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The 2007 European e-Business Readiness Index

William Castaings, Stefano Tarantola

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The 2007 European e-Business Readiness Index

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Abstract: This report is a methodological analysis on the composite index of the information and communication technology (ICT) adoption and use by enterprises in Europe. Efficient adoption and use of ICT is a key factor to help European enterprises to raise their productivity and competitiveness. The 2007 European E-Business Readiness Index, evaluated using data from the 2006 European enterprise survey of ICT use and e-commerce by Eurostat, is a useful mechanism for comparing e-business adoption and use by firms in the various European countries by sector, size and country. European E-business Readiness Index measures by 6 components the ICT adoption and by 6 components the ICT use. Report describes basic indicators and data coverage. The composite indicators obtained with 2006 data are compared with results from earlier years. Analyses include probability density estimates for scores and a robustness analysis in order to asses the significance of differences in scores among countries.
Further information: http://ec.europa.eu/enterprise/ict/policy/ebi/index_en.htm)
Keywords: ICT, e-business, adoption, composite indicators, eEurope2005, i2010

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Executive Summary

Information and communication technologies (ICT) are a powerful driver for economy-wide productivity, growth and jobs. The ICT sector contributes to a quarter of the EU's GDP growth and investment and innovation in ICT generate around 45% of our productivity growth.

ICT adoption and uptake in enterprises has a continuously important impact on the business processes, organisations, performance and competitiveness of enterprises. Respectively, ICT spending has increased.[1] The benchmarking of the "e-readiness" has been globally for many years an important issue. This is well reflected in the yearly Economist Intelligence Unit's (EIU) E-readiness studies[2] and in the global reports of the Bridges – organisation[3].

This report describes the results of the composite indicator on e-business readiness for European countries, using data from the 2006 European Union ISS (Information Society Statistics) enterprise survey, as collected by National Statistical Institutes and collected and verified by Eurostat, as available from Eurostat in May 2007[4]. The composite index is made of two core dimensions: adoption of (ICT) by business, and use of ICT by business. Since the 2004 pilot exercise, the index has proven to be a useful tool for gauging sectoral and country progress and a useful mechanism for benchmarking e-business readiness.

Enterprises in many countries have made significant progress during the last observation period (from 2005 to 2006).

Although quantitatively the country scores are much lower for use than adoption, the pattern of country performance for the category Use of ICT is globally similar to that of adoption. Denmark is comforting its leading position and the top ranks are still occupied by other Nordic countries (Norway, Sweden, Finland, Iceland) together with the Netherlands and Germany. Together with the Mediterranean Member States, most of the states from the Eastern part of Europe which joined the EU recently (2004 and 2007) are still in the developing stage of their e-business environment. Estonia, Slovakia, Check Republic and Slovenia who joined the EU in 2004 reach a relatively fair level of ICT Adoption and Use.

The broad generic level of e-Business Readiness Index underlies rather remarkable variation of the ICT adoption and use among different industry sectors and among different size of companies.

[1] OECD, Information Technology Outlook 2006, Table 1A.2.5, p. 61. (ISBN 92-64-02643-6). Table data: http://dx.doi.org/10.1787/110545204168

[2] Please see: EIU & IBM 2005 report addressing 65 countries: http://www.eiu.com/2005eReadinessRankings

[3] The report from Bridges – organisation contains an inventory of e-readiness assessments of a total of 188 countries (http://www.bridges.org/files/active/0/ereadiness_whowhatwhere_bridges.pdf)

[4] Data sets are periodically revised and some changes and withdrawals of data have taken place. The methodical changes are typically notified in the metadata of published data by Eurostat.

1. INTRODUCTION

This report is the fourth yearly report on the e-business readiness indicators after the report on the pilot study conducted in 2004 on the enterprise survey 2003 (Nardo *et al*, 2004).

Information and communication technologies (ICT) are a powerful driver for economy-wide productivity, growth and jobs. The ICT sector contributes to a quarter of the EU's GDP growth, and investments and innovations in ICT generate around 45% of our productivity growth. ICT adoption and uptake in enterprises has an important impact to the business processes, organisations, performance and competitiveness of enterprises. The number and diversity of organisations monitoring "e-readiness" reflects the importance of this issue. Composite indicators (CI) are aggregate measures that are calculated as weighted combinations of selected sub-indicators via underlying models of the policy domains of interest. They are increasingly used by media and policy makers to communicate information on the situation of countries or regions in various policy fields.

This paper describes the results of the CI of e-business readiness for European enterprises, using data from the 2006 Eurostat enterprise survey. The CI is made of two core dimensions: Adoption of ICT by business and Use of ICT by business. Country ranking, trends and comparisons across sectors of economic activity are discussed in the present paper. The CI provides a valuable summary measure of the e-business readiness of enterprises in all European countries. When the country scores derived from a super-aggregate merging of ICT Adoption and ICT Use are compared to similar analyses (broader geographic coverage) carried out by other organisations, the outcomes related to the countries which participated in the 2006 ICT enterprise survey match very well. When compared to the rankings obtained with the World Economic Forum's Network Readiness Index (NRI) and the e-Readiness Index from the Economist Intelligence Unit, the calculated rank correlations coefficients (Spearman's rank correlation coefficient) are respectively 0.92 and 0.94.

Additionally to the present report, the main findings of the study are also disseminated using advanced analysis and visualization tools. A Java applet (available from http://statind.jrc.it/ebiz_applet/ReadinessIndex.htm) was designed in collaboration with the FernUniversität in Hagen which demonstrated remarkable experience in the visual communication of official statistics (*Mittag*, 2006). Moreover, the set up of a Dashboard for the 2007 e-Business Readiness (available from http://esl.jrc.it/dc/E-Business_Index/) was carried out with the co-operation of the developer of this widely used JRC tool dedicated to the presentation complex indicator sets in a highly communicative format (*Jesinghaus*, 2003).

The broad generic level of e-Business Readiness Index underlies rather remarkable variations of ICT adoption and use among different industry sectors and among different sizes of companies.

Document structure:
This document contains an introductory section within the general framework, the composition of the index and the data available. The second section describes the index results for the category adoption and use of ICT and their comparisons. The main findings are followed by a detailed analysis of the 2006 figures and an examination of the trends. The analysis is consolidated by a robustness assessment to the assumptions and methodological choices made for the construction of the index.

BASIC INDICATORS AND DATA COVERAGE

1.1. Data sources, index components and the continuous development of the composite indicator

The e-business readiness index is one of the policy sub-indicators selected by the Council Resolution of 28 January 2003 (5197/03) of the European Union to monitor progress in the implementation of the eEurope 2005 Action Plan (COM(2002) 263 final).

In the i2010 framework, comparing the development of the information society in the Member States on the basis of certain indicators is still an important issue. A set of benchmarking indicators has been selected and the future e-business readiness indicator aims to use as its basic components data from i2010 indicators. A suitable subset of indicators from eEurope 2005 Action Plan indicators (from 2004 to 2006 data) and from i2010 indicators (from 2007 to 2010) is planned to be selected to obtain a continuous time series from 2004 to 2010.

Eurostat and National Statistical Institutes have developed from the 2001 onwards piloted "E-Commerce and ICT usage of enterprises" – survey a comprehensive statistical yearly data collection exercise, Information Society Statistics, which was endorsed by the legal basis EC(2004)808 in April 2004. This annual survey aims to produce harmonised and comparable statistics on the European enterprises access to and use of ICT systems. The survey measures the level and the type of the ICT used by European business. For this reason the indicators of the index are grouped into two categories measuring the various components of a country's technological development: 6 basic indicators for the group 'Adoption of ICT by business' and 6 basic indicators for the group 'Use of ICT by business'. The raw data for the basic indicators are expressed as percentages: 11 indicators are percentages of enterprises and one indicator (*a4*) is percentage of employees (see Table 1 and

Table 2).

Table 1. 2006 e-business readiness Index: list of basic indicators for adoption of ICT

Adoption of ICT: basic indicators	*Code*
Percentage of enterprises that use Internet	*a1*
Percentage of enterprises that have web/home page	*a2*
Percentage of enterprises that use at least two 2 security facilities at the time of the survey	*a3*
Percentage of total number of persons employees using computer with their normal work routine	*a4*
Percentage of enterprises having broadband connection to internet	*a5*
Percentage of enterprises with LAN and using an Intranet and Extranet	*a6*

Table 2. 2006 e-business readiness Index: list of base indicators for use of ICT

Use of ICT: basic indicators	*Code*
Percentage of enterprises that have purchased products / services via the internet, EDI[5] or any other computer mediated network where these are >1% of total purchases	*b1*
Percentage of enterprises that have received orders via the internet, EDI or any other computer mediated network where these are >1% of total turnover	*b2*
Percentage of enterprises whose IT systems for managing orders or purchases are linked automatically with other internal IT systems	*b3*
Percentage enterprises whose IT systems are linked automatically to IT systems of suppliers or customers outside their enterprise group	*b4*
Percentage of enterprises with Internet access using the internet for banking and financial services	*b5*
Percentage of enterprises that have sold products to other enterprises via a presence on specialised internet market places	*b6*

For an extensive description of the different steps underlying the development of a composite indicator the reader is referred to the joint OECD/JRC handbook (Nardo et al, 2005). In the present case, the components indicators are aggregated using a participatory weighing scheme involving a panel of national representatives. Weights were assigned to the indicators according to a "budget allocation scheme", which consists in asking each expert in the panel to distribute 100 "points" proportionally to the relevance of the indicators for measuring e-Readiness. The set of weights given in Table 3 represents the average of weights provided by twelve national representatives of the e-BSN[6]. Although the table presents rounded values (which do not sum up to one), all available digits were used for the calculations.

a1	***a2***	***a3***	***a4***	***a5***	***a6***
0.18	0.16	0.10	0.16	0.21	0.20
b1	***b2***	***b3***	***b4***	***b5***	***b6***
0.17	0.17	0.21	0.21	0.12	0.13

Table 3 Average Budget Allocation weights for the different index components

Using the *nc* basic indicators (denoted $I_k, k=1,\ldots,nc$) and the corresponding weights (noted denoted $w_k, k=1,\ldots,nc$) for the aggregation, the value of the composite indicator CI (adoption or use) is given by:

$$CI = \sum_{k=1}^{nc} w_k I_k$$

The validity, interpretability and explanatory power of the e-business readiness index depends on the quality and completeness of the data. The basic indicators are being updated in view of the i2010 initiative and the dynamic nature of e-business will obviously cause adjustment needs in 2007-2010.

[5] Electronic Data Interchange

[6] e-Business Support Network is a body established as part of eEurope 2005 Action Plan. http://www.e-bsn.org/portal/home.do

Although the index as it stands is partial and constrained by data limitations, we see it as a valuable comparative tool that helps to identify the progress made in enterprises and hopefully also to motivate national policymakers to further support enterprises in their efforts.

1.2. Survey of available data

The data used throughout the analysis[7] refer to the European businesses of different sizes and sectors of economic activity covered by the 2006 Community Survey on ICT Usage and e-Commerce in Enterprises. The survey includes indicators for the EU27, as well as Norway and Iceland (members of the European Free Trade Association - EFTA). The model survey was developed by Eurostat in close collaboration with Member States and the OECD. From the results obtained, aggregates (mostly binomial proportions) were compiled by the National Statistical Institutes (NSI) of the Member States for the total population and for different breakdowns defined by 2 background variables: the main economic activity of the enterprise (NACE groupings) and the number of persons employed (size categories).

