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The 2006 European e-Business Readiness

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Ari Latvala (Directorate General for Enterprise and Industry).

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The 2006 European e-Business Readiness Index

William Castaings*, Stefano Tarantola*, Ari Latvala**

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 2006 European E-Business Readiness Index, evaluated using data from the 2005 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. General composite indicator results of 2005 data are compared with results from earlier years. Analyses include probability density estimates for scores, robustness analysis, and correlation and principal component analysis. Data quality and normalisation methodology are discussed and proposals for future development of the index are presented. Total of 64 pages, with 17 Tables and 41 Figures.
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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Table of Contents

List of Tables

List of Figures

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. Internet or other computer networks sales represented 8.5 % of total enterprises' sales according to the Community 2004 survey.

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 2005 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 August 2006[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 2004 to 2005). The Nordic countries, Sweden, Finland and Denmark steadily occupy the top ranks as they have consistently done for the last 3 years. This highly technological region constitutes one of the most advanced and competitive markets in the world. Together with Portugal and Greece, most of the States from the Eastern part of Europe which joined the EU in 2004 are still in the developing stage of their e-business environment.

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. More detailed level analysis can be found on the e-Business W@tch – project website (www.ebusiness-watch.org).

[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 third yearly report on the e-business readiness indicators. It follows the 2005 report (*Pennoni et al*, 2005) and the report on the pilot study conducted in 2004 on the enterprise survey 2003 (Nardo *et al*, 2004). A comprehensive guide on constructing and using composite indicators for policy-makers and other interested parties can be found in a joint OECD/JRC handbook (Nardo *et al*, 2005).
The evaluation of the index has been conducted by the Joint Research Centre of the European Commission using the enterprise survey data collected by Directorate General Eurostat. The text of this report has been prepared by the Joint Research Centre and the Directorate General Enterprise and Industry.

The index provides a valuable summary measure of the e-business readiness of the European enterprises. When the ranking derived from a *super-aggregate* merging ICT Adoption and ICT Use categories is compared to similar analysis (broader geographic coverage) carried out by other organisations, the outcomes related to the countries which participated in the 2005 ICT enterprise survey match very well. Depending on the adopted weighting scheme rank correlations range between 0.83 and 0.85 with the World Economic Forum's Networked Readiness Index [5](NRI) rankings, from 0.90 to 0.91 with the e-Readiness Index from the Economist Intelligence Unit[6].
There are significant differences across the 26 European countries in both categories adoption and use. Enterprises in many countries have made significant progress during the last observation period (from 2004 to 2005). Although the correlation between the rankings of adoption and use of ICT is quite high, some countries do well in adoption and much less in use of ICT.
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 2006 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 variation of the ICT adoption and use among different industry sectors and among different size of companies. More detailed level analysis can be found on the e-Business W@tch – project website (www.ebusiness-watch.org).
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 evolution of the index in the period 2004 – 2005 is also described enlightening the comparison for the countries which provided data for both years.

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[5] The Networked Readiness Index ranking published by the World Economic Forum is available from http://www.weforum.org/pdf/Global_Competitiveness_Reports/Reports/gitr_2006/rankings.pdf

[6] The e-Readiness Index ranking from the Economist Intelligence Unit is available from http://graphics.eiu.com/files/ad_pdfs/2005Ereadiness_Ranking_WP.pdf

The third section draws the results of the robustness assessment to the assumptions and methodological choices made for the construction of the index.
The statistical analysis is complemented with a multivariate analysis and a discussion on data quality and the normalization methodology in the fourth and fifth sections.
The last section draws the conclusions and the various Appendixes describe the methodology adopted for the imputation of missing data, provide an overview of the values of the indicators and propose a benchmarking of countries by sectors of economic activity.

2. BASIC INDICATORS AND DATA COVERAGE

2.1. 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).
With the new i2010 initiative, a set of benchmarking indicators has been selected for that 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.
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).
The different weighting schemes employed for the construction of the composite indicators are summarized in Table 3. The budget allocation weights represent the average of the information provided by twelve national representatives of the e-business support network (e-BSN[7]). A detailed description of the assignment of weights can be found in the Annex of the pilot study 2004 (Nardo *et al*, 2004). The factor analysis weights were derived from the multivariate analysis (section 5) according to the methdology described in the joint OECD/JRC handbook on constructing composite indicators (Nardo *et al*, 2005).
As the e-business readiness indicator components measure different, related aspects of ICT adoption and ICT use, they are necessarily correlated (section 5). Further, as the ICT uptake progress in enterprises, and these adopt more and more e-business processes, one can expect the increase of the correlation of different indicators measuring related e-business aspects. This is exactly what the data from the 2005 survey also indicate.

Ideally, these indicators would include all relevant aspects of the phenomenon, be different in causal-effect relationships, be easily quantifiable and be scale neutral. The ISS Enterprise survey of Eurostat and National Statistical Institutes of the EU cannot accommodate all interesting variables. It is not possible to measure all important issues, due to restrictions in the surveys and due to burden to respondent.

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

Table 1. 2005 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. 2005 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[8] 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*

Table 3. Summary of the different weighting schemes used in the e-business index

Adoption of ICT	Equal weights	Budget allocation	Factor analysis	Use of ICT	Equal weights	Budget allocation	Factor analysis
a1	0.17	0.18	0.13	*b1*	0.17	0.17	0.20
a2	0.17	0.16	0.38	*b2*	0.17	0.17	0.19
a3	0.17	0.10	0.19	*b3*	0.17	0.21	0.10
a4	0.17	0.16	0.14	*b4*	0.17	0.21	0.20
a5	0.17	0.21	0.08	*b5*	0.17	0.12	0.14
a6	0.17	0.20	0.08	*b6*	0.17	0.13	0.16

[8] Electronic Data Interchange

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.

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.

2.2. Survey of available data

The data used throughout the analysis[9] refer to the European businesses of different sizes and sectors of economic activity covered by the 2005 Community Survey on ICT Usage and e-Commerce in Enterprises. The survey includes indicators for the EU25[10] Member States, plus the two new Member States: Bulgaria and Romania, as well as Norway and Iceland. 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 for the 2003, 2004 and 2005 surveys. 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.

Table 4. NACE categories (without the financial sector)

Sector D	Manufacturing
Sector E	Electricity, gas and water supply
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

[9] as available from Eurostat in August 2006

[10] At the time of data compilation and writing this report, Bulgaria and Romania were still not Members of the European Union.

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

France, Romania and Iceland did not conduct the community survey in 2005 and the results were not received for Bulgaria and Turkey. The previously cited countries will not be considered in the current analysis and missing values will be imputed for Hungary, Luxembourg, Malta and Portugal featuring a single missing component. Compared to the dataset for 2004, the 2005 dataset is more complete. There were 11 values missing in the previous year, while there are only 4 missing values this year.

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

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

3. MAIN FINDINGS

The e-business index is firstly presented as a weighted average of the component indicators by considering three alternative weighting methods: equal weights, budget allocation, and factor analysis–based weights. For the budget allocation method, rather than comparing the individual expert opinions, which vary substantially, we focus on the 'average consensus' among the group of experts. Such 'consensus weights' are obtained by taking the average across the experts' weights for each component indicator. Lastly, the different index components and the various breakdowns (company size, sector of economic activity) are analysed for the European average.
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.

3.1. 2005 scores and rankings

3.1.1. ICT Adoption

The scores and rankings (see Table 7) for adoption of ICT provide a relative gauge of e-business progress in the European countries. The Nordic countries, Sweden, Finland and Denmark steadily occupy the top ranks as they have done consistently for the last 3 years. This highly technological region constitutes one of the most advanced and competitive markets in the world.
Together with Portugal and Greece, most of the States from the Eastern part of Europe which joined the EU in 2004 (see Figure 1) are still in the developing stage of their e-business environment. They suffer from the existence of barriers, costs and infrastructure problems which will probably be alleviated by the efforts dedicated to cohesion among the Member States of the European Union.
When slight differences in aggregated scores are combined with the natural heterogeneity of the performances at the component level, the relative positions of the countries can be slightly affected by the weighting scheme. Volatility in the calculated ranks affects mainly the middle-ranked countries (from Luxembourg to Ireland in Table 7). These countries lie in a relatively small interval for the scores of the ICT Adoption aggregate (see the estimated probability density function in Figure 4). The diversity of the underlying economic systems, with different prevalence of enterprises of small, medium and large size and different strategic sectors, adds to the complexity of the picture. However, the country rankings for adoption seem reasonably stable to the change of the weighting scheme.

3.1.2. ICT Use

The scores and rankings for the use of ICT are provided by Table 2 and the geographic disparities are shown in Figure 2. The leading position of Denmark 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. Since the tremendous growth in ICT is mainly due to ICT services, as expected, the country performs very well for all ICT use indicators. As emphasized in an Interim Report prepared for the European Commission[11] in 2004, "*there are huge public*

[11] Interim Report (2004), Benchmarking national and regional policies in support of the competitiveness of the ICT sector in the EU, Prepared for European Commission, Directorate-General Enterprises, D4 under Contract FIF 20030871

investments in IT, extensive funding of research institutions and new incubator environments. There is strong support and commitment from the Public Sector in promoting the ICT Sector in Denmark, thus providing opportunities for public/private initiatives and projects."

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. However, mainly because the aggregated scores lie in a smaller interval (see the estimated probability density function of Figure 4), the ranking is less stable across the different weighting schemes. Moreover, for most countries the heterogeneity of components scores is higher for Use of ICT rather than for Adoption of ICT. This feature is an additional contributor to an increased instability in the rankings.

While Sweden was leading for ICT Adoption, its relative position is between the 5th and the 8th rank, depending on the weighting scheme, for ICT Use. When the budget allocation is selected, the weights assigned (see Table 3) to the indicators referring to the connectivity of IT systems (indicators *b3* and *b4*) lead to lower aggregated scores for Sweden because the country occupies the 17th rank for these aspects of ICT Use. A similar behaviour is encountered for Belgium, which drops from 3 to 6 ranks (depending on the weighting scheme) compared to ICT Adoption. The weights obtained with factor analysis emphasize the influence of the component *b1* (see Table 3) and the country does not perform very well for this particular indicator. On the contrary, when both rankings are compared, some countries like Ireland (14th versus 9th rank), Italy (16th versus 11th rank), Greece (19th versus 12th rank) and Portugal (21th versus 14th rank) show better performances for the Use of ICT.

For the particular case of United Kingdom, as mentioned in the 2005 e-Business Readiness index report (*Nardo et al*, 2005), in October 2005, a representative of the country National Statistical Institute (ONS) reported that their survey questions for indicators b3 and b4 (see explanation in Table 2) were worded differently compared to the model questionnaire of Eurostat. According to the 2005 UK model questionnaire, this wording inconsistency with the Eurostat model questionnaire was not corrected and therefore, the resulting under-estimation of components *b3* and *b4* still holds. 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.

Table 7. 2005 e-Readiness ICT Adoption – Scores and rankings according to three different weighting schemes: budget allocation expert average, equal and factor analysis weights for 25 European countries and the average of EU 25

Countries	Scores - Budget allocation weights (consensus)	Ranking - Budget allocation weights (consensus)	Ranking - Equal weights	Ranking - Factor analysis weights
Sweden	75.7	1	1	1
Finland	74.4	2	2	2
Denmark	73.7	3	3	3
Belgium	70.6	4	4	4
Norway	68.3	5	5	5
Germany	67.4	6	6	6
Netherlands	66.3	7	7	7
Luxembourg	64.4	8	9	9
Malta	63.9	9	10	11
United Kingdom	63.4	10	8	8
Austria	62.4	11	11	10
Slovenia	62.2	12	12	12
Spain	59.8	13	13	14
Ireland	57.9	14	14	13
Estonia	56.2	15	15	15
Italy	55.1	16	16	16
Czech republic	54.7	17	17	17
Slovakia	54.5	18	18	18
Greece	52.7	19	19	19
Poland	49.7	20	20	20
Portugal	49.4	21	21	22
Cyprus	48.1	22	22	21
Lithuania	48.0	23	23	23
Hungary	43.3	24	24	24
Latvia	40.0	25	25	25
EU25	60.8	-	-	-

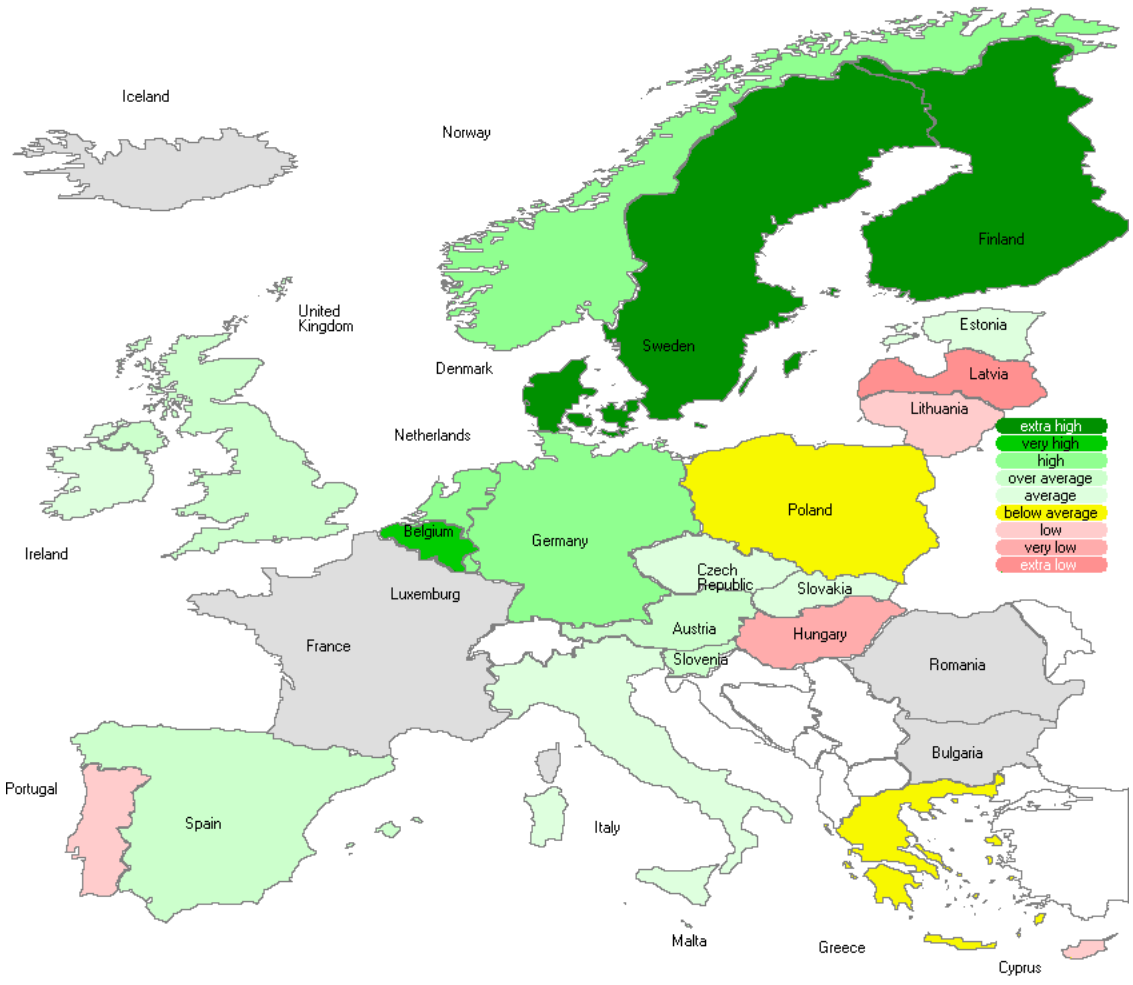

Figure 1. Geographic disparities of 2005 ICT Adoption scores (consensus budget allocation weights)

Table 8. 2005 e-Readiness ICT Use – Scores and rankings according to three different weighting schemes: equal weights, budget allocation expert average and factor analysis for 25 European Countries and the average of EU 25

Countries	Scores - Budget allocation weights (consensus)	Ranking - Budget allocation weights (consensus)	Ranking - Equal weights	Ranking - Factor analysis weights
Denmark	40.3	1	1	1
Finland	33.3	2	2	4
Germany	31.0	3	4	2
Norway	30.5	4	3	3
Netherlands	30.5	5	6	8
Malta	28.8	6	9	7
Belgium	28.8	7	7	10
Sweden	28.3	8	5	5
Ireland	28.2	9	8	6
Luxembourg	26.7	10	11	11
Italy	26.3	11	13	15
Greece	26.1	12	12	13
Austria	26.0	13	10	12
Portugal	24.3	14	15	14
United Kingdom	24.0	15	14	9
Slovenia	21.5	16	16	17
Czech republic	20.4	17	17	16
Estonia	20.3	18	18	18
Slovakia	18.9	19	19	20
Spain	17.9	20	20	22
Lithuania	16.8	21	21	21
Cyprus	16.5	22	22	19
Poland	14.4	23	23	23
Latvia	12.7	24	24	25
Hungary	12.6	25	25	24
EU25	25.0	-	-	-

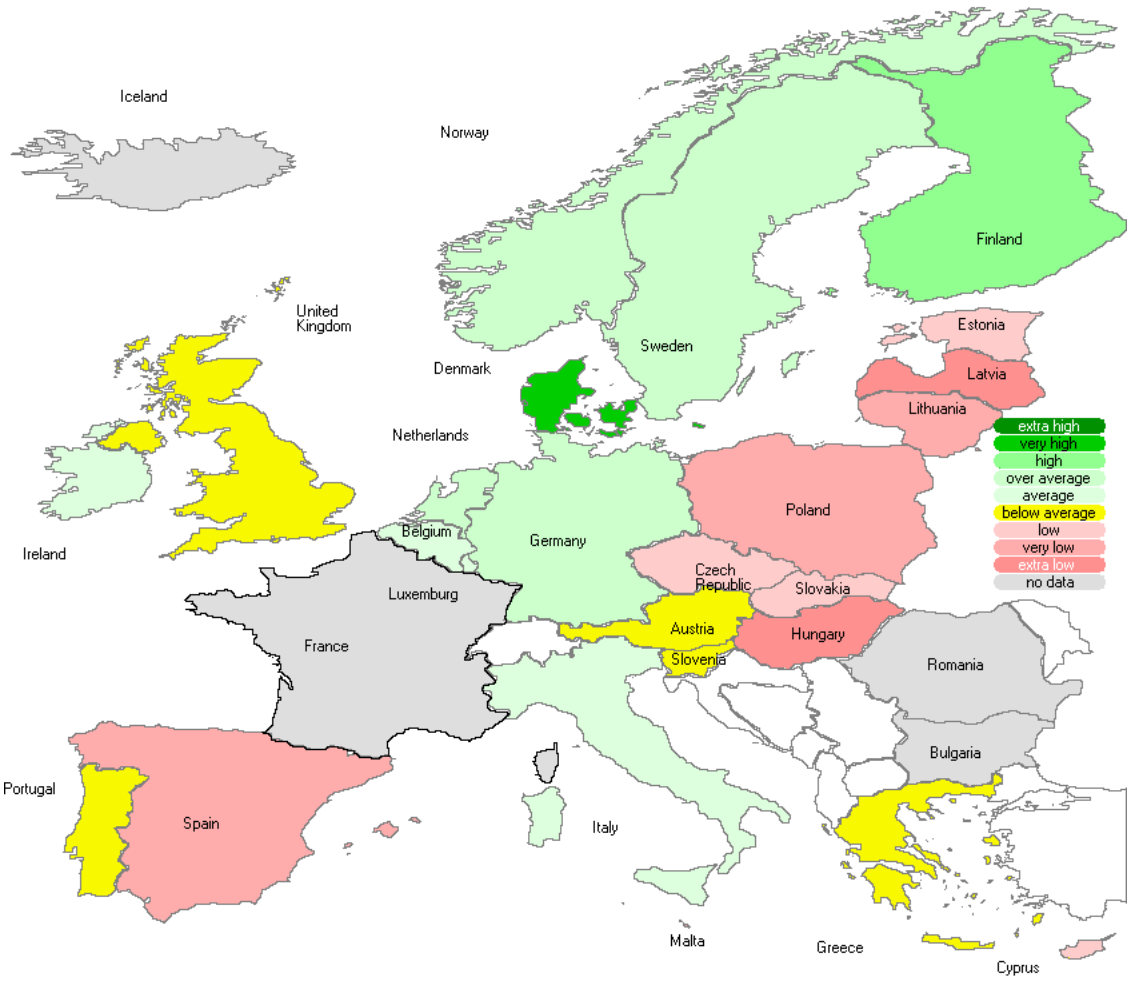

Figure 2. Geographic disparities of 2005 ICT Use scores (consensus budget allocation weights)

3.1.3. Adoption versus Use

A graphical representation of adoption versus use scores for the 25 countries but also for the EU25 aggregate is proposed in Figure 3. The correspondence between the country codes with the full names of the Member States is given by Table 6. Using the EU25 aggregate, the XY region is divided in 4 parts characterising the practical use of the adopted ICT infrastructures. With respect to the EU25 aggregate, the 4 zones categorize the performances of the countries with respect to the EU25 average estimated by Eurostat. Since the correlation between scores is important (r = 0.84), 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.

