UNIVERSITY OF WUPPERTAL
BERGISCHE UNIVERSITÄT WUPPERTAL

EUROPÄISCHE WIRTSCHAFT
UND
INTERNATIONALE MAKROÖKONOMIK

Stanislaw Kubielas
Magdalena Olender-Skorek

ICT Modernization in Central and Eastern Europe

Diskussionsbeitrag 197
Discussion Paper 197

Europäische Wirtschaft und Internationale Wirtschaftsbeziehungen
European Economy and International Economic Relations
ISSN 1430-5445

Stanislaw Kubielas
Magdalena Olender-Skorek

ICT Modernization in Central and Eastern Europe

May 2014

Herausgeber/Editor: Prof. Dr. Paul J.J. Welfens, Jean Monnet Chair in European Economic Integration

EUROPÄISCHES INSTITUT FÜR INTERNATIONALE WIRTSCHAFTSBEZIEHUNGEN (EIIW)/
EUROPEAN INSTITUTE FOR INTERNATIONAL ECONOMIC RELATIONS
Bergische Universität Wuppertal, Campus Freudenberg, Rainer-Gruenter-Straße 21,
D-42119 Wuppertal, Germany
Tel.: (0)202 – 439 13 71
Fax: (0)202 – 439 13 77
E-mail: welfens@eiiw.uni-wuppertal.de
www.eiiw.eu

JEL classification: F14, F15, L63, L86, L96, N14, O31, O33, P27
Key words: Innovation, Telecommunication, EU, CEE, Convergence ICT, RCA in ICT Trade, Internet, Technology Gap, Knowledge Diffusion, Regulation

Summary: The paper characterizes main trends in ICT implementation and diffusion in the CEE countries in terms of market volume, its dynamics, economic development and ICT trade integration within the EU market. This gives support to the hypothesis of gradual closing up of technology gap in ICT sector between the CEE and the 'old' EU countries in the course of the ongoing process of integration and catching up. The second part of the paper delivers a detailed account of the modernization level achieved in Poland and other CEE countries in particular ICT segments and score rankings as against other EU countries. The focus is on the relationship between NRI index, as a measure of ICT development, and GDP per capita, competitiveness and productivity. Finally, the level of ICT services in CEE is assessed, in particular, in the area of broadband, mobile telecommunication, and e-services.

Zusammenfassung: Der vorliegende Beitrag charakterisiert wesentliche Trends im Bereich der IKT- Implementierung und – Diffusion in mittel- und osteuropäischen Ländern im Hinblick auf das Marktvolumen, dessen Dynamik, die ökonomische Entwicklung und die IKT-Handelsintegration im EU-Markt. Dies unterstützt die Hypothese der allmählichen Schließung von einer Technologielücke im IKT-Sektor zwischen den mittel- und osteuropäischen Ländern und den „alten" EU-Ländern im Rahmen des fortlaufenden Prozesses der Integration und des Aufholprozesses. Der zweite Teil des Beitrages liefert einen detaillierten Bericht über das Modernisierungsniveau, das in Polen und den anderen mittel- und osteuropäischen Ländern erreicht wurde. Der Schwerpunkt liegt dabei auf der Beziehung zwischen dem NRI – Index, als Indikator für die IKT-Entwicklung, und dem BIP pro Kopf, der Wettbewerbsfähigkeit sowie der Produktivität. Schließlich wird das Niveau der IKT – Services in den mittel- und osteuropäischen Ländern insbesondere im Bereich des Breitbandes, der mobilen Telekommunikation sowie der E-Services beurteilen.

Prof. Dr. Stanislaw Kubielas, University of Warsaw, Faculty of Economic Sciences,
Department of Macroeconomics and International Trade Theory,
Phone: +48 022 8313201, Fax: +48 022 8312846
kubielas@wne.uw.edu.pl

Dr. Magdalena Olender-Skorek, University of Warsaw, Faculty of Management,
Phone: +48 022 5534119
molender@mail.wz.uw.edu.pl

ICT Modernization in Central and Eastern Europe

Discussion Paper 197

Table of Contents

List of Figures

List of Tables

1. Introduction

Advanced information and communication technologies are at the heart of recent socio-economic development and transformation in both the industrialised and developing countries. This is because ICT is a typical general-purpose technology (GPT), similar to GPT examples of former technological paradigms like steam power, electricity, combustion engine etc. The structure of the recent paradigm is, however, more complicated as it is a combination or a fusion of two technological strands - information processing based on the inventions of microprocessor and computer, and information transmission based on telecommunication techniques which evolved from wire to wireless connections, from analogue to digital transmission and switches. Therefore, we can delineate two broad areas of ICT: information technology (IT), and telecommunication technology (TT). In each of these areas we further have two segments: hard equipment manufacturing, software production and operation services. It is then IT equipment manufacturing, and software production on one side, and provision of IT and software services, on the other side. In the telecom segment (TT), we can also distinguish between telecom equipment manufacturing and provision of telecom services by operators. We will follow these distinctions in the subsequent analysis.

As for a GPT technology, we are faced with a wide field for variety of applications. Apart from ICT producers there exists a large area of ICT users where we usually distinguish three institutional sectors – private individual households, enterprise sector, and government. Thus the spread of ICT will to a significant degree depend on the absorption capabilities and preferences of potential users that have to be considered while analysing the diffusion process. In the paper we also follow this classification of areas for diffusion.

Because most of the primary ICT inventions took place in advanced Western countries, and not in the CEE region, the dynamics of ICT implementation and digital modernization among the CEE countries may be analysed within a framework of the technology gap model. However, a simple application of the logistic (S-shaped) curve will probably fail here because the diffusion process in this particular area is much more complicated than was the case elsewhere and so far. What must be taken into account are in particular: strong network effects, high degree of complementarity between various developments and applications of information technology, endogenous absorption capacities (IT skills), lagged productivity and performance effect. There is one additional feature in diffusion process of ICT compared to the previous generations of GPTs. For the first time in history of technological revolutions, it is a sort of self-diffusing technology which creates the instruments for its own diffusion, unlike steam power, electricity or combustion engine, to take some examples of previous GPTs. This is due to a high modularity of ICT production process (and highly codified knowledge) enabling product fragmentation and a revolution in communications which enables fast self-driven spillover.

The CEE countries could obviously draw heavily from the advantage of their backwardness as predicted by Gerschenkron in other context. It was so much easier as the IT was featured by well codified knowledge, often embodied in relatively easy to assemble or to recombine modules. Thus the start up of assimilation process was soon launched in

the late eighties.[1] Since then, the ICT sector underwent successive stages of development and diffusion from automation of steering processes in industry, office information processing, to service sector applications (telecommunication, finance, distribution, transport, media and entertainment). Especially in the field of services technology diffusion usually takes longer time since absorption capacity demands building up a suitable institutional framework. Furthermore, the scope of proliferation of information technology in services (scale and network effects) is limited by the size of service sector in the economy. A relatively smaller and less developed share of the service sector in the CEE countries could have been a constraint for fast diffusion. Thus, we can imagine a digitalisation trajectory of the CEE region as a bunch of overlapping IT product cycles with widely differing diffusion parameters. Furthermore, country-specific effects of digitalisation trajectory can arise from different regulatory environments which have strong impact on the share of ICT in total investment spending.

2. The value and dynamics of ICT market in Central and Eastern Europe[2]

The size of the ICT market in the Central and Eastern Europe is relatively small as compared to the US or even the EU-25. According to the EITO data, it was expected in 2012 to be in the range of 47,3 billion euros, excluding Russia, and about 107 billion euros with Russia, while the EU-25 ICT market amounted to 677billion euros and the US market to 762 billion euros.[3] The CE market makes up around 7% of that of EU-25 (or US), or 16% when Russia is included. The latter constitutes about a half of the ICT market in the CEE. Without Russia, the largest CE market is Poland with its share of 36%, and then Czech Republic (17%), Hungary (12%), and Romania (12%). For assessment of relative sizes, it is useful to bear in mind other emerging economies like India with ICT market valued at 73 billion euros, Brazil at 96 billion euros, and China at 229 billion euros. Altogether the emerging world (BRIC plus CEE) covers for a world ICT market share of about 500 billion euros (of which 10% is CE) which is already comparable to the volumes of EU-25 and US.

Although emerging economies do not represent individually a big ICT market value, they grow much faster than ICT markets of advanced economies (Table 2). Emerging economies continued to drive the world growth in ICT sector despite an overall declining investment climate in the developed world. Compared to the growth rates above 10% in

[1] The diffusion of new technology was spectaculary fast in some CEE countries. For instance, Poland reached the degree of diffusion in the area of PC manufacturing such that indigenous firms were able to capture the major share of domestic market for PC clones as the only country in Europe at the time, in the second half of the nineties. See S. Kubielas (2000), p. 294.

[2] CEE term in our analysis covers eleven countries: Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Russian Federation, Slovak Republic, Slovenia, We sometimes use the term CE for Central Europe when excluding Russia from our statistics.

[3] The authors' calculations are based on the EITO data.

China or India, the ICT sector in the CE countries was expected, according to the EITO, to increase at a slower pace of about 3% in 2011, while the Russian ICT sector was still expected to rise by 9,5%. Taking a look at the growth rates of ICT markets over the period of 2005-2011 a visible slowdown may be noted due to a negative breakdown in the trend during the crisis year 2009. However, afterwards the rates recovered but in a moderate way, and sometimes did not return to the pre-crisis level. On the whole, the ICT sector in the CE recorded an increase of 35% for the entire period of 2005-20011, and with Russia an increase of 66%. Among the CE countries the fastest growing ICT sectors appeared to be in Russia (an increase of 108%), Slovakia (57%), Czech Republic (53%), and Bulgaria (45%). Poland recorded a moderate increase of around 30%, similar to Estonia or Slovenia. Within the period investigated, there could be noted an abrupt acceleration in the pre-crisis year 2007, and a common decline in the crisis year 2009. Thus the ICT investment was not balanced over time, but much dependent on the ups and downs along the business cycle. In particular a negative demand effect was seen during the crisis when ICT markets significantly shrank in all the countries under investigation.

Table 1: Total ICT market values in CEE, EU-25 and USA in Billion Euros

	2005	2006	2007	2008	2009	2010	2011*
Poland	12,625	13,678	15,907	16,394	15,573	15,931	16,345
Bulgaria	1,742	1,912	2,452	2,559	2,419	2,421	2,518
Czech R.	5,210	5,598	7,552	8,122	7,799	7,786	7,993
Estonia	0,769	0,862	1,044	1,083	0,968	0,982	1,014
Hungary	5,015	5,514	6,030	6,306	5,905	5,906	5,993
Latvia	0,790	0,890	1,108	1,145	1,026	1,058	1,110
Lithuania	0,823	0,899	2,118	1,223	1,045	1,030	1,041
Romania	4,276	5,203	5,920	5,885	5,441	5,262	5,465
Slovakia	2,230	2,440	3,344	3,495	3,344	3,360	3,509
Slovenia	1,305	1,389	1,809	1,880	1,754	1,689	1,743
Russia	25,601	29,933	38,102	45,207	41,32	48,714	53,342
EU-25	621,561	641,544	666,207	675,721	647,157	652,853	663,325
USA	600,861	627,944	628,427	692,956	678,008	704,963	726,785

Source: EITO Report 2011 * Forecast

Table 2: Annual growth rates of ICT sector in CEE, EU-25 and USA in per cent

	2006	2007	2008	2009	2010	2011*	Period
Poland	8,3	16,3	3,1	-5,0	2,3	2,6	29,5
Bulgaria	9,8	28,2	4,4	-5,5	0,1	4,0	44,5
Czech R.	7,4	34,9	7,5	-4,0	-0,2	2,7	53,4
Estonia	12,1	21,1	3,7	-10,6	1,4	3,3	31,9
Hungary	10,0	9,4	4,6	-6,4	0,0	1,5	19,5
Latvia	12,7	24,5	3,3	-10,4	3,1	4,9	40,5
Lithuania	9,2	135,6	-42,3	-14,6	-1,4	1,1	26,5
Romania	21,7	13,8	-0,6	-7,5	-3,3	3,9	27,8
Slovakia	9,4	37,0	4,5	-4,3	0,5	4,4	57,4
Slovenia	6,4	30,2	3,9	-6,7	-3,7	3,2	33,6
Russia	16,9	27,3	18,6	-8,6	17,9	9,5	108,4
EU-25	3,2	3,8	1,4	-4,2	0,9	1,6	6,7
USA	4,5	0,1	10,3	-2,2	4,0	3,1	21,0

Source: EITO Report 2011 * Forecast

Table 3: ICT per head in CEE, EU-25 and USA in Euro

	2005	2006	2007	2008	2009	2010	2011*
Poland	331	358	417	430	409	418	428
Bulgaria	224	248	319	335	318	320	336
Czech R.	510	546	734	782	745	741	759
Estonia	571	641	778	808	722	733	757
Hungary	497	547	599	628	589	590	600
Latvia	343	388	486	504	454	471	498
Lithuania	240	264	626	363	312	309	321
Romania	197	241	275	273	253	245	255
Slovakia	414	453	620	647	618	619	646
Slovenia	653	693	900	935	863	825	850
Russia	178	210	268	318	291	343	373
EU-25	1346	1383	1429	1442	1375	1383	1401
USA	2028	2100	2081	2273	2205	2299	2352

Source: EITO Report 2011 * Forecast

Table 4: ICI as a percentage of GDP (PPP) in CEE, EU-25 and USA

	2005	2006	2007	2008	2009	2010	2011*
Poland	2,9	2,9	3,1	3,1	2,9	2,7	2,8
Bulgaria	2,7	2,8	3,2	3,1	3,1	3,0	3,2
Czech R.	2,9	2,9	3,5	3,7	3,7	3,7	3,8
Estonia	4,1	4,1	4,4	4,7	4,8	4,7	4,8
Hungary	3,5	3,7	3,9	3,9	3,9	3,8	3,9
Latvia	3,2	3,2	3,5	3,6	3,7	3,7	4,0
Lithuania	2,0	2,0	4,2	2,4	2,4	2,2	2,3
Romania	2,5	2,6	2,6	2,3	2,3	2,2	2,3
Slovakia	3,1	3,0	3,7	3,6	3,6	3,4	3,6
Slovenia	3,3	3,3	4,1	4,1	4,2	3,9	4,1
EU-25	5,8	5,6	5,5	5,6	5,7	5,5	5,5
USA	5,7	5,8	5,5	6,2	6,4	6,2	6,3

Source: Own calculation based on EITO Report 2011, and EUROSTAT * Forecast

In terms of ICT market value per head, the CEE countries were very dispersed at the beginning of the period and remained so (Table 3). In 2005 the spread of the dispersion between the highest level, 653 euros in Slovenia, and the lowest, 178 euros in Russia, was 3,66, which did not change much in 2011, i.e. was slightly reduced to 3,33, between the level of 850 euros in Slovenia and that of 321 euros in Lithuania. Comparing to the levels in USA (2352 euros) or EU-25 (1400 euros) the CEE countries are lagging far behind. It is worth of noting that the dispersion among the countries is not that large if we take a look at the ratio of ICT to GDP (Table 4). The ratio of the country with the highest share of ICT in GDP, 4,8% in Estonia, to that with the lowest share, 2,3% in Lithuania and Romania, is slightly above 2. The ratios did not change much over the period, so the spread remained stable. This means that although the level of ICT expenditures rose significantly over time and a wide initial dispersion in levels across the countries was just only slightly reduced, their ICT/GDP ratio remained remarkably stable and much less differentiated. However, the indicator at the end of the period was considerably below that for USA (6,3%) or EU-25 (5,5%).

