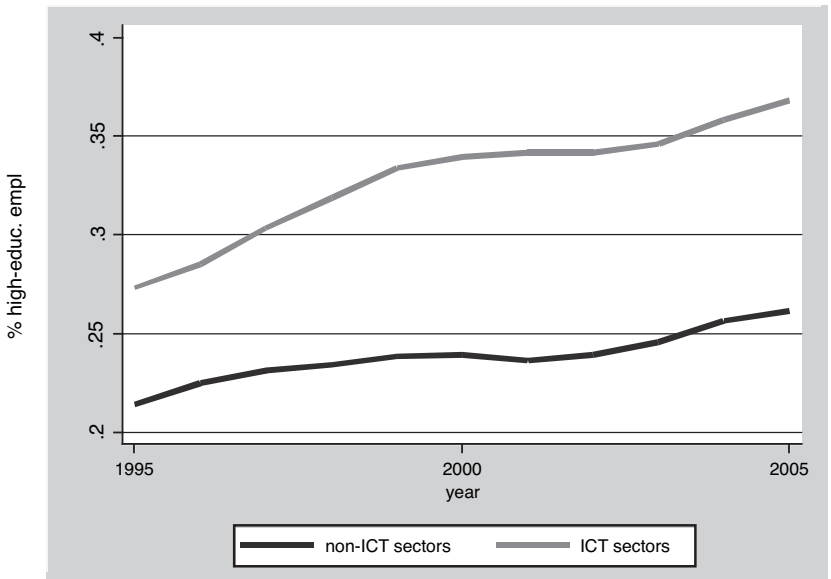
Looking at the percentages concerning the EU25, the table above shows that, on the one hand, ICT sub-sectors do have a higher proportion of highly-educated workers compared to the rest of sectors of the economy. The same applies to the percentage of employees with professional occupation for most sectors of the economy, except for the Post and Telecommunication sector where this percentage does not appear to be very different to the other sectors of the economy. When looking at differences between the EU15 and the new Member States, in all 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 sector. The contribution of the new Member States to the EU25 percentages is relatively low, however, given that almost all EU employment in that sector is made in the EU15 as shown previously in Table 1. Indeed, the evidence presented here shows that the relative shift in ICT manufacturing employment from the EU15 to the NMS appears therefore to be made in lower-skilled, manufacturing activities. For those ICT sub-sectors, especially in the ICT service sectors, where the NMS tend to employ a higher proportion of skilled workers, almost 90% of employment is still made in the EU15 and the evolution of the past decades seem to indicate that these differences are likely to persist. Figure 2 provides a dynamic overview of the share of highly-educated employees in total employment for the EU15[2]. 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.

The proportion of people with higher-education degree employed in the ICT sectors 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 1, this increase is clearly less pronounced compared to the ICT sectors 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 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). The rise in the proportion of highly-skilled workers in total employment experienced a rebound from 2003 onward. Here again, the evolution of the share of skilled workers in total employment can be related to more general business cycles features in the ICT sectors. For instance, when considering the major OECD economies (i.e., Japan, the US and the EU25), total employ-

[2] Data for NMS were not available for almost all years considered in Figure 1 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.

Figure 2. Percentage of highly-skilled employees in ICT and non ICT sectors, EU15, 1995-2005