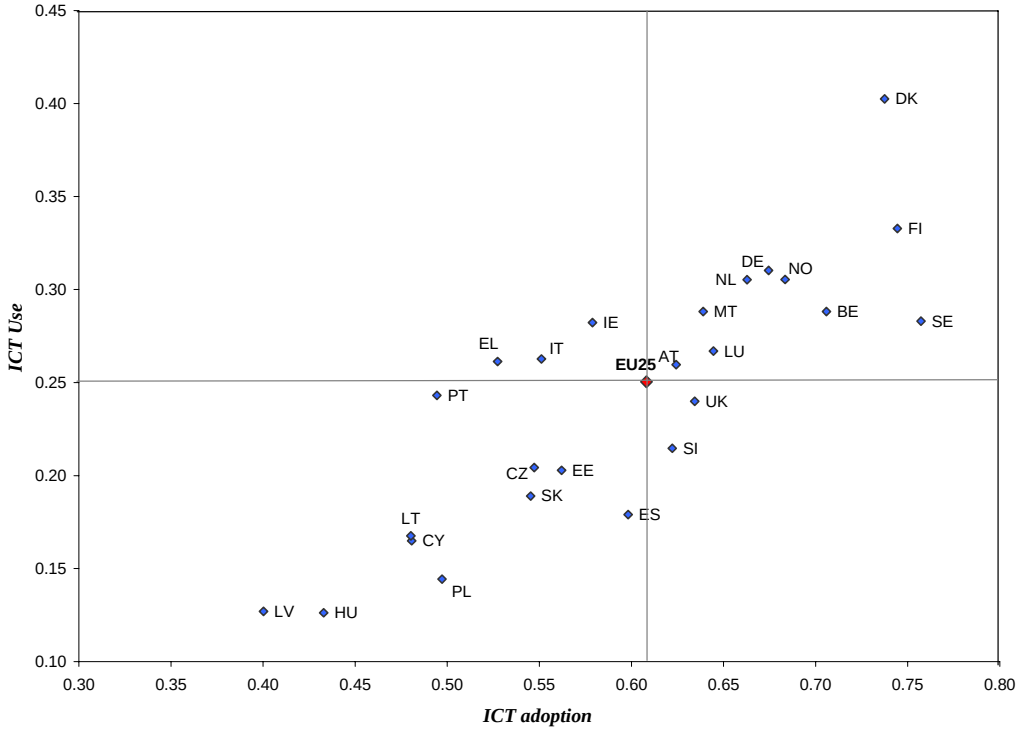

Figure 3. ICT Adoption scores vs. ICT Use scores employing the budget allocation weighting scheme, the red diamond indicates the EU25 aggregate

As underlined previously, the Nordic countries Denmark, Finland and Sweden are in the forefront for e-Business Readiness. Among the Member States which joined the EU in 2004, Slovenia and especially Malta are performing very well. With respect to the EU25 average, Ireland, Italy and Greece can be distinguished for their efficiency in using ICT infrastructures given the investments made. Portugal and Spain are the only countries from the former EU15 which did not reach the European average for both adoption and use of ICT. However, while Spain achieved fair performances for all ICT adoptions components and *b5* (Percentage of enterprises with Internet access using the internet for banking and financial services), Portugal did that for most ICT use indicators.

3.2. Comparison of e-Business Readiness indicators with previous surveys

In the pilot study carried out in 2003, all the countries of the former EU15 plus Norway but Greece and France were considered (Table 6). The scope of the study was greatly extended in 2004 (from 15 to 26 countries); Malta joined in the 2005 community survey, however Bulgaria and Romania did not participate.

Using the aggregated scores calculated by Eurostat for EU25 index components, the e-business index was calculated for the European average for both 2004 and 2005 (using budget allocation weights). The analysis of the trend indicates that the European e-Business Readiness index is featuring a reasonable improvement for ICT adoption (from 0.56 to 0.61) but very limited for ICT Use (from 0.24 to 0.25). Note that the Member States composing the *sample* are not strictly the same from one year to the next; the histograms in Figure 4 were estimated using the Member States scores for both adoption and use. Note that the obtained curves are smooth non-parametric estimates (using Gaussian kernels). Therefore, even if the histograms are characterised by a bell-shape, the

mean cannot be inferred directly from the graph because the underlying distributions are not symmetric. However, it is very clear from this graph that there is a clear shift of the ICT Adoption distribution toward larger scores. The left tail of the distribution in 2004 (not present in 2005) can be attributed to Romania and Bulgaria which did not participate in the 2005 community survey. On the contrary, stagnation and convergence (reduction of the histogram width) characterises the evolution of the use of ICT.

It can be seen from Figure 5 that the 2004-2005 progress of Slovakia for ICT adoption is outstanding. According to the budget allocation weights, the country gained 6 ranks compared to last year. For the 2004-2005 trend, the distinction with other countries is particularly pronounced for *a1* (+20.9%), *a2* (+14.4%) and *a3* (+47%) indicators. The early results from the 2006 community survey corroborate the values estimated for 2005. However, the 2004-2005 trend observed for the previously mentioned components is really an outlier. The Slovak republic participated in the survey for the first time in 2004, it is possible that difficulties were encountered in the conduction of the survey. Norway, Greece, United Kingdom and Portugal are also featuring important improvements compared to last year. Since significant advances were achieved for most countries, the stagnation of Latvia and Cyprus in terms of scores leads to an unfavourable alteration of their relative positions in the ranking.

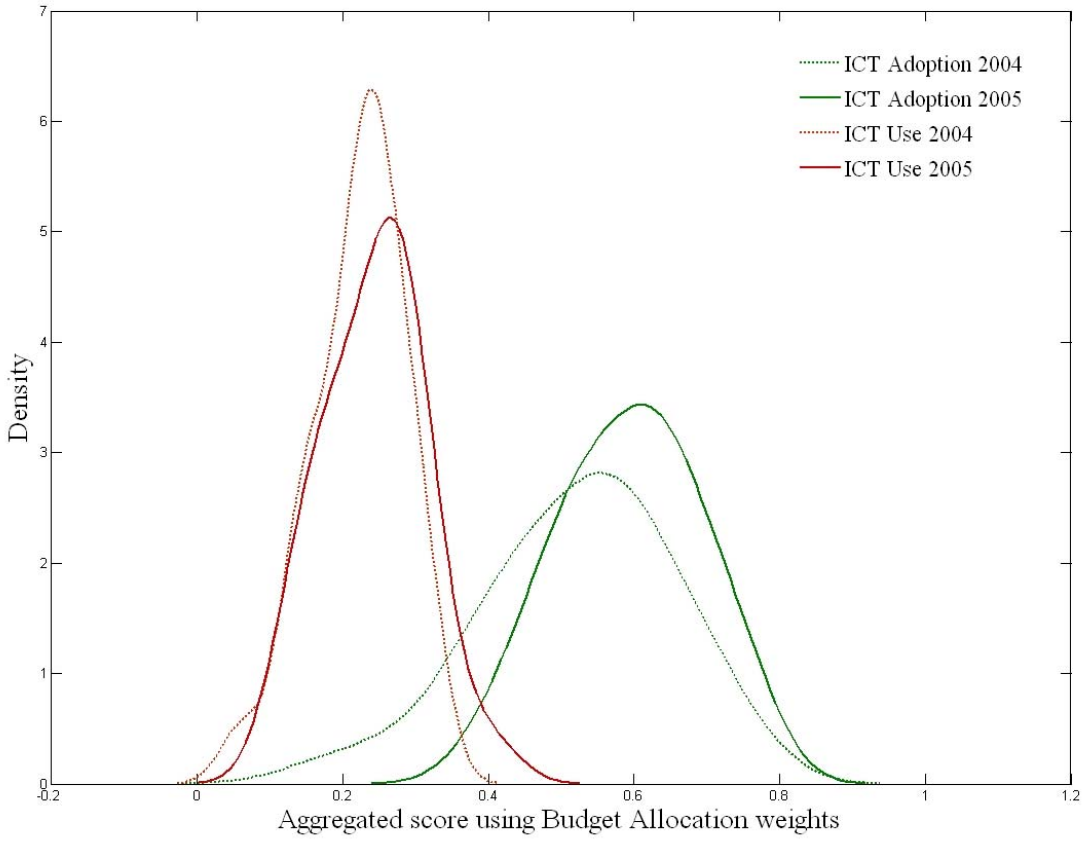

Figure 4. Probability density estimates (using normal kernel functions) for the country scores

Although the amelioration of performances was a general trend for the adoption of ICT, this is not the case for use (see Figure 6). An important number of countries are featuring stagnation and performances even declined for a few Member States. However, except for

Estonia and Cyprus, it is probable that the inferred decline is largely due to the imputation of missing values. In fact, it is very regrettable that for Hungary, Check Republic and United Kingdom the components featuring the largest decrease are those for which imputation was carried out (*b3* imputed for Hungary in 2005, *b3* and *b4* imputed for Check Republic in 2004 and *b5* imputed for United Kingdom in 2004).When the methodology recently adopted for the imputation of missing values (see Appendix A) is applied for the 2004 dataset, even if the estimated values are slightly different, the resulting trend is similar. The particular case of United Kingdom was already emphasized in section 3.1.2, however if the comparison with other countries is not reliable, the wording inconsistency in the survey (holding for both 2004 and 2005) does not influence the trend.

The breakthrough of Denmark is very clear and largely due to improvements in the connectivity of IT systems (+26.3% for indicator *b3* and +12.1% for indicator *b4*). The previously mentioned components are the most important according to the consensus budget allocation weights (Table 3). Thanks to the achieved improvements, the country moved for the 3rd to a comfortable leading position in ICT Use. However, in terms of ranks the progress of Norway is even more convincing (From 12th to 4th rank between 2004 and 2005). Figure 6 also shows significant advances for Greece, Italy and Slovakia. However, the 2004 Italian data set was updated since the publication of the 2005 e-Business Readiness index report. When the relative positions provided by Table 8 are compared to the ranking published in this report, this improvement does not translate into positions gained for Italy because the estimated position was overly optimistic in 2004. Among the updates carried out for this dataset, the imputed value for the component *b1* (21.7% imputed in 2004) was replaced by the pooled estimate (5.9%).

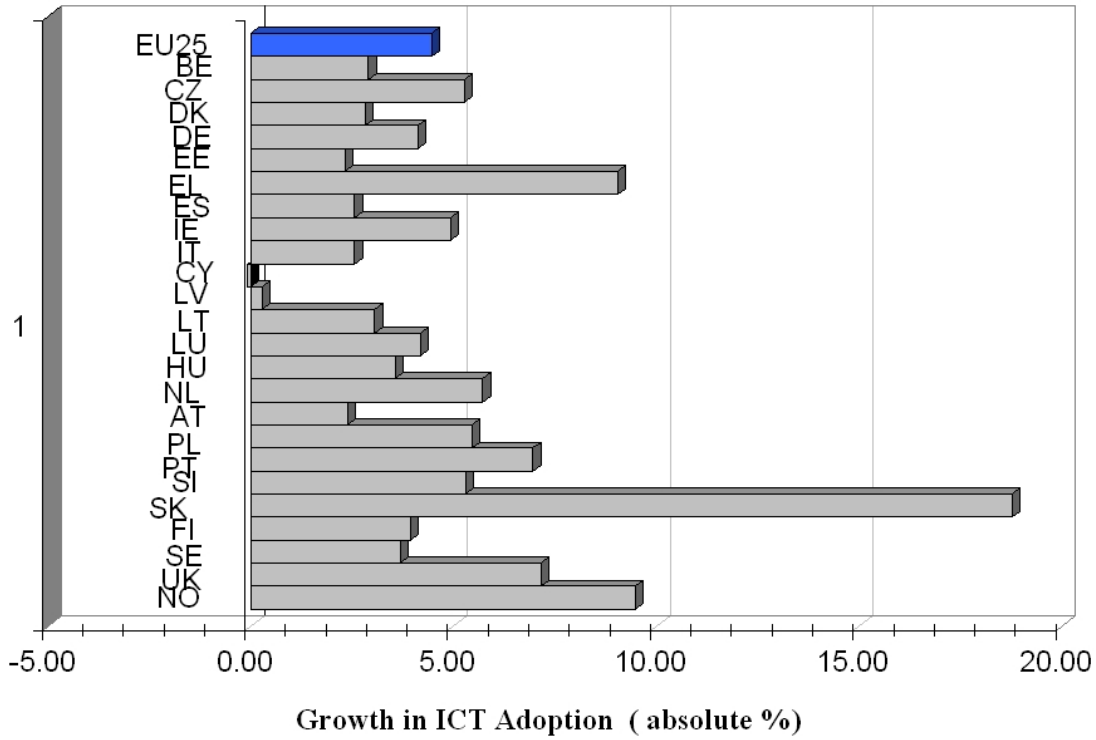

Figure 5. 2004-2005 trend (in absolute %) for ICT adoption (consensus budget allocation weights)

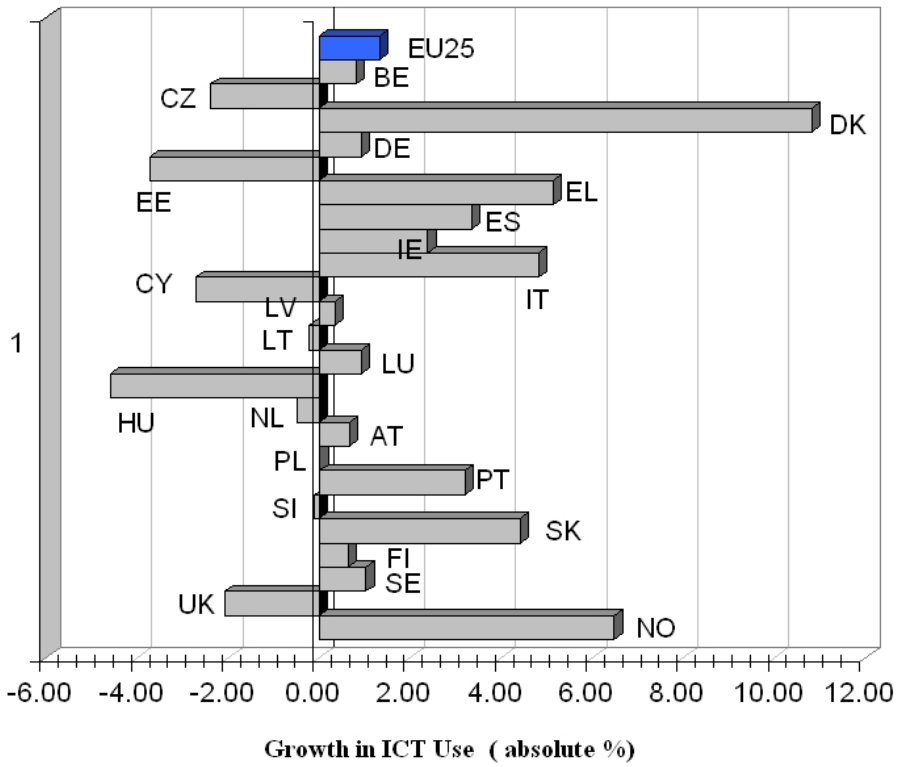

Figure 6. 2004-2005 trend for ICT use (consensus budget allocation weights)

The analysis of Figure 5 and Figure 6 reveals that the case of Norway and Greece is particularly remarkable because those Member States are part of the leading bunch for improvement in both adoption and use of ICT.

A detailed analysis of the trends for the index components show that the Member States lie in different locations of the saturation curve. The new Member States which were not really advanced in terms of adoption and use of ICT show significant progress for all adoption indicators but also for indicator *b5* (use of internet for banking and financial services). Some other countries, already leading are now developing other capabilities, especially related to the use of ICT (particularly *b2* and *b6*).

For the countries involved in the 3 surveys, Figure 7 shows the evolution of adoption vs. use scores between 2003 and 2005. Since the targeted objective is to reach the top-right corner of the graph, all countries converge to this goal but with different trajectories. However, the countries presented here are part of EU15 (countries for which data is available for the 3 years) and the spread of the different trajectories is relatively small.