Thus, summing up the above statistical overview, we can conclude with some preliminary hypotheses, as follows:

1. ICT sector grew in the CEE countries in 2005-20011 considerably, but at different rates across individual economies; if we pool them with US and EU-25, and take the initial level of GDP per head (2005) as a discriminating factor, it can be seen that in general the countries with higher initial GDP per head ratio recorded slower rates of growth for their ICT; a sort of structural convergence in terms of ICT sector sizes relative to GDP per head (Fig. 1).
2. If we compare the initial nominal level of ICT per head with the subsequent growth within the entire period for the same sample as above, we can again note an inverse relationship: a higher ICT per head at the outset corresponds to a lower ICT growth rate over the period (Fig. 2). This suggest a sort of retardation process evolving as

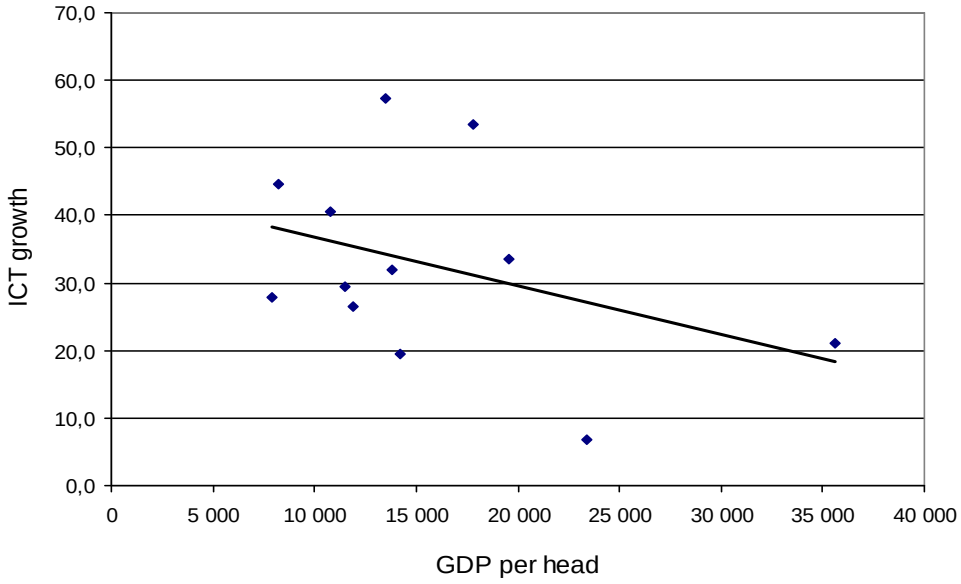
the ICT intensity per head increases during the ICT diffusion; consistent with the diffusion theory of the product life cycle.

3. Finally, comparing ICT shares in GDP with period-averaged GDP growth rates, we can find that the latter are inversely correlated with the ICT/GDP ratio (Fig. 3). This finding may be surprising as it might suggest that ICT input works counter-productive for economic growth.[4] However, after having disentangled this black box of plausible interrelationships, it can be argued that at low levels of GDP and ICT per head we observe higher rates of ICT increases, but also higher GDP growth rates following convergence and marginal productivity theories. At higher levels of GDP and ICT per head the rate of growth of ICT intensity is decreasing, but as ICT shares in GDP get higher and higher its productivity is leveling off as other sources of TFP are being exhausted. Therefore we can not find directly any positive impact of higher ICT proportion in GDP on its growth rate as we could not find similar relationship for capital intensity. Furthermore what is striking is a relative stability of that proportion over time that was observed in our sample of the CEE countries.

A partial solution to this puzzle can be reached by a more detailed analysis of ICT impact on productivity. A pioneer study on this issue covering the CEE countries was carried out by B. van Ark and M. Piatkowski (2004) who found that the contribution of ICT capital to growth of labour productivity was quite different in old and new EU member countries.[5] While generally annual growth rates of labour productivity (measured as GDP per person employed) are significantly higher in the catching up CEE countries that in the old Europe and even the ICT contribution to growth rates is slightly exceeding that in the western Europe, the relative ICT capital share in labour productivity growth in the CEE countries are much smaller than in the old EU members. It is simply because the TFP share is more powerful factor for labour productivity increase in the catching up CEE countries. Thus the contribution of ICT capital increases in rising productivity levels, but they rise at a decreasing rate. Hence declining productivity growth rates may correspond to increasing ICT input to GDP. This may then be a partial explanation for our puzzle.

[4] This may sound as even a stronger supposition than the Solow's paradox on ICT productivity.
[5] See B. van Ark and M. Piatkowski, (2004), p. 225.

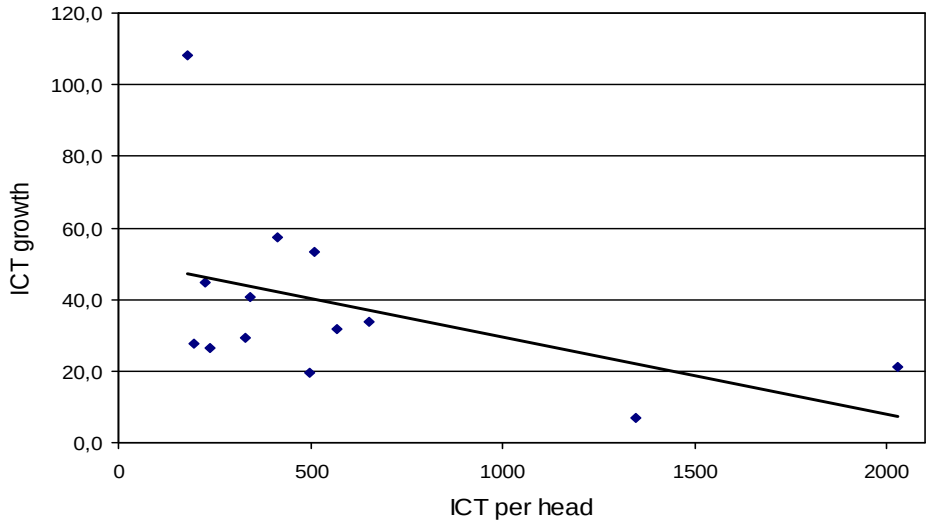
Figure 1: GDP/head (PPP EUR) in 2005 vs ICT growth (%) in 2005-2011



Source: Own calculation based on EITO Report 2011, and EUROSTAT

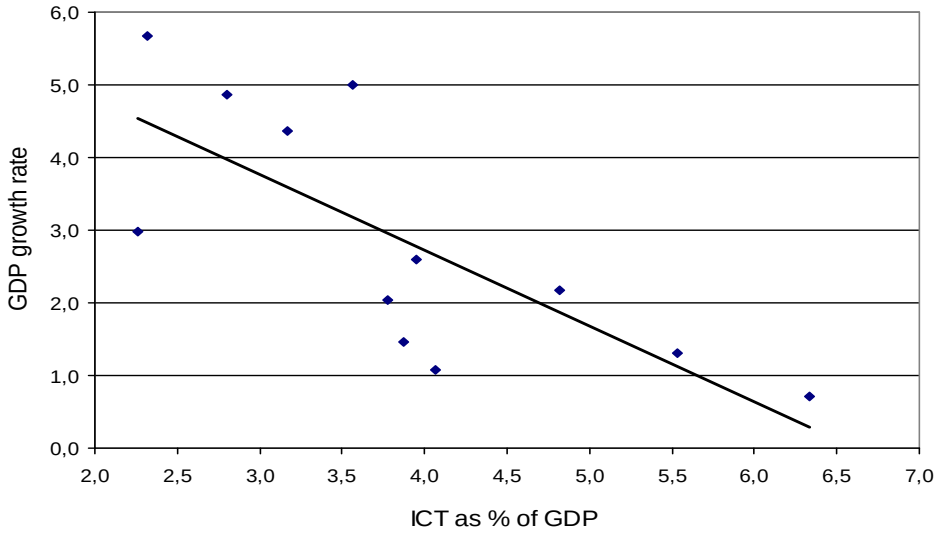
Another interesting observation that can be read from the data relates to the IT and TT shares in ICT total across countries and over time. There is a general correlation that countries with lower GDP per head and ICT per head show higher share of telecommunication in the whole ICT market and as they evolve over time their IT share, and in particular IT services, in ICT market value increases at the expense of telecommunication segment. It is then that economies with more mature and advanced ICT sector indicate higher proportion of IT, and especially IT services, in the whole ICT market value, and vice versa. This effect may be caused by the overlapping of various production cycles within the same family of related technologies, in particular arising from intertwining of technology development and diffusion trajectories of various related ICT products /hardware and software with differentiated application scope and scale/.

Figure 2: ICT/head in EUR in 2005 vs ICT growth (%) in 2005-2011



Source: Own calculation based on EITO Report 2011, and EUROSTAT

Figure 3: ICT as per cent of GDP in 2011 vs annual average GDP growth (%) in 2005-2011



Source: Own calculation based on EITO Report 2011, and EUROSTAT

3. ICT trade integration between CEE and EU

An analysis of the trade pattern in ICT goods between the CEE countries and the old EU countries can be reasonably framed within the technology gap theory with reference to product cycle model, or even the *flying geese* concept of Akamadsu (1956). IT revolution took off in the advanced economies and then spread to the CEE countries following a

technology gap spillover dynamics determined by technology gap size and absorption capabilities of catching up countries. The technology gap between the old EU and the CEE countries has increased immensely in the area of IT technology over the eighties when the IT revolution gained momentum in the world and the CEE countries remained relatively closed to world trade and foreign investment. The opening up at the beginning of the nineties created favourable conditions for spillover of ICT innovations, but the levels of absorption capabilities varied across the region and were different for various innovative products characteristics (knowledge- or scale-intensity, standardization-maturity). However, the diffusion in ICT sector was much facilitated by product cycle fragmentation and decreasing transaction costs of production relocation due to the advances in ICT technology. Therefore, spillover processes often followed the trajectory of a product cycle model in the sense that production of innovations originally introduced in the technology frontier countries (old EU) has been subsequently relocated to catching up countries (new EU) via outsourcing, foreign direct investment or strategic alliances. This had the result accurately described by Akamadsu as a *flying geese* phenomenon. From the perspective of catching up country the diffusion used to start up from importing innovative products, whereas after having learnt the imported technology the imitator did set up its own manufacturing of imitated product primarily for sale onto the local market, and finally for export to the countries where it was originally introduced. The process is being observed in changing trade patterns between technology frontier and catching up countries, and especially in changing countries' revealed comparative advantages in ICT exports which we can investigate by using RCA indices defined by Balassa (1965).

Our analysis covers trade in ICT goods between the eleven CEE countries (Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Russian Federation, Slovak Republic, Slovenia) and the EU-27 in the years 1996-2010. The data used is based on 3-digit SITC rev.3 product classification from the WITS database[6]. We have defined ICT products according to Dunnewijk and Meijers (2008) as:[7]

- Office machines and automatic data-processing machines (SITC 75),
- Telecommunication, sound-recording/reproducing apparatus, and equipment (SITC 76),
- Electrical machinery, apparatus, appliances and electrical parts thereof (SITC 77),
- Professional, scientific and controlling instruments and apparatus (SITC 87),
- Photographic apparatus, equipment and supplies, optical goods, watches and clocks (SITC 88).

The selected range of products classified as ICT is rather broad and could be further split to more homogenous categories. As suggested by Welfens and Vogelsang (2008) ICT products differ in knowledge-intensity and scale-intensity.[8] These features might be crucial

[6] https://wits.worldbank.org/WITS World Integrated Trade Solutions compiled by Eurostat, UNCTAD, WTO.

[7] T. Dunnewejk, H. Meijers, Chapter III. Empirical Analysis of the Competitive Trade Position, in H. Meijers, B. Dachs, P.J.J. Welfens (eds.), *Internationalisation of European ICT Activities. Dynamics of Information and Communications Technology*, Springer-Verlag, Berlin Heidelberg 2008, p. 85, and 263-264. This classification includes electronic household equipment which is often not covered by a narrow ICT goods definition.