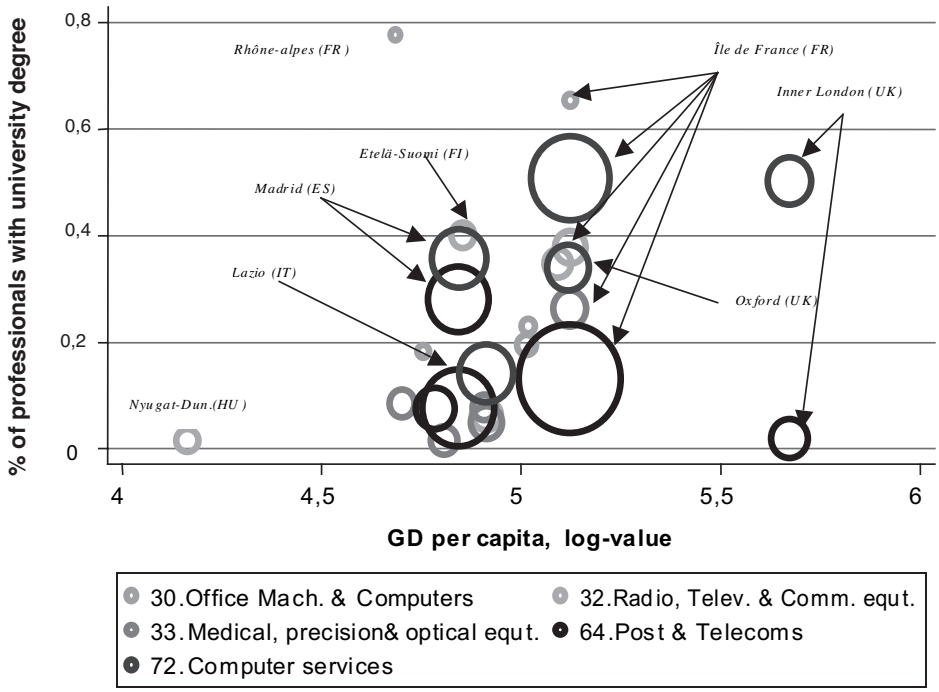
Sources: Eurostat, LFS and JRC/IPTS.

ment in the ICT sectors 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 sectors of activity though, with the Office, Machinery and Computers 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 and Related activities (NACE 72) sector.

The light curve in Figure 2 shows that the evolution described for the ICT sectors can be observed also, to some extent, for the rest of sectors 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. We now turn to the analysis of the nature of ICT employment at regional level The first question to be addressed concerns the spatial distribution of employees with the above characteristics in order to see whether the regional structure depicted previously in Section 3.3.2 is reflected 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 those changes have been taking place. Here we consider more specifically the link between the proportion of high-education/professionals and the GDP per capita of each region for the year 2004. We would like to check whether one should expect that the regions where skilled workers in ICT are mostly concentrated are also the richest

ones. The Figure 3 below provides information by sub-sector, selecting only the five largest EU regions for each ICT sub-sector in order to facilitate the interpretation of the results.

Figure 3. Percentage of highly-educated/professionals in total ICT employees vs. GDP *per capita* in 2004. ICT Sub-sectors. Five largest EU regions only



Sources: Eurostat, LFS and Barrios *et al*. (2007)
Note: Circles' size given by regions' sub-sector employment.

Overall, the positive relationship observed earlier between the level of GDP per capita and the percentage of highly educated professionals holds. One can observe also that the aforementioned positive relationship gets stronger for large regions (i.e., big circles). 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, regions with a high proportion of university-educated professionals in a specific ICT sub-sector tend also to have also relatively high proportion the rest of ICT sub-sectors. It must be noted, however, that some ICT-sub-sectors such as 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 sectors (Nace 72), in turn, have the highest percentage.

5. The attractiveness of EU regions for ICT businesses' location

The previous sections have provided descriptive evidence on the structure and nature of ICT employment in EU regions. We now turn to the analysis of the influence of these elements on the attractiveness of EU regions for business location. The questions regarding the attractiveness of regions are arguably of great importance when considering ICT sectors given the role played by these types of activities in the globalisation process and, by the same token, in the potential for regional development. Here we focus on the location choices of multinationals rather than considering the location choices of local companies such as SMEs because of the bias existing for SMEs which does not apply in the case of multinationals. This bias, as suggested earlier, assumes that 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 this reason and also because of the need to avoid the region of residence bias just mentioned, it is preferable to consider only the location of multinationals. By definition, these firms do locate their activity in a different countries and therefore are more likely to undertake cross-border comparisons of regions' characteristics. The data on multinationals' location is taken from the Amadeus databse of the Bureau van Dijk. This data covers all large firms in major sectors including ICT activities. The data also contain information on SMEs although it is less representative in this case. One potential issue when using this data for an analysis of businesses' location is that it concerns firm-level and not plant-level data. It follows that even in the case of a firms with multiple subsidiaries, these firms will most of the time record only one single location. This feature arguably introduces a bias since most large companies tend to cluster in capital cities or areas surrounding these cities. In practice however, a detailed inspection of the data shows that this bias is relatively minor in the present case and that the data provided by Amadeus on regional employment for instance matches rather closely aggregated data provided by Eurostat at the NUTS2 level[3].