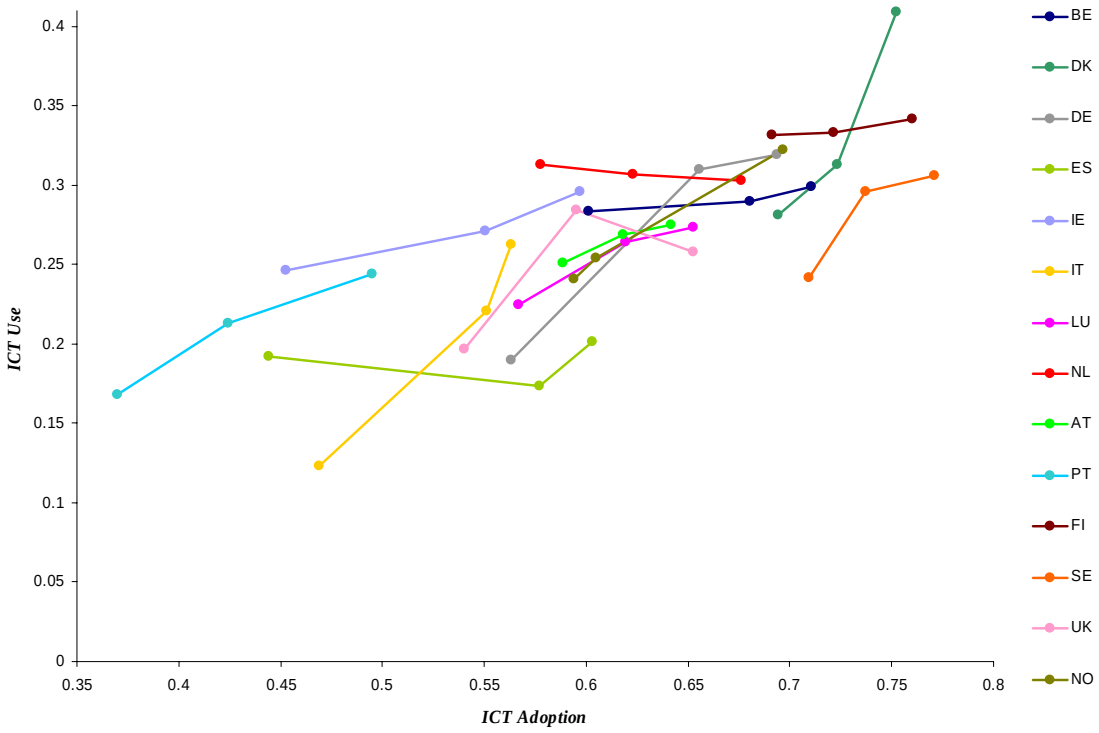

Figure 7. Evolution of ICT Adoption and Use scores between 2003 and 2005 (colour graph)

Over the period 2003-2005, Germany, Italy, Portugal and Norway achieved important advances for both Adoption and Use of ICT. An important number of Member States are nearing stagnation or featuring decrease for the ICT use component (for instance Netherlands, Spain, Belgium, and Finland). The case of Spain is interesting because this country has shown outstanding progress in the adoption of ICT infrastructures while advances in use are only initiated. On the contrary, Denmark was already a very good performer for ICT adoption in 2003. Although the country is still progressing, advances are much more important for the use of ICT. It is important to note that the best performers in Adoption of ICT approach saturation and feature moderate improvements compared to countries which are still at developing stage. As indicated previously, the apparent decline of United Kingdom in ICT Use is mainly due to an overestimation of the indicator *b5* in 2004.

3.3. Components and breakdown analysis for the European Union

For the EU25 aggregate estimated by Eurostat, the scores achieved for the basic indicators in 2004 and 2005 are provided by Figure 8. Quantitatively, the values are much lower for use than adoption. The variability among countries is quite different from one component to another (see Figure 9 and Figure 10). Although, a few laggards cause a secondary peak in the distribution, most countries reach a high level (close to saturation) for the indicator *a1* (percentage of enterprises that use Internet). 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. However, the shape of the distribution of this indicator across the countries reflects inequalities among them. 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[12] and BEACON[13] projects of the 6th framework programme.

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.

Concerning the use of ICT infrastructures, although heterogeneity is rather important for most components (Figure 10), there is a concentration around modest performances for the most advanced aspects (*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. However, for the previously mentioned aspect (also for purchases via computer mediated network – component *b1*) 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. Among the ICT Use indicators, the components *b2*, *b3*, *b4* and *b6* related to the reception of orders via computer mediated networks and the connectivity of IT systems, certainly represent the most advanced aspects. It is precisely for the previously mentioned Adoption and Use components (*a6*, *b2, b3* and *b4*) that the gap between Small, Medium and Large companies is the largest (Figure 11).

[12] 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.

[13] 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.

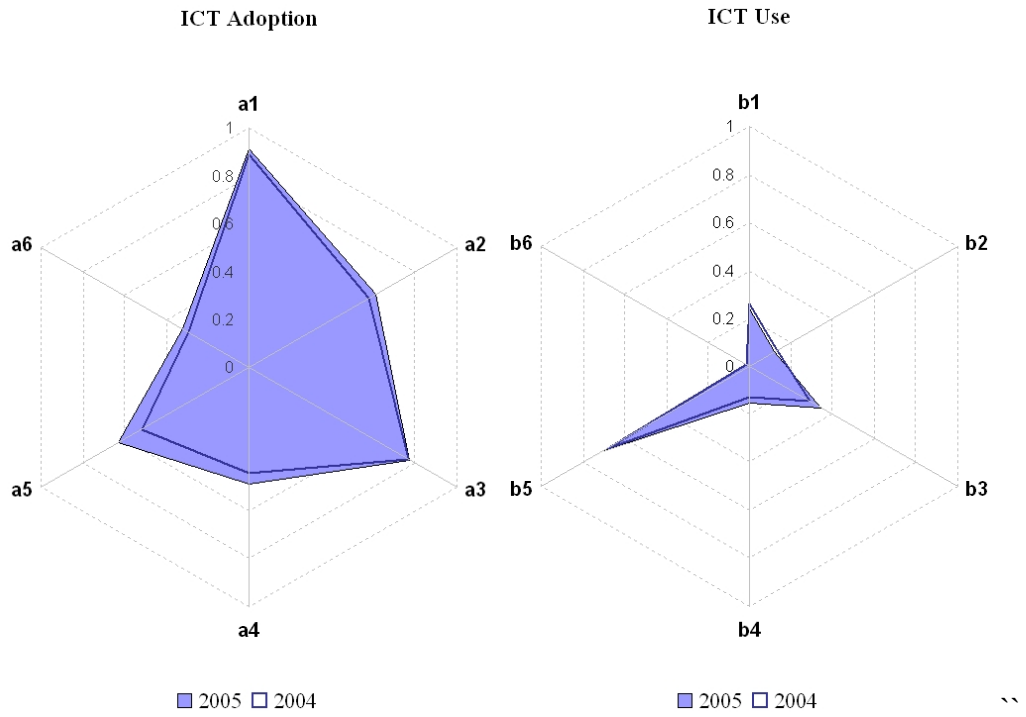

Figure 8. 2004-2005 evolution EU25 e-Business Readiness index components

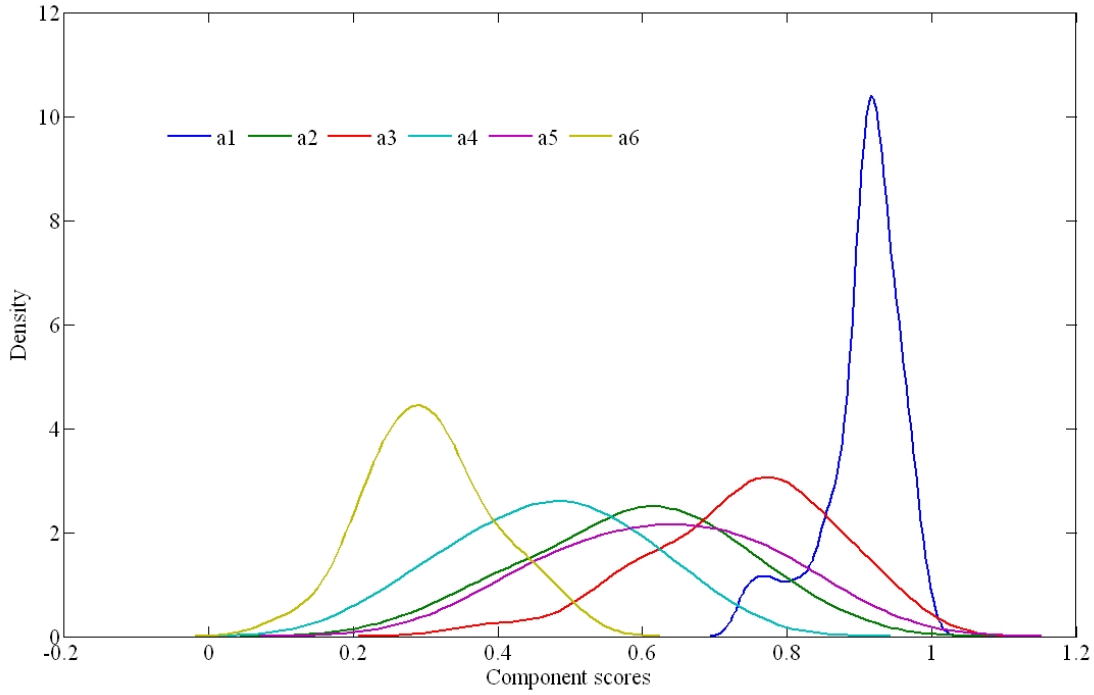

Figure 9. ICT Adoption indicators: probability density estimates (using normal kernel functions) across the country scores (colour figure)

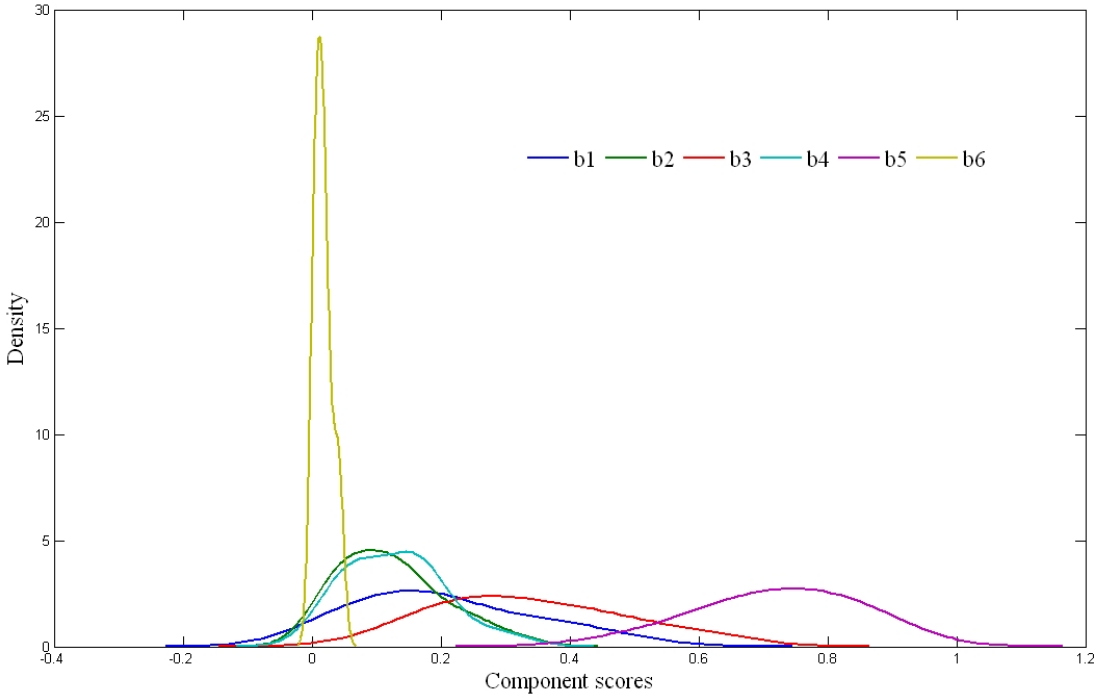

Figure 10. ICT Use indicators: probability density estimates (using normal kernel functions) across the country scores (colour figure)

Compared to last year, the performances are maintained or improved for all adoption indicators while *b1* and *b2* (purchase and reception of orders via computer mediated networks) slightly declined (respectively -2.09% and -1.56%). As the bandwidth delivered to end-users increases in all countries, the corresponding indicator (*a4* for broadband connection to internet) features the greatest amelioration (nearly +11%).

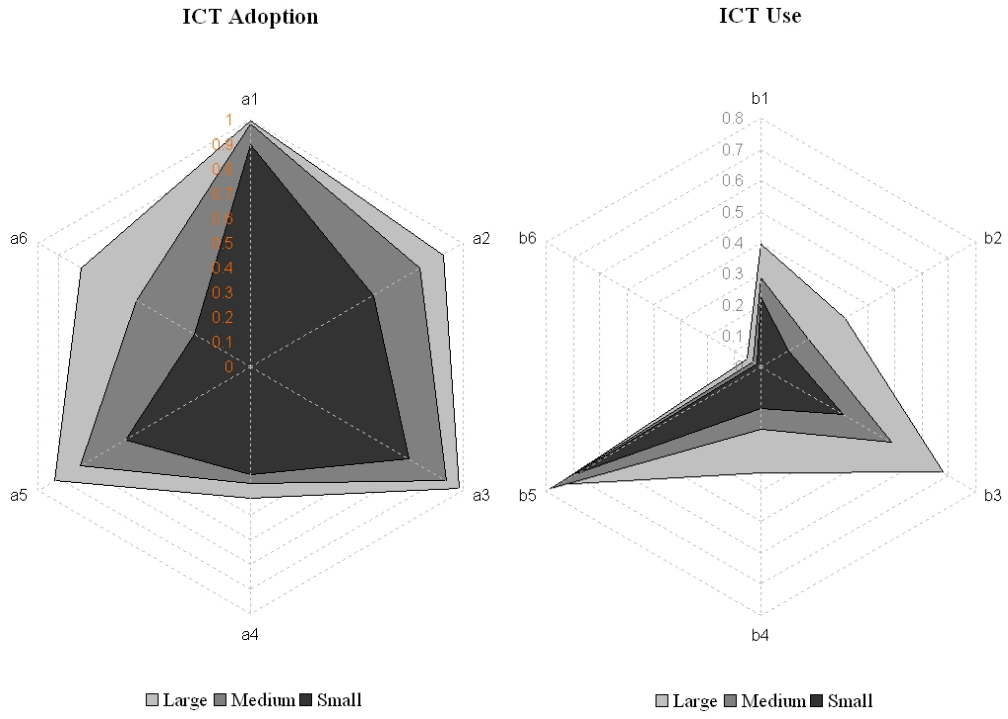

Figure 11. 2005 EU25 e-Business Readiness components across firm size

For the EU25 aggregate, during the 2004-2005 period, the gap between large and medium size enterprises has decreased, while it increased between small and medium size companies. Therefore, when compared to the results published in the 2004 e-Business Readiness index report, the overlapping between small and medium size clouds is smaller than last year (Figure 12). Accordingly, the overlap is important between large and medium size enterprises.

Moreover, in order to understand the achievements of the different sectors, the composite indicators were computed for all sectors using the NACE breakdown for both EU25 and EU15 (Figure 13). Using this representation, one can analyze the vitality of the different sectors of economic activity for the Adoption and Use of ICT, assess sector by sector the efficiency of the harmonization process. According to the aggregates estimated by Eurostat, EU15 and EU25 show similar performances for the Adoption and Use of ICT for sectors O and H (Motion picture, video, radio and television activities and Hotels; camping sites, other provision of short-stay accommodation); those sectors also feature the most important advances between 2004 and 2005. The gap to be recovered is still quite significant for the Wholesale and retail trade sector of economic activity, but also for Manufacturing. For both EU15 and EU25, the improvements are relatively limited for the sectors F and K (Construction and Real Estate, Renting and Business Activities). For each sector, the heterogeneity of aggregated scores (ICT adoption and use) achieved by the different countries is described by Figure 9 and Figure 10. The sector featuring the most important cohesion is indisputably the sector H (Hotels; camping sites, other provision of short-stay accommodation). Another "*trans-national oriented*" sector (Sector I: Transport, storage and communication) shows similar features for the use of ICT. Given that the range of values is significantly smaller for ICT use (Figure 8), there is an important overlapping of the probability density functions among the different sectors. In order, to compare to achievements of the different countries, ICT Adoption scores are plotted against ICT Use for the NACE categories listed in Table 1 (see Appendix C)

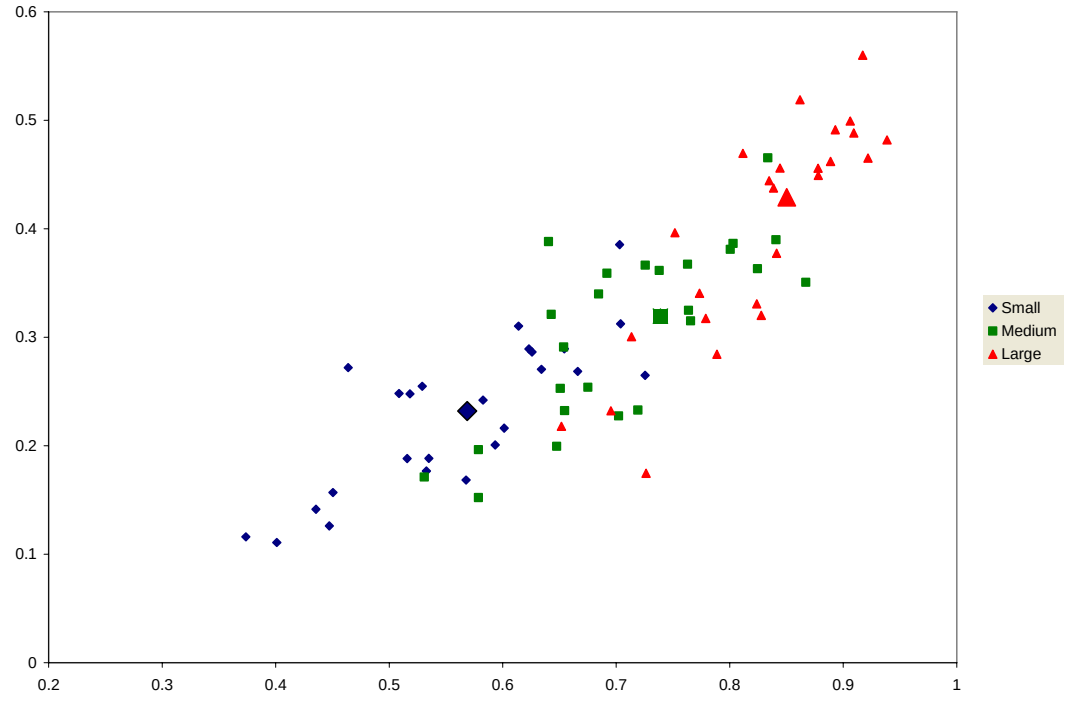

Figure 12. 2005 ICT Adoption scores vs. ICT use scores by firm size (weighting scheme is budget allocation). The EU25 aggregate scores are in bold.