[8] P.J.J. Welfens and M. Vogelsang, ibidem, p. 13-15.

in terms of diffusion and absorption conditions as high knowledge-intensity requires high human capital in host country for effective technology adoption, and high scale-intensity raises the importance of comparative unit cost advantages and scale effects. Along these two axes we can distinguish four product groups: innovative scale intensive (knowledge and scale intensive), traditional scale intensive (knowledge extensive and scale intensive), traditional niche products (low knowledge and scale intensity), innovative niche products (high knowledge but low scale intensity). At the disaggregated 3-digit level it might be possible to assign particular products to specific knowledge or scale intensity classes, but without doing so formally we shall only confine ourselves to an intuitive assessment when analyzing the results. Secondly, we will focus our analysis on proportions instead of absolute values in order to avoid the problem of deflators, and since we are interested in ICT sector integration within the EU we will concentrate on the intra-EU trade only.

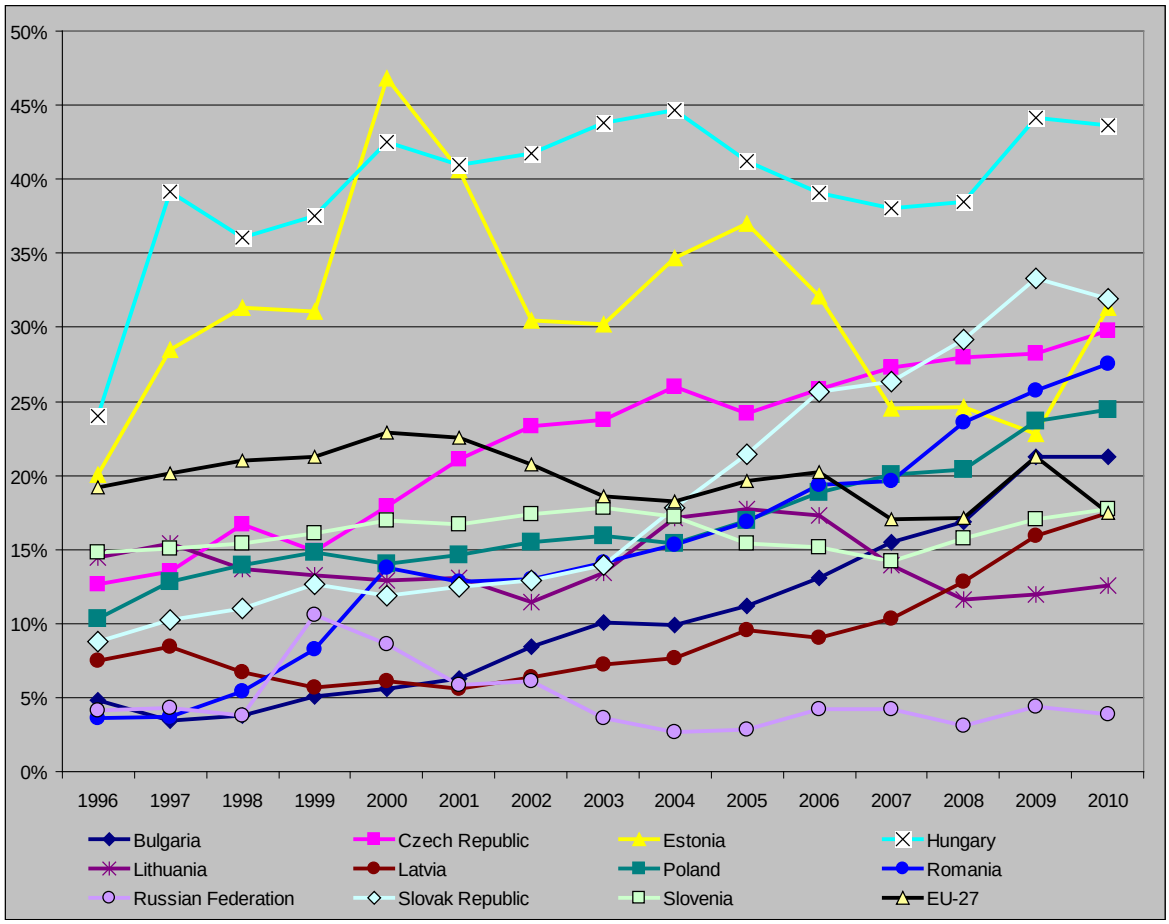
The value of the ICT exports to the EU-27 of the eleven CEE countries under consideration was in the range of 7 billion dollars in 1996 and rose to about 108 billion dollars in 2010, while the total intra-EU-27 ICT exports increased in the same period from 215 billion dollars to 418 billion dollars. This is that as the EU-27 exports of ICT goods only doubled the ICT exports of the CEEC multiplied by a factor of 15, though from a very low base level. But export shares were not evenly distributed across the CEE countries. Three largest exporters were Hungary (24% share in 2010), Czech Republic (26%) and Poland (22%). Between 1997 and 2004, prior to the EU accession, Hungary's exports reached temporarily even 40% share of the total CEE exports of ITC. Czech exports share was more or less stable while Poland increased its share visibly after the EU accession. Apart from these countries only Slovak Republic (14%) and Romania (7,5%) enjoyed a meaningful export position since other countries' shares either did not exceed 2%, or declined to around that level like Estonia, despite of manufacturing exports heavily concentrated on ICT, or Slovenia.

Looking at the ICT share in country's total manufacturing exports in the last 15 years we can immediately note a significant difference between old and new members of the EU.[9] As Fig. 4 shows the share of ICT exports in total manufacturing exports in the old Europe remained more or less stable at around 20%, while the same ratio in the CEE countries increased from a level much below that in the old EU countries to that above it in some cases or close to in others. With the exception of early leaders Hungary and Estonia, with 30-40 % shares, in most of the CEEC at the beginning of the period the ratio was between about 4% in Romania, Russia or Bulgaria and 14% in Slovenia or Lithuania. Shortly before the EU accession Czech Republic passed the ICT level of EU exports followed by Slovak Republic, with Poland and Romania catching up later on. Only Russia and Lithuania stayed with low ICT intensity of exports unchanged. The picture becomes even more clear when we take the ratio of exports to imports in ICT products. Here again, all the CEEC except for Hungary and Slovenia exhibited deficits (the ratio below 50%) at the beginning of the period. The situation dramatically changed after the accession for Slovak Republic, Czech Republic and Poland as the value of their exports of ICT goods grew to exceed twice that of their imports by now, while the position of Romania and Bulgaria also

[9] We take manufacturing exports as a benchmark because ICT products are basically manufactures and we want to leave aside the problems of sectoral composition of various economies with different natural resource endowments as determinants for development of agriculture and extracting industries.

slightly improved. It should be stressed that the upward trend of the ratio was primarily brought about by increases in exports because the share of ICT imports in total manufacturing imports did not change much, showing hardly a moderate upward drift in some countries. However, in both cross-sections an apparent convergence tendency in ICT-export intensity could have been remarked.

Figure 4: ICT share in total manufacturing exports of CEEC in 1996-2010



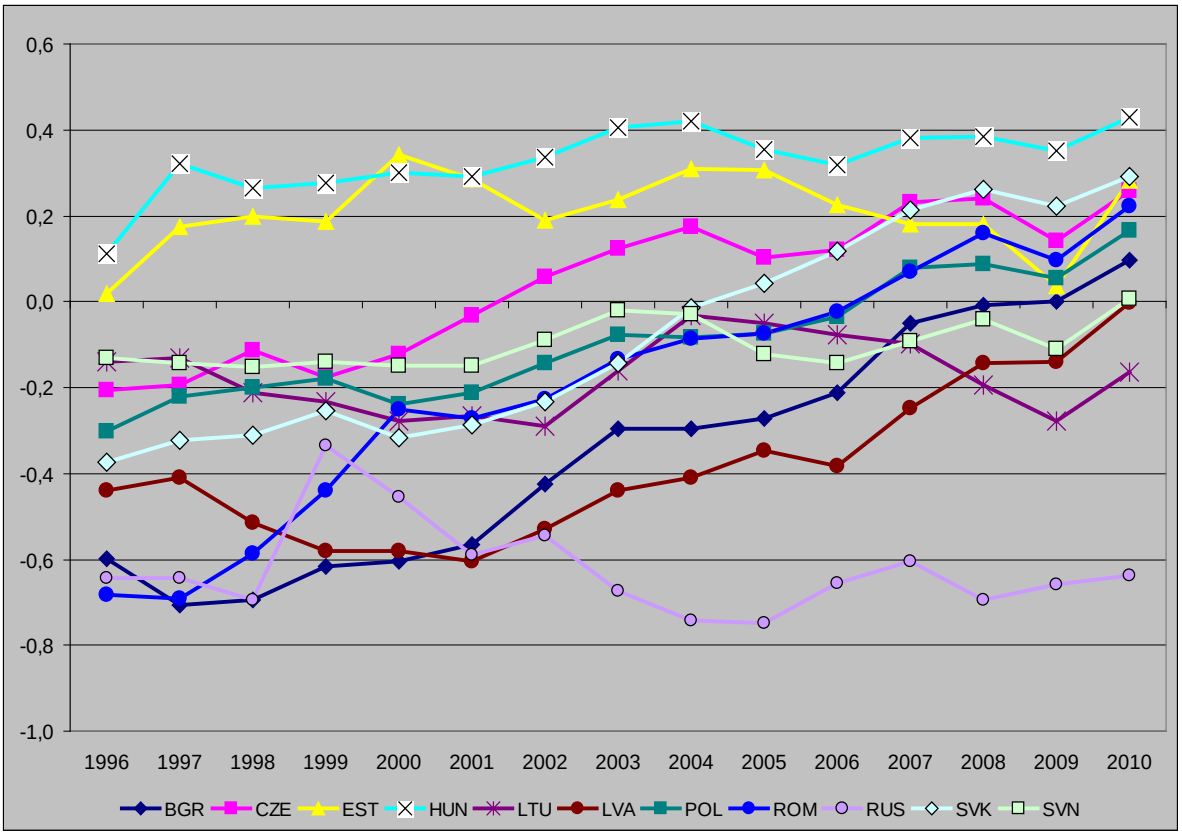
Source: Own calculation based on WITS database.

For evaluation of specialization trends we apply the Balassa's revealed comparative advantage index RCA calculated in a symmetric form which take values in the range +/-1. In our application the indicator shows the ratio of the share of ICT exports in total manufacturing exports of a country in question to the same measure for the benchmark which in our analysis is the EU-27 ICT export share in total manufacturing exports. This benchmark is quite comfortable because ICT-export intensity of the EU-27 did not change much over the investigated period; so it is well-suited as a measuring device.

Fig. 5 shows the evolution of aggregate ICT RCA indices for individual CEE countries which generally increased over time, especially for the countries lagging behind at the beginning of the period (another confirmation of convergence hypothesis). It can also be noted that almost all the CEE countries except for Hungary and Estonia had negative RCA until the EU accession in 2004, only Czech Republic managed to switch from negative to

positive RCA as early as in 2002. But finally, at the end of the period, there were left only three CEE countries with negative RCA - Lithuania, Latvia and Russia, with Hungary still at the top but being caught up by Czech and Slovak Republics, and further on also by Poland and Romania. Surprisingly, Estonia has lost a large part of its initial comparative advantage almost approaching zero in 2009. Also, in the evolution of aggregate ICT RCA indices we can observe a convergence among the CEE economies; only the Russian Federation continued to fall behind. In general, a switchover of comparative advantages from negative into positive means that some CEE countries began to export more ICT products in proportion to their total manufacturing exports than the old EU which signifies that the production of some ICT products might have been relocated from the old EU to new member countries. The question is which ones?

Figure 5: Revealed Comparative Advantages of ICT sector in CEEC in 1996-2010



Source: Own calculation based on WITS database.

In the subsector of computers (SITC 75) only two countries have displayed a positive comparative advantage, Hungary from the very beginning, but has lost it at the end of the period, and Czech Republic which achieved that position in the middle of the period and still continued to improve it later on; finally, in the last year, Poland joined the club of countries with positive RCA in computers industry. Other countries though actually upgraded their competitive positions, in particular after the EU accession, did not reach positive levels of RCA. Only Russia and Bulgaria lagged completely behind without any improvement, and Estonia dramatically declined almost to the bottom from its initially

positive position. In this subsector we could not notice any convergence, but rather divergence ensuing from possible differences in absorptive capabilities and different market scale effects.

In the telecom subsector (SITC 76) we have a much wider spread of comparative advantages across the countries under consideration. Hungary and Estonia hold top positions with positive RCA all time, and are being caught up with soon after the EU accession by Slovakia, Czech Republic and Poland. However, the spread of comparative advantages remained quite large all time, and despite some average improvement across the group four countries were left with negative RCA until the end of the period – Lithuania, Slovenia, Russia and Bulgaria. Nonetheless, an overall upgrading of comparative advantage of the CEE countries in telecom equipment exports was more impressive than in the field of computers.

The best average comparative position of the CEE economies appears to reside in the subsector of electrical and electronic equipment (SITC 77). We can see here both visible improvement, convergence and positive RCA in most of the countries after the accession. Only Russia and Latvia remained disadvantaged all time, and Lithuania surprisingly lost competitiveness after the accession. It might be that technology transfer was easier in this sector due to a higher degree of standardization especially in consumer electronics, and electrical appliances. This is why the companies from the CEE countries soon assimilated sufficient technological knowledge to be able to supply advanced western European markets with products of acceptable quality.