The NACE and size categories are grouped in a hierarchical way into several levels. The present study is based on the level 2 for NACE and on the level 3 for size categories. The various breakdowns are described by Table 4 and Table 5; Micro-enterprises (optional information in the community survey) and financial services (addressed by a specific survey) are not covered by the current analysis.

Table 6 provides at the country level an overview of the percentage of available data from 2003 to 2006. To give an idea, a single indicator missing for a given country represents a drop of approximately 8% in data availability. The measure is highlighted in red for countries that did not participate in the community survey, in orange when the data sets were not delivered on time. The provided values reflect data availability during the various JRC e-Business Readiness analyses. Since some values were provided afterwards or removed for inconsistency, this does not exactly reflect the current state of the Eurostat database.

Table 4. NACE categories (without the financial sector)

Sector D	Manufacturing
Sector F	Construction
Sector G	Wholesale and retail trade
Sector H	Hotels; camping sites, other provision of short-stay accommodation
Sector I	Transport, storage and communication
Sector K	Real estate, Renting and Business activities
Sector O	Motion picture, video, radio and television activities

Table 5. Size categories (without the financial sector)

Small enterprises	10 to 49 persons employed
Medium enterprises	50 to 249 persons employed
Large enterprises	250 or more persons employed

Apart from Malta, all EU27 countries are considered in the current analysis. Italy, Luxembourg, Portugal and Slovakia did not provide a complete dataset but missing value were imputed using multi-

[7] as available from Eurostat in May 2007 at URL: http://epp.eurostat.ec.europa.eu/portal/page?_pageid=2973,64549069,2973_64554066&_dad=portal&_schema=PORTAL

linear regression. Only the explaining variables featuring important correlations with the missing component were considered. The obtained results lead to a consistent temporal trend.

Table 6. Data availability (in %) for 2003, 2004, 2005 and 2006 survey

Member state	Code	2003	2004	2005	2006
Austria	AT	100	100	100	100
Belgium	BE	100	100	100	100
Bulgaria	BG	**0**	100	**0**	100
Cyprus	CY	**0**	100	100	100
Czech republic	CZ	**75**	**83**	100	100
Denmark	DK	100	**100**	100	100
Estonia	EE	**0**	92	100	100
Finland	FI	100	100	100	100
France	FR	**50**	**0**	**0**	100
Germany	DE	75	100	100	100
Greece	EL	**100**	100	100	100
Hungary	HU	**0**	92	**92**	100
Iceland	IS	100	**0**	**0**	100
Ireland	IE	100	**100**	100	100
Italy	IT	100	**92**	100	**92**
Latvia	LV	**0**	100	100	100
Lithuania	LT	**0**	100	100	100
Luxembourg	LU	100	100	**92**	**92**
Malta	MT	**67**	**0**	**92**	**0**
Netherlands	NL	100	100	100	100
Norway	NO	100	100	100	100
Poland	PL	**0**	100	100	100
Portugal	PT	100	100	**92**	**83**
Romania	RO	**0**	**83**	**0**	100
Slovakia	SK	**0**	100	100	**83**
Slovenia	SI	**0**	100	100	100
Spain	ES	100	100	100	100
Sweden	SE	100	92	100	100
United Kingdom	UK	67	75	100	100
Total	29	15	26	25	28

2. MAIN FINDINGS

The e-business index is presented as a weighted average of the component indicators by considering the budget allocation weights. One should observe the fact that this report is about the ICT Adoption and Use of enterprises. Whenever only the name of a country is used in the report, this should always be interpreted to refer to a survey sample of enterprises of that country.

2.1. Rankings for ICT Adoption and Use

The scores and rankings for the Adoption and Use of ICT (see Table 7) provide a relative gauge of e-business progress in 28 countries (26 European Union Member States and 2 Countries members of the European Free Trade Association). The indices for Adoption and Use for the aggregate EU27 are calculated from component indicators estimated by Eurostat.

ICT Adoption		
Countries	**Score**	**Rank**
Finland	78.06	1
Sweden	77.28	2
Iceland	76.00	3
Denmark	75.72	4
Netherlands	72.64	5
Belgium	71.72	6
Norway	71.27	7
Germany	70.10	8
France	69.11	9
United Kingdom	68.43	10
Austria	67.96	11
Luxembourg	67.92	12
Ireland	64.35	13
Slovenia	63.36	14
Spain	63.17	15
Italy	60.48	16
Czech republic	60.11	17
Estonia	59.91	18
Slovakia	57.44	19
Greece	55.42	20
Portugal	52.28	21
Poland	52.09	22
Lithuania	51.36	23
Cyprius	51.15	24
Hungary	48.75	25
Latvia	45.35	26
Bulgaria	43.01	27
Romania	32.42	28
EU27	63.86	

ICT Use		
Countries	**Score**	**Rank**
Denmark	41.42	1
Netherlands	35.22	2
Norway	34.26	3
Ireland	33.20	4
Germany	33.04	5
Iceland	32.42	6
Finland	30.85	7
Austria	30.68	8
Sweden	30.58	9
France	30.10	10
Belgium	28.35	11
United Kingdom	27.89	12
Luxembourg	27.01	13
Greece	26.71	14
Italy	23.95	15
Estonia	23.40	16
Spain	22.94	17
Czech republic	22.76	18
Slovakia	22.03	19
Slovenia	21.71	20
Lithuania	21.15	21
Portugal	19.31	22
Cyprius	19.16	23
Poland	17.39	24
Latvia	13.73	25
Hungary	12.21	26
Romania	11.03	27
Bulgaria	7.71	28
EU27	26.46	

Table 7 2006 e-Business Readiness ICT Adoption and Use – Scores and rankings according to the budget allocation weights

Although quantitatively the Country scores are much lower for Use than Adoption, the pattern of country performance for the category Use of ICT is globally similar to that of Adoption. The corresponding rank Spearman rank correlation coefficient between Adoption and Use is equal to 0.91.

The countries from the northern part of Europe steadily occupy the top ranks and have consistently done so for the last 3 years. The leading position of Denmark for ICT use is really outstanding. According to both the Network Readiness Index from the World Economic Forum and the e-Readiness rankings from the Economist Intelligence Unit, this country is also leading worldwide. Slight differences in scores are observed in the mid-ranks and stress the need for a robustness analysis (see section 5). Together with the Mediterranean Member States, most of the states from the Eastern part of Europe which joined the EU recently (2004 and 2007) are still in the developing stage of their e-business environment.

For an appraisal of the variability of the performances achieved by the different Countries, estimates of the probability density function using the Member States for both Adoption and Use are provided by Figure 1. The obtained curves were estimated using Gaussian kernels. Therefore they represent non-parametric smooth estimates which are not truncated (i.e values outside the [0,1] range) and not necessarily symmetric. This asymmetry is more pronounced for ICT Adoption for which the distributions are characterised by a negative skew (elongated tail at the left). In other terms, while the performances are quite balanced across countries for ICT Use, there is an important and heterogeneous group of countries lagging behind (increase of the mass of the left tail of the distribution without causing an additional mode) for ICT Adoption.

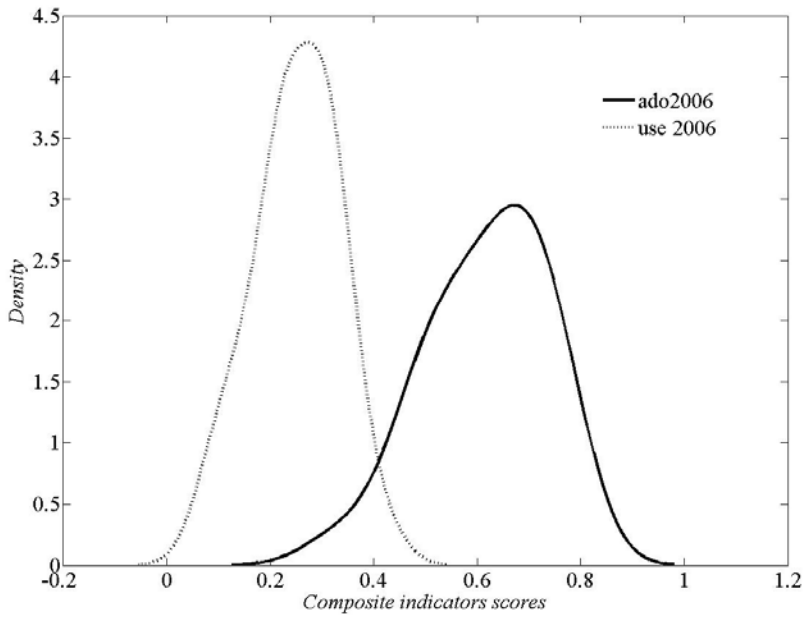

Figure 1 Probability density estimates for Adoption and Use country scores

2.2. Relation between ICT Adoption and Use

A graphical representation of Adoption versus Use scores for the 28 countries but also for the EU27 aggregate is proposed by Figure 2. The correspondence between the country codes with the full names is given by Table 6. Using the EU27 aggregate, the plane is divided in 4 parts characterising the

practical use of the adopted ICT infrastructures. With respect to the EU27 aggregate, the 4 zones categorize the performances of the countries with respect to the EU27 average estimated by Eurostat. Since the correlation between Adoption and Use scores is important (r = 0.91), most of the countries lie along the diagonal depicting a positive correlation. Most of the time good performances in ICT Adoption are coming along with a satisfactory level of ICT Use. With respect to the EU27 average, Greece can be distinguished for its efficiency in using ICT infrastructures given the investments made. Portugal, Spain and Italy are the only Countries from the former EU15 which are still below the European average for both adoption and use of ICT. The different countries were grouped in 4 clusters (see Figure 2). The countries were split into groups of similar size depending on their relative position along the regression line (Adoption vs Use). We did not apply methods of cluster analysis as the outcomes are critically sensitive to the key features of the clustering algorithms (such as distance measure and predefined thresholds).

Apart from the Netherlands and Germany, the cluster of countries leading for both Adoption and Use of ICT (cluster 1) is essentially composed of Nordic countries. The second cluster contains countries form the North-western part of continental Europe. Together of with some countries member of the former EU15 (Greece, Italy and Spain), Estonia, Slovakia, Check Republic and Slovenia who joined the EU in 2004 reach a relatively fair level of ICT Adoption and Use. Apart from Portugal, the fourth cluster is composed of countries that recently joined the EU (2004 and 2007).