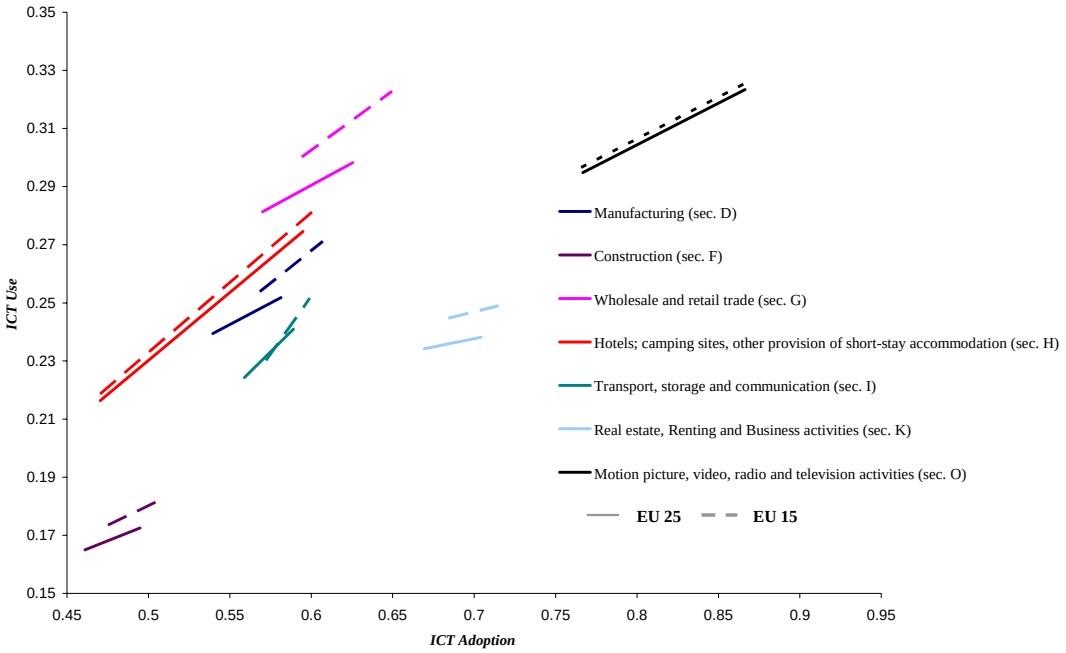

Figure 13. 2004-2005 evolution of ICT Adoption and Use for the EU25 and EU15 aggregates, breakdown by sectors (weighting scheme is budget allocation) (colour figure)

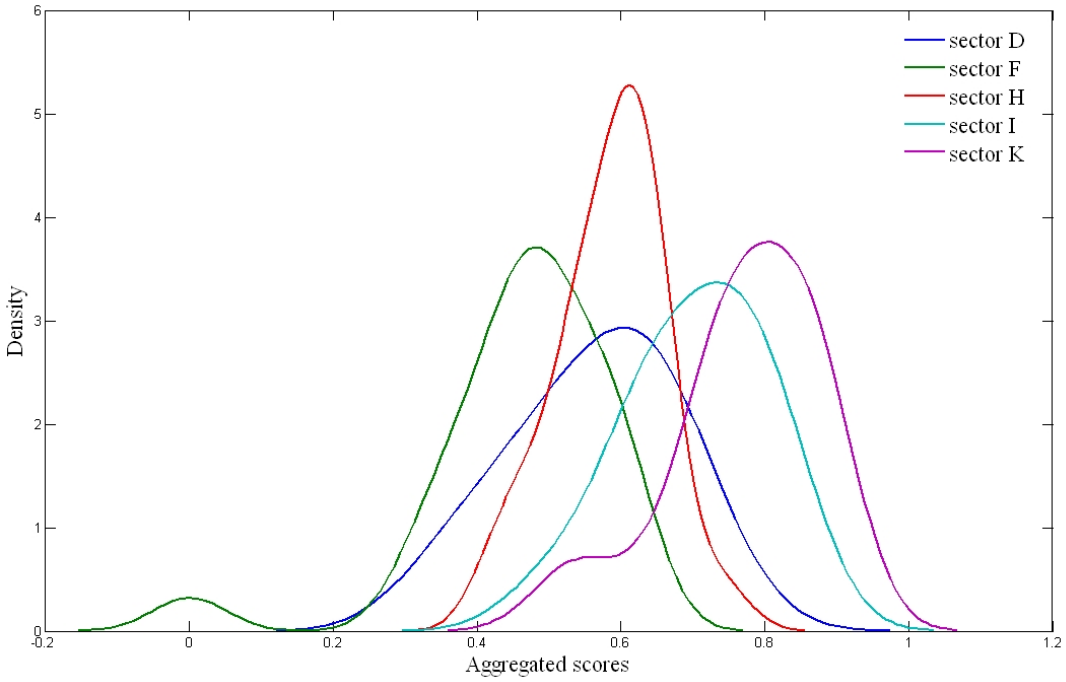

Figure 14. ICT Adoption composite index for five sectors: probability density estimates (using normal kernel functions) across the country scores (budget Allocation weights) (colour figure)

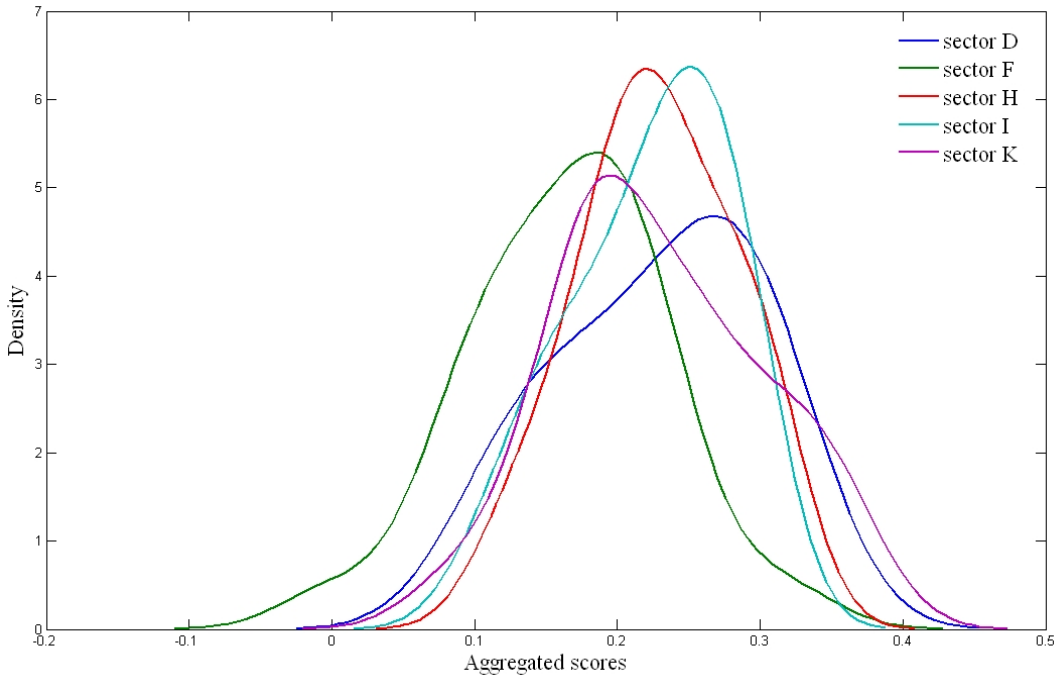

Figure 15. ICT Use composite index for five sectors: probability density estimates (using normal kernel functions) across the country scores (budget Allocation weights) (colour figure)

4. ROBUSTNESS ANALYSIS

The relative position of the different countries in the ranking (Table 7 and Table 8) relies on the scores obtained for the corresponding composite indicators (ICT Adoption and ICT Use). Given the definition of the basic indicators (Table 1 and Table 2), normalization was not performed (see discussion in section 6.2) and the previously cited composites are based on the estimated proportions for the various index components and on the weights employed during the aggregation process.

A synergic use of the uncertainty analysis and sensitivity analysis of the composite indicators has recently been applied to gauge the robustness of the index and to increase its transparency (Saisana *et al*., 2005). The proposed methodology was applied to the 2005 e-Business Readiness by Tarantola *et al* (2006). We follow this approach in this section by allowing the uncertain input factors to vary simultaneously.

In absolute terms, since all proportions were estimated from samples of the targeted population, all proportions (for all countries and all indicators) are uncertain. However, in this study we will focus on the uncertainty related to the imputation of missing values. For the representation of the *imputation uncertainty*, the uncertainty bounds for the multiple linear regression were evaluated (see Appendix A). Using the mean values and the calculated confidence bounds, a probability density function (normal distribution assumption) was specified for each imputed value. For some of the input factors, it was necessary to operate a truncation of the probability density function (PDF) in order to avoid sampled values outside the [0,1] interval.

Concerning the weights specified for the aggregation of index components, a single weighting approach is considered but the nominal values for the weights are uncertain. In

fact, instead of taking into account all the possible weighting strategies, we assume that the Budget Allocation strategy is most appropriate for the problem under study and we consider the weights provided by the different experts as different realizations. Table 9 and Table 10 present the values provided by the experts for the budget allocation weights for each basic indicator. It can be seen that the spread is relatively important for the various components. A discrete uniform probability density function was used for the choice of the weighting scheme.

Therefore, since 4 values were imputed, only 5 input factors are involved in the robustness analysis. The input factors are summarized in Table 11 with their probability density functions. The input factor X_5 has a discrete uniform distribution and it selects among 12 different sets of weights provided by the national representatives.

Table 9. Weights obtained from national representatives of the e-BSN for the category adoption of ICT

Indicators	*Budget allocation weights*											
a1	*0.25*	*0.10*	*0.17*	*0.10*	*0.15*	*0.15*	*0.20*	*0.30*	*0.10*	*0.20*	*0.05*	*0.36*
a2	*0.15*	*0.10*	*0.17*	*0.10*	*0.15*	*0.10*	*0.25*	*0.20*	*0.10*	*0.10*	*0.05*	*0.39*
a3	*0.10*	*0.20*	*0.17*	*0.00*	*0.15*	*0.15*	*0.10*	*0.05*	*0.05*	*0.10*	*0.15*	*0.01*
a4	*0.15*	*0.15*	*0.17*	*0.00*	*0.10*	*0.20*	*0.10*	*0.15*	*0.20*	*0.30*	*0.20*	*0.15*
a5	*0.25*	*0.20*	*0.17*	*0.40*	*0.25*	*0.30*	*0.15*	*0.10*	*0.25*	*0.20*	*0.25*	*0.05*
a6	*0.10*	*0.25*	*0.17*	*0.40*	*0.20*	*0.10*	*0.20*	*0.20*	*0.30*	*0.10*	*0.30*	*0.03*

Table 10. Weights obtained from national representatives of the e-BSN for the category use of ICT

Indicators	*Budget allocation weights*											
b1	*0.10*	*0.10*	*0.17*	*0.10*	*0.15*	*0.15*	*0.20*	*0.25*	*0.25*	*0.20*	*0.15*	*0.16*
b2	*0.15*	*0.15*	*0.17*	*0.10*	*0.15*	*0.15*	*0.20*	*0.25*	*0.25*	*0.20*	*0.15*	*0.16*
b3	*0.20*	*0.20*	*0.17*	*0.40*	*0.25*	*0.25*	*0.15*	*0.15*	*0.25*	*0.20*	*0.10*	*0.16*
b4	*0.15*	*0.25*	*0.17*	*0.40*	*0.25*	*0.30*	*0.15*	*0.05*	*0.10*	*0.20*	*0.30*	*0.16*
b5	*0.25*	*0.20*	*0.17*	*0.00*	*0.10*	*0.10*	*0.10*	*0.15*	*0.05*	*0.10*	*0.05*	*0.20*
b6	*0.15*	*0.10*	*0.17*	*0.00*	*0.10*	*0.05*	*0.20*	*0.15*	*0.10*	*0.10*	*0.25*	*0.16*

Table 11. Five uncertain input factors for the robustness analysis

Input factor	*Definition*	*Pdf*
X_1	Imputed value (a4) for MT	*N(0.4872,0.0699)*
X_2	Imputed value (b3) for HU	*N(0.2378,0.157)*
X_3	Imputed value (b6) for LU	*N(0.0187,0.0082)*
X_4	Imputed value (b6) for PT	*N(0.0089,0.0087)*
X_5	Choice of the weighting scheme	*Discrete Uniform(1,12)*

Using the definition of the different input factors given by Table 11, a multivariate sample was generated. For each sample point, the e-readiness index is evaluated for all the countries, thus obtaining a set of index values of the same size of the sample. Using the different realizations, the median, 5th and 95th percentiles were computed for each country. The EU25 and EU15 aggregates are included for comparison.

The results of the robustness analysis are shown in Figure 16 for the category Adoption, in Figure 17 for the category Use. The countries are shown in decreasing order of ranking. The graph displays the median (black horizontal bar) and the corresponding 5^{th} and 95^{th} percentile bounds of the distribution of the output which reflects the uncertainty due to the input factors. We interpret the 5^{th} percentile of a country's rank distribution as its best rank and we define the 'volatility' as the difference between a country's best and worst rank which are given by the 5^{th} and the 95^{th} percentiles of the rank distribution. Partially overlapping bounds indicate situations when the ranking of the corresponding countries can be affected by the uncertain input factors.

When compared to the results obtained for the 2005 e-Business Readiness index report, even if the number of imputed values is lower than last year (4 instead of 11), the volatility in the calculated ranks increased significantly, especially for the ICT use composite indicator. Looking at the change in the shape of the scores probability density function from 2004 to 2005 (see Figure 4), it can be seen that the width of the probability distribution is reduced. Indeed, as the difference among country scores is decreasing, the ranking obviously is more sensitive to small changes in scores.

Moreover, the gap between EU15 and EU25 (Figure 16 and Figure 17) is significant for ICT Use composite indicator but narrower for ICT Adoption. In other terms, the convergence and harmonization process is much more advanced for the Adoption of ICT infrastructures.

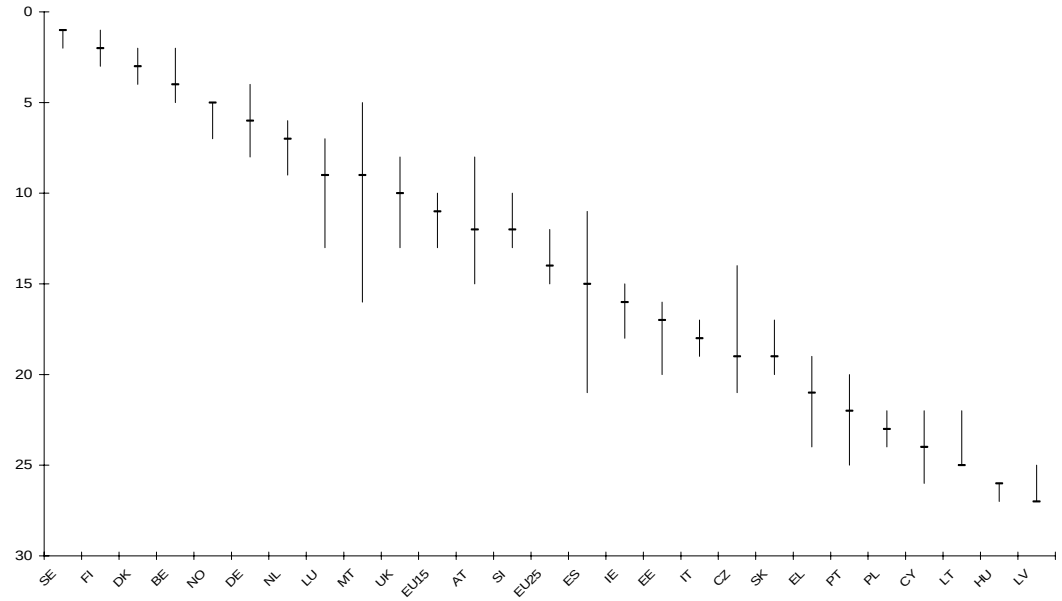

Figure 16. Results of the robustness analysis showing the median (-) and the corresponding 5th and 95th percentiles (bounds) of the distribution of the adoption rankings for the 26 European countries. Countries are ordered according to their median ranking. Uncertain input factors for all the countries are the weighting scheme (budget allocation weights); MT has additional uncertain factors for the imputed value

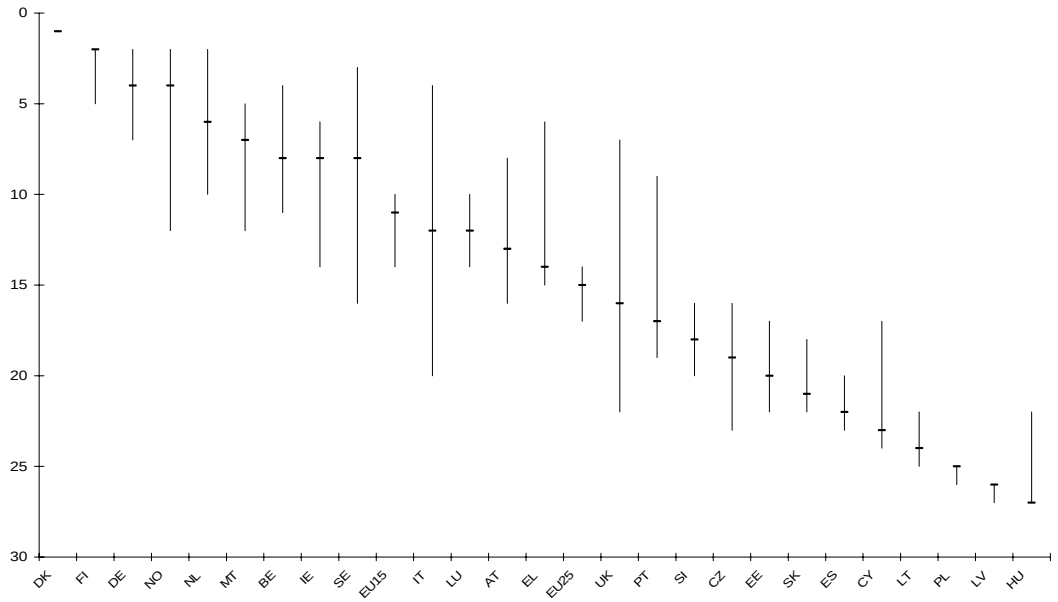

Figure 17. Results of the robustness analysis showing the median (-) and the corresponding 5th and 95th percentiles (bounds) of the distribution of the use rankings for the 26 European countries. Uncertain input factors for all the countries are the weighting scheme (budget allocation weights); HU, LU and PT have additional uncertain factors for the imputed values. Countries are ordered according to their median ranking

The propensity of a given country to be characterized by an important volatility in the calculated ranks depend on its position in the aggregated scores probability distribution function (Figure 4) but also on the heterogeneity in terms of achieved performances at the component level. In fact, looking at Table 3 and estimating the weights variance across experts for all components (using Table 9 and Table 10), one can see that the components featuring the most important consensus Budget Allocation weights are also characterised by a very important variance. In other words, the most uncertain weights are also those which have the larger influence on the aggregated scores (*a5* and *a6* for ICT Adoption, *b3* and *b4* for ICT Use). For a given country, if the performances (in terms of ranks at the indicator level) for such components are really different (significantly higher or lower) from the achievements for other indicators, the volatility of the country ranks is likely to be increased.

For the adoption of ICT, a part from the only country for which an indicator was imputed (*a4* imputed for Malta), the countries featuring an important variability for the ranks show the previously described behaviour (see Figure 18). Concerning the Use of ICT, a similar assessment is provided Figure 19. Given the scores achieved for the different countries for the indicator *b6* (percentage of enterprises that have sold products to other enterprises via a presence on specialised internet market places below 5%), the imputed value does not have a significant a significant impact on the calculated aggregated scores. For this reason, among the countries for which values were imputed for ICT Use, only Portugal and marginally Hungary are showing significant volatility on the calculated ranks. Portugal is characterised by the same behaviour described for Italy (good position for indicator *b4* when compared to the other components) and for Hungary the indicator *b3* (and not *b6*) was imputed.