In the area of instruments (SITC 87), the prevailing RCA pattern is negative all time, though generally improving, but only two countries, Hungary and Bulgaria, noted a continued definite trend upward and attained positive levels of RCA finally. This was mainly due to their specialization in measuring and controlling instruments (SITC 874), and also medical instrument (SITC 872) in Hungary. There were as well registered some temporary erratic upward jumps in Russia and Lithuania, but without any definite trend. Estonia and Slovenia crawled around zero with minor upward and downward deviations. This distribution of specialization may be typical for knowledge intensive niche industries which seems exactly to be the case.

The trend in photo-optical goods was rather horizontal, but in similarly negative RCA values with some minor improvements in Czech Republic or Slovenia. The only country that achieved positive RCA index through a systematic upward climbing was Bulgaria. This is also a knowledge intensive niche industry and Bulgaria exhibited a systematic specialization in photographic and cinematographic supplies (SITC 882), possibly through subcontracting agreements.

The share of ICT imports in total manufacturing imports of CEE countries did not change in aggregate, but some structural changes were visible. Computer imports share was declining and that of telecom equipment increasing, as well as electrical equipment imports in some countries. General increase of aggregate ICT share in manufacturing imports could be noted only in Bulgaria, Hungary, Romania, Slovak Republic. A relatively stable ICT import share in CEE manufacturing imports was paralleled by a similarly stable share of ICT exports in total manufacturing exports of the old Europe.

Some structural and volume changes in ICT exports could have been remarked rather in the CEE countries, while in the old EU members the export proportions between computers, telecom and electrical equipment remained more stable and balanced, with only a slightly declining share of computers, and an increasing telecom equipment. On the contrary, in the CEE area we were faced with increases both in value and share of ICT in total manufacturing exports, which over time tended to exceed imports in most of the CEEC, especially after the accession. In the whole EU the specialization pattern was more balanced across subsectors, while the CEE countries concentrated more and more on specific niches. In particular, larger economies tended to specialize both in knowledge intensive and scale intensive ICT subsectors like computers, what was the case in Hungary, Czech Republic and finally Poland which exhibited positive RCA in the subsector. Medium sized CEE economies with sufficient absorption capabilities like Slovakia and Estonia joined the group of larger economies in telecom equipment exports, followed by other small economies attempting to catch up. RCA indices improved in that sector with less important economies of scale, but the differentiation of comparative advantages across countries remained quite large. The greatest average progress in RCA was attained in the subsector of electrical appliances where high rate of convergence signifies easy technology transfer, perhaps because of relatively less knowledge intensity, and this subsector usually took the largest and fastest growing share in ICT exports of the CEE countries. Finally, in the other two niche subsectors (instruments and photo-optical goods) with differing knowledge intensity, specialization improvement was incidental and negative RCA prevailed.

On the whole, we may presume that the CEE economies took over some products more matured in the perspective of product cycle and supplied them back to the more advanced EU economies. The process was intensified through the EU enlargement and extension of the common market. To test this *flying geese* model we pooled the data series on ICT exports/imports, ICT/head, and ICT/GDP ratios and found a positive and significant correlation between both ICT exports/imports ratio, on one side, and either ICT/head or ICT/GDP ratios, on the other side. In both cases the correlation found was more than 50% being slightly stronger regarding the former relationship (ICT/head).

Table 5: RCA indices of ICT subsectors in CEEC in 1996-2010

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
								Computers SITC 75							
BGR	-0,884	-0,950	-0,965	-0,934	-0,885	-0,893	-0,820	-0,775	-0,814	-0,776	-0,751	-0,796	-0,805	-0,797	-0,712
CZE	-0,601	-0,681	-0,580	-0,645	-0,508	-0,266	0,230	0,168	0,166	0,191	0,302	0,363	0,389	0,386	0,447
EST	0,125	-0,339	-0,625	-0,748	-0,842	-0,860	-0,849	-0,806	-0,874	-0,863	-0,763	-0,511	-0,571	-0,693	-0,762
HUN	-0,817	0,370	0,294	0,336	0,347	0,166	0,183	0,236	0,193	0,141	0,099	0,174	0,132	-0,013	-0,107
LTU	-0,828	-0,775	-0,786	-0,824	-0,793	-0,758	-0,785	-0,752	-0,532	-0,279	-0,206	-0,246	-0,340	-0,532	-0,469
LVA	-0,753	-0,677	-0,741	-0,834	-0,821	-0,736	-0,702	-0,720	-0,695	-0,506	-0,505	-0,202	-0,246	-0,089	-0,122
POL	-0,866	-0,913	-0,881	-0,873	-0,882	-0,907	-0,882	-0,892	-0,853	-0,829	-0,834	-0,700	-0,277	-0,027	0,027
ROM	-0,984	-0,991	-0,954	-0,521	-0,516	-0,717	-0,930	-0,824	-0,878	-0,760	-0,541	-0,503	-0,190	-0,542	-0,512
RUS	-0,873	-0,877	-0,867	-0,799	-0,904	-0,972	-0,931	-0,901	-0,916	-0,929	-0,922	-0,889	-0,870	-0,783	-0,867
SVK	-0,930	-0,861	-0,708	-0,553	-0,678	-0,745	-0,725	-0,483	-0,225	-0,121	-0,242	-0,382	-0,312	-0,423	-0,413
SVN	-0,947	-0,957	-0,944	-0,934	-0,927	-0,915	-0,902	-0,876	-0,855	-0,882	-0,815	-0,762	-0,390	-0,392	-0,476
								Telecom SITC 76							
BGR	-0,849	-0,849	-0,896	-0,854	-0,854	-0,802	-0,679	-0,546	-0,729	-0,713	-0,782	-0,457	-0,281	-0,014	-0,186
CZE	-0,542	-0,591	-0,502	-0,607	-0,421	-0,112	-0,203	-0,070	0,092	-0,067	-0,138	0,214	0,289	0,251	0,239
EST	0,384	0,682	0,685	0,655	0,747	0,724	0,616	0,653	0,710	0,699	0,521	0,383	0,395	0,313	0,564
HUN	0,082	0,464	0,438	0,395	0,415	0,510	0,582	0,640	0,678	0,599	0,464	0,580	0,615	0,688	0,681
LTU	-0,147	-0,086	-0,384	-0,424	-0,507	-0,536	-0,434	-0,322	0,003	-0,018	-0,099	-0,054	-0,194	-0,035	-0,008
LVA	-0,571	-0,664	-0,787	-0,775	-0,813	-0,697	-0,701	-0,650	-0,610	-0,455	-0,590	-0,185	0,199	0,268	0,323
POL	-0,282	0,013	0,016	-0,047	-0,160	-0,049	0,009	0,029	-0,029	0,005	0,035	0,278	0,315	0,366	0,363
ROM	-0,887	-0,955	-0,817	-0,743	-0,035	-0,132	-0,201	-0,129	-0,159	-0,396	-0,570	-0,518	-0,180	0,246	0,313
RUS	-0,627	-0,665	-0,779	-0,658	-0,849	-0,870	-0,831	-0,867	-0,893	-0,900	-0,540	-0,583	-0,902	-0,756	-0,835
SVK	-0,385	-0,244	-0,327	-0,421	-0,498	-0,341	-0,384	-0,396	-0,135	0,192	0,363	0,583	0,644	0,678	0,656
SVN	-0,550	-0,581	-0,707	-0,741	-0,683	-0,732	-0,683	-0,693	-0,835	-0,860	-0,852	-0,847	-0,765	-0,667	-0,632
								Electrical SITC 77							
BGR	-0,378	-0,541	-0,527	-0,416	-0,392	-0,346	-0,177	-0,021	0,039	0,033	0,128	0,222	0,228	0,153	0,356
CZE	0,056	0,123	0,199	0,176	0,207	0,172	0,133	0,243	0,298	0,201	0,220	0,243	0,215	0,038	0,253
EST	-0,269	-0,153	-0,171	-0,122	-0,173	-0,178	-0,024	0,046	0,034	0,064	0,213	0,308	0,281	0,099	0,321
HUN	0,388	0,331	0,251	0,269	0,284	0,263	0,261	0,344	0,313	0,288	0,335	0,338	0,315	0,157	0,339
LTU	0,147	0,157	0,104	0,107	0,066	0,054	-0,014	0,132	0,193	0,082	0,039	-0,041	-0,168	-0,416	-0,214
LVA	-0,198	-0,128	-0,278	-0,424	-0,437	-0,481	-0,356	-0,238	-0,201	-0,219	-0,155	-0,259	-0,301	-0,392	-0,190
POL	-0,025	0,033	0,038	0,104	0,062	0,042	0,108	0,200	0,205	0,182	0,232	0,261	0,169	0,004	0,203
ROM	-0,431	-0,415	-0,290	-0,186	-0,137	-0,070	0,082	0,180	0,264	0,291	0,390	0,428	0,427	0,252	0,424
RUS	-0,606	-0,621	-0,653	-0,141	-0,307	-0,489	-0,408	-0,556	-0,591	-0,627	-0,649	-0,556	-0,589	-0,633	-0,542
SVK	-0,121	-0,056	-0,053	0,039	0,013	0,003	0,082	0,162	0,234	0,144	0,137	0,099	0,058	-0,098	0,109
SVN	0,160	0,184	0,195	0,231	0,240	0,222	0,279	0,341	0,353	0,246	0,265	0,270	0,243	0,121	0,327
								Instruments SITC 87							
BGR	-0,630	-0,653	-0,540	-0,484	-0,560	-0,462	-0,401	-0,289	-0,270	-0,177	0,060	0,180	0,159	0,001	0,148
CZE	-0,237	-0,287	-0,216	-0,303	-0,318	-0,246	-0,293	-0,149	-0,108	-0,228	-0,222	-0,188	-0,225	-0,342	-0,276
EST	-0,221	-0,221	0,028	-0,002	-0,010	-0,138	-0,042	0,038	0,030	-0,079	-0,085	-0,024	0,037	-0,125	0,005
HUN	-0,100	-0,363	-0,416	-0,432	-0,348	-0,189	-0,135	0,026	0,069	0,101	0,206	0,318	0,283	0,137	0,300
LTU	-0,473	-0,413	-0,278	-0,282	-0,262	-0,211	-0,206	-0,090	-0,110	-0,156	-0,129	-0,026	0,023	-0,019	0,064
LVA	-0,656	-0,652	-0,495	-0,225	-0,129	-0,543	-0,456	-0,225	-0,206	-0,269	-0,595	-0,665	-0,628	-0,590	-0,330
POL	-0,504	-0,563	-0,577	-0,518	-0,571	-0,554	-0,548	-0,387	-0,343	-0,370	-0,386	-0,372	-0,387	-0,516	-0,369
ROM	-0,777	-0,768	-0,693	-0,749	-0,744	-0,670	-0,686	-0,671	-0,577	-0,480	-0,453	-0,359	-0,258	-0,302	-0,184
RUS	-0,376	-0,340	-0,319	0,204	0,257	0,115	0,054	-0,284	-0,599	-0,547	-0,492	-0,335	-0,432	-0,426	-0,280
SVK	-0,340	-0,477	-0,509	-0,539	-0,557	-0,473	-0,432	-0,414	-0,444	-0,521	-0,492	-0,454	-0,429	-0,509	-0,408
SVN	0,110	0,021	0,056	0,075	0,009	0,035	0,032	0,100	0,067	0,014	-0,008	-0,063	-0,059	-0,191	-0,121
								Photo-optical SITC 88							
BGR	-0,522	-0,517	-0,410	-0,154	-0,074	-0,161	-0,006	0,003	-0,028	-0,077	0,123	0,148	0,063	0,120	0,112
CZE	-0,318	-0,316	-0,266	-0,346	-0,343	-0,358	-0,424	-0,264	-0,335	-0,140	-0,255	-0,273	-0,234	-0,168	-0,117
EST	-0,772	-0,793	-0,864	-0,824	-0,813	-0,856	-0,891	-0,869	-0,928	-0,935	-0,830	-0,862	-0,834	-0,830	-0,707
HUN	-0,361	-0,638	-0,634	-0,519	-0,369	-0,220	-0,212	-0,260	-0,379	-0,638	-0,651	-0,692	-0,629	-0,650	-0,564
LTU	-0,382	-0,545	-0,668	-0,686	-0,746	-0,657	-0,657	-0,644	-0,586	-0,400	-0,336	-0,552	-0,567	-0,581	-0,500
LVA	-0,638	-0,760	-0,716	-0,607	-0,597	-0,589	-0,554	-0,541	-0,555	-0,382	-0,203	-0,037	-0,218	-0,500	-0,256
POL	-0,829	-0,713	-0,762	-0,820	-0,862	-0,862	-0,860	-0,786	-0,637	-0,627	-0,582	-0,626	-0,683	-0,664	-0,583
ROM	-0,862	-0,788	-0,735	-0,782	-0,717	-0,554	-0,641	-0,615	-0,655	-0,763	-0,722	-0,838	-0,856	-0,885	-0,765
RUS	-0,507	-0,328	-0,598	-0,506	-0,601	-0,744	-0,682	-0,648	-0,727	-0,662	-0,730	-0,579	-0,756	-0,804	-0,800
SVK	-0,799	-0,848	-0,904	-0,894	-0,931	-0,946	-0,897	-0,821	-0,687	-0,616	-0,684	-0,564	-0,718	-0,665	-0,709
SVN	-0,182	-0,138	-0,259	-0,148	-0,144	-0,199	-0,121	-0,024	0,028	-0,085	-0,001	-0,020	0,048	-0,140	-0,005

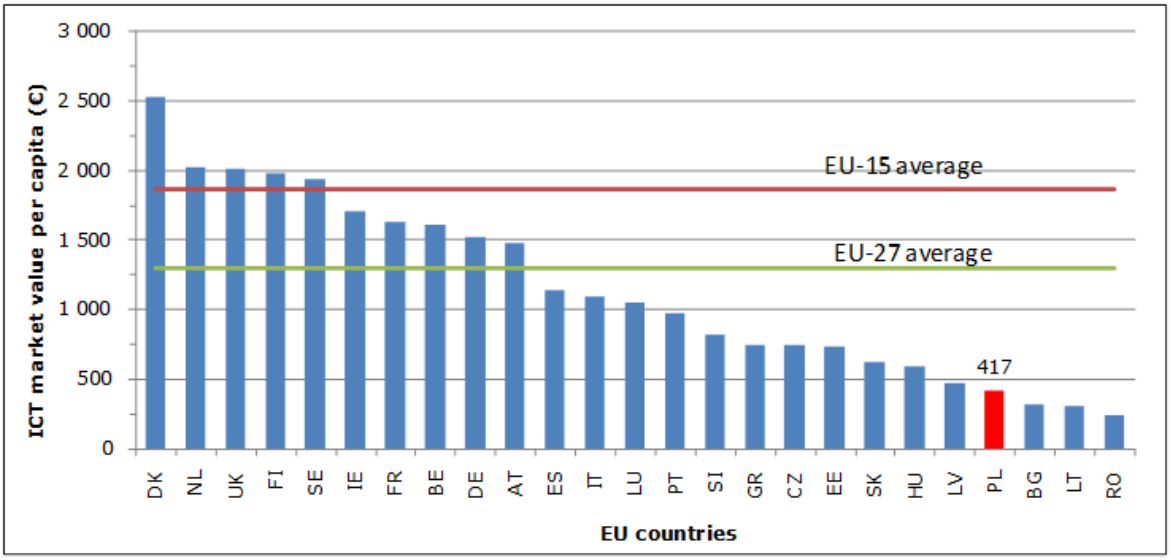
Source: Own calculation based on WITS database.