3.1. The determinants of multinationals' location choices in ICT sectors

The empirical modelling strategy used here assumes that regional characteristics can be compared by a given multinational. These characteristics will in turn determine

[3] More details on the Amadeus database can be found at: http://www.bvdim.com/.

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 3 provides further details on the econometric 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 to a limited number of regional characteristics for the econometric analysis.

Table 7 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 SMEs in regional development, the first variable to be considered is represented by the density of SMEs which is represented by the number of SMEs per square kilometre. According to this variable, a high density of SMEs in a given ICT sector will attract multinationals if, for instance, 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 7. Definition of explanatory variables used and data sources

Variable name	*Definition*	*Statistical source*	*Geographic Level*
Market Size	Ln(GDPs) where Ys is the GDP in PPP for regions	Eurostat	NUTS2
Education	% of Labour force with at terciary education level	Labour force Survey (Eurostat) and DG JRC, IPTS	NUTS2
Specialisation	% of total employment in the ICT sector considered	Eurostat and DG JRC, IPTS	NUTS2
NMS	Dummy variable equal to 1 if NUTS2 region located in one of the 10 new Member States that entered the EU in May 2004	DG JRC, IPTS	Country
Density SMEs	Log of the number of SMEs per sq. km in the ICT sector considered	Bureau van Dijk, Eurostat and DG JRC, IPTS	NUTS2

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 is 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 explain 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 if firms need to get access to local providers or are tied to local purchasers of their products. For instance, in the case of an electronic component company, it may need to locate close to its main clients in order to save on transport costs. In the context of multinationals' location choices, 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 impose 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 as previously defined.

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 sector. According to this latter variable, one may expect ICT multinationals to be attracted by regions with a highly qualified workforce in case the nature of activities to be undertaken there are skill-intensive.

Finally, in order to investigate whether potential differences exist between the old and new EU Member States, we also include a dummy variable that takes a value equal to one when a region is located in one of the ten Member States that have joined the EU in May 2004. This variable will be equal to zero for the rest of regions. Table 8 provides the results of our estimation of the location choice model represented by equation [3] of Appendix 5 including the explanatory variable described above.

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 of being chosen as location site by a given multinational, independently of the ICT sector considered. By contrast, the fact that a region

Table 8. 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)
NMS	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.

is located in a new Member State seems to be relevant only in the cases of the manufacture of Radio, Television and Communication Equipment and Post and Telecommunications where regions located in the NMS have, on average, tended to be more attractive for multinationals' location. While the results depicted by Table 8 appear to be relatively homogenous across the different ICT 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 sector. Given the descriptive evidence provided in 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 sectors 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 more minor role in the Computing service sector as compared to the other ICT sectors, although this role is still positive and highly significant. The density of SMEs is especially less relevant in the case of the two ICT service sectors where the potential role played by this type of firms as intermediate providers of multinational firms is likely to be less relevant than in the case of manufacturing activities.