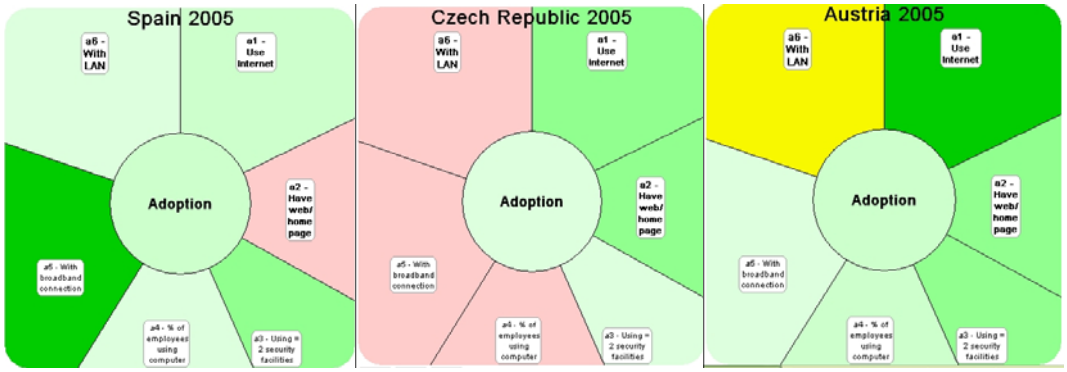

Figure 18. Dashboard showing the heterogeneity in ICT Adoption components (from red to green for the relative position for the various indicators, the area being proportional to the consensus budget allocation weights)

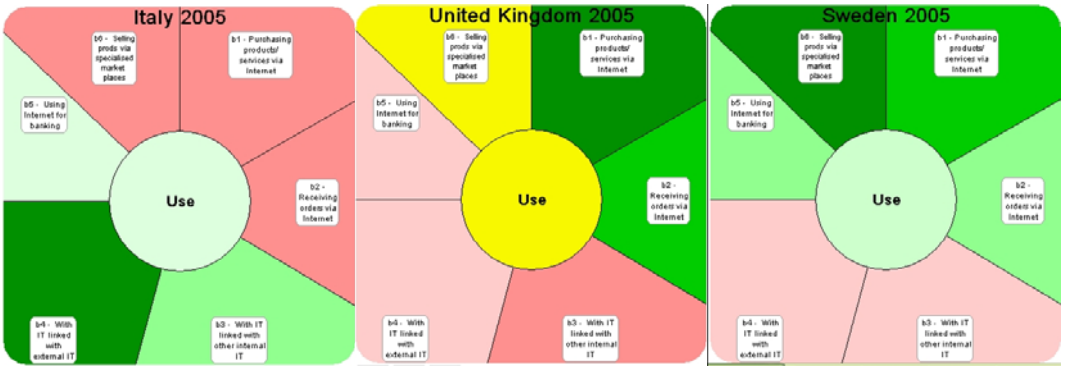

Figure 19. Dashboard showing the heterogeneity in ICT components (from red to green for the relative position for the various indicators, the area being proportional to the consensus budget allocation weights)

In order to assess the relative performance of the countries who participated in the 2005 survey with respect to the EU25 average, the difference was calculated for all the aggregated scores realizations. By providing the percentage of realizations for which a given country performs above and below the European average, Figure 20 and Figure 21 yield the required assessment acknowledging the uncertainty in the weights and in the imputation process for the four missing indicators.

Figure 20. Comparison to EU25 for ICT Adoption (percentage of realizations below and/or above the European average)

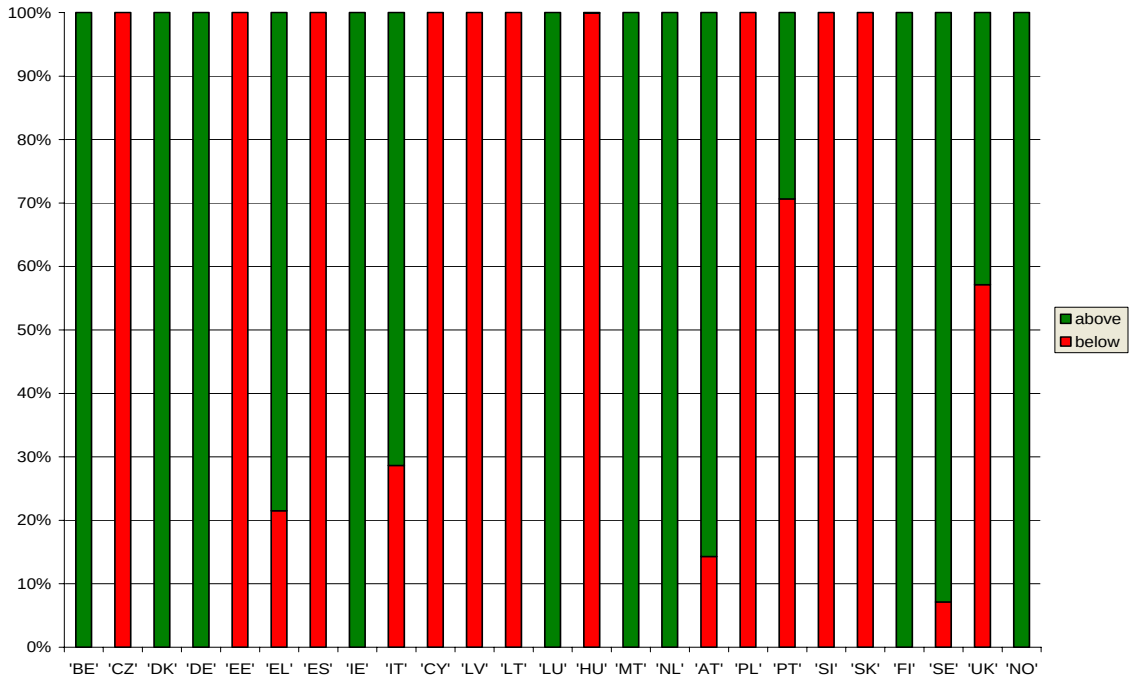

Figure 21. Comparison to EU25 aggregate for ICT Use (percentage of realizations below and/or above the European average)

5. MULTIVARIATE ANALYSIS

The e-Business Readiness index is composed of 2 themes, each theme containing 6 indicators. In order to examine the interrelationship among the base indicators, correlation and principal component analysis were carried out at the country level.

5.1. Correlation analysis

For the 2005 survey, the correlation matrix is presented in Table 12. Highlighting the coefficients higher than 0.7 shows that relations are stronger among the adoptions components. In particular, the correlation among the first 4 ICT Adoption indicators (see Table 1) is relatively high. Moreover, when compared to the results obtained with the 2004 data set, it seems that the correlation among indicators is increasing: 20 pairs of indicators have correlation coefficient higher than 0.7 instead of 14 last year. The previously mentioned result is another sign that the convergence and harmonization of process is largely initiated. However, this also calls for a revision (in progress) of the e-Business Readiness framework.

Concerning the Use of ICT, the components featuring the higher correlations coefficient are related to the purchases and orders via computer mediated network (components *b1, b2* and *b6)*. Among the correlations between ICT Adoption and Use components, the highest coefficient is obtained for the obvious relation between *a2* (Percentage of enterprises that have web/home page) and *b2* (Percentage of enterprises that have received orders via computer mediated network).

Table 12. Correlation matrix for Adoption and Use indicators

a1	1										
a2	**0.85**	1									
a3	**0.83**	**0.87**	1								
a4	**0.77**	**0.81**	**0.89**	1							
a5	0.56	0.55	**0.72**	**0.72**	1						
a6	0.64	0.61	0.66	**0.73**	0.56	1					
b1	0.50	**0.72**	0.69	0.63	0.40	0.54	1				
b2	0.61	**0.80**	**0.75**	**0.74**	0.62	0.54	**0.86**	1			
b3	0.43	0.39	0.54	0.54	0.39	0.48	0.10	0.29	1		
b4	0.35	0.26	0.41	0.30	0.31	0.37	0.16	0.24	**0.75**	1	
b5	0.70	0.49	0.48	0.45	0.60	0.31	0.09	0.38	0.21	0.13	1
b6	0.55	**0.75**	**0.78**	**0.77**	0.59	0.57	**0.77**	**0.83**	0.44	0.24	0.29
	a1	*a2*	*a3*	*a4*	*a5*	*a6*	*b1*	*b2*	*b3*	*b4*	*b5*

5.2. Principal component analysis

The principal component analysis using Varimax rotation revealed that 3 principal components explain ~83% (instead of ~82% 2004) of the data (Table 13). Given the nature of the index components, the composite index conveys multidimensional information but inherent and indubitable relations reduce the “statistical dimension” of the data set.

Table 13. Determination of the number of principal components - Total, percentage and cumulative variance explained

Component	*Initial Eigenvalues*		
	Total	***% of variance***	***Cumulative %***
1	7.242	60.35	60.35
2	1.523	12.69	73.04
3	1.178	9.82	82.86
4	0.554	4.61	87.47
5	0.512	4.26	91.73
6	0.385	3.20	94.94
7	0.242	2.01	96.95
8	0.131	1.09	98.04
9	0.098	0.82	98.04
10	0.064	0.54	99.40
11	0.043	0.36	99.76
12	0.029	0.24	100.00

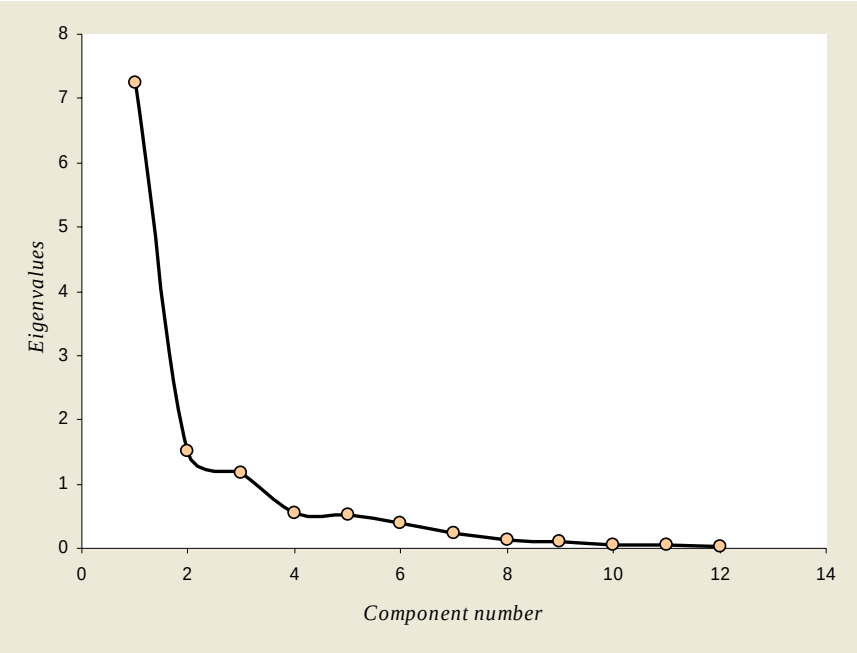

Figure 22. Eigenvalues spectrum

In terms of explained variance, compared to the 2004 survey, the first axis of the principal component analysis was slightly reinforced (from 57.8% to 60.3%) and the difference between the 2 other diminished (gap reduced from 7.1% to 2.8%). Therefore, the plot of eigenvalues (Figure 22) shows that the transition from rapid to gradual decrease is very rapid and occurs sooner than last year. The plateau characterizing the spectrum (Figure 22) and the values displayed in Table 13 show that the contributions of the second and third axis are now comparable.

After the Varimax rotation, most components load on the first axis and all indicators are somehow loaded on one of the 3 axis. The analysis confirmed that the variability in the data set is driven by the "Use" indicators. The different groups of indicators providing independent information seem consistent with the definition of the components. The most important statistical dimensions in the dataset are provided by components referring to orders and purchases via computer mediated networks (*b1*, *b2* and indirectly *b6* and *a2*)

loading on the first component the connectivity of IT systems (*b3* and *b4*) loading on the second.

When compared to the results form the principal component analysis carried out on the 2004 data set (*Pennoni et al, 2005*), while the same factors load on the first component, there is a flip between the second and third components. It is important to note that the 4 indicators featuring the highest loadings on the first 2 axis were also retained by (*Sajeva et al, 2005*) in the proposal of a sketched list of e-business core indicators for the i2010 initiative (revised framework for e-business indicators). The PCA analysis was also carried out on the indicators for the 2 categories separately in order to compute the weights for aggregation. The calculated weights are available in Table 3.

Table 14. Rotated component loading matrix

Indicators	*Principal component*		
	1	*2*	*3*
a1	-0.50	-0.26	**0.72**
a2	**-0.76**	-0.17	0.48
a3	**-0.73**	-0.36	0.50
a4	**-0.72**	-0.32	0.49
a5	-0.44	-0.25	**0.64**
a6	**-0.57**	-0.41	0.33
b1	**-0.96**	0.02	-0.01
b2	**-0.88**	-0.08	0.27
b3	-0.17	**-0.91**	0.19
b4	-0.09	**-0.91**	0.06
b5	-0.06	-0.01	**0.95**
b6	**-0.86**	-0.22	0.20

5.2.1. Comparison with 2003 and 2004 survey

The increasing correlation among index components was already emphasized. Using only the data provided by the member states who participated in all surveys, the PCA analysis was carried out for the 3 years. Even with this limited number of cases, the analysis of Figure 23 confirms that the "statistical dimension" of this data set is decreasing significantly over the 3 years.

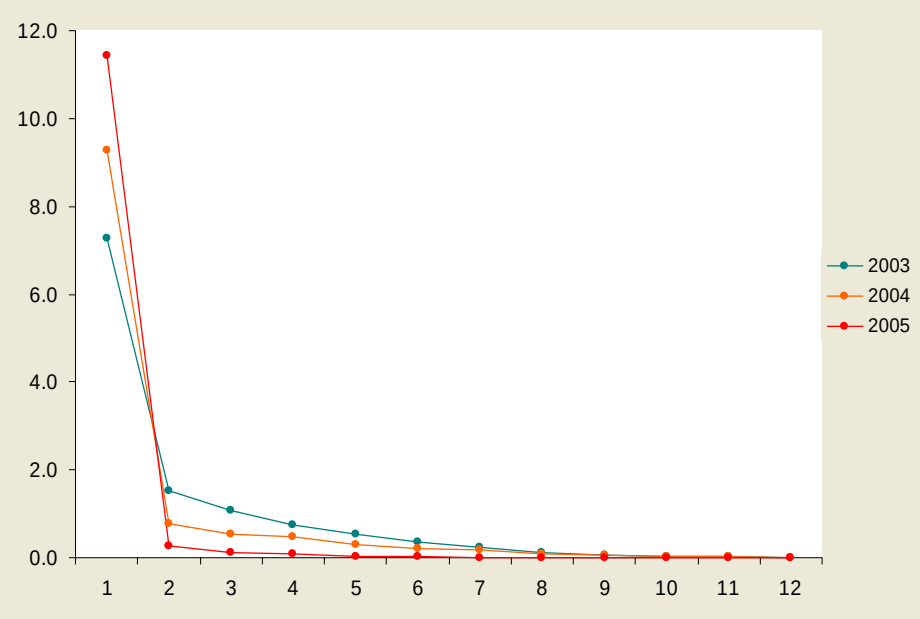

Figure 23. Evolution of eigenvalues spectra between 2003 and 2005 for the countries who participated in all surveys (colour graph)

When for each year, all the countries participating in the community survey are used for the PCA analysis, the "statistical dimension" of the data set is practically conserved because the scores from New Member States provide additional variability in the data set.

6. DISCUSSION OF DATA QUALITY AND NORMALIZATION METHODOLOGY

6.1. Sampling error and potential limitations of the inference

In the framework of the ICT enterprise survey, the data sets used for this analysis were collected by National Statistical Institutes (NSI's), then assembled and verified by Eurostat. Since all individuals of the targeted population cannot be pooled, the survey is based on a probability sample from which results representative of the population are derived.

In order to help NSI's to translate the Eurostat model questionnaire into national languages and to implement the national surveys following a harmonised methodology, for the 2006 survey a "*Methodological Manual for statistics on the Information Society*" was compiled by Eutostat with the contribution the various NSI's. The recommendation in the previously cited report is to use a stratified sample of enterprises with the aim to form groups of units characterised, in terms of the variables collected in the survey, by maximum homogeneity within the group and maximum heterogeneity between the groups. The examination of the National Methodological reports revealed that most countries used stratified random samples for the 2005 enterprise survey and provided the required accuracy measures.

In fact, the use of a sample survey unavoidably leads to sampling error. Eurostat is working toward the set up of a harmonized and systematic methodology to compute accuracy measures for the all indicators produced. To this aim, the countries participating in the community survey are invited to provide sampling error estimates taking into account the real sampling design used. Following the structure of the report template provided by Eurostat, the NSI's report information related to the sample design but also accuracy measures (sampling error) for a set of indicators and categories (breakdown by firm size and sector of economic activity). The reliability of the estimates are reported by means of a coefficient of variation (estimated relative standard error) which is the ratio of

the square root of the variance of the estimator for the proportion to the expected value of the proportion. It is estimated by the ratio of the square root of the estimate of the sampling variance to the estimated value.

Among accuracy measures provided for the questions of the General Enterprise survey, only 2 indicators match with the e-business readiness components (indicators *a1* and *a4*). The others consist of filter questions or were not selected in the current framework. The present analysis is discussing the reliability of the estimates for the overall population of enterprises (country level). As expected the provided values vary very significantly from one country to another and from one indicator to another.

Even if significant efforts are dedicated (guidelines supply) to promote convergence in terms of methodologies, quality control systems are of course country-specific as most statistical institutes have standard procedures and guidelines for plausibility checks or logic tests of datasets. In the same way, it is unlikely that a uniform approach was used for the estimation of the relative standard error provided by the different participants. Under the simple random sample hypothesis, a rough approximation of the sample error was also carried out at the country level using the sample and population sizes.

In order to assess the significance of yearly changes, significance testing was performed for the 2004-2005 trend for the e-Business Readiness components. Assuming the samples are independent, a contestable assumption given the ratio between the sample and population sizes for some countries (ranging from 0.12% to 69.79%), the Z-test was applied with a significance level of 0.05. The test statistic includes the variance of the proportions estimates. Using the classic formulation for the test, the variance is unknown and estimated using the simple random sample hypothesis. However, as underlined previously, the vast majority of samples were stratified for the community survey. For the countries which provided the coefficient of variation and the sample size for both 2004 and 2005, the following Table 15 compares the results for the test (for indicators *a1* and *a4*) depending on the sampling variance used (computed under simple random hypothesis or derived from the provided coefficients of variation).

Table 15. Comparison of the significance testing results (for indicators *a1* and *a4*) depending accuracy measure used (1 indicates that the hypothesis stating that the 2004 and 2005 proportions are equal is rejected)

	variance unknown	variance known	variance unknown	Variance known
	a1	***a1***	***a4***	***a4***
AT	1	1	1	0
CZ	1	0	0	0
DE	0	0	1	1
EL	1	0	0	0
IE	0	0	1	1
LV	0	0	0	0
NO	1	1	1	0
PL	1	0	1	0
SE	0	0	0	0
SI	1	0	1	0
SK	1	1	1	1
UK	1	0	1	0

Because, the variance derived from the coefficient of variations reported is very often higher than the one calculated under the simple random sample hypothesis, the number of countries for which the trend is significant is less important. Although the trend is not

significant for many countries, the situation might be completely different for other indicators.