4. Case Study: ICT sector in Poland

4.1 General characteristics and structural changes

According to GUS (Central Statistical Office) statistics the ICT sector in Poland grew by 44% in 2004-2008, and by EITO statistics it grew only by 29% from 2005 through 2011; despite a visible slowdown the rates still remain impressive. What is noteworthy Poland survived the global economic crisis better than most of other European economies. This can be seen in the ICT market that slightly declined by 5% in 2009, but within two years recovered to the pre-crisis level what among the CEE countries was only attained by Slovenia and Russia. This was probably due to a large domestic market but nonetheless exports did also play a positive role. The strongest upswing was observed in IT segment that confirms our conjecture on the acceleration of IT relative to TT as the country matures in ICT. Finally, ICT expenditures per head in 2011 are expected to be at the level of 428 euros, and ICT share of GDP at 2,8%. It is true that Poland is not on the top of ICT development trajectory in Europe, but it is well on the way of convergence to the EU mean. The value of ICT market per capita placed Poland in 2010 behind Czech Republic, Slovakia, Hungary or even Latvia and before only three EU states: Bulgaria, Lithuania and Romania.

Figure 6: Value of the ICT market (per capita), 2010 (€)



Source: European Information Technology Observatory (EITO) and EUROSTAT, 2010

The ICT sector in Poland comprises now about two thousand enterprises which employ close to 200 000 people (191 000 in 2008). That is comparable to the size of the Polish banking sector. Between 2004 and 2008 ICT employment rose by 40 thousand (i.e. more than 20%). The increase in the number of firms was mainly due to a spectacular growth in the pre-crisis year 2008 when the number of new firms was up 20% year on year, and concentrated mostly in ICT services (30%). Henceforth, a reorientation of newcomers

towards services is to be noted in contrast to what was observed in the first half of the decade. The other remarkable change was a faster growth of the number of firms in information technology than telecommunication segment in the second half of the decade compared to the previous period. These tendencies signify an upgrading of the ICT production structure towards more mature phases of ICT product cycle that could be identified in advanced economies. The data show that IT services share in ICT employment increased from 21% to 29% over the period of 2004-2008 (GUS) and the market value share of IT (comprising equipment and services) in total ICT rose from 19% to 35% between 2005 and 2011 (EITO), while the share of telecommunication market decreased proportionally. New trends in the evolution of ICT market may have been underpinned by a gradual saturation of the pent-up demand for telecom services inherited from the former planned economy system.

Looking from the product characteristics side, the IT market growth was driven by the consumer's demand shift from desktop to portable computers of which sales accounted for a major part of IT equipment segment. Considerable demand for IT equipment was also created by tenders of governmental institutions and private enterprise business for server infrastructure and external disk storage projects. IT service market which is dominated by the local Polish IT companies was traditionally driven by orders from financial and telecommunication sectors. In this market segment information technology competences have been fully absorbed by indigenous service providers and foreign companies have not been playing any important role since the late nineties.[10] In contrast, the telecommunication segment remained relatively stable over time, with only mobile telephony (especially smartphone penetration rose to 34% in 2011, one of the highest in the CEE) having continued to rise in sales even in the crisis year. However, the revenue of carrier service providers did not record any notable increase and remained rather stagnant. This may be due to an overcrowded marketplace in Poland with the largest number of virtual players in the CEE countries.

It should be stressed that the ICT market and production in Poland depends heavily on foreign trade, imports and exports. At the initial stages of technology transfer the economy was dominated by imports in ICT sector. But this has been gradually changing over time. While in 2004 total ICT exports amounted to 16 billion PLN by 2008 (pre-crisis) it reached 22,5 billion PLN (an increase by 40%), and in the crisis year 2009 it almost doubled its pre-crisis level to 35,8 billion PLN. On the other hand, ICT imports rose between 2006 and 2009 only by 15,7% from the level of 33,8 billion PLN to 39,1 billion PLN. This is why the ICT trade deficit of Poland decreased in this period from 13,2 billion PLN to 3,3 billion PLN. Over the same period the share of ICT in total Polish exports increased from 6% to 8,5%, and the share of ICT imports in total imports slightly decreased from 8,6% to 8,4%.[11]

It is then remarkable that during the slowdown of 2009 Polish ICT exports visibly increased despite an overall demand crash in the Western Europe. The only explanation can be that the quality of ICT products has become comparable to Western standards so

[10] See also S. Kubielas (2000).

[11] This section is based on the data by GUS (Polish Central Statistical Office) which do not include a major part of consumer electronics under the definition of ICT. They may be different from the data used in the proceeding sections based on a broader definition of ICT.

that they could become good substitutes for domestic production on old EU-members markets, and price competitive; according to the *flying geese* model. Thus in some segments of ICT market we can note an appearance of the succeeding phase of PLC when the product is being imported by the country of its prior invention (origin). Productivity in ICT production is well above the average of manufacturing and services; in 2008 the difference in labour productivity was estimated at 28% by GUS, and the advantage of IT services was still higher. Additionally, though higher than in other sectors wages in ICT increased at a slower rate than elsewhere in the economy. So both these factors may contribute to comparative advantages in trade that would explain the ICT trade balance of Poland during the slowdown.

Table 6: Main characteristics of the Polish ICT sector development

ICT employment	**2004**	**2005**	**2006**	**2007**	**2008**
ICT Total	150 980	153 460	165 082	181 494	190 822
ICT Equipment	58 583	61 069	67 107	75 978	73 809
ICT Services	92 397	92 391	97 975	105 516	117 013
IT Services	32 195	34 900	39 431	40 054	54 130
Telecom Services	57 600	54 492	55 532	56 796	58 170
ICT Services in ICT in %	61,2	60,2	59,3	58,1	61,3
IT Services in ICT in %	21,3	22,7	23,9	22,1	28,4
ICT sales Million PLN	**2004**	**2005**	**2006**	**2007**	**2008**
ICT Total	75 423	77 557	86 842	99 553	108 354
ICT Equipment	23 491	23 562	29 442	34 321	34 358
ICT Services	51 932	53 995	57 400	65 232	73 996
IT Services	10 523	11 581	12 403	14 323	17 574
Telecom Services	37 396	38 190	40 182	42 270	45 834
ICT Services in ICT in %	68,9	69,6	66,1	65,5	68,3
IT Services in ICT in %	14,0	14,9	14,3	14,4	16,2
ICT exports Million PLN	**2004**	**2005**	**2006**	**2007**	**2008**
ICT Total	15 944	14 705	20 625	24 439	22 460
ICT Equipment	13 671	12 126	17 644	20 546	17 697
ICT Services	2 272	2 578	2 980	3 893	4 764
IT Services	1 574	1 766	1 830	2 275	2 948
Telecom Services	638	712	808	986	1 012
ICT imports Million PLN		**2006**	**2007**	**2008**	**2009**
ICT Total imports		33 800	30 500	36 600	39 100
ICT trade balance		-13 175	-6 061	-14 140	-3 300
Total exports		343 800	386 600	405 400	423 200
ICT share in exports		6,0	6,3	5,5	8,5
Total imports		394 000	456 800	497 000	463 400
ICT share in imports		8,6	6,7	7,4	8,4

Source: Information Society in Poland, GUS, 2010, 2011.

4.2 ICT users in Poland: households and enterprises

Major contribution of ICT to economic welfare, growth and productivity comes not from ICT production itself but from diffusion of information and communication technologies among economic entities, households and enterprises. Unlike ICT manufacturing (in particular that of equipment), the assimilation of ready-to-implement ICT products does not require much current or cumulated R&D effort, but rather an adequate level of human capital in terms of skill and education. Thus, skills not R&D is the main factor of absorption capability in the process of ICT diffusion (apart from capital investments on infrastructure). In this respect the CEE countries seem to be advantaged in comparison to the Southern European EU members, because of their relative higher average education level. This may facilitate a fast spreading of general purpose technology like ICT.

Table 6 shows that although full catching up with the EU might not yet have been completed we can see an impressive acceleration in the second half of the last decade. The gap of Poland to the EU-27 in computer access in households was almost closed in 2010, and the diffusion was surprisingly fast in rural areas where the access rate almost doubled. A similar tendency can be seen in internet access by households which has also approached the EU-27 average, and in rural areas more than doubled within four years. What is still clearly lagging behind is the proliferation of broadband, especially in rural areas.

In the enterprise sector, a still higher rate of ICT diffusion can be observed and the catch-up process is nearly done. Computer access reached the EU-27 average and in large enterprises stays at 100% since 2007. In 2008 Poland reached the EU average internet access by enterprises of 93%, and now the sector is investing mainly in integrating internet with ongoing management practices.

Table 7: ICT access and usage by households and enterprises in Poland

	2006	2007	2008	2009	2010
Households in %					
Computer access	45,4	53,7	58,9	66,1	69,0
Big cities	52,9	60,0	64,0	71,5	72,9
Rural area	36,4	46,0	52,8	60,2	63,7
EU-27 average			68,0	71,0	
Computer usage	43,0	46,2	49,9	55,3	57,7
Internet access	35,9	41,0	47,6	58,6	63,4
Big cities	45,6	49,9	56,0	65,1	68,8
Rural area	25,1	28,9	36,1	50,5	56,2
EU-27 average			60,0	64,5	
Broadband	21,6	29,6	37,9	51,1	56,8
Big cities	31,5	40,3	48,7	60,7	63,7
Rural area	9,8	16,2	23,9	40,6	46,9
Broadband/Internet			80,0	87,0	90,0
Internet usage	34,4	39,0	44,3	51,6	54,6
Enterprises in %					
Computer access	93,0	95,0	95,0	93,0	97,0
Internet access	89,0	92,0	93,0	90,0	96,0
Min. density region	83,0	n.a.	88,0	85,0	91,6

Max. density region	96,0	n.a.	98,0	93,0	98,5
Broadband	46,0	53,0	58,0	58,0	70,0

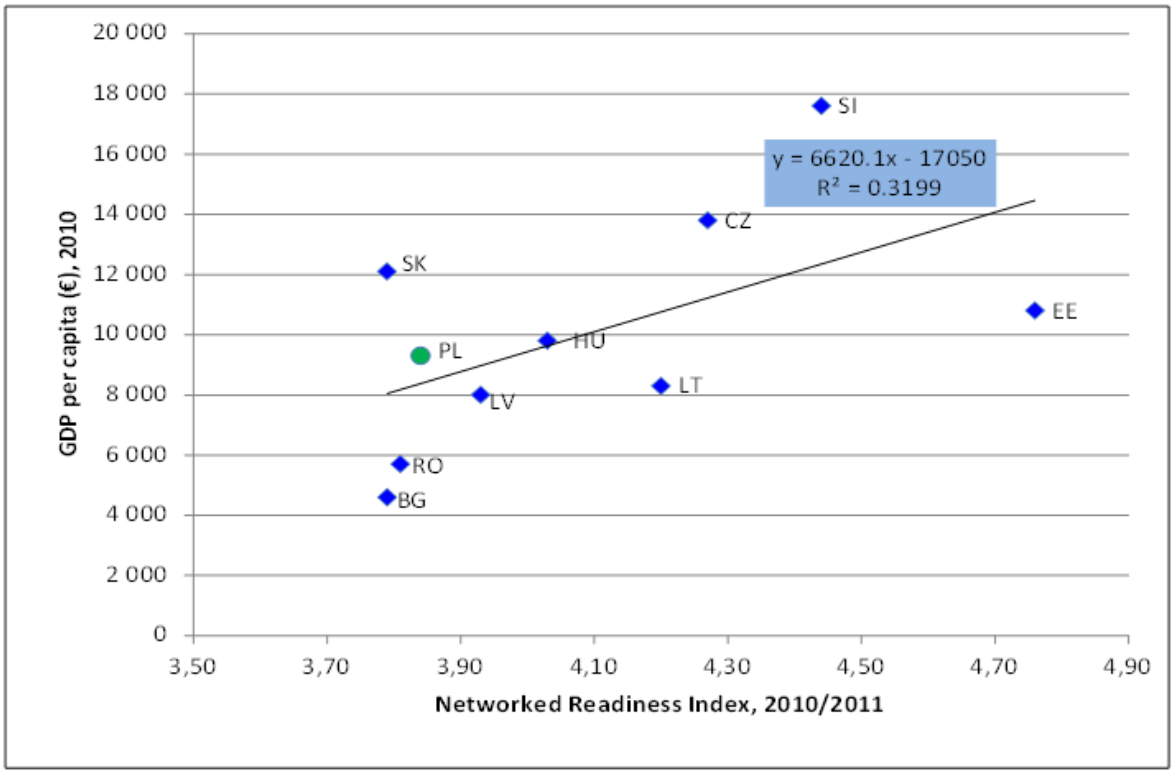
Source: Information Society in Poland, GUS, 2010, 2011.