One advantage of the estimation results described in Table 8 is that one can calculate the estimated probability of each and every EU region of being chosen by a mul-

tinational. In particular, by calculating such estimated probabilities, one takes into account of the influence exerted by the explanatory variables considered. The big difference therefore with the simple descriptive statistics counting the frequency multinationals' location 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 as 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 7 to compute for each sector/region the following statistics:

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

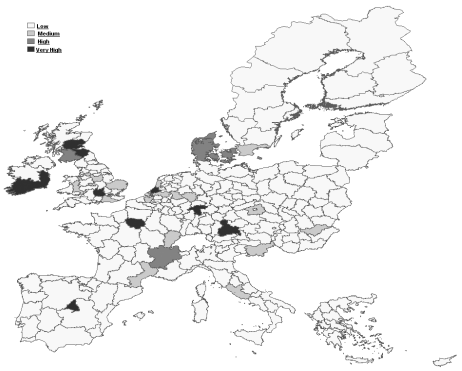
where y_r is the probability of a given region r at time t to be chosen as location site by a multinational and X are the regions' characteristics which estimated elasticities are given by the econometric results. With the estimates of b provided by Table 7, one can therefore easily calculate the values 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 sectors we use the same classification criteria[4]. These groups are shown in Maps 2-6, which display the results obtained after calculating the expression above.

According to maps 3-7, the most attractive regions for FDI are mainly located in the old Member States regions in most 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 new Member States 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 sectors although even for these sectors the most attractive NMS regions appear to lag behind the most highly specialised old MS regions mentioned before.

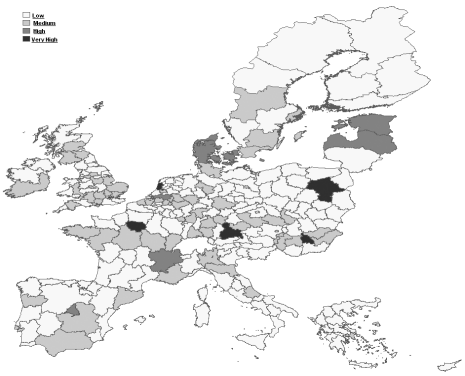
[4] It is important to note that because the probabilities calculated after estimating equation [3] are conditional on observed explanatory variables, the values obtained cannot be directly interpreted such that one can only classify regions according to the same classification criteria across the different ICT sectors.

Maps 3-7. Estimated probability of a European region for being chosen by a multinational

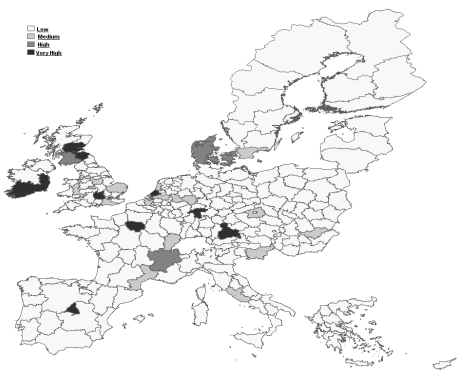
Map 3. Office Machinery & Computers (Nace 30)



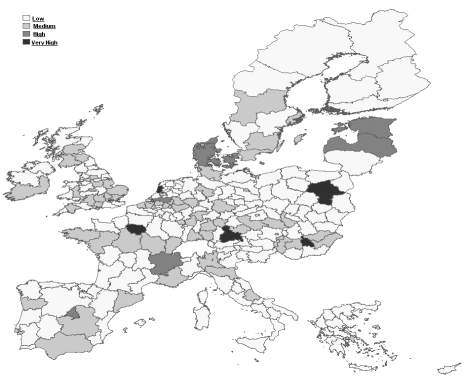
Map 4. Radio, Tel. & Comm. Equipment (Nace 32)



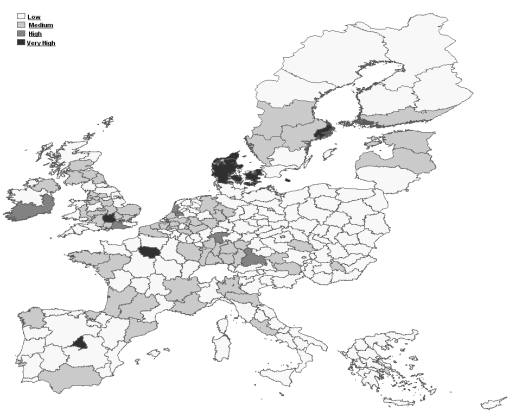
Map 5. Medical, precision & optical Equipment (Nace 33)