Assuming that the variance computed using simple random sampling is an acceptable approximation for the sampling error, the sampling error is the same from one indicator to another. Under this hypothesis, the calculation of accuracy measures for the aggregates (ICT Adoption and ICT Use) is straightforward and the significance of the trend can be investigated for the composite indicators. The results are given in Table 16 and show that while the trend is significant for most countries for ICT Adoption, this is not the case for ICT Use. According to this analysis, Latvia, Lithuania and Cyprus are not featuring statistically significant progress for both aspects of e-Business Readiness.

The statistical hypothesis tests carried out this section require subjective judgment in setting a predetermined acceptable probability of making an inferential error caused by the sampling error. Moreover, given the potential uncertainty associated to the relative standard error estimates and the dichotomous nature of statistical testing results, the importance of the results presented in this section should not be overemphasized. Some of the limitations related to hypothesis testing on the temporal evolution of aggregated proportions will be alleviated with the coming availability of accurate and comparable sampling error estimates. Eurostat already set up Task Force on variance estimation and published a monograph of official statistics on "*Variance estimation methods in the European Union*" which discuss the procedures to be used for the estimation of sampling error taking into account the sampling design.

Table 16. Significance testing results for ICT Adoption and ICT Use composite indicators (1 indicates that the hypothesis stating that the 2004 and 2005 aggregates are equal is rejected)

	Adoption	Use
AT	1	0
BE	1	0
CY	0	0
CZ	1	1
DE	1	0
DK	1	1
EL	1	1
ES	1	1
IE	1	1
IT	1	1
LT	0	0
LU	1	0
LV	0	0
NL	1	0
NO	1	1
PL	1	0
PT	1	1
SE	1	0
SI	1	0
SK	1	1
UK	1	1

6.2. Normalization methodology

The indicators selected for aggregation in two themes (ICT Adoption and ICT Use) convey quantitative information for different aspects of e-Business Readiness. From the definition of the different components (Table 1 and Table 2), one can see that all quantities are expressed in percentages. The current methodology, adopted after the workshop on composite indicators for e-business readiness organised by JRC in 2003, assumes that all indicators are already commensurable. This absence of preliminary rescaling was supported by the different experts participating to the previously mentioned meeting.

However, even if indicators are expressed in the same unit, the range of values and the level accessible in finite time might be very different from one component to another. The variability of countries performances for the different indicators was previously described by the corresponding probability density estimates (Figure 9 and Figure 10). Before the application of any weighting scheme, the normalization methodology should ensure equal importance to all the index components. If no normalization is carried out, it means implicitly that the contribution to the aggregate of a given indicator is proportional to the score achieved. The components featuring smaller scores will not play a significant role in the estimated performance for the composite. For instance, 0.1% might be very difficult to gain a particular indicator and this obtained advantage can be completely damped by other indicators having higher scores and characterised by important variations from one year to another. Such is situation is encountered for the indicator *b6* (Percentage of enterprises that have sold products to other enterprises via a presence on specialised internet market places) for the use of ICT. For this particular indicator, scores range between 0.16% and 4.53% which is very low compare to the other ICT Use components (Figure 10). It is shown in Figure 24 that the use of the re-scaling method (min-max normalization) implemented in the Dashboard software alters significantly the ICT Use ranks.

Because Sweden and Norway (highlighted on the figure) are excellent performers for the indicators featuring very low scores (*b6* and *b2*), a few positions in the ranking are gained when the components are normalized before aggregation. However, as emphasized by *Nardo et al* (2005), for indicator values lying within an interval with very small range, this latter is widened applying the re-scaling, thus explicitly increasing the effect on the composite indicator. Special care should be also dedicated to reliability analysis for outliers, which could have a distortion effect on the normalised indicator.

Generally, the aggregates calculated from the survey results differ with respect to their units of measurement and their variability. For the case under study, binomial proportions were calculated for all components but show different mean and spread. Although there is no consensus on suitable normalization method, the absence of decision is a decision. Therefore, even if the ranking can be dependent on the choice of the normalization method, removing the requirement to normalize data (as suggested among other by *Cherchye et al*, 2006) do not necessarily eliminate the potential points of criticism. If the indicators selected for the composition of an aggregated measure (composite index) are all relevant, it seems reasonable to avoid aggregation distortions stemming from differences in indicators means. This issue should be further investigated and might lead to a revision of the current framework.

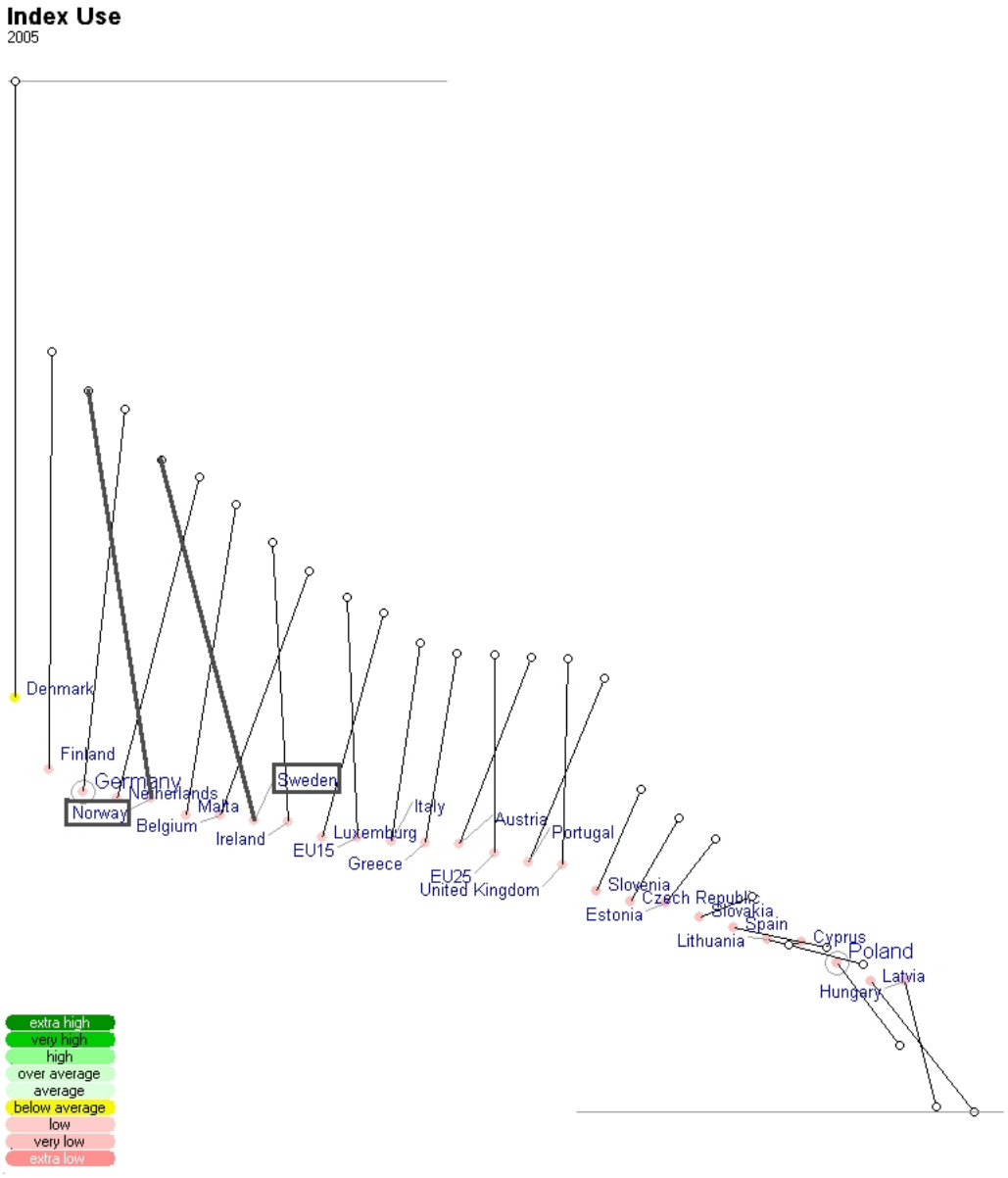

Figure 24. Effect of the absence of normalization on the ICT Use ranks (original position –colour point- without normalization and new position with re-scaling)

7. CONCLUSIONS

The 2006 European e-business readiness index, evaluated using data from the 2005 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*) understand better the relationships between the sub-indicators, (*iv*) rigorously test robustness of the index to the implicit and explicit assumptions and methodological choices made. Such results and comparisons have facilitated the interpretation of the index. The analysis of the significance of the trends underlying the highlighted key figures and the critical examination of the currently adopted normalization methodology open new prospects and should improve the reliability of the e-Business Readiness index.

The community survey still needs to be extended to additional countries but the data coverage is improving thanks to a significant reduction of missing values. 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. However, mainly because the aggregated scores stays in a smaller interval the ranking is less stable across the different weighting schemes.

The Nordic countries, Sweden, Finland and Denmark steadily occupy the top ranks as they have consistently done for the last 3 years. This highly technological region constitutes one of the most advanced and competitive markets in the world. Together with Portugal and Greece, most of the States from the Eastern part of Europe which joined the EU in 2004 are still in the developing stage of their e-business environment. In order to enhance the applicability and the utility of the e-Business Readiness index, the scope of the study is currently extended and should cover sector and country level (country profiles) analysis in the near future.

As mentioned in the previous report, we consider that 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.

8. REFERENCES

e-Business W@tch Synthesis Report 2005, http://www.ebusiness-watch.org

European Commission (2002). Communication from the Commission: e-Europe 2005 Action Plan COM (2002) 263. Available at: http://europa.eu.int/information_society/eeurope/news_library/documents/eeurope2005/eeurope2005_en.pdf

Saisana M.; Saltelli A. and Tarantola S. (2005a). Uncertainty and sensitivity techniques as tools for the analysis and validation of composite indicators, Journal of the Royal Statistical Society A, 168, 307-323.

European Commission DG ESTAT (2006), Methodological manual for statistics on the Information Society, Eurostat methodological manual for the 2006 survey.

European Commission DG ESTAT (2002), Monographs of official statistics, Variance estimation methods in the European Union.

Interim Report (2004), Benchmarking national and regional policies in support of the competitiveness of the ICT sector in the EU, Prepared for European Commission, Directorate-General Enterprises, D4 under Contract FIF 20030871

Jesinghaus, J (2003), The Dashboard Manual (http://esl.jrc.it/dc/index.htm)

Mittag, H.-J (2006), Educating the public - The role of e-learning and visual communication of official data (available from http://www.fernuni-hagen.de/jmittag/publikationnen/CES-22-03-06.pdf)

9. APPENDIX A: IMPUTATION OF MISSING DATA

Firstly, the missing values were imputed using single linear regression and the confidence bounds were calculated. Given that the values obtained using regression with other indicators (also featuring high correlation) fall outside the estimated confidence bounds, multiple regression was applied for the imputation of the missing values. The following figures provide an overview of the imputation process for all missing values.

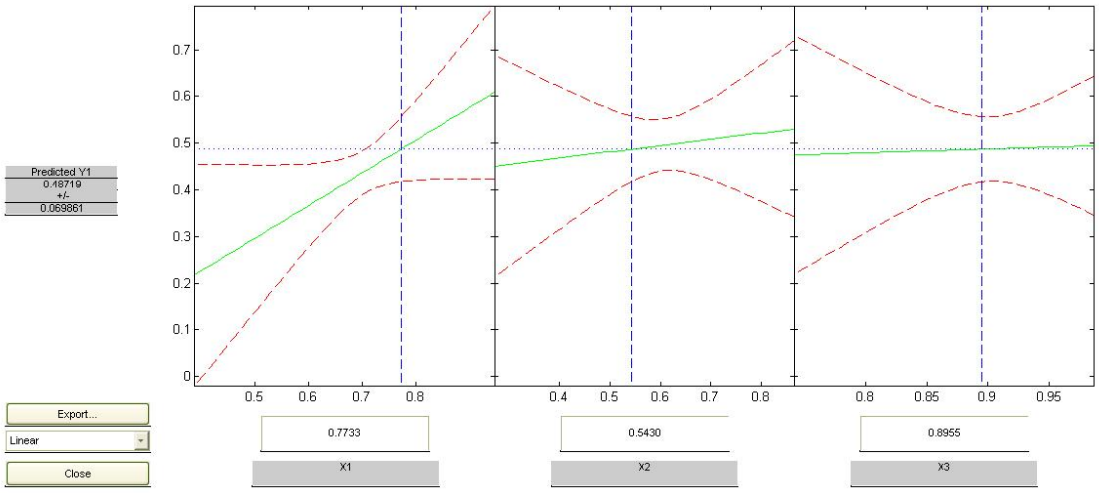

Figure 25. Multiple regression for the imputation of indicator (a4) for MT, regression with predictor variables *a3*, *a2* and *a1*

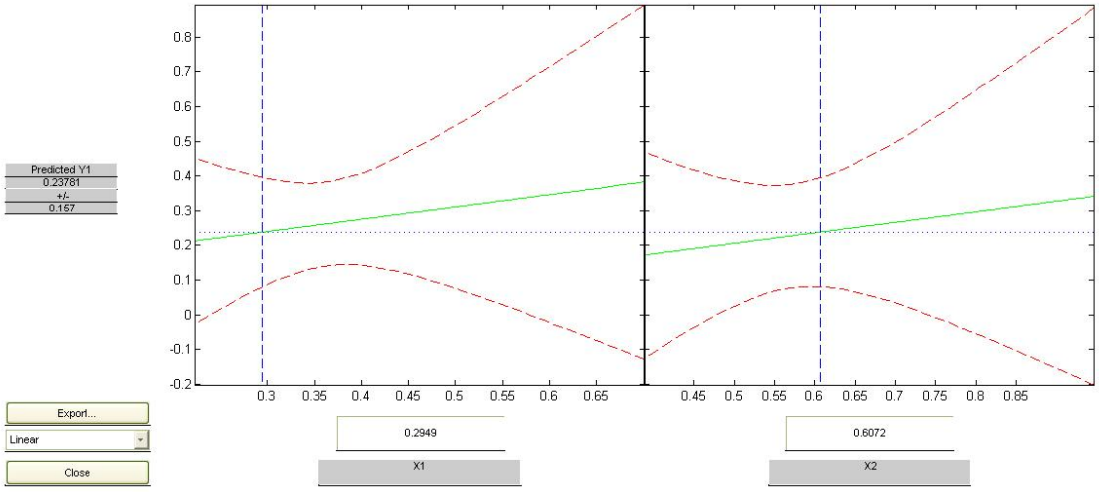

Figure 26. Multiple regression for the imputation of indicator (b3) for HU, regression with predictor variables *a3* and *a4*

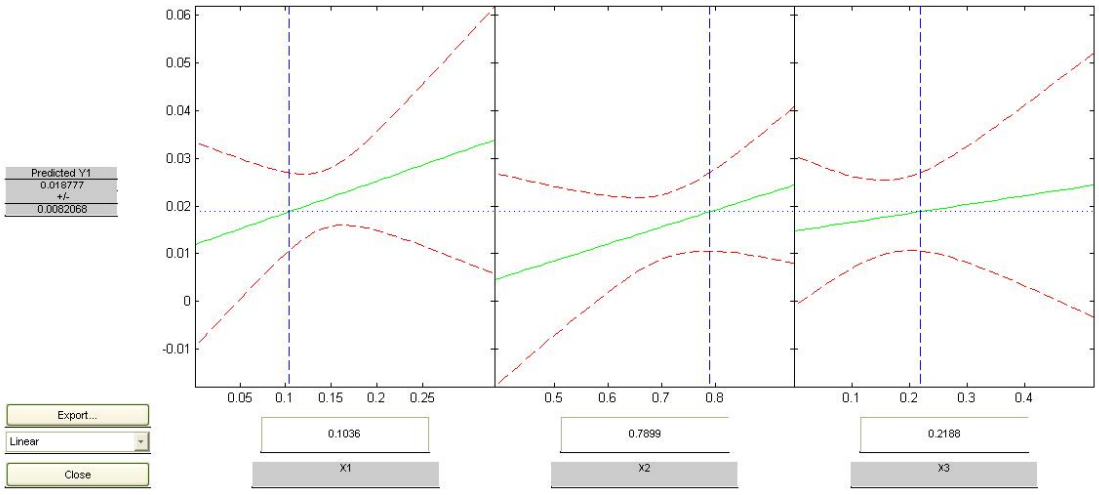

Figure 27. Multiple regression for the imputation of indicator (b6) for LU, regression with predictor variables *b2*, *a3* and *b1*

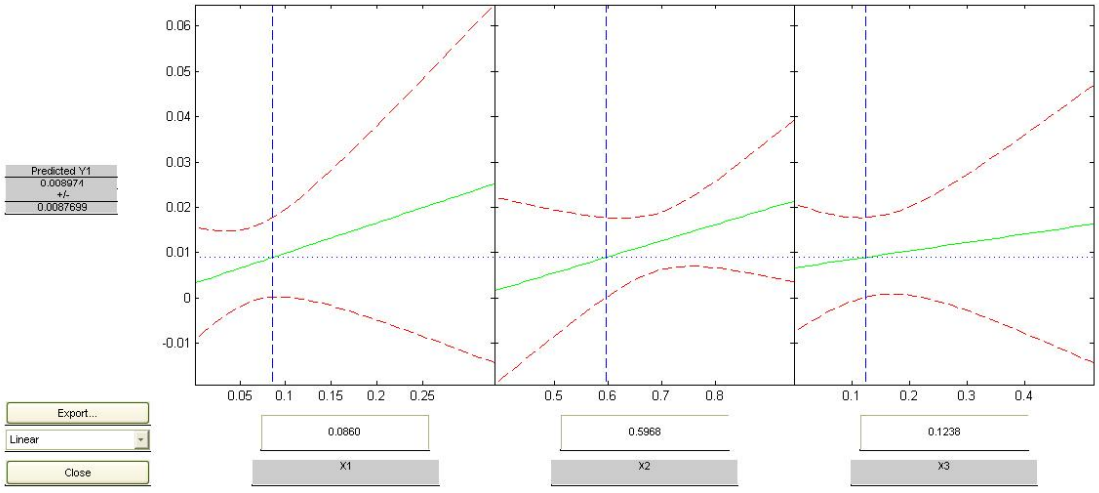

Figure 28. Multiple regression for the imputation of indicator (b6) for PT, , regression with predictor variables *b2*, *a3* and *b1*