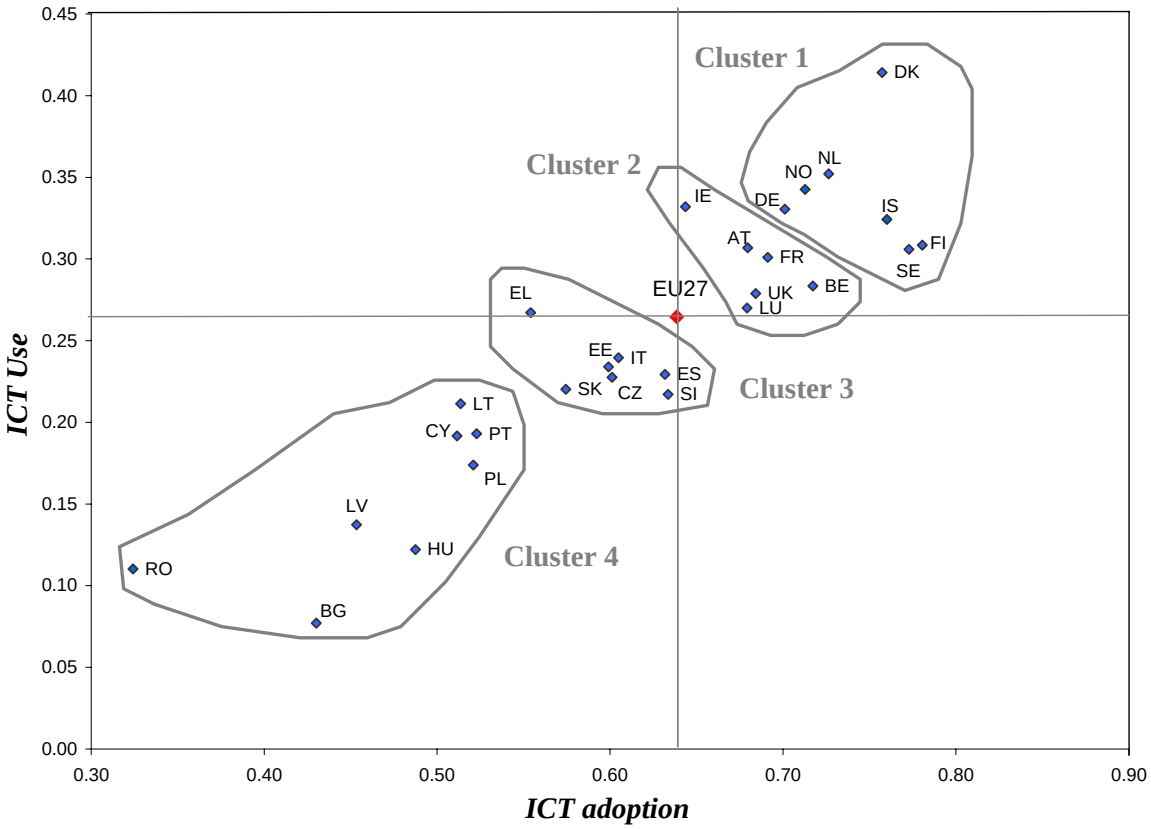

Figure 2 Adoption scores vs. Use scores employing the budget allocation weighting scheme. The red diamond indicates the EU27 aggregate

3. DETAILED ANALYSIS OF 2006 FIGURES

In order to deepen the analysis carried out in the previous section, the variability of the different component indicators is analysed and the influence of the firm size or sector of economic activity on the composite indicators scores assessed.

3.1. Variability in performances for composite indicators components

The outstanding leading position of Denmark for ICT Use, underlined in the previous paragraph, is also quite clear in the (*b1*,*b2*) plane. It is basically the only country for which good and similar levels were achieved for the percentage of enterprises purchasing and receiving orders via computer mediated network (see Figure 3). The other countries lie on a regression line characterised by a higher percentage of enterprises purchasing orders via computer mediated network.

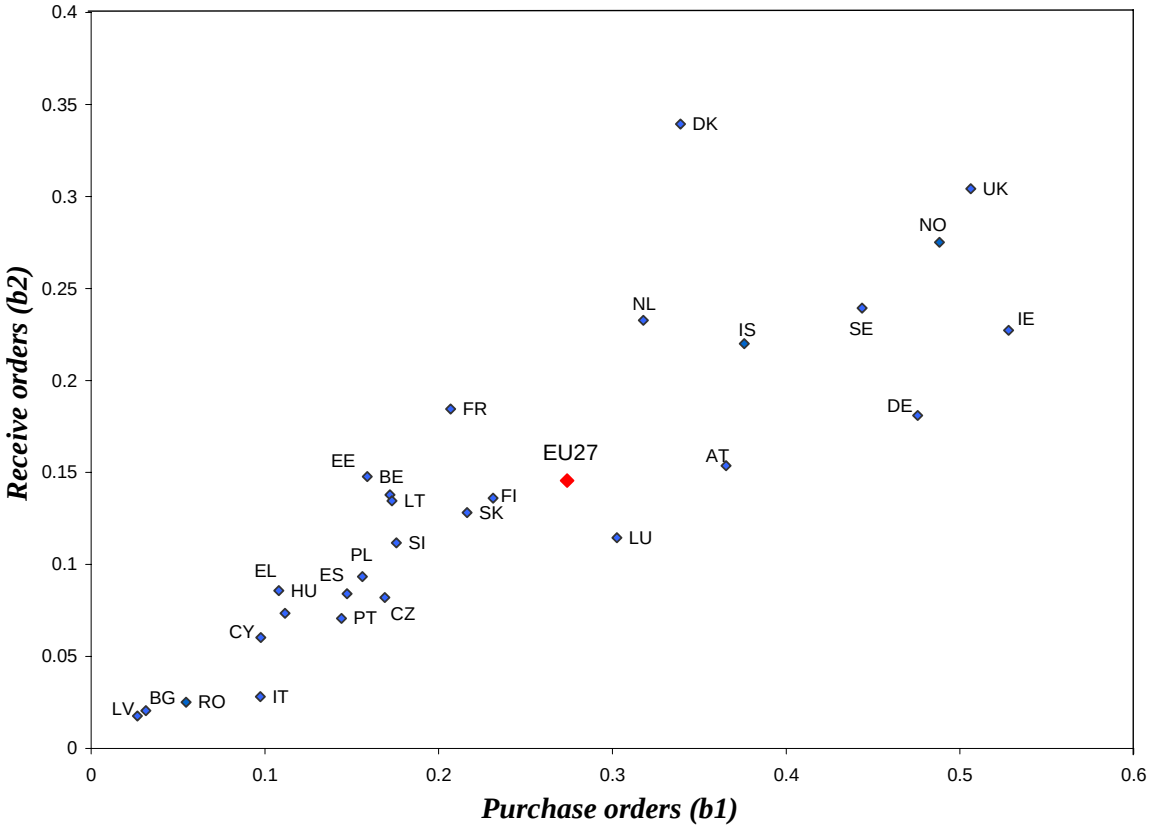

Figure 3 Relation between purchases and orders via computer mediated network

Another feature which can be inferred from Figure 3 is that most countries show modest performances for both indicators *b1* and *b2*. Moreover, there is a lot of heterogeneity among the countries showing performances above the EU27 average. This variability can be assessed for index components by estimating, a probability density function for the scores (Figure 4 and Figure 5). The only difference with Figure 1 is that the distribution is computed for the basic indicators rather than for the Adoption and Use composite indicators.

While the probability density functions of scores for the Adoption indicators are mostly characterised by a negative skew (left elongated tail), the contrary can be observed for most ICT Use indicators (particularly *b1*, *b2* and *b4*). In other terms, for the Adoption of ICT, although many countries (main mode of the distribution) achieved good performances, numerous countries still that have to catch up (negative skew, important group of laggards). For the Use of ICT, most countries are still in developing stage (main mode in the lower part of the range) and advances are initiated by an heterogeneous group of leaders (right elongated tail). A few highlights are proposed in the following for specific indicators.

For the indicator *a1* (percentage of enterprises that use Internet), although a few countries lagging behind cause a small secondary peak in the distribution, most countries reach a very high level for this indicator. The adoption component featuring the lowest value refers to advanced information and

communication technologies (indicator *a6:* Percentage of enterprises with LAN and using an Intranet and Extranet*)*. Focusing on the technological advances which mainly depend on the enterprise (to be opposed to Broadband Internet access), the set up and maintenance of private computer networks (LAN) represents the more sophisticated aspect covered be the adoption components. Moreover, given the definition of this indicator (see Table 1), only the firms using internet protocols for sharing information (intranet and extranet) are included. While performances seem relatively balanced for the indicators *a4* and *a5* (Percentage of total number of persons employees using computer with their normal work routine, Percentage of enterprises having broadband connection to internet), the left elongated left tail observed for *a2* and *a3* (percentage of enterprises having a homepage, percentage of enterprises having more than 2 security facilities) emphasise the existence of an important group of countries lagging behind.

Concerning the Use of ICT infrastructures, although heterogeneity is rather important for most components (Figure 5), there is a concentration around modest performances for the most advanced aspects of ICT usage (indicators *b2*, *b4* and *b6*). The only indicator accounting values similar to those obtained for the adoption components refer to the use of internet for banking and financial services (indicator *b5*). In fact, for the previously mentioned aspect the enterprise is mainly a consumer of internet services provided by other companies. Therefore, this is probably the component requiring less effort for its achievement. The shape of the distribution for this indicator (left elongated tail) is also very similar to the one observed for some Adoption indicators.

Apart from *b5*, most components, and particularly b1 (Percentage of enterprises that have purchased products / services via the internet, Electronic Data Interchange or any other computer mediated network where these are >1% of total purchases) feature a positive skew (heterogeneous group of leading countries). While countries performances lie in a very small range for *b6* (Percentage of enterprises that have sold products to other enterprises via a presence on specialised internet market places), the variance is very important for the indicator *b3* (Percentage of enterprises whose IT systems for managing orders or purchases are linked automatically with other internal IT systems).