5. ICT sector performance and services in the CEE countries

5.1 ICT performance in NRI perspective

One of the most popular indexes measuring ICT development is Networked Readiness Index (NRI) positively correlated with GDP per capita. The correlation ratio for EU-27 equals 0.7, but in CEE countries the relationship is not so strong (correlation ratio equals 0.57 in this case) but still positive. Within the CEE members, the best effects reached Estonia, the country with not the highest GDP p.c. level but with NRI almost as high as in Belgium. The worst situation was noted in Slovakia and Bulgaria. Slovakia, despite of quite high GDP p.c. level, has poor NRI performance. What is more, Slovakia reached the worst scores in government and infrastructure spheres (in 2011). Individual usage performed well in Slovakia, on contrary to individual readiness. Despite of low level of ICT education, the Slovakians are active (but not sophisticated) internet users. On contrary are the Polish, where networked readiness is higher than usage. Problems are not abilities but possibilities of the Polish society (details in Table 7). Poland keeps better scores in individuals' subindexes than in regulatory and government usage. The Polish administration has low ICT equipment level. Even if e-government services improved, it didn't translate into its usage by administration.

Figure 7: NRI and GDP per capita across CEE countries (2010/2011)



Source: Own calculation based on: World Economic Forum (*The Global Information Technology Report 2010/2011*) and EUROSTAT

The distribution of ICT usage and readiness across EU countries seems to be a proof of no uniform information society scenario across CEE countries. For example, Polish ICT evolution is a consequence of open economy and open market introduction at the beginning of economic transformation. Enterprises were the first market players to face the post-transition reality. The second were individuals, with no obligations but just having their own preferences. And finally were formal institutions, where there are some "old thinkers" still. The ICT development is just a photograph of the market players' status in the new Polish reality. Slovakia's case, instead, shows another ICT development path with different regulations, implementation and internet users' profile. The biggest outlier in this case is Estonia, with extremely high Networked Readiness Index. Estonia performed well thanks to its Finish linkage. As a post-transition country, Estonia has low labour cost, and additionally, Estonian government pursues a low-taxes policy that encouraged neighbouring Finland to invest and run business in Tallin instead of Helsinki.

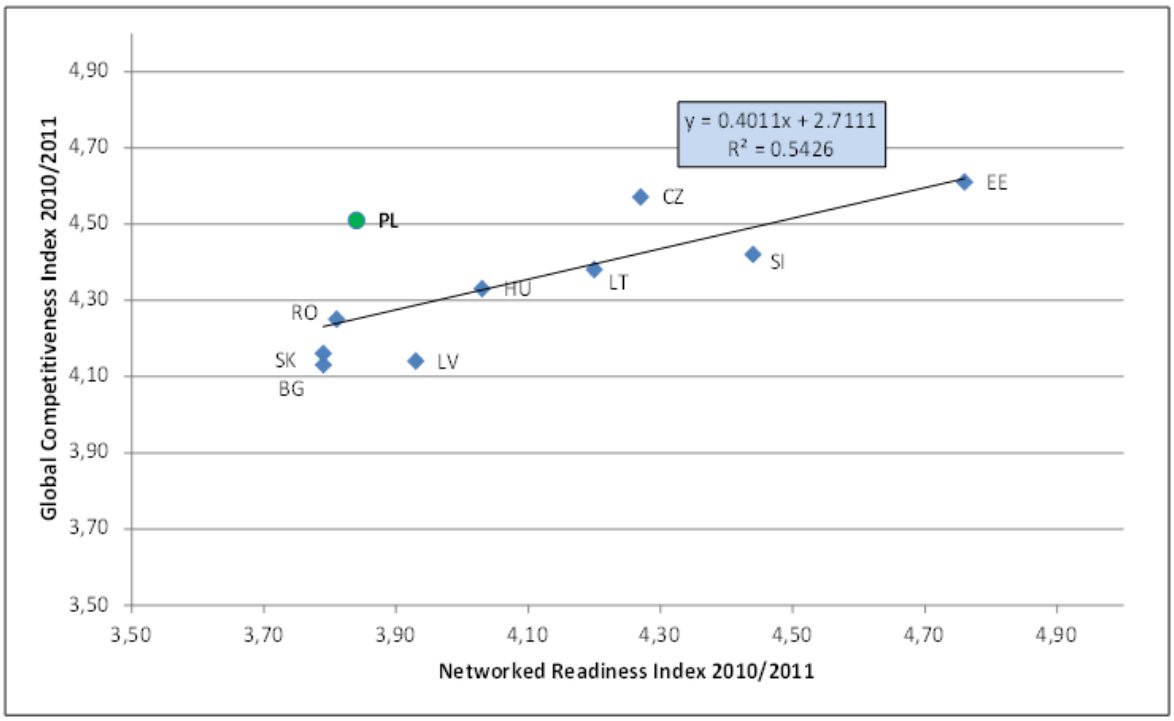
Table 8: NRI ranking across European Union states, 2010

Ranking position	SUBINDEX											
	ENVIRONMENT				READINESS				USAGE			
		2nd level index				2nd level index				2nd level index		
		Market	Regulatory	Infrastructure		Individual	Business	Government		Individual	Business	Government
1.	SE	LU	SE	SE	FI	FI	SE	MT	SE	SE	SE	DK
2.	FI	FI	FI	NL	SE	DK	FI	LU	FI	FI	DE	UK
3.	NL	SE	LU	UK	DK	CY	DE	SE	DK	LU	FI	EE
4.	LU	DK	DE	FI	LU	LU	NL	PT	UK	DK	FR	ES
5.	UK	NL	UK	DK	DE	SE	BE	FI	NL	NL	UK	FR
6.	DK	UK	DK	DE	NL	NL	DK	DK	DE	UK	NL	SE
7.	DE	CY	NL	FR	MT	DE	IE	EE	FR	AT	DK	NL
8.	AT	DE	AT	BE	BE	BE	UK	DE	LU	DE	LU	DE
9.	FR	BE	IE	LU	AT	MT	FR	AT	AT	EE	AT	MT
10.	IE	AT	FR	AT	FR	AT	LU	NL	EE	BE	MT	AT
11.	BE	EE	BE	IE	UK	SI	AT	FR	MT	FR	IE	BE
12.	EE	FR	MT	EE	EE	EE	CZ	UK	BE	MT	BE	FI
13.	MT	IE	EE	SI	IE	FR	ES	CY	ES	PT	EE	LT
14.	CY	PT	CY	MT	PT	LV	EE	BE	IE	SI	CZ	PT
15.	SI	SI	PT	ES	CY	IE	SI	CZ	PT	IE	HU	SI
16.	PT	MT	ES	CZ	SI	UK	MT	SI	SI	ES	CY	IE
17.	ES	SK	SI	CY	CZ	IT	PT	IE	LT	LT	LT	CY
18.	CZ	ES	CZ	LT	LT	RO	IT	LT	CY	CY	PT	LU
19.	LT	CZ	HU	PT	IT	LT	CY	ES	CZ	BG	SI	HU
20.	HU	LT	LT	GR	ES	CZ	PL	HU	HU	SK	ES	BG
21.	SK	PL	LV	HU	LV	GR	HU	BG	BG	IT	IT	CZ
22.	GR	HU	SK	IT	PL	PL	LT	PL	IT	CZ	PL	GR
23.	IT	LV	GR	BG	RO	PT	RO	GR	LV	HU	LV	LV
24.	LV	IT	RO	PL	HU	BG	SK	LV	SK	LV	SK	RO
25.	RO	RO	IT	RO	GR	HU	LV	IT	PL	PL	RO	IT
26.	PL	GR	PL	SK	BG	ES	GR	RO	GR	GR	BG	PL
27.	BG	BG	BG	LV	SK	SK	BG	SK	RO	RO	GR	SK

Source: World Economic Forum (The Global Information Technology Report 2010/2011)

Networked readiness is extremely important for competitiveness level. The higher the networked readiness, the higher the competitiveness (see Figure 8.), especially in the developed EU states, where the correlation is higher than within the CEE countries (0.96 and 0.74 respectively). It may suggest that competitiveness performance increases with the level of development, mainly thanks to implemented ICT technologies. It is in particular true as far as we are talking about Sweden, Denmark, Finland, Netherlands, Germany, Great Britain, France, Austria, Belgium or Luxemburg. There the regression is linear with R^2=0.94. The CEE countries' ICT models are unlike each other what can be seen in R^2=0.54 for linear regression. Poland is an outlier within CEE countries. Excluding Poland from CEE, linear regressions' R^2 improves up to 0.8, automatically. Poland appears to be more competitive than predicted by the regression.

Figure 8: The relationship between the NRI and GCI, across CEE countries 2010/2011

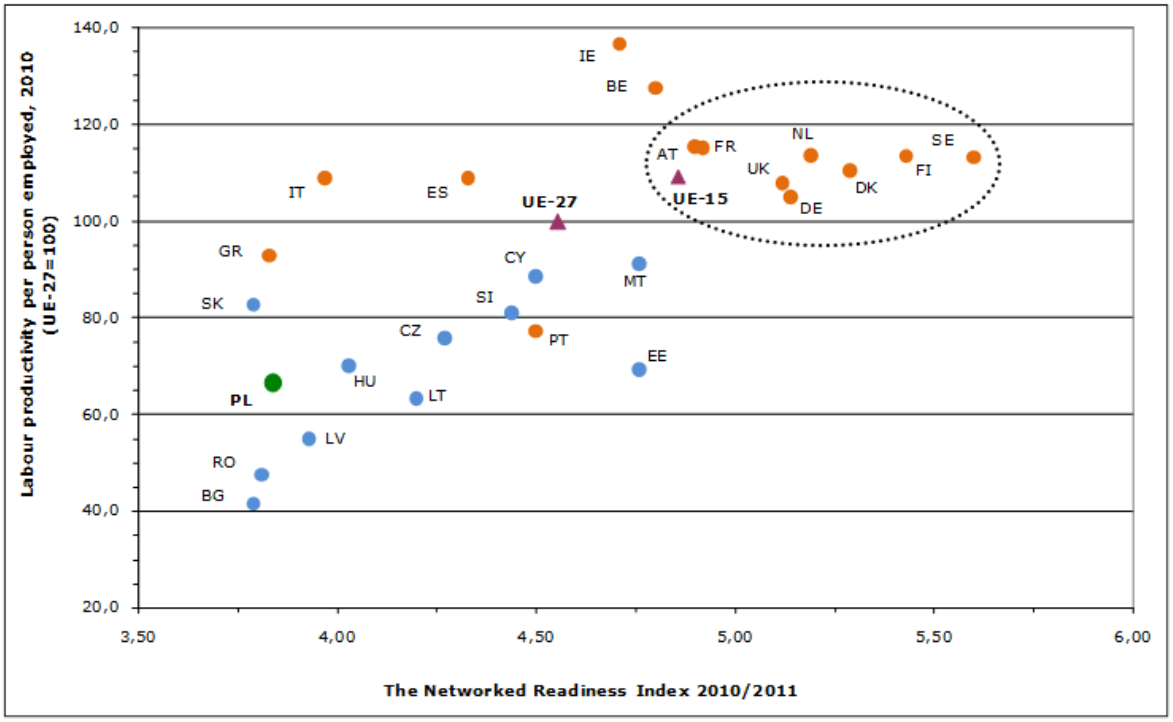


Source: Own calculation based on: World Economic Forum, The Global Competitiveness Report 2010/2011; The Global Information Technology Report 2010/2011

Other parameters worth taking into account in ICT development benchmarking are labour productivity and NRI. In accordance with Figure 9, all EU states can easily be divided into three separate groups. First of them are "old" members (with Scandinavian countries on the top) where productivity and the level of network readiness (NRI) are both very high. It might suggest a strong relationship between productivity and technological progress, but the statistics would deny such a straightforward relationship in this case: there is no regression between productivity and NRI for the countries at a certain level of maturity. This seems to be consistent with our previous finding that at a certain level of maturity with high proportion of ICT investment in GDP its impact on the rates of productivity increase and GDP growth declines, despite the fact that the relative contribution of ICT to productivity increases as compared to less advanced countries. The second group is created by "new EU members". They all have low level of productivity and relatively low level of network readiness (NRI), but the relationship between these two components shapes in a regular linear regression positively sloped (especially after excluding Slovakia, Poland, and Estonia).[12] The final third group are lagging behind countries from "old" EU (GR, IT, ES) that have not passed the magic 4.5 points in NRI yet, although they keep quite high levels of productivity.

[12] Poland has extremely low NRI level and Estonia has very high NRI.