10. APPENDIX B: UNIVARIATE ANALYSIS

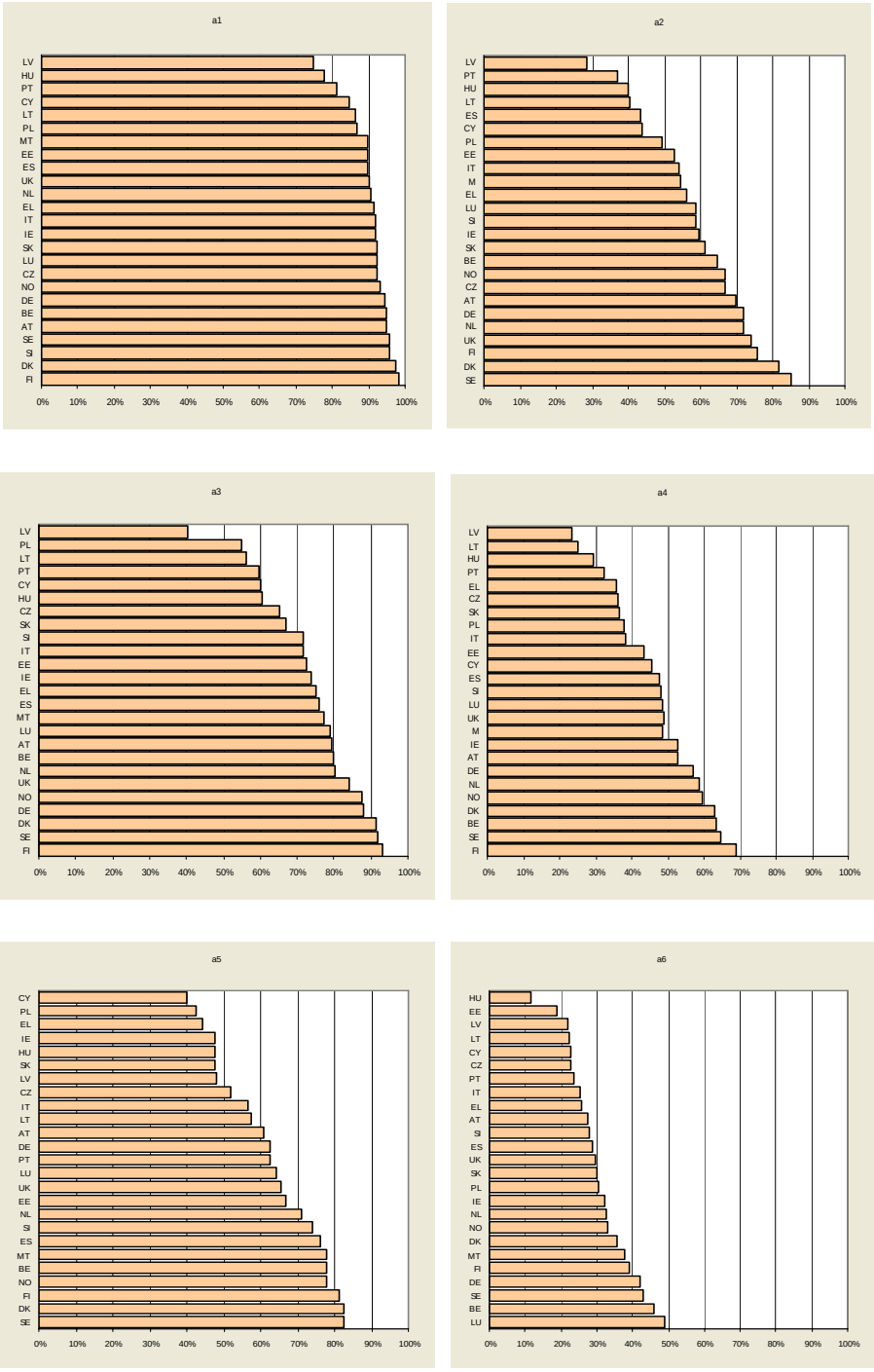

Figure 29. 2005 ICT adoption components

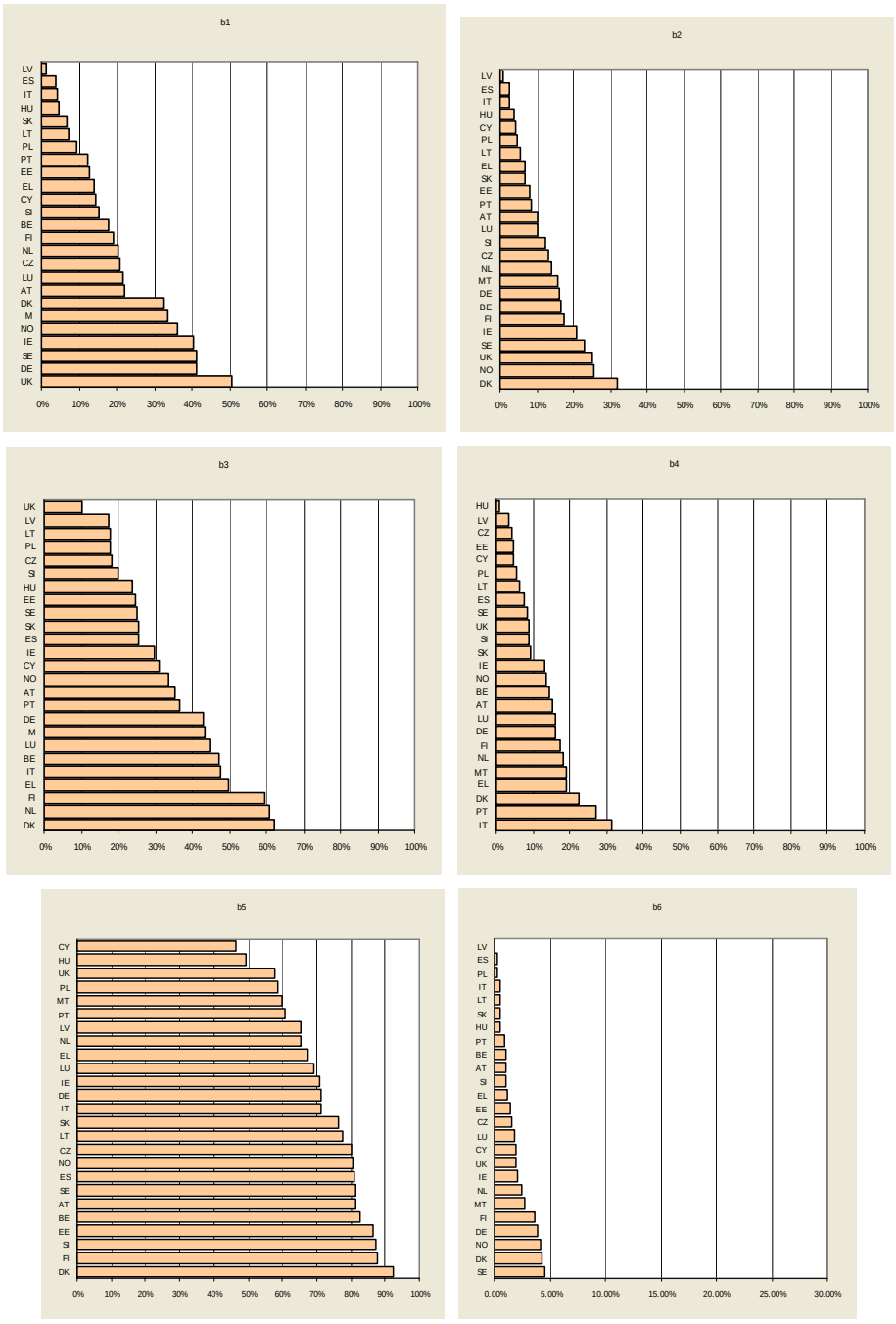

Figure 30. 2005 ICT Use components

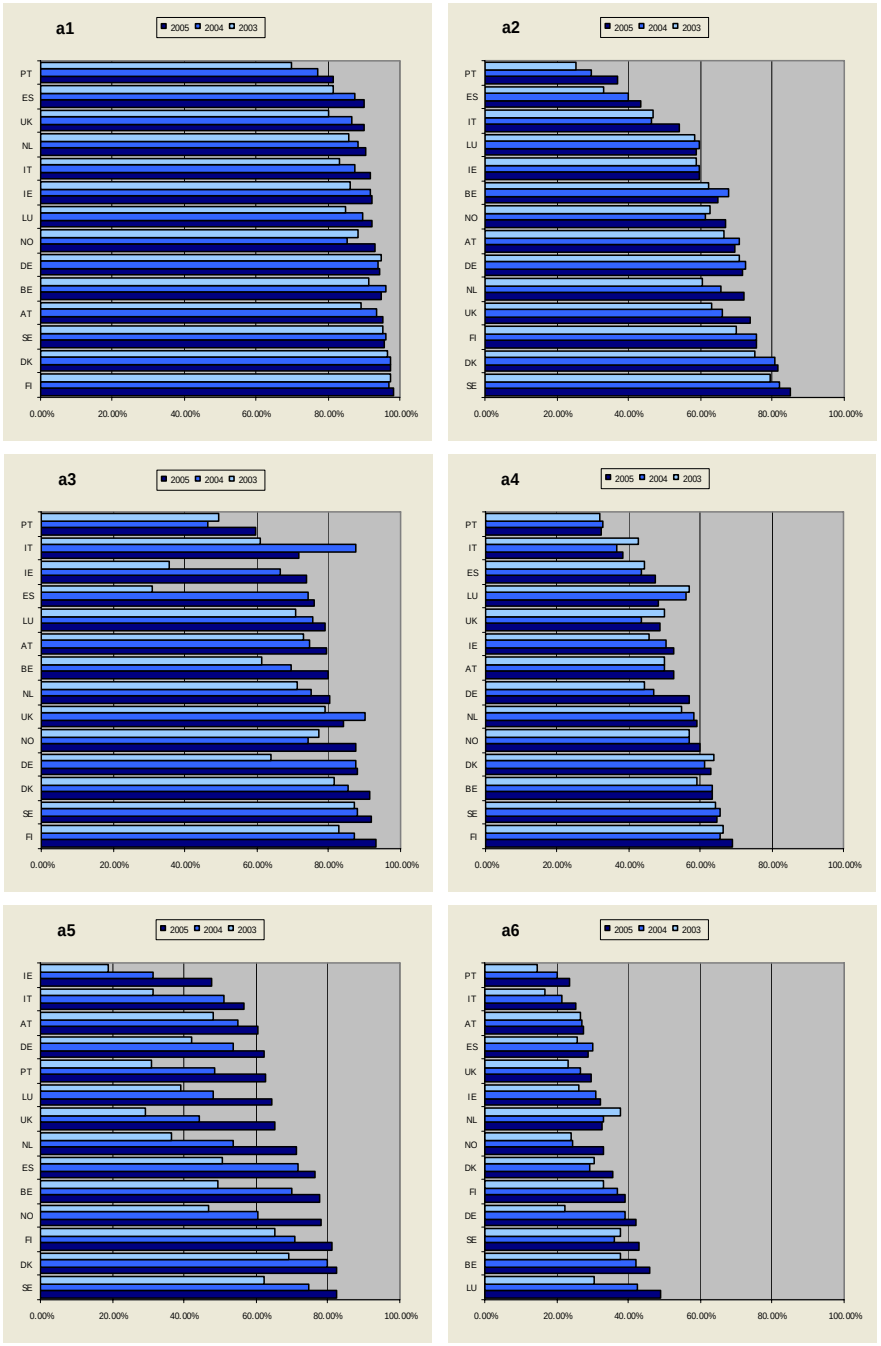

Figure 31. Evolution of ICT components for the countries involved in all surveys

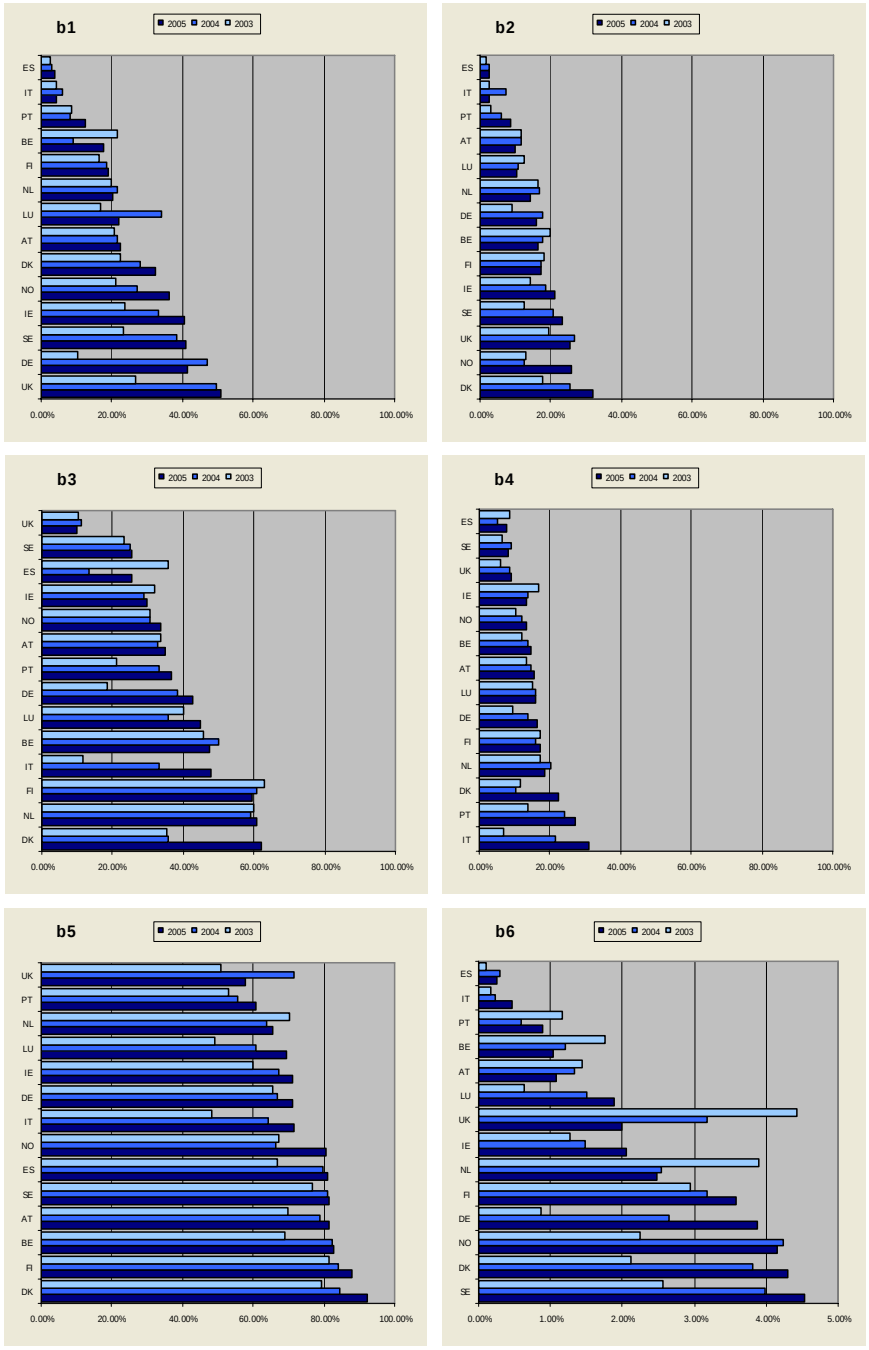

Figure 32. Evolution of ICT Use for the countries involved in all surveys

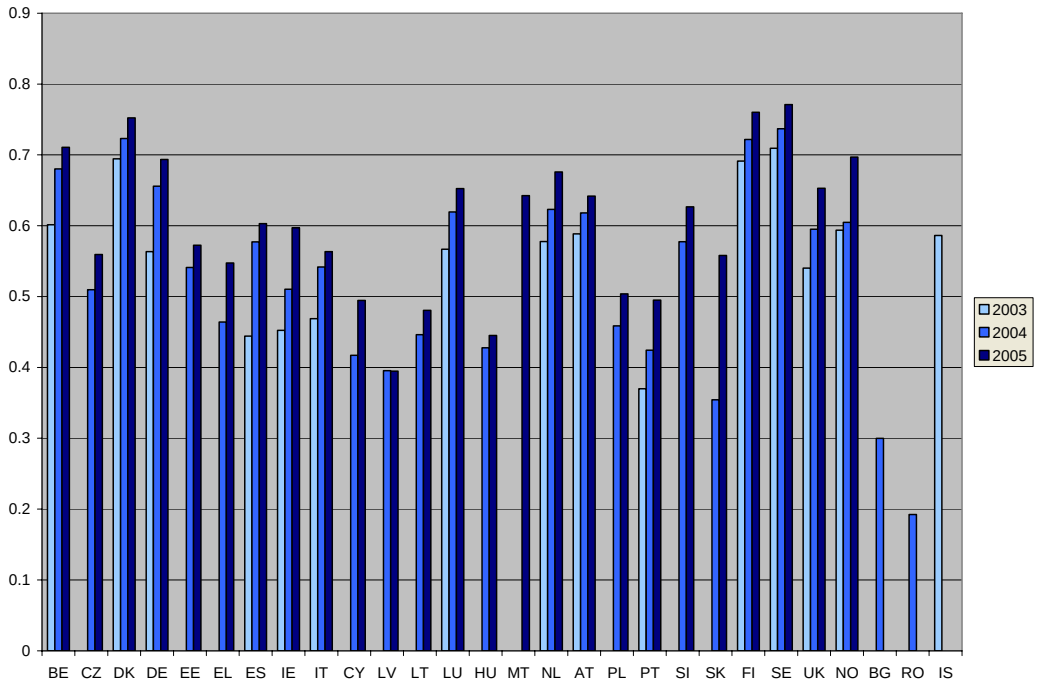

Figure 33. Adoption composite indicators for all surveys (equal weights)

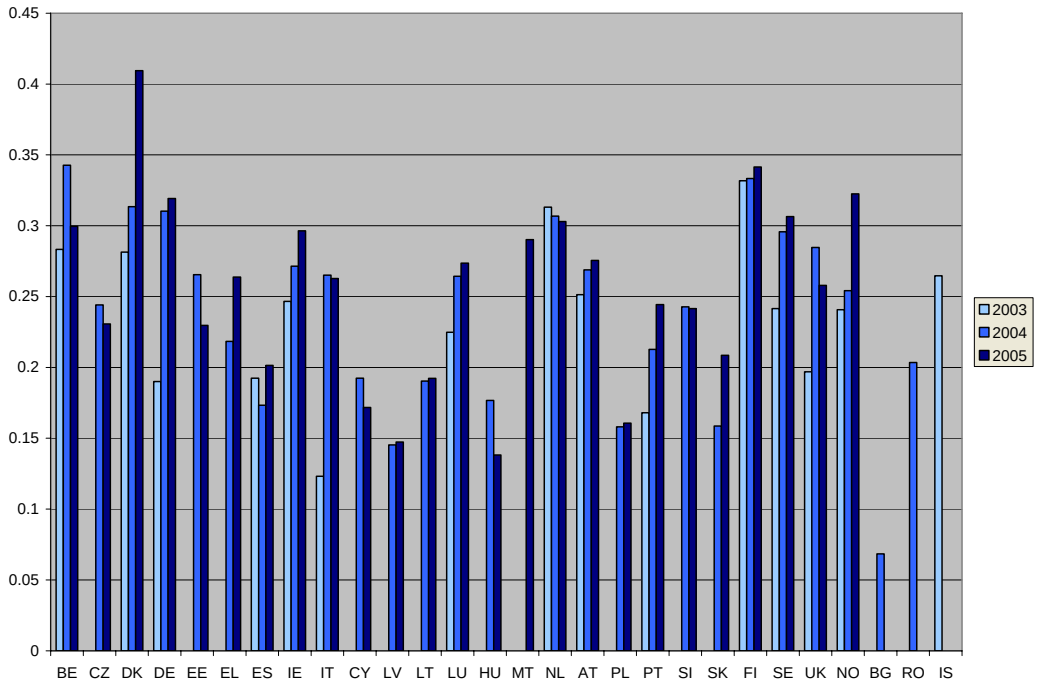

Figure 34. Use Composite indicators for all surveys (equal weights)

11. APPENDIX C: BENCHMARKING BY SECTORS OF ECONOMIC ACTIVITY

As underlined in the e-Business Watch report, country comparisons should be taken with care because they partly reflect industry structure. Some the results might reflect, at least to some extent, the structure of the economy rather than the overall e-maturity of firms. The repartition of the different sector of activity for each country is provided by Table 17.