Map 6. Post & Telecommunications (Nace 64)



Map 7. Computing Services (Nace 72)



Sources: Data from Amadeus database, Bureua van Dijk. *Estimation based on Equation (3) and result of Column (1) of Table 7. Predicted probabilities computed according to Equation (2) (Appendix 3).*

4. Summary of findings and policy implications

The Study shows that ICT sectors tend 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. ICT sectors appear 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). When considering the nature of ICT activities, ICT sectors appear to present a higher proportion of highly educated/professionals in their total employment as compared to the rest of 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 Computing service sector is almost exclusively responsible for these evolutions. The strong expansion in the Computing service 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 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 new Member States, 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. A growing number of multinationals have located subsidiaries in the Member States that have acceded the EU in May 2004 while before the 2000s, multinationals tended to favour location in UK, Irish, Dutch and German regions. Here again, overall ICT evolutions are largely governed by the booming ICT computing services sector. For this specific sector, the core ICT EU regions from Ireland, UK, the Netherland, South of Germany, Austria, the Madrid region and the South of Finland and Sweden have been the most attractive for foreign investors. Overall these regions also appear to be the most attractive locations for multinationals. 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 Computing service industry while the presence of ICT SMEs appear to be more influential for ICT manufacturing. This result tends to support the idea that the impressive growth of the computing service sector has tended to be localised in regions already highly specialised in this type of activity tending to reinforce existing cluster. This results, in particular, is suggestive of the role played by potential agglomeration economies related to knowledge and technological spillovers.

This paper has provided evidence for the role played by the computing services 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 testimonial offices— most of the time, their employees are meant to carry out their work at the contractor

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 as well as by favouring 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.

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. In particular, wireless and mobile technologies are making connectivity more widely accessible and increasingly affordable. Indeed, Europe presents a well-developed mobile communication infrastructure, mainly due to the technological and economic success of the GSM . Future Cohesion policy programmes should 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 should aim at favouring the attractiveness of EU backward regions, especially when considering ICT businesses' location. Given the low (physical) capital requirement that characterises ICT services, these sectors offer great potential for regional development. These policy implications do not necessary call for a one size-fit-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.

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Annex 1. Taxonomy of ICT-producing industries

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

Source: OECD (2002b).

Annex 2. More details on the use of the Eurostat Labour Force Survey used

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. 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 (2002a) 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, these figures can be used nevertheless 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, 2002a) definition and the interpretation of figures on the occupations included in the Researchers category. The Frascati manual (see OECD, 2002a, 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. An alternative way to identify R&D workers is by considering levels of formal education. 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. According to the OECD, "both occupation and education series are important in the context of studying human resour-

ces 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. A particularly important point of the OECD classification of Researchers as indicated in OECD (2002a) 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 to perform an analysis based on this classification for the ICT sub-sectors.

Annex 3. 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 a 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 *Pr* be the probability of choosing region r as location site:

$$P_r \equiv prob\left(\pi_r \rangle \pi_k\right) = prob\ \left[\varepsilon_k \langle \varepsilon_r + b\left(X_r - X_k\right)\right], \qquad \forall r \neq k \tag{1}$$

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 *Xr* compared to the characteristics of the regions *k*, X_k. The $\hat{A}$ 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 $\hat{A}$ are iii according to a type I extreme-value distribution, the probability of choosing location *r* becomes

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

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

$$\Pi_{kjt} = \beta\, X_{jit} + E_{kjt} \tag{3}$$

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 pro-

cedures 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 (1976) in order to specifically control for the fact that alternative location choices are likely to be correlated between regions belonging to the same country.