Figure 9: Labour productivity per person employed and NRI



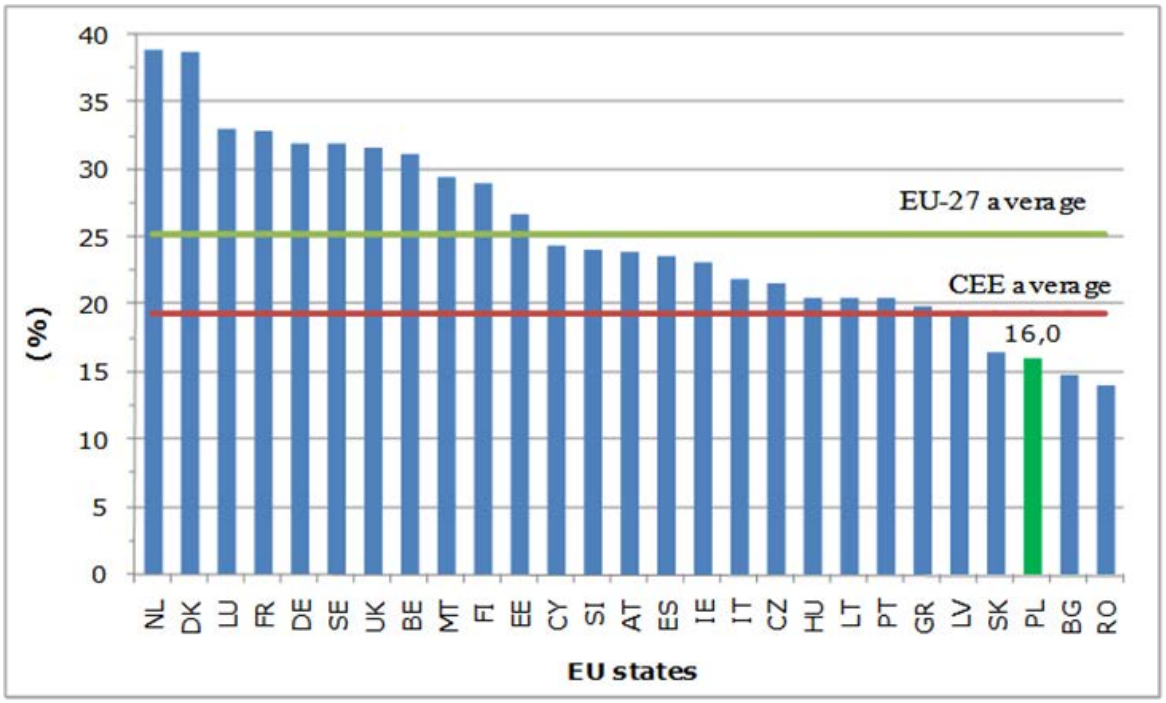
Source: Own calculation based on: World Economic Forum, *The Global Information Technology Reports 2010/2011*and EUROSTAT

5.2 The development of ICT services

5.2.1 Broadband

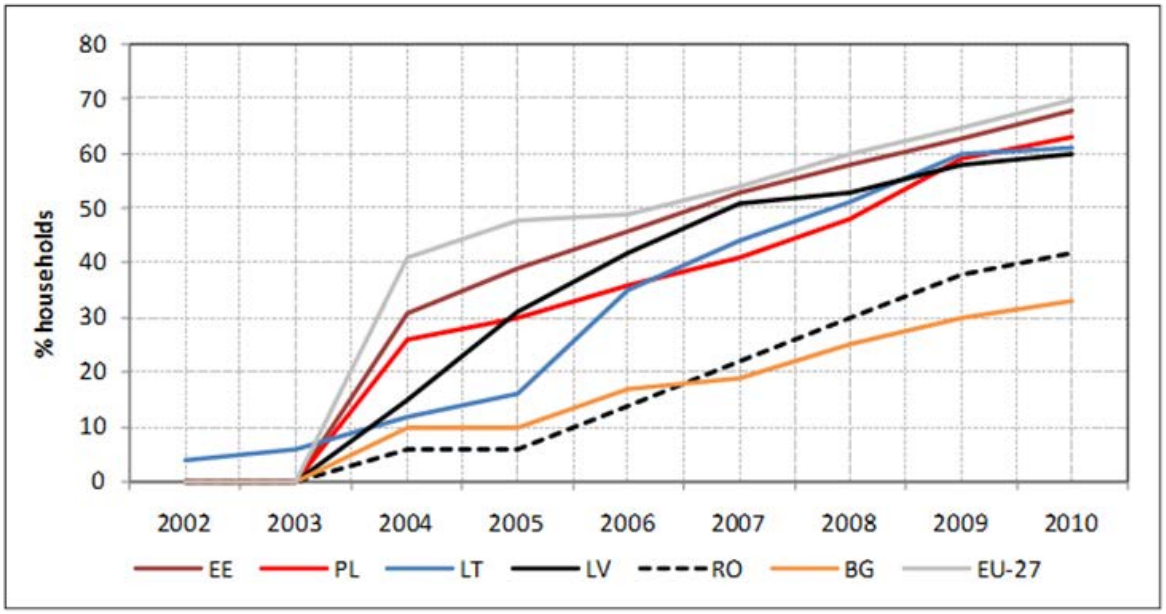
Poland places 25th in scoring (across 27 EU states) of broadband penetration rate per head with 16% of population using fast internet connection (Figure 10). The EU states staying behind Poland, are the two last EU members from CEE: Bulgaria and Romania. The rest of the CEEC are placed above Poland but at the tail of the old EU members. Taking into account that broadband internet connection is household dedicated service (not a personal service with couple of connections within one household), Polish as well as CEE statistics improves greatly (Figure 11). But important are also parameters of the connection, especially because owing to high speeds, advanced services (like multimedia services) become available. The list of internet connection speeds is presented in Figure 12. The speed of connection is strictly correlated with broadband development. The bests are Greece, Bulgaria and Romania. The quality of connection is low in Poland as far as the most popular speed is between 144 kb/s and 2 Mbit/s. Next to Poland is Estonia, with poor speed performance. Amazing high position of both Bulgaria and Romania is a result of young network tradition. These states started their infrastructure investments recently and that is why they used the latest standards of connections and technologies. It all means that CEE countries are able to compete in infrastructure quality with better developed countries, that can be labeled a ‘leapfrogging’.

Figure 10: Broadband penetration rate per head in EU states (January, 2011)



Source: European Commission, *Digital Agenda Scoreboard*, 2011, 2011

Figure 11: Households broadband internet access in selected EU states



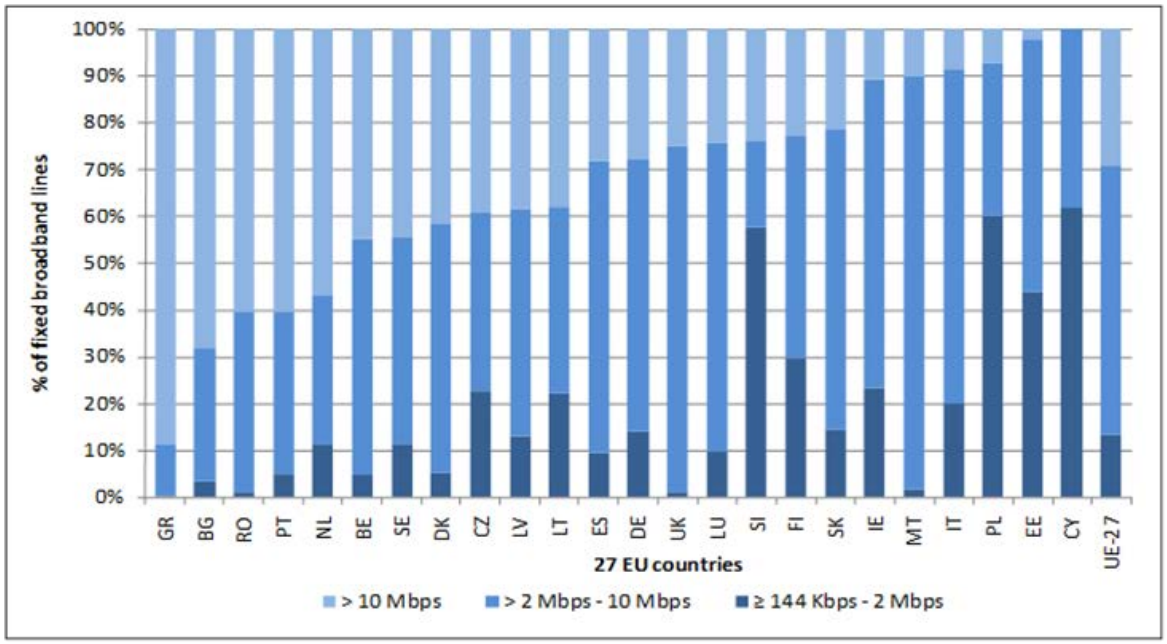
Source: EUROSTAT

It is worth adding that broadband statistics are often underreported, In particular, contribution of internet access from local small providers is believed to be seriously under-reported in Poland. Cable TV operators, free from heavy-handed regulation became large internet service providers, which focused on high density areas, holding a dominant position in local areas, but still having only a few percentage market share in a whole

country scale. Polish case is a specific one, even among post-transition countries. But it is not the only non-typical observation, the other is the Czech Republic. It has mobile broadband developed well enough to substitute fixed connections what also gives a certain level of underestimation (as far as mobile broadband access is not calculated into broadband internet).

Talking about broadband without having mentioned of fibre (FTTH technology) is useless. Fibre-optic networks are built not only in developed EU countries, but also in CEE members. But the models are different. In Poland for example, till the end of 2008 the Polish incumbent didn't build any single fibre line, except for a 6-month trial in Warsaw. On the other hand, local operators have their own fibre network at the last mile level. In October 2009, after an "investment strike", the incumbent operator and the regulator made an agreement. The regulator (UKE) dropped TP SA functional separation plans and promised stable regulations and new BSA rates (implementing cost plus instead of retail minus formula). TP SA, on the other hand, was obliged to build 1.2 bln of fast broadband connections within 3 years. Nowadays the balance is still poor for fibre networks in Poland. Total number of FTTH subscribers in December 2009 was estimated by the FTTH Council at 21,000, what gives a penetration rate at about 0.055% (probably the lowest in Europe). The statistics should improve as soon as the main infrastructure projects will end. On the contrary, Slovakia is one of the examples of beneficiaries of EU funds that enabled to well develop a mobile infrastructure despite the lack of DSL technology. Satisfying level of FTTH has also been attained by Slovenia and Estonia.

Figure 12: Fixed broadband lines by speed, 2010



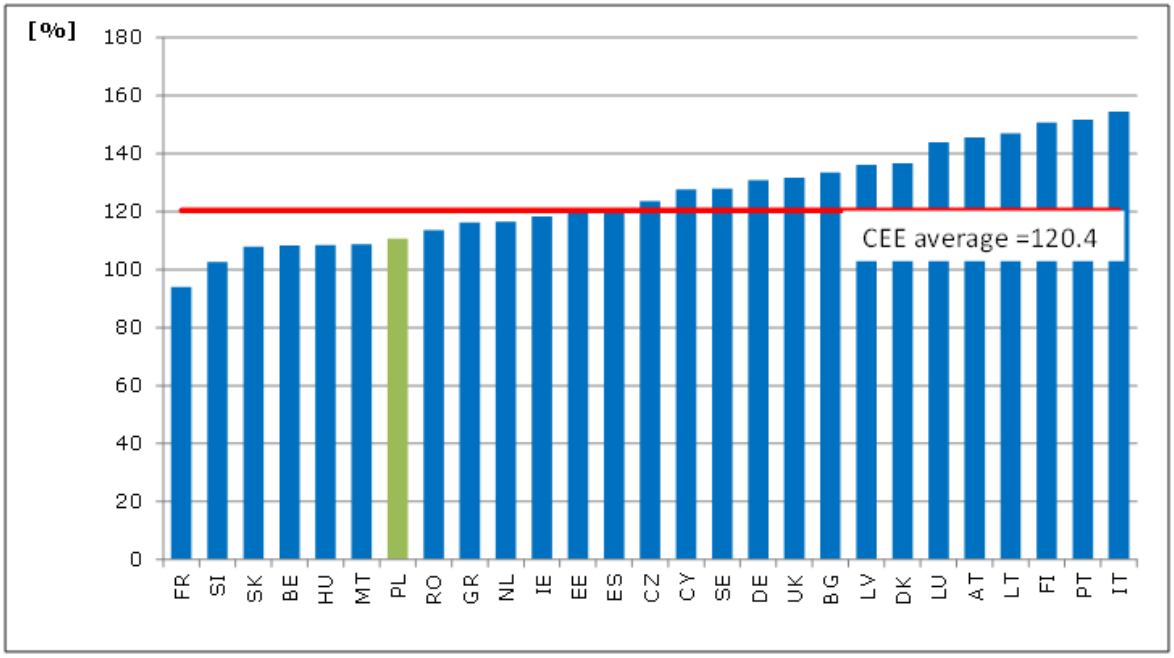
Source: European Commission, *Digital Agenda Scoreboard*, 2011, 2011

5.2.2 Mobile and e-services

The importance of mobile services becomes higher and higher systematically, what is measured by raising mobile penetration rate. Some of CEE countries performed extremely well in this indicator – i.e. Lithuania (with 147%), Latvia (136%) and Bulgaria (133.4%).

Within all EU countries only France reached penetration rate below 100%, caused by substitutive infrastructure. Mobile penetration rate depends on fixed penetration rate rather than on overall country development. It implies that CEE countries are indistinctive from other EU members from mobile penetration ratio point of view. It is a consequence of investment rate of return, but also European regulatory policy and liberalization process. Mobile policy seems to be pursued in a competent way, making all rules not as strict as for fixed telephony. We can also observe mobile-fixed substitution in CEE countries – the same trend as in the rest of the world.[13] Recent initiatives in the area, such as Radio Spectrum Policy Programme, turned the attention to mobile broadband, including rural areas. It will surely improve mobile popularity as much as fixed broadband internet did. Of course, not in all the CEE countries mobile access develops at the same pace. Analyzing each country in more detail, it is visible that Poland has abnormal high level of SMS and MMS and extremely low number of MVNOs (mobile virtual network operators). The opposite is Hungary with its well developed mobile market competition and many profitable MVNOs.

Figure 13: Mobile penetration rate in EU countries



Source: European Commission, *Commission Staff Working Paper*, SEC(2011)708, Brussels, May 31, 2011, and *Digital Agenda Scoreboard*, 2011.