In order to assess the performances of the different countries at the sector level, adoption versus use scores (similar to Figure 3) are plotted for each sector. When the number of missing is less than 4, missing values were imputed using multi-linear regression (among the components for the given sector). Otherwise we consider that the data set is incomplete for the country. Budget allocation weights were used for the calculation of the aggregates.

	Sector D	Sector F	Sector G	Sector H	Sector I	Sector K	Sector O
AT	23.3%	18.6%	27.0%	4.7%	8.4%	17.6%	0.4%
BE	28.0%	13.2%	31.0%	1.3%	10.8%	15.1%	0.5%
CY	28.8%	12.6%	31.1%	8.0%	8.7%	9.6%	1.2%
CZ	34.0%	14.2%	27.7%	1.4%	6.3%	16.1%	0.2%
DE	29.0%	16.9%	25.8%	2.6%	6.9%	18.5%	0.4%
DK	26.3%	18.1%	28.6%	1.4%	8.7%	16.4%	0.5%
EE	31.7%	13.9%	28.9%	1.5%	10.5%	13.0%	0.4%
EL	34.0%	6.4%	33.7%	7.8%	7.6%	9.6%	0.9%
ES	21.8%	5.3%	19.2%	9.0%	11.8%	12.9%	0.0%
FI	37.1%	11.4%	22.0%	1.5%	9.4%	18.1%	0.5%
HU	34.2%	14.5%	27.9%	1.6%	5.7%	15.9%	0.2%
IE	23.9%	5.5%	35.8%	5.5%	7.2%	18.3%	3.8%
IT	48.6%	14.4%	17.4%	3.0%	6.1%	10.2%	0.3%
LT	28.6%	13.1%	35.7%	1.2%	10.8%	10.2%	0.3%
LU	12.7%	26.0%	28.5%	2.8%	11.0%	18.5%	0.6%
LV	24.9%	12.3%	38.3%	0.9%	9.5%	13.8%	0.4%
MT	34.7%	8.8%	34.9%	9.0%	7.3%	4.0%	1.4%
NL	20.6%	15.0%	31.1%	1.7%	8.4%	22.8%	0.4%
NO	20.1%	15.3%	36.7%	2.8%	8.1%	16.6%	0.4%
PL	39.0%	12.0%	31.5%	1.4%	4.7%	11.1%	0.3%
PT	38.0%	20.0%	27.0%	1.9%	4.8%	8.1%	0.2%
SE	27.3%	13.0%	27.9%	2.3%	9.1%	20.0%	0.4%
SI	38.0%	16.9%	22.9%	1.8%	4.9%	15.0%	0.4%
SK	32.3%	14.8%	30.4%	1.7%	5.3%	15.2%	0.3%
UK	24.6%	10.9%	26.1%	2.9%	6.3%	28.6%	0.5%

Table 17. Proportions of the different sector of economic activity across the countries

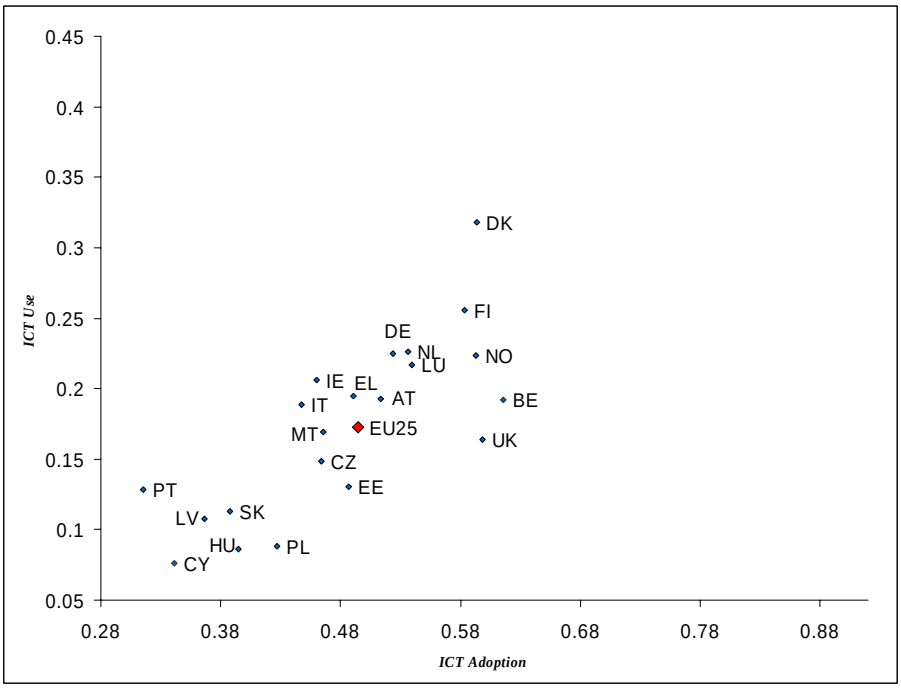

Figure 35. Construction sector (no data for BG, FR, IS, RO)

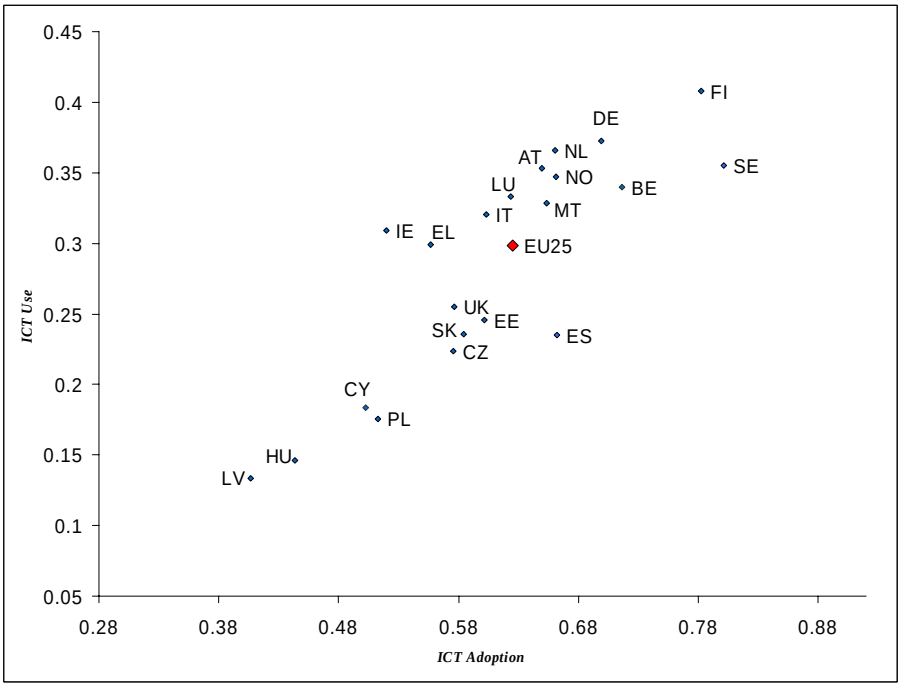

Figure 36. Wholesale and retail trade sector (no data for BG,DK,FR,IS,RO and incomplete data set for PT, SI)

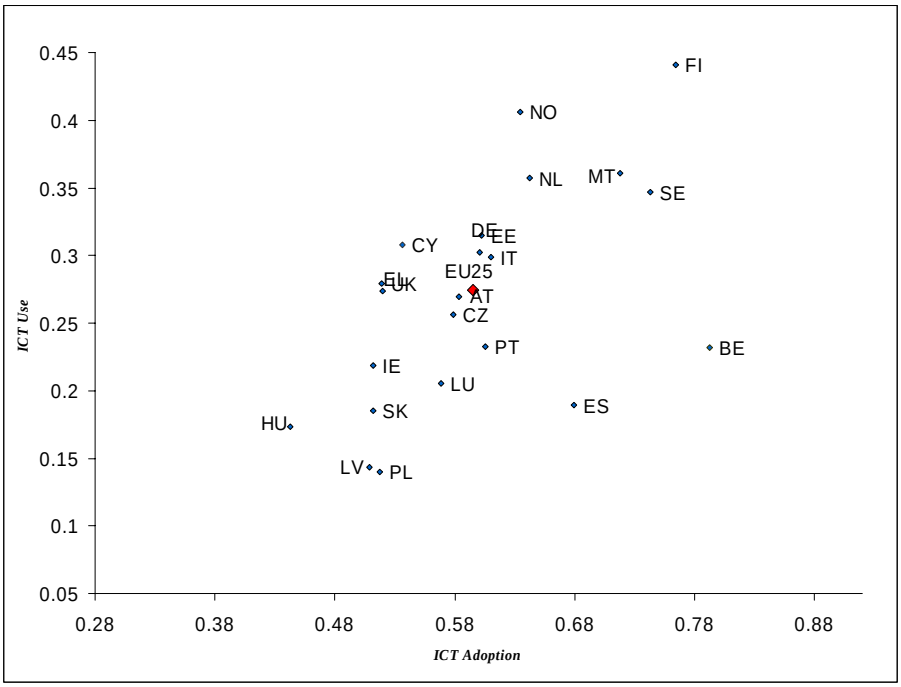

Figure 37. Hotels; camping sites, other provision of short-stay accommodation sector (no data for BG,DK,FR,IS,RO and incomplete date set for SI)

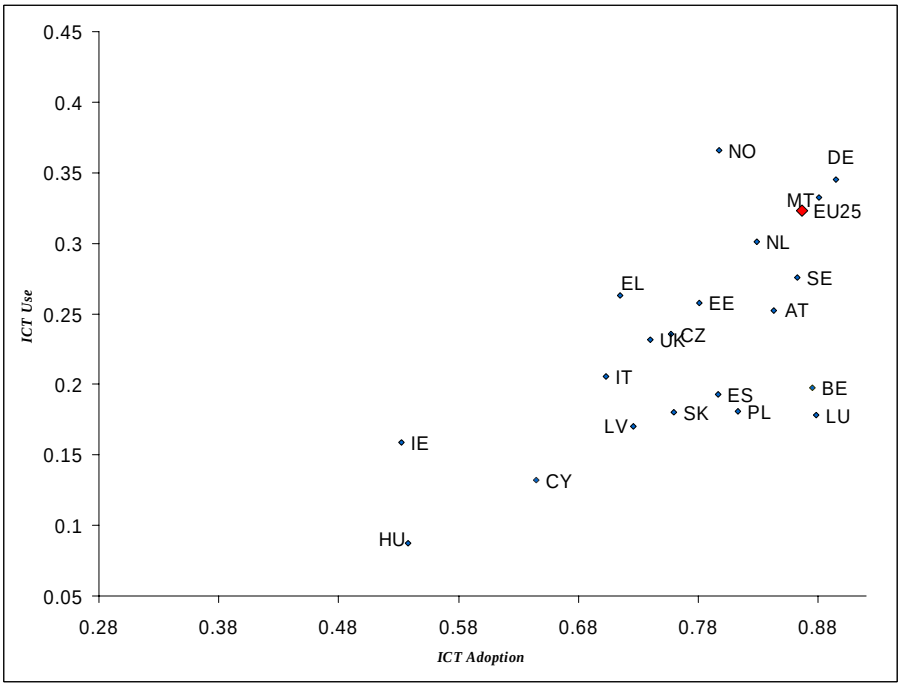

Figure 38. Motion picture, video, radio and television activities sector (no data for BG,DK,FR,IS,RO and incomplete data set for FI,PT)

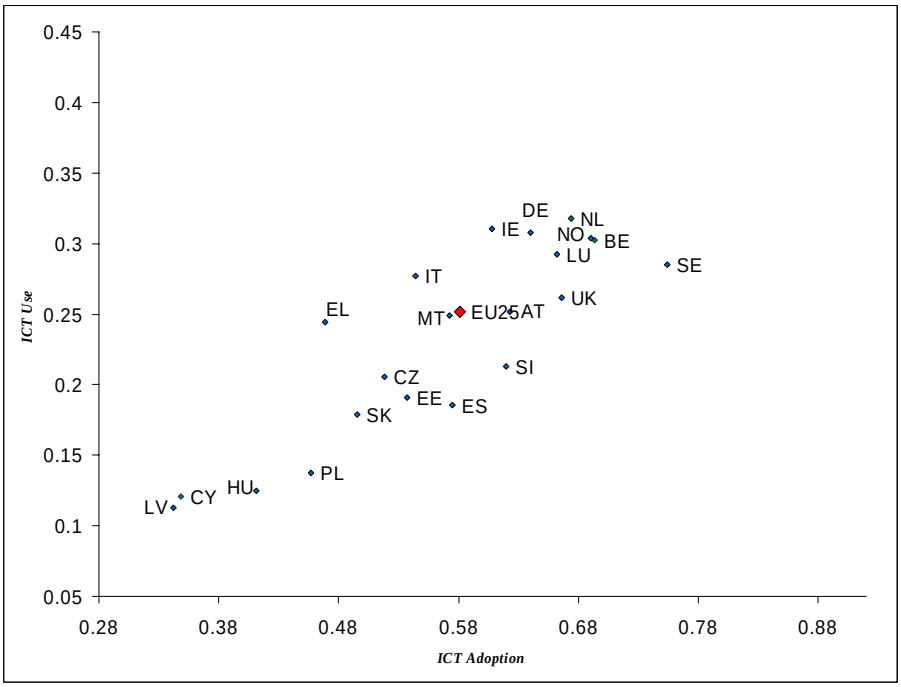

Figure 39. Manufacturing sector (no data for BG,DK,FR,IS,RO and incomplete data set for FI,PT)

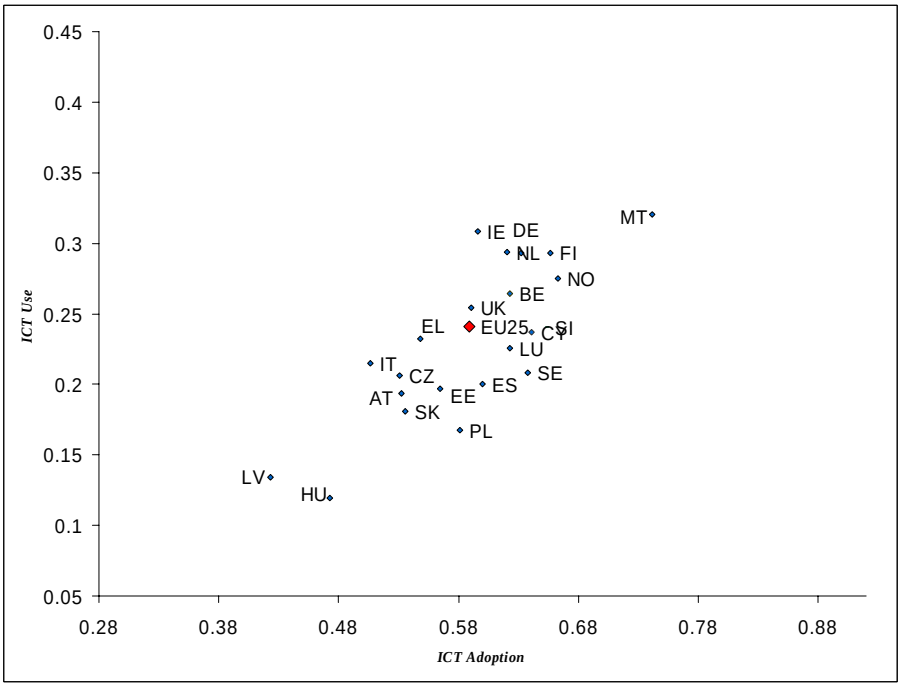

Figure 40. Transport, storage and communication sector (no data for BG,DK,FR,IS,RO and incomplete data set for PT)

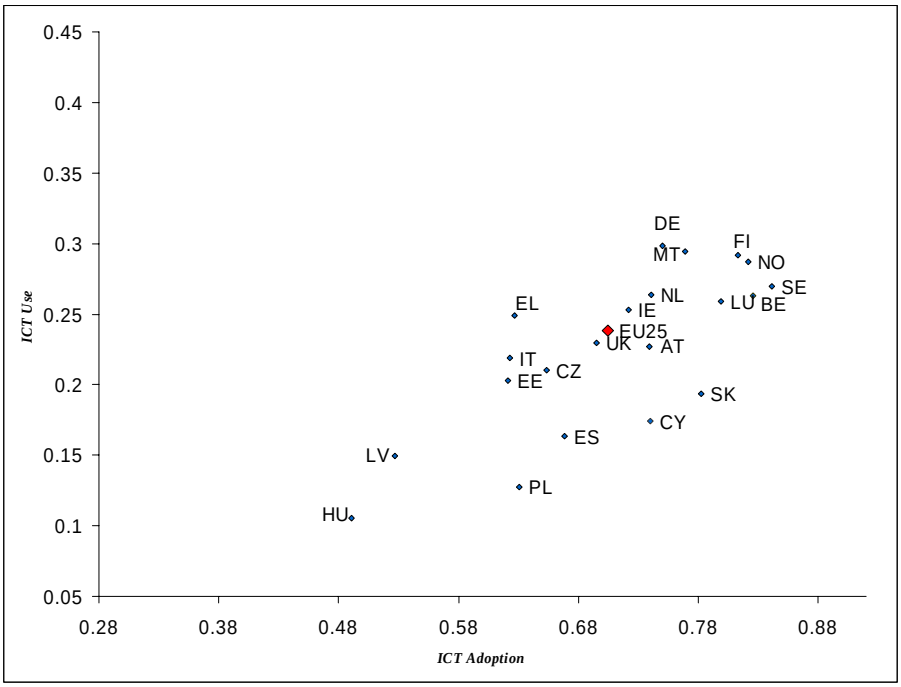

Figure 41. Real estate, Renting and Business activities sector (no data for BG,DK,FR, IS,RO and incomplete data set for PT,SI)

European Commission

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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 2006 European E-Business Readiness Index, evaluated using data from the 2005 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. General composite indicator results of 2005 data are compared with results from earlier years. Analyses include probability density estimates for scores, robustness analysis, and correlation and principal component analysis. Data quality and normalisation methodology are discussed and proposals for future development of the index are presented.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.