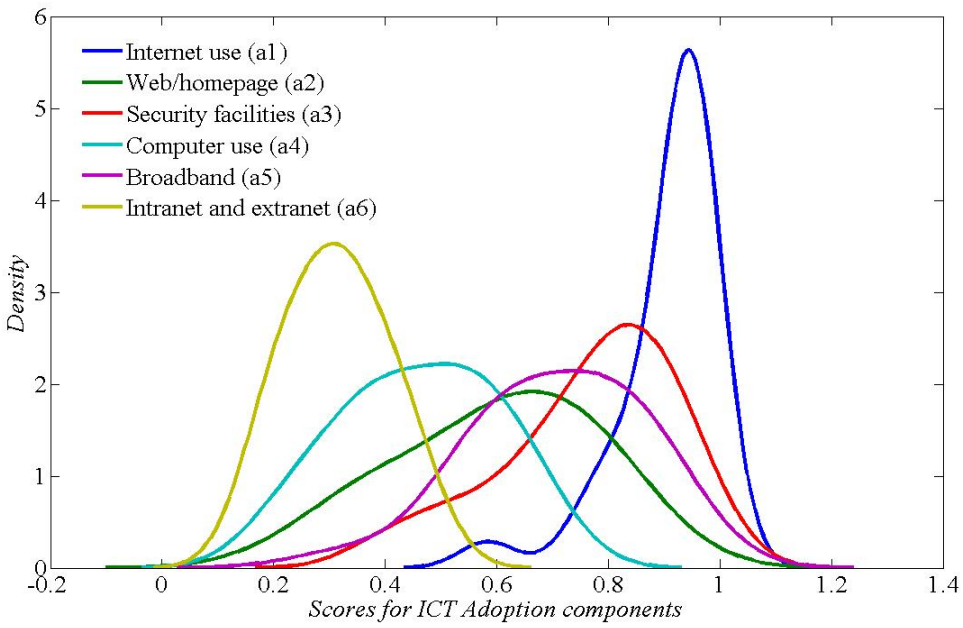

Figure 4 Variability in country scores for ICT Adoption components

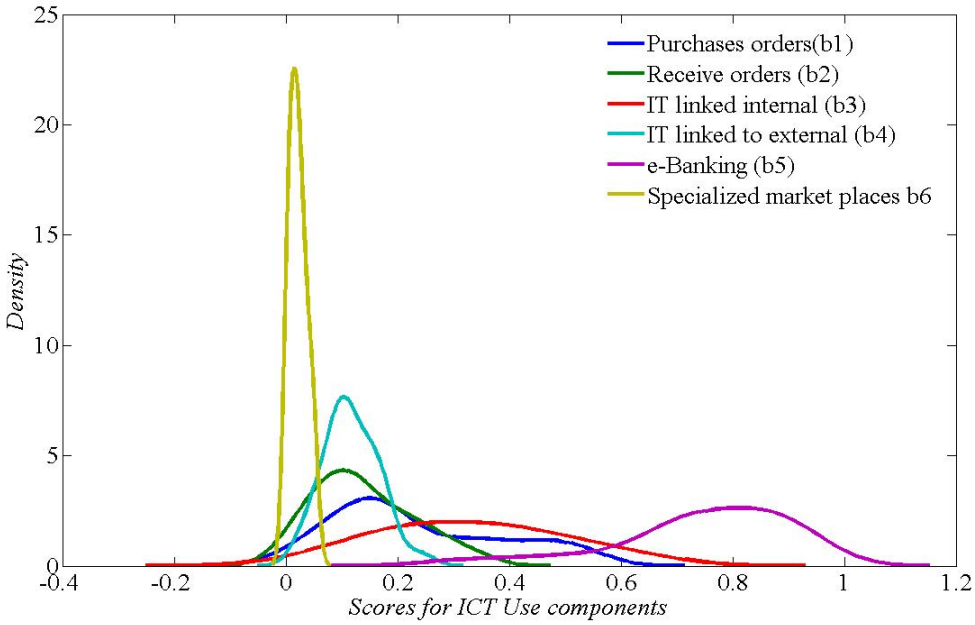

Figure 5 Variability in country scores for ICT Use components

3.2. Analysis by firm size and sectors of economic activity

Rather than restricting the analysis to the data available at the country level, the different breakdowns presented by Table 4 and Table 5 are exploited in the current paragraph. The missing values, numerous when compared to data availability at the country level, were also imputed using multi-linear regression. The European Commission launched e-Business W@tch[8] in late 2001 to monitor the adoption, development and impact of electronic business practices in different sectors of the economy in the European Union and beyond. The present analysis does not provide such a detailed level analysis but emphasizes the very important diversity in term of performances for the e-Business Readiness composite indicators. Although adequate business solutions might specific to a given firm size or sector of economic activity, the results of this benchmarking exercise provide an interesting insight.

3.2.1. Analysis by firm size

As expected, when the scores for the Adoption and Use composite indicators are analysed separately for firms of comparable size, larger enterprises perform better for both Adoption and Use (see Figure 6 and Figure 7). When shape of the various probability density functions are analysed, good scores and important cohesion (smaller variance) are achieved by large enterprises for ICT Adoption. For large and medium enterprises, the presence of a small group of lagging countries cause a slight deviation to the normal distribution in the lower part of the range for both Adoption and Use. This left elongated tail is more pronounced for ICT Use. For small firms, while they show modest but balanced performances for ICT Use, the left elongated left tail observed for ICT Adoption is even characterised by 2 distinct groups: the first trying to catch up and a group of laggards.

The results obtained mainly reflect the fact that depending on the company size, the need for complex of infrastructures and the affordable financial cost underlie important variations. This will result in different performance and saturation levels.

[8] http://www.ebusiness-watch.org

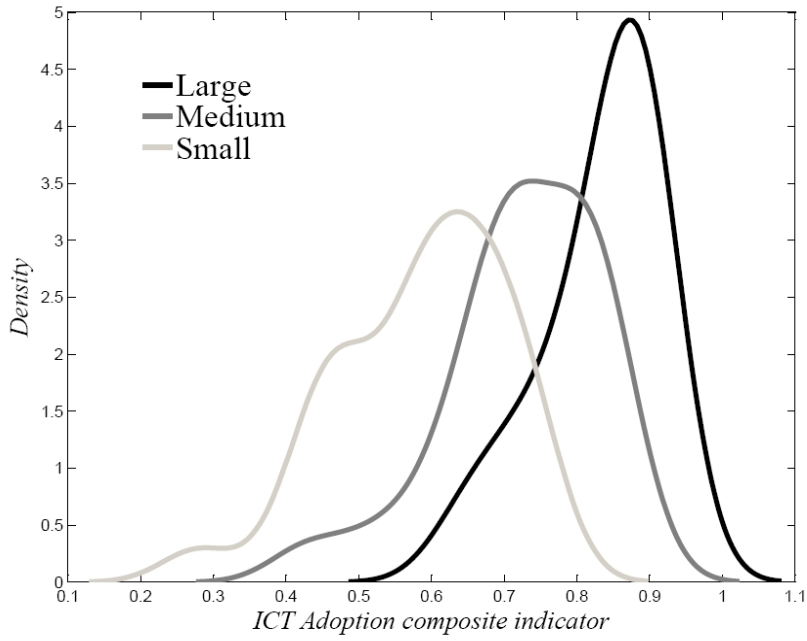

Figure 6 Probability density function of country scores for ICT Adoption depending on the firm size

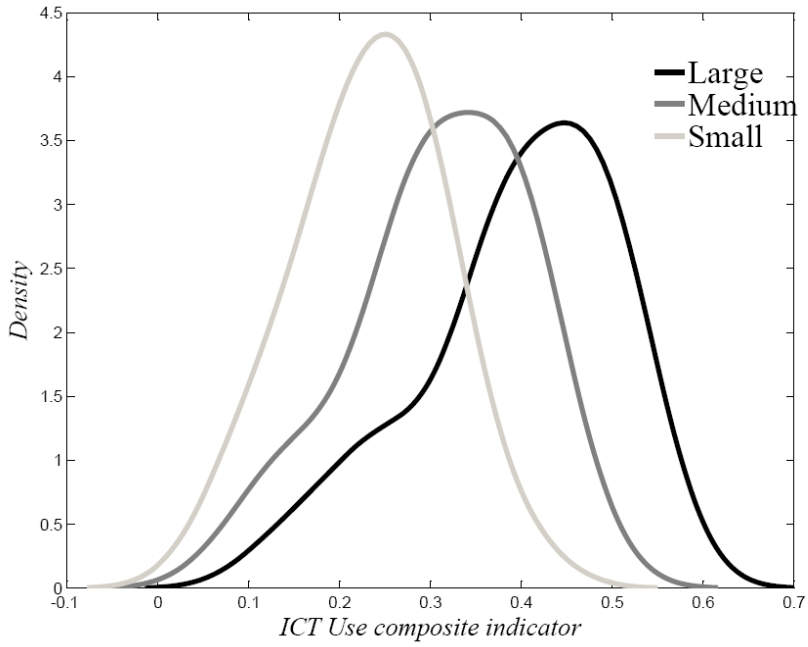

Figure 7 Probability density function of country scores for ICT Use depending on the firm size

3.2.2. Analysis by sectors of economic activity

While, the relation between the company size and the performances in ICT Adoption and Use is relatively obvious, the picture is slightly more complex when analysed for different sectors of economic activity. For the EU27 aggregate, the performances in ICT Adoption and Use are compared for different sectors of economic activity (see Figure 8). The sector O (Motion picture, video, radio and television activities) represents less than 1% of the population but show outstanding performances for both Adoption and Use. The sector lagging behind is the sector F (i.e Construction). However, as underlined in the 2006 e-Business W@tch report, the computer-based systems and technologies are

gaining acceptance because they can have significant economic potential for this industry. However, most aspects do not refer to the electronic communication business solutions.

Given the definition of the composite indicators used in the current benchmarking framework, sectors G (Wholesale and retail trade) and H (Provision of short stay accommodation) seem to be characterised by an important Use of ICT given the investments made (i.e ICT Adoption). The contrary can be observed for the sector K (Real Estate, Renting and Business Activities). As emphasized before for the effect of the company size, depending on their needs different sectors of economic activity will be characterised by different performance and saturation levels.

Although some sectors show similar performances in ICT Adoption or/and Use for the EU27 aggregate, the analysis of the probability distribution among countries (for the same sector) reveal very different features (see Figure 9 and Figure 10). As an illustration, sectors I (Transports, storage and communications) and D (Manufacturing) have achieved neighbouring levels of adoption when the EU27 aggregates are compared. However, while the variability seem quite balanced for sector I, an important group of lagging countries can be clearly distinguished for sector D (i.e elongated left tail featuring another mode of the distribution). A similar shape can be observed for the sectors O (Motion picture, video, radio and television activities) and G (Real estate, Renting and Business activities) but the group of countries trying to catch up perform better for the sector G (second mode of the distribution closer to the main mode).

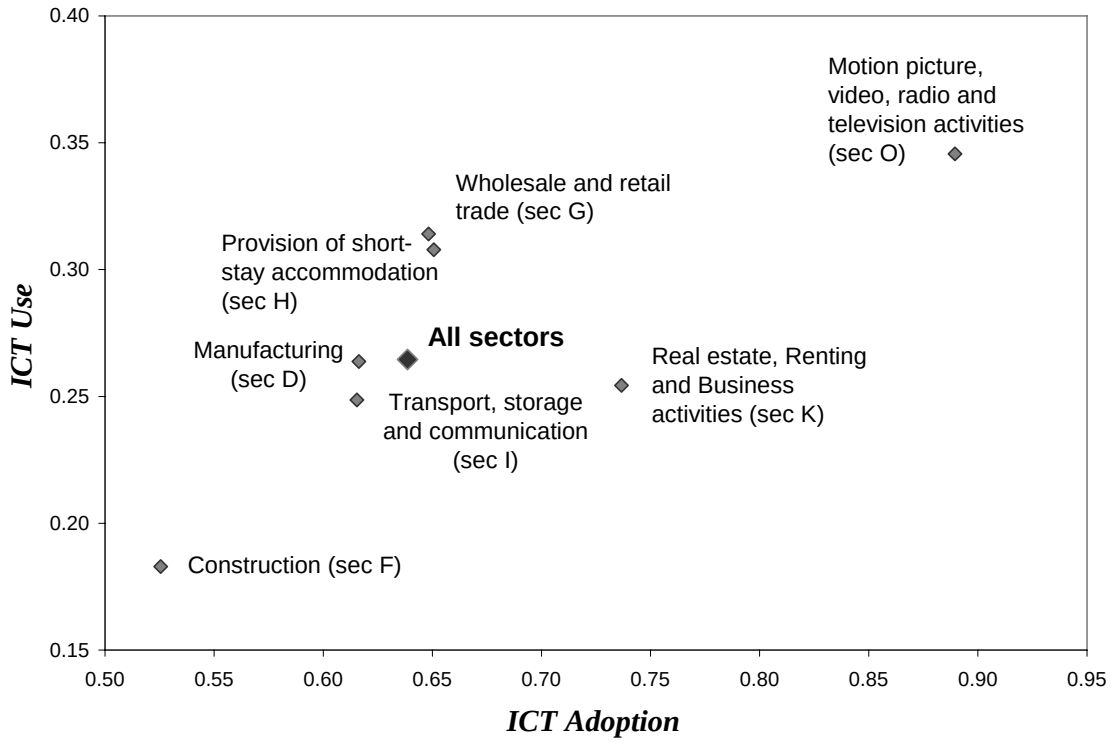

Figure 8 Adoption scores vs. Use scores for different sectors of economic activity at the European level (EU27 aggregate)

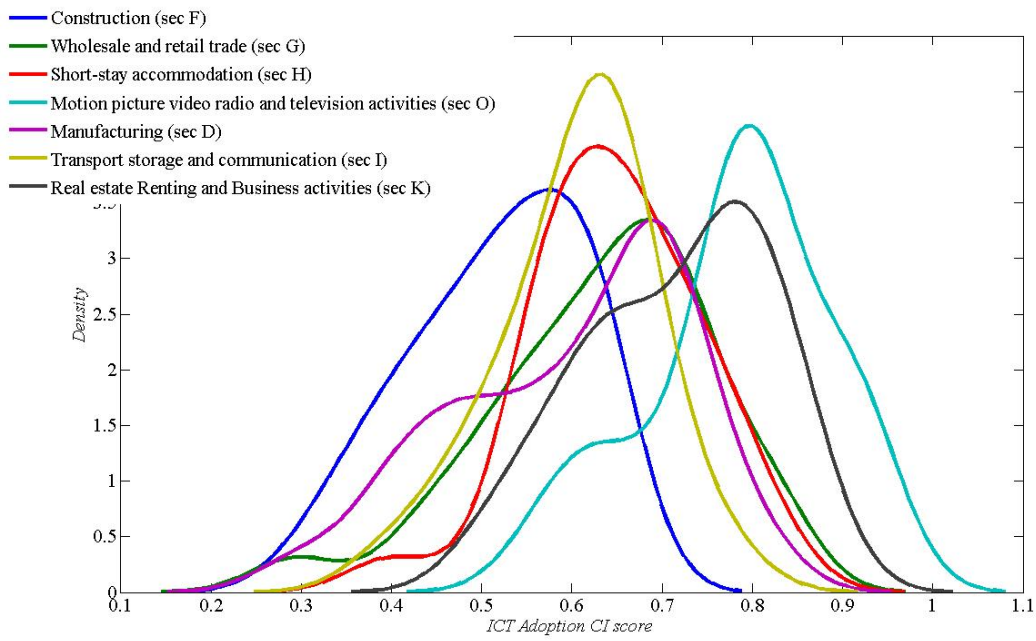

Figure 9 Probability density estimates (using normal kernel functions) for the country scores for ICT Adoption in 2006 depending on the sector of economic activity

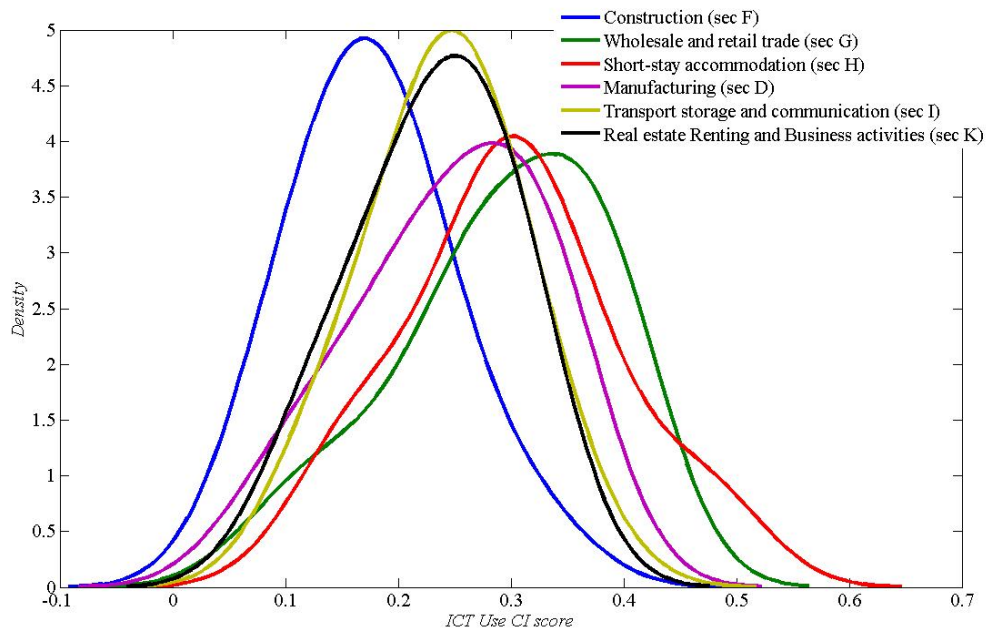

Figure 10 Probability density estimates (using normal kernel functions) for the country scores for ICT Use in 2006 depending on the sector of economic activity

For the Use of ICT (Figure 10), while the variability of scores is generally more balanced, there is important and heterogeneous group of lagging countries (negative skew) for the sectors G (Wholesale and retail trade) and D (Manufacturing). Given the important diversity (in size) of enterprises providing short-stay accommodation, the variability of country scores is very important for the sector H. Lastly, the sectors I (Transport, storage and communication) and K (Real estate, Renting and Business activities) have both similar levels of ICT Use on average but show also similar variability in country scores.

4. TREND IN ICT ADOPTION AND USE

In order to analyse the trend in ICT Adoption and Use, the results of the previous ICT enterprise surveys were used. Since some errors in the database can be identified only when new data become available, the composite indicators for 2003, 2004 and 2005 were re-calculated using the updated version of the Eurostat database instead the using the values published in previous JRC e-Business Readiness reports. The imputation of missing values for 2003, 2004 and 2005 is also carried out using multi-linear regression. When necessary (inconsistent temporal trend) an additional correction was carried out using the values observed for the other surveys.

4.1. Analysis of the overall trend

The temporal shift of the distributions toward larger scores (Figure 11) is very clear for ICT Adoption and still moderate for ICT Use. The left tails of the distributions are slightly more elongated in 2004 and 2006 because Bulgaria and Romania did not participate in the 2005 survey. Unfortunately, it seems that the progress made in ICT Adoption does not come along with the reduction of inequalities (persistence of elongated left tail). The slight improvement in ICT Use also comes with an increase of the variance (i.e decrease of peak density and more elongated tails) which means that the differences in countries relative performances are increasing.

The evolution of the probability density function for ICT Use from 2004 to 2005 is also interesting. The distribution is slightly bi-modal for those 2 years but there is a shift during the 2004-2005 period. The leading group became dominant and the followers became the second mode of the distribution.

In 2006, the distribution of scores for ICT present a bell shape which is, according to the results provided by Figure 7, mainly due to the contribution of small enterprises (representing more than 80% of the population). In fact, the ICT Use distribution for medium and large enterprises are mainly characterised by a negative skew, i.e elongated left tail of the distribution.

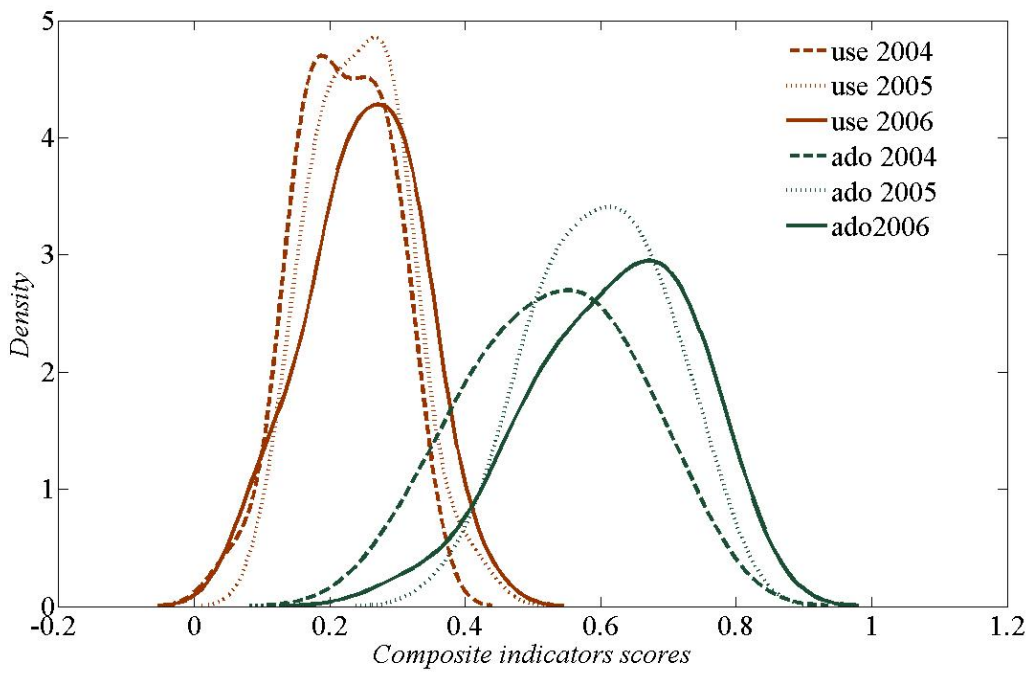

Figure 11 Probability density estimates (using normal kernel functions) for the country scores in 2004,2005 and 2006

4.2. Analysis of country trends for the composite indicators

In order to track the evolution of specific countries, the evolution of ICT Adoption and Use scores over time (using the last version of the available data for the past surveys) is displayed separately for the 4 clusters identified previously (from Figure 12 to Figure 15). A solid line is drawn between 2 points only if data is available for successive years and the same scale was kept for all the figures in order to facilitate the comparison.

Many countries are characterized by slight advances, stagnation or even recession of ICT Use. However, it is important to emphasize that apart from Estonia (Figure 14), the main reason leading to decrease in ICT Use is mainly inconsistent variations (sometimes more than 20% from one year to another) of the indicators *b3* (percentage of enterprises whose IT systems for managing orders or purchases are linked automatically with other internal IT systems), sometimes together with *b4* (percentage enterprises whose IT systems are linked automatically to IT systems of suppliers or customers outside their enterprise group). The concerned countries are namely Finland, United Kingdom, Spain, Cyprus, Portugal and Hungary. For the particular case of United Kingdom, a working inconsistency with the Eurostat model questionnaire for the indicators b3 and b4 was underlined in the previous JRC e-Business Readiness reports. Since this country cannot be compared with the other for these index values, the reliability of its relative position in the ICT Use ranking is contestable. Similar difficulties might have been encountered by other countries. Apart from the comparison to other countries for the level of ICT, for a given country, inconsistencies in the trend might be due to corrections of the Eurostat model questionnaire. In fact, when an important update has been carried out to the model questionnaire, results are no longer comparable from one year to another.

Apart from the features discussed previously, the analysis of the figures reveals that significant progress in ICT Use is usually made when a satisfactory level of ICT Adoption is already achieved. In fact, most of the countries featuring important improvements in ICT Use during the period are leading countries, i.e members of cluster 1. Important progress was achieved for both Adoption and Use for Denmark, Norway, Germany and Sweden. For the countries approaching saturation (ex Demark and Sweden) for the Adoption of ICT (according to the current definition of the components), advances are mainly realized for the Use of ICT. Although it is not possible to follow the detailed trajectory of Iceland (no data available for 2004 and 2005), both Adoption and Use were significantly improved in the 2003-2006 period.

While both Netherlands and Finland where featuring stagnation for ICT Use in the 2003-2005 period the evolution is quite different between 2005 and 2006. A significant improvement is observed for the Netherlands and a slight decrease is observed for Finland. The apparent recession of ICT Use in Finland is mainly due to significant decrease for indicators *b2*, *b3* and *b4* (respectively -3.76%, -9.16% and -4.32%). The results from the 2007 enterprise survey should bring some information for the confirmation or invalidation of this trend.

For the second cluster, apart from the United Kingdom and Belgium, all countries show satisfactory, relatively constant and comparable progress over the period for both Adoption and Use of ICT (particularly, Ireland, Austria and Luxembourg). France who provided a workable dataset only for the 2006 survey appear to be one of good performers of this cluster. For the trajectory of Belgium is close to stagnation for ICT Use, the situation is quite different for the United Kingdom (situation already discussed).

The analysis of Figure 14 reveals that the progress achieved by Slovakia over the 2004-2006 period, specially for ICT Adoption between 2004 and 2005, is really outstanding (+47% for the indicator a3 between 2004 and 2005). Some of the Adoption components might have been underestimated in 2004. Italy, Czech Republic and Portugal (in cluster 4, Figure 15) also show significant progress over the

period. The progression of Greece in ICT Adoption from 2005 to 2006 is mainly due to a strange drop of the indicator *a3* (-23.14%). The slight decrease in ICT Use for Portugal between 2005 and 2006 is due to a drop of 8.61% for the indicator *b3* (situation already discussed). For Italy and Portugal, the values were imputed for the indicator *b4* because they were recently removed by Eurostat for all surveys. Similarly, while Hungary participated in the 2005 survey, all indicators values were recently removed from the Eurostat database. The drop in ICT Use from 2004 to 2006 is mainly due to the indicator *b3* (-29.34%). While the progress seem significant for Spain from 2004 to 2006, for both ICT Adoption and Use, a similar variation of the indicator b3 (-22.49%) was experienced from 2003 to 2004. More generally, the reliability of the results obtained for the some countries for ICT Use (particularly for indicators *b3* and *b4*) and especially for the first time they participated in the community survey (generally 2004) is questionable.

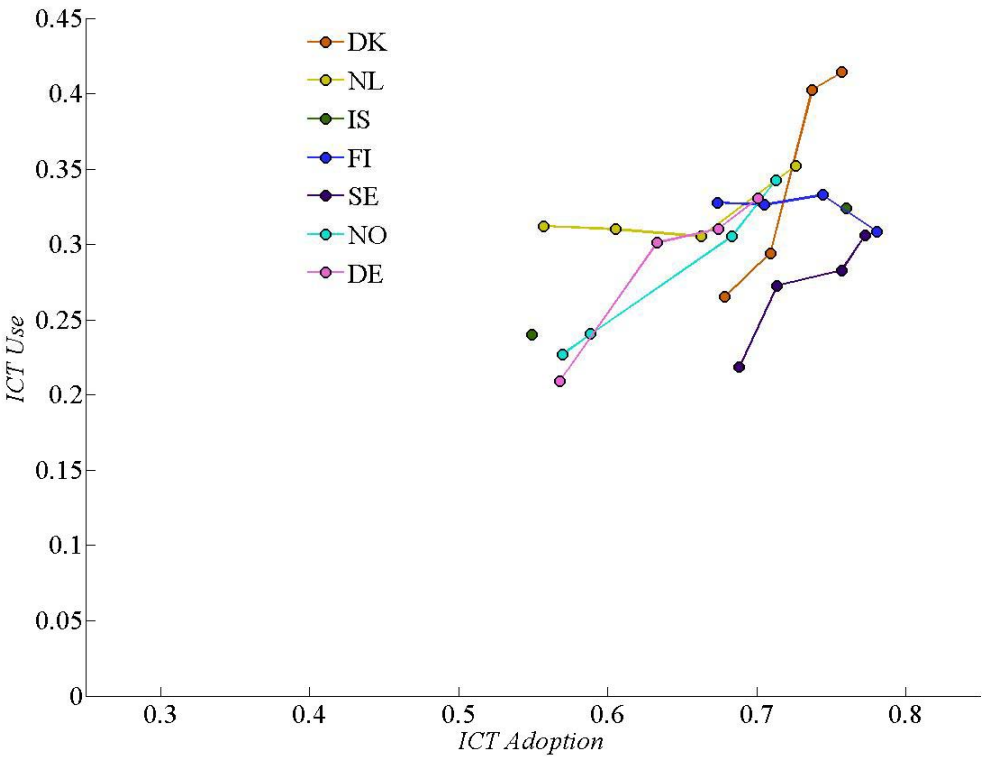

Figure 12 Evolution of ICT Adoption and Use across years for countries of the cluster 1

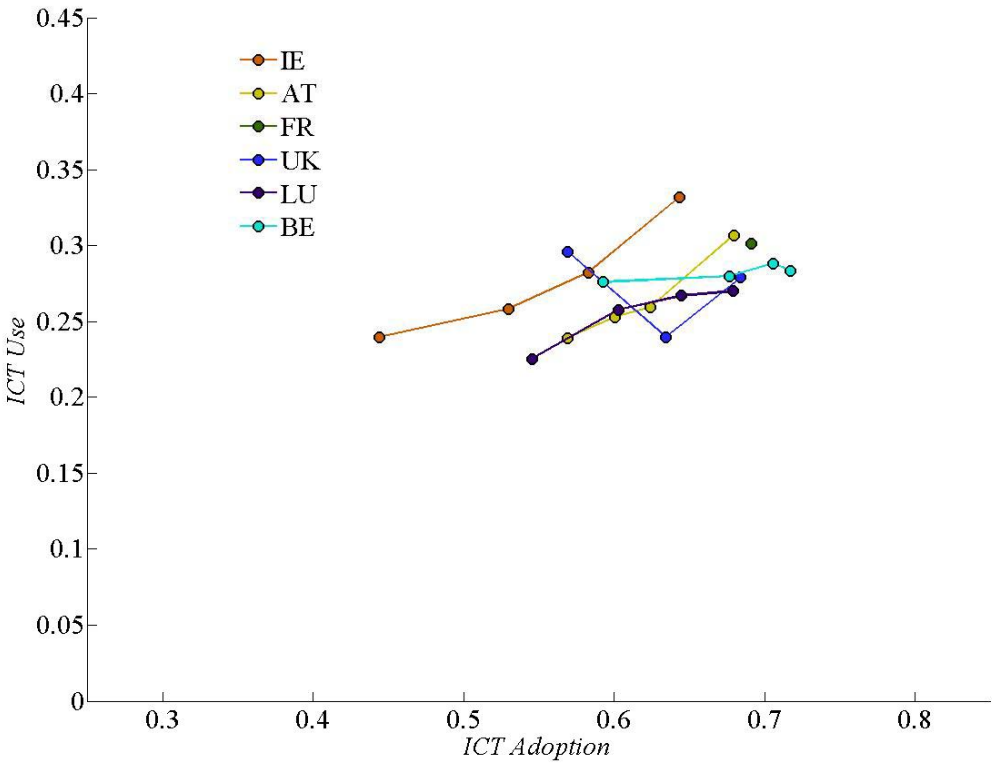

Figure 13 Evolution of ICT Adoption and Use across years for countries of the cluster 2

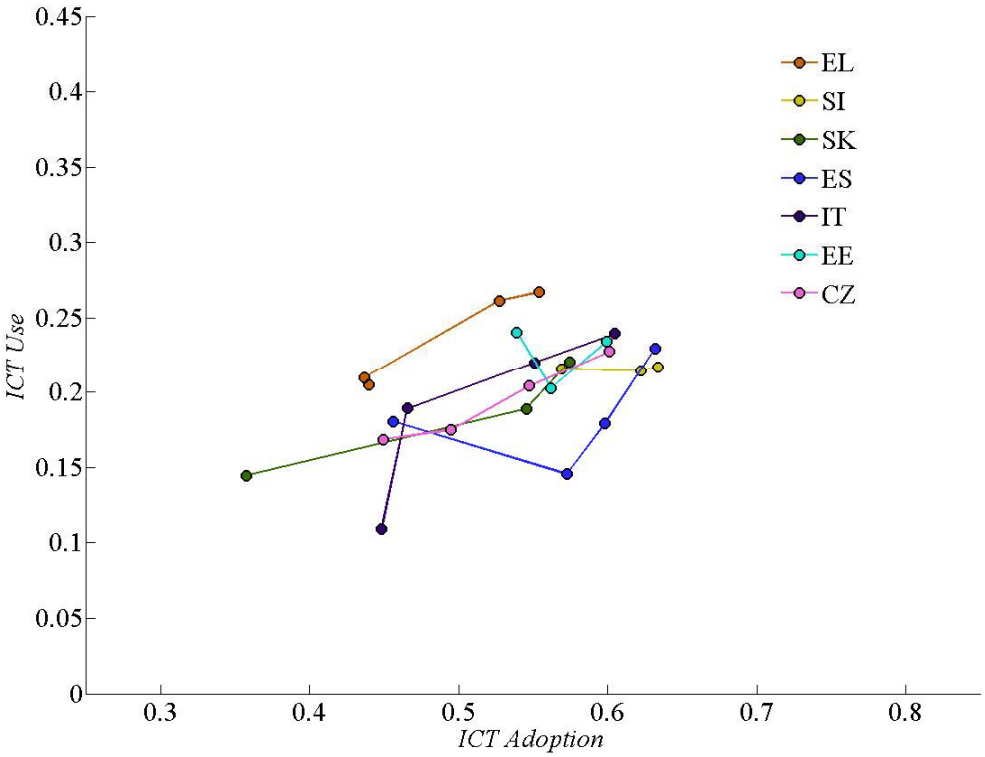

Figure 14 Evolution of ICT Adoption and Use across years for countries of the cluster 3

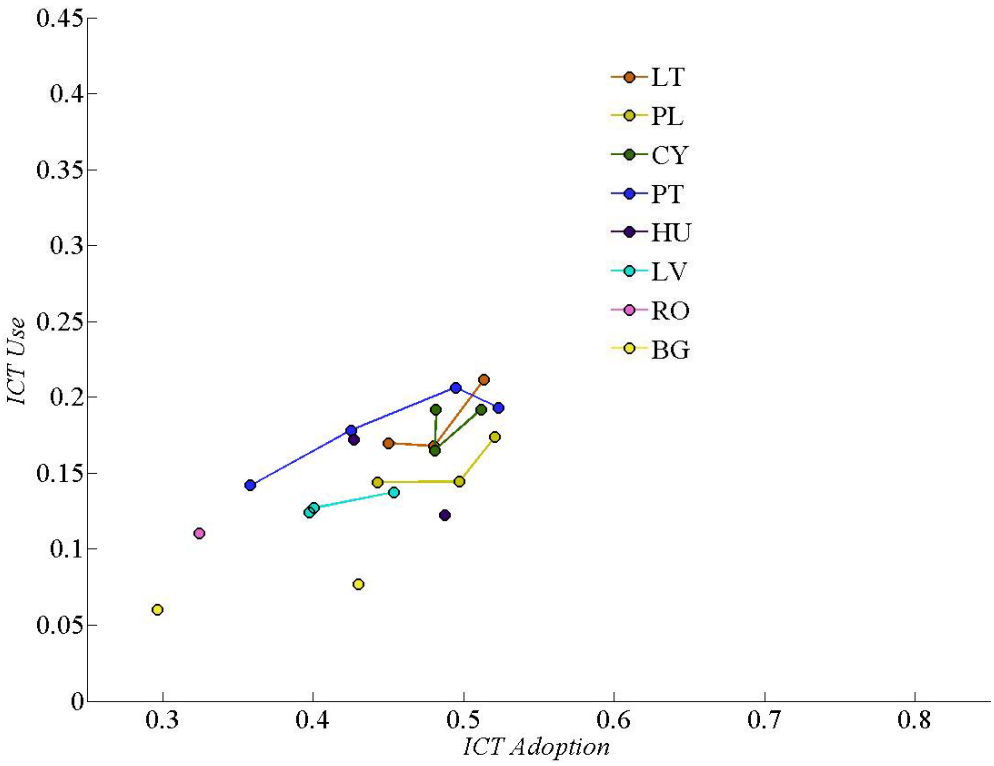

Figure 15 Evolution of ICT Adoption and Use across years for countries of the cluster 4

4.3. Analysis of the overall trend for specific indicators

The overall trend for the composite indicators was analysed in section 4.1 and specific country trends were analysed in the previous paragraph. Both are mainly driven by the temporal evolution is the basic indicators. While the variability of country scores for the different components was also discussed previously (section 3.1), its evolution is examined in this section. The dynamics underlying the trends for different aspects of ICT Adoption and Use is fairly different. The analysis of the temporal evolution of the probability density of country scores can be a key element in order to asses this behaviour. This analysis is proposed for a few components in the following paragraphs.

As indicated by the consensus budget allocations weights (see Table 3), the component *a5* (percentage of enterprises having broadband connection to internet) is a very important driver for e-Business Readiness. The significance of this control lever is fully acknowledged by the European Commission who encourages and support initiatives and actions dedicated to this issue. Representative examples are for instance the BReATH[9] and BEACON[10] projects of the 6th framework programme. The analysis of Figure 16 reveals that the trend is remarkably good for the probability density function of the indicator *a5*. It is not only characterised by an increase of country performances (shift toward larger scores) but also by a reduction is inequalities (reduction of the variance).

[9] BReATH (http://www.ist-breath.net/): the main objective of BReATH is to stimulate and support the transfer of know-how and best practices in planning and delivering broadband e-services and access to the EU New Member States and Associated Candidate Countries, involving as many stakeholders and actors as possible and fostering cross-border research collaboration.

[10] BEACON (http://www.ovum.com/beacon/): the main objective of this project is to conduct a socio-economic impact assessment of broadband access and use in the context of electronic services and related issues in the networked, knowledge based economy.

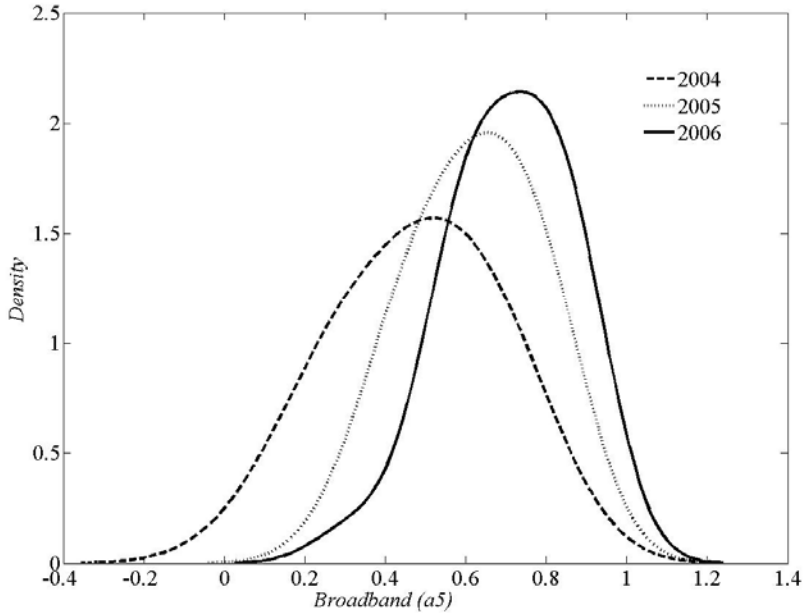

Figure 16 Evolution of the probability density function for the indicator *a5* (percentage of enterprises having broadband connection to internet)

This is a perfect illustration showing that both growth and cohesion can be achieved for specific aspects of ICT Adoption and Use. Unfortunately this ideal evolution is not generalized and very often advances are mainly achieved by a small group of leaders progressively reinforced over time (see Figure 17).

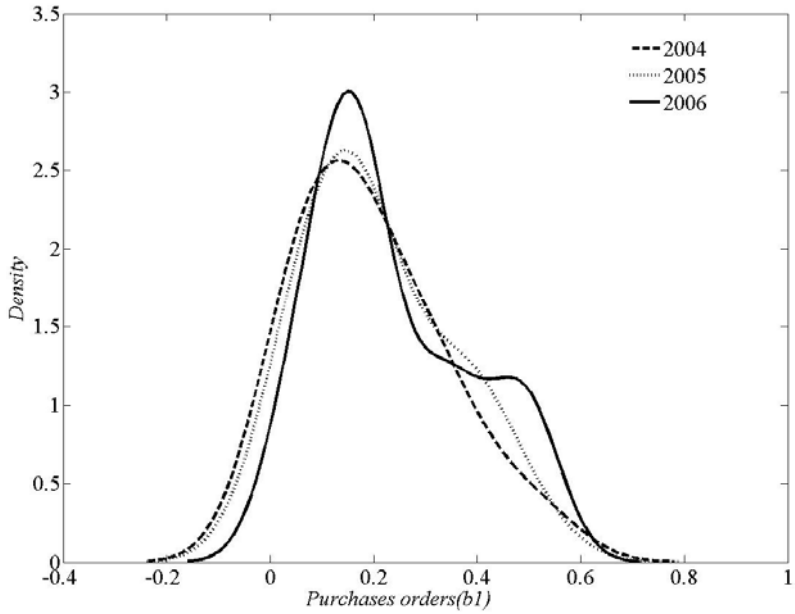

Figure 17 Evolution of the probability density function for the indicator *b1* (percentage of enterprises that have purchased products / services via the internet, Electronic Data Interchange (EDI) or any other computer mediated network where these are >1% of total purchases)

In this case, the shift towards larger scores is not very important for the main mode and left tail of the distribution. A similar but a slightly different behaviour can be observed for the indicator characterised by the smaller scores. In fact, although all countries are still characterised by very low scores for the indicator *b6* (percentage of enterprises that have sold products to other enterprises via presence on specialized internet market places) the group of leading countries was significantly reinforced. However, there is still a lot if inequalities and the shift of the distribution towards larger scores is also accompanied by an increased in variability.

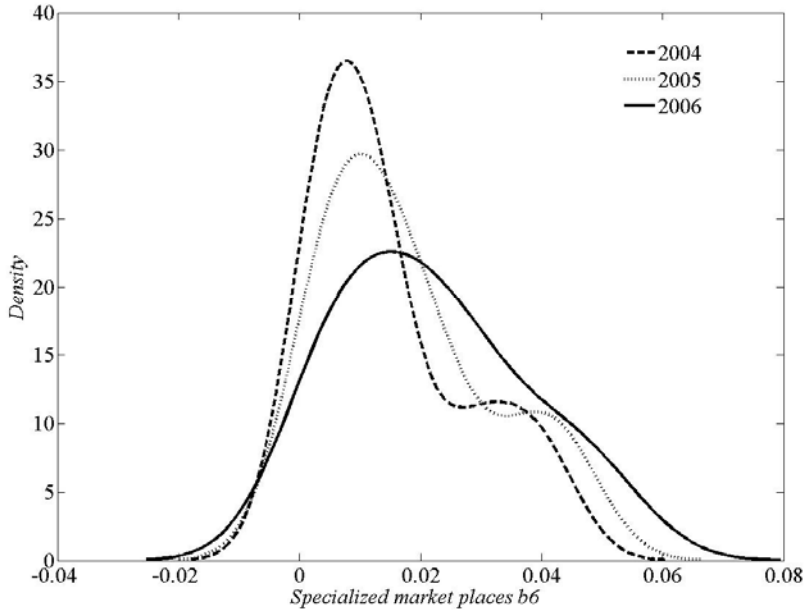

Figure 18 Evolution of the probability density function for the indicator b6 (percentage of enterprises that have sold products to other enterprises via a presence on specialised internet market places)

5. ROBUSTNESS ANALYSIS

The composite indicator scores are affected by uncertainty which is partly due to the experts preferences in the assignment of weights. In order to quantify this uncertainty we choose e-BSN experts at random and use averaging over the sets provided by the selected experts. Other sources of uncertainty (e.g imputation of missing values) could be taken into account in order to assess the robustness of the ranking this point is not addressed in the current paper (see Saisana *et al* 2005; Tarantola *et al*, 2006).

Therefore, each country is characterised by a cloud of points rather than a single couple a scores (i.e scores for ICT Adoption and Use). The results obtained for the different clusters defined previously are provided by Figure 19, Figure 20, Figure 21 and Figure 22. The analysis of the previously mentioned figures shows that apart for the countries standing far from a regression line which could be drawn on Figure 2 (i.e Denmark, Ireland, Greece, Romania) there is substantial amount of overlapping between country scores. This overlapping is more pronounced for medium ranks for which country scores lie in smaller intervals.

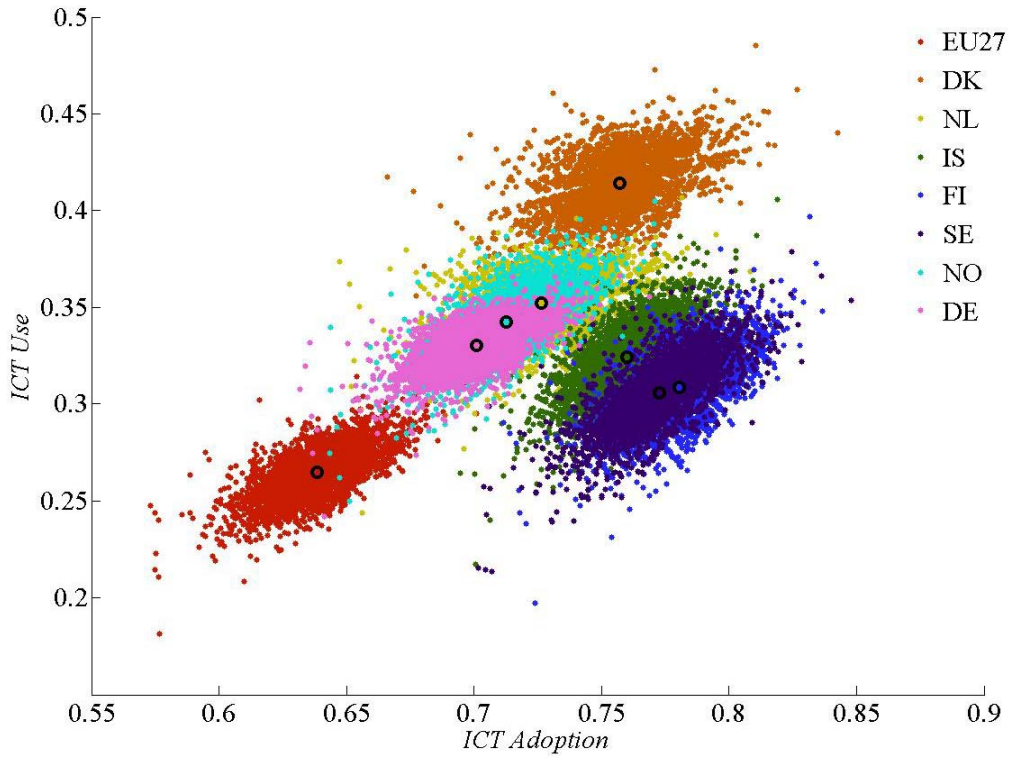

Figure 19 Uncertainty analysis for the countries of the cluster 1 – uncertainty on the weights taken into account

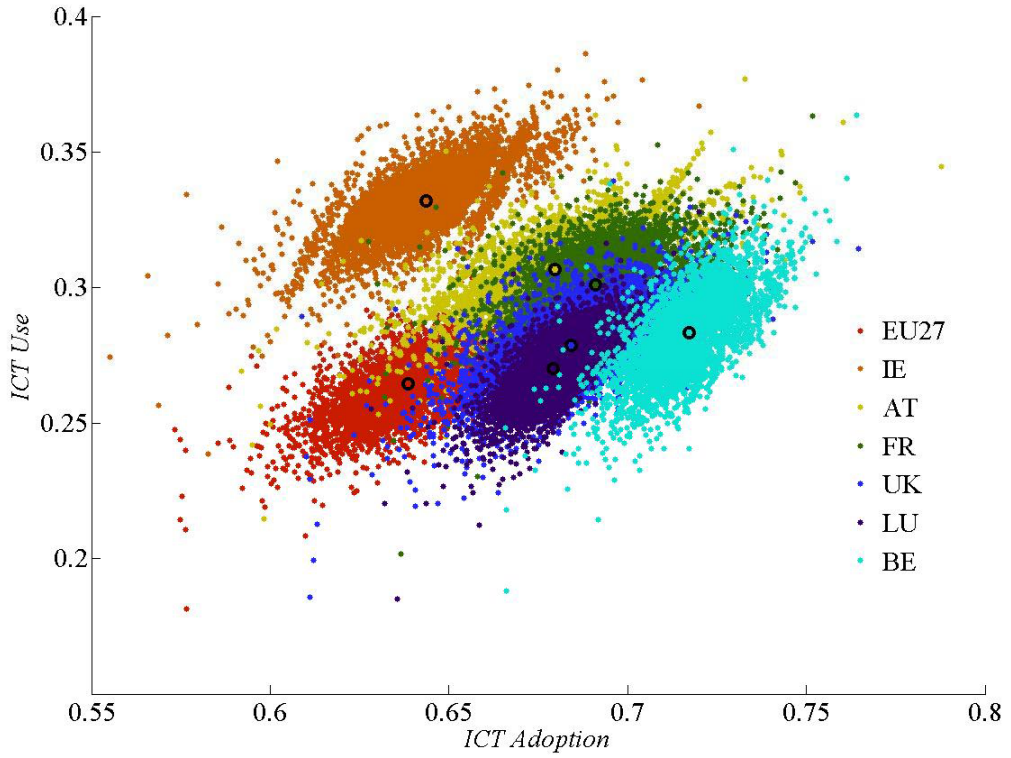

Figure 20 Uncertainty analysis for the countries of the cluster 2 – uncertainty on the weights taken into account

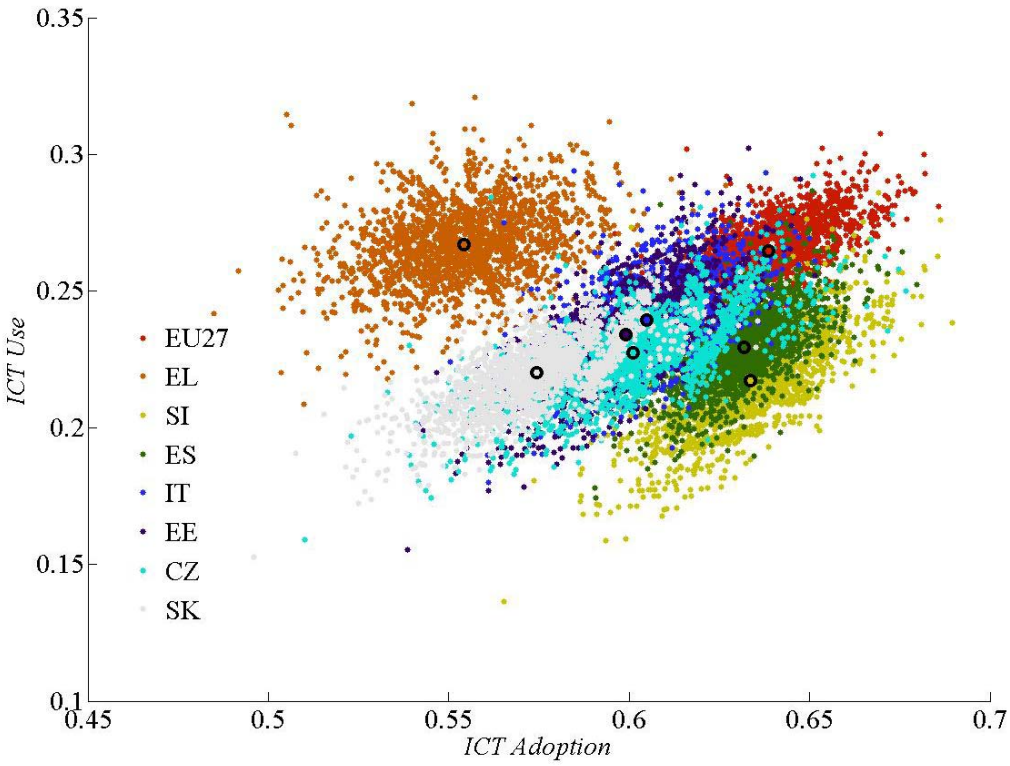

Figure 21 Uncertainty analysis for the countries of the cluster 3 – uncertainty on the weights taken into account

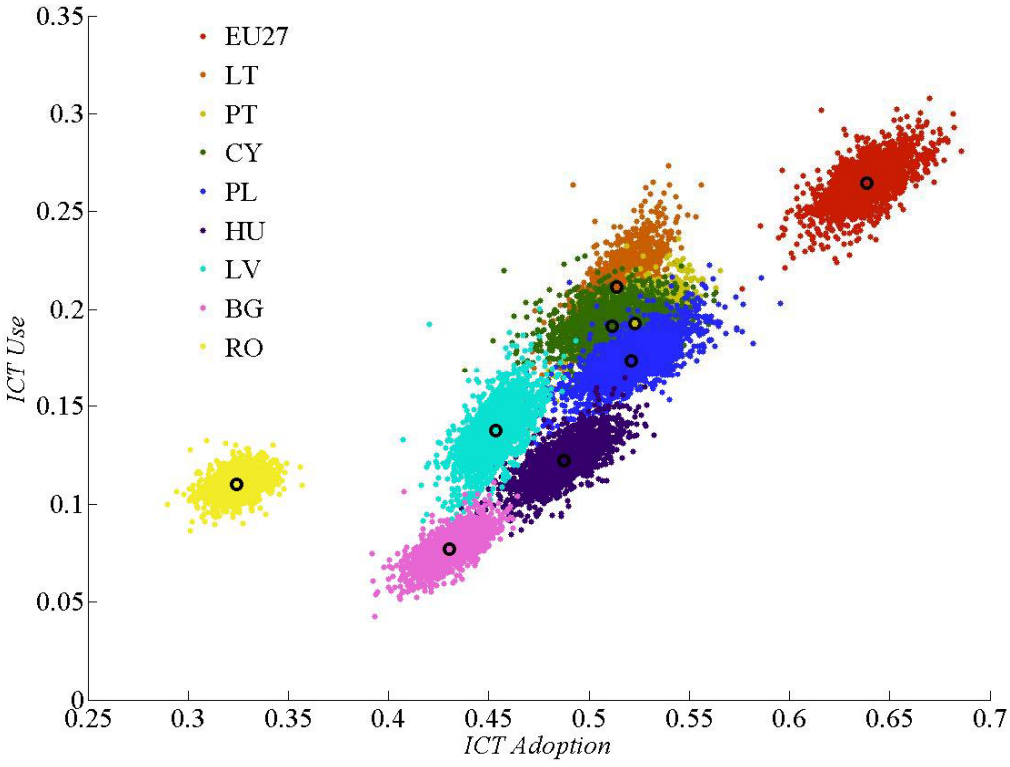

Figure 22 Uncertainty analysis for the countries of the cluster 4 – uncertainty on the weights taken into account

While the leading position of Denmark cannot be contested (see Figure 19), two groups of countries (subgroups Germany-Norway-Netherlands and Iceland-Sweden-Finland) show similar performances. However, it is also clear that the first group performs better in ICT Use and the second in ICT Adoption. The analysis of the second cluster (Figure 20) shows that the United Kingdom and Luxembourg cannot be really distinguished, the same for France and Austria. The advantage of the first group for the Use of ICT can be also contested. Among the group of countries, Belgium can be distinguished for good performances in ICT Adoption and Ireland for good performances in ICT Use. Similarly, the advantage of Greece over countries of the same group (cluster 3, Figure 21) for the Use of ICT is very clear. For the last cluster (Figure 22), while Portugal, Poland, Cyprus and Lithuania show neighbouring performances, the countries lagging behind (Bulgaria, Romania, Latvia and Hungary) can be clearly distinguished.

CONCLUSIONS

The 2007 European e-business readiness index, evaluated using data from the 2006 European enterprise survey, is a useful mechanism for comparing e-business Adoption and Use by firms in the various European countries. In the calculation of the index we made an extensive use of statistical modelling and analysis techniques to (*i*) impute missing data, (*ii*) investigate similarities and differences among the European countries with respect to their business performance, (*iii*) rigorously test robustness of the index to the implicit and explicit assumptions and methodological choices made. Apart from the country ranking which is classically derived from the results, it has been shown that the analysis of the probability function of country scores is a useful tool to assess variability, trends, and comparisons across sectors of economic activity.

Although quantitatively the country scores are much lower for use than adoption, the pattern of country performance for the category Use of ICT is globally similar to that of adoption. Denmark is comforting its leading position and the top ranks are still occupied by other Nordic countries (Norway, Sweden, Finland, Iceland) together with the Netherlands and Germany. Together with the Mediterranean Member States, most of the states from the Eastern part of Europe which joined the EU recently (2004 and 2007) are still in the developing stage of their e-business environment. Estonia, Slovakia, Check Republic and Slovenia who joined the EU in 2004 reach a relatively fair level of ICT Adoption and Use.

The components of the e-business readiness need to be revised in view of the i2010 initiative, as some important elements in the category adoption and use are currently missing. A critical revision of the conceptual model of e-business is currently ongoing between Eurostat, the Joint Research Centre and the Directorate General Enterprise and Industry and the Directorate General Information Society and Media.

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Abstract
This report is a methodological analysis on the composite index of the information and communication technology (ICT) adoption and use by enterprises in the Europe. Efficient adoption and use of ICT is a key factor to help European enterprises to raise their productivity and competitiveness. The 2007 European E-Business Readiness Index, evaluated using data from the 2006 European enterprise survey of ICT use and e-commerce by Eurostat, is a useful mechanism for comparing e-business adoption and use by firms in the various European countries by sector, size and country. European E-business Readiness Index measures by 6 components the ICT adoption and by 6 components the ICT use. Report describes basic indicators and data coverage. The composite indicators obtained with 2006 data are compared with results from earlier years. Analyses include probability density estimates for scores and a robustness analysis in order to asses the significance of differences in scores among countries.

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