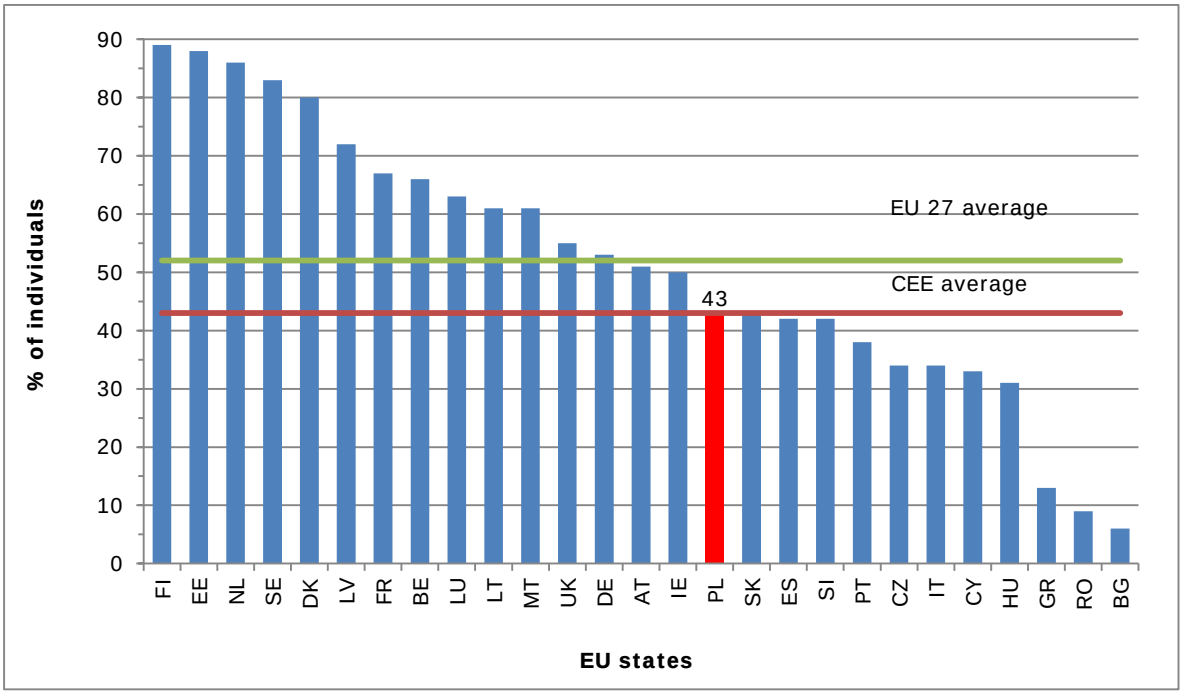
Penetration rate for e-services in most CEE countries has improved recently. One of the example is Poland getting 13th place (with 46% internet users) in e-commerce – just between Belgium (49%) and Slovakia (42%). E-commerce increases faster in Poland than EU average, so the ranking may give Poland higher location in next years. Leaders are still the old EU members: United Kingdom (79%), Denmark (76%) and Netherlands (74%). At the bottom Lithuania (17%), Bulgaria (11%) and Romania (9%) are located. The fact is that e-commerce in post transition countries (in Poland mainly) grows very fast and

[13] As an example, the strong point of the Polish case is really poor fixed infrastructure performance vs good wireless and mobile infrastructure. It is a consequence of regulatory policy and liberalization process, as well as the infrastructure investments in favour of mobile network.

nowadays is one of the most important e-services. Polish enterprises have about 7% turnover from electronic trade (the EU average was about 13% the same time). According to data, the bigger is an enterprise the bigger is its e-trade turnover. The biggest e-commerce rate of growth (within all EU, not only CEE countries) was noted in Poland. This extremely high popularity first of all is because of auction platforms (mainly Allegro and e-Bay). They generate more revenue than online shops, but in fact online shops are also active players on auction platforms so the data may be misleading.

CEE countries have also excellent performance in internet banking. The leader, not only from CEE point of view, but within EU as a whole, is Estonia. The usage of internet banking within the last 3 months, ranks Estonia on the 2nd place (with 98% of individuals). But even other CEE countries performed well in e-banking usage and in many cases it is true that they just left behind the early stage of banking development, when people were distrustful to the new opportunity of time savings.

Figure 14: Percentage of individuals who used internet banking in the last three months, 2010



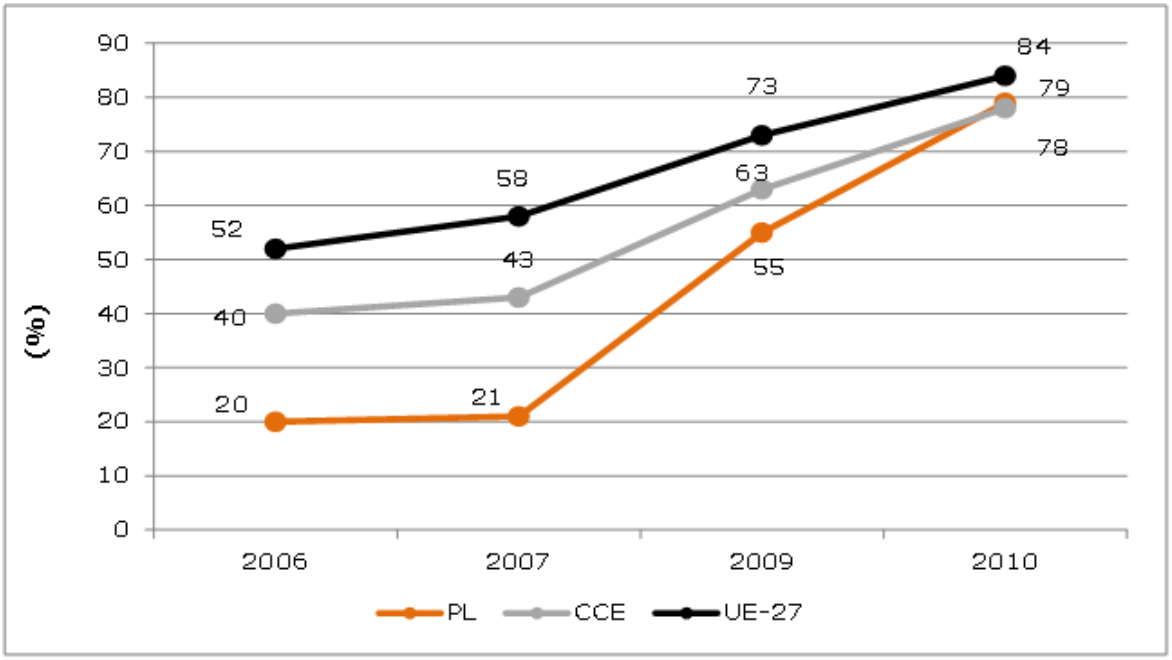
Source: EUROSTAT

As talking about e-administration, it must be confirmed that CEE countries didn't reach the highest notes. The best within the group were Slovenia, Latvia and Estonia (13th, 14th and 15th position across EU-27, respectively). Poland, for many years was one of the worst within EU countries in e-administration area. Administrative employees appeared to be a bottleneck. In 2009 one of the Polish research institutes checked clerks' e-skill and published its shocking backup. The latest data show that Polish situation stopped being one of the worst. Of course the improvement was not only a result of market development, but it was certain strategic plan of the Polish government mainly. Online income taxes implementation, e-signature, multimedia guides for agencies' clients – it all gave the expected performance. The demand side was also more conscious and had wider

possibility to get needed internet connection. The biggest accelerations were in business sphere. Now came the time to make e-services in administration more sophisticated, and more complex. More complex will be services, more internet users are expected to use it.

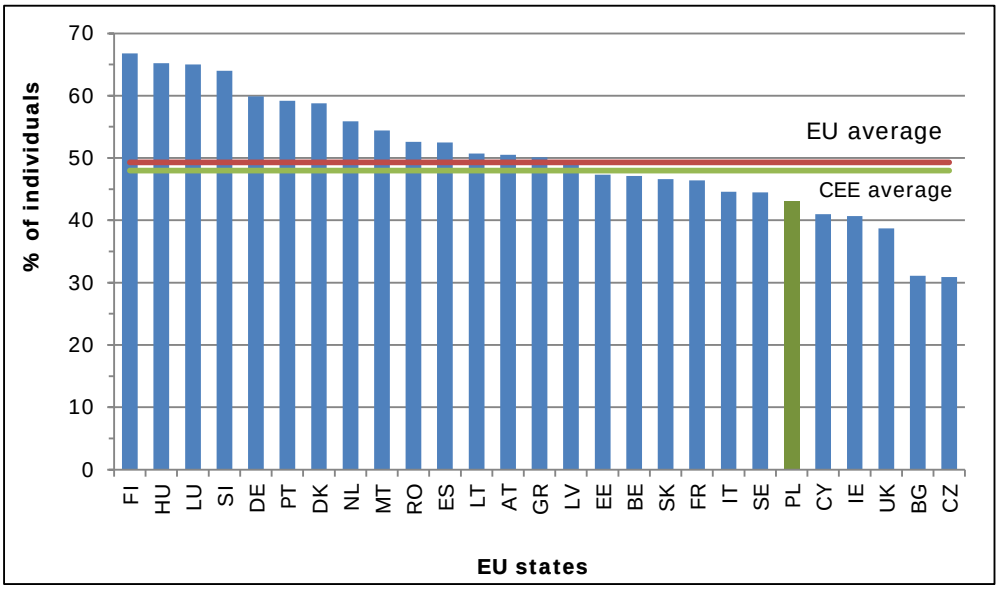
E-health is the next online service which seems to have brilliant future. Taking into account the lack of time in modern societies (stress, unhealthy food, sport avoiding) and the fact that the society is getting older, health problems turn out to be crucial not only within "old" EU members, but also within CEE countries. Although e-health services are at the beginning of its development in many countries, their distribution is not much diverse between EU and CEE countries (Figure 16). Amazingly, high scores are for Hungary and Slovenia, when the weakest were Czech Republic, Bulgaria and United Kingdom. Poland keeps a quite good position (in nearby of EU average with its 43% of individuals).

Figure 15: Changes in availability of e-administration in European states



Source: EUROSTAT

Figure 16: Percentage of individuals who used Internet for seeking health information in the last three months, 2010



Source: EUROSTAT

6. Conclusions

ICT market in Central and Eastern Europe is undergoing a fast transformation caused primarily by a diffusion of interrelated ICT innovations. ICT sector grew in the CEE countries considerably in 2005-20011, but at different rates across particular economies. However, there could be noticed a convergence tendency accompanied by a sort of retardation process setting in as the ICT intensity per head increased during the diffusion. Surprisingly, we found a negative correlation of period-averaged GDP growth rates with the ICT/GDP ratio across countries. It could be explained by arguing that ICT is gaining importance with higher GDP and ICT rates per head, but with higher ICT/GDP ratio (and higher ICT capital intensity of labour) GDP grows at decreasing rates. This might be interpreted as another evidence for diminishing marginal returns, even in the knowledge-based economy, similar to that of capital with increasing capital intensity. There could also be found another similarity in relative stability of the ICT/GDP ratio in individual countries over time. This resembles some properties of the neoclassical production function when ICT be substituted for capital.

It was also noted that CEE economies with more mature and advanced ICT sector had indicated higher proportion of IT, and especially IT services, in the whole ICT market value, which increased at the expense of telecommunication segment, and vice versa. This effect might have been caused by the overlapping of various production cycles within the same family of related technologies, in particular arising from intertwining of technology development and diffusion trajectories of various related products in information technology, telecommunications or related services.

There was found a close relationship between Networked Readiness Index (NRI), measuring ICT development, and GDP per capita, competitiveness, and labour productivity. The indicators were generally positively correlated with NRI, but the correlation appeared to be stronger for more advanced EU countries than for catching up CEEC. In the latter case other non-ICT factors were likely to be also responsible for growth and competitiveness. We have expected a strong relationship between productivity increases and technological progress expressed in NRI, but the statistics would deny such a straightforward relationship: there was no correlation between productivity and NRI for the countries at the top level of ICT maturity. This seems to be consistent with our finding that at a certain level of maturity with high proportion of ICT investment in GDP its impact on the rates of productivity increase and GDP growth declines, despite the fact that the relative contribution of ICT to productivity increases as compared to less advanced countries. Thus, a stronger absolute marginal impact of ICT development on productivity should be expected in the less developed CEE countries with still lower ICT intensity of factor content.

CEE ICT market improved significantly during the last few years but still keeps a low level in comparison with the rest of EU. Nowadays, a poor infrastructure performance is not such a big problem as the situation is changing very fast. Newcomers can invest in new technologies (mobile: LTE, fixed: fibre), although the process still takes a lot of time and it is not yet visible in statistics for all CEE countries. In a better situation are CEE countries (Bulgaria, Romania) that started to build up their infrastructure recently (by comparison to the rest of EU). They have reached the best infrastructure quality indexes, while keeping the worst position within EU penetration rates. These are real windows of opportunity for latecomers as they can catch up with the latest generation of technology and outstrip countries which innovated earlier what is sometimes called *leapfrogging*.

The catching up process can be followed very well by looking at the changes of trade patterns in ICT goods between CEE and the old EU. A switchover of ICT comparative advantages from negative into positive in some CEE countries means that they began to export more ICT products in proportion to their total manufactures exports than the old EU. This signifies that the production of some ICT products might have been relocated from the old EU to new member countries. In the CEE area we were faced with increases both in value and share of ICT in total manufacturing exports, which over time tended to exceed imports in most of the CEEC, especially after the accession. In the whole EU the specialization pattern was more balanced across ICT subsectors, while the CEE countries concentrated more and more on specific niches. In particular larger CEE economies tended to specialize both in knowledge intensive and scale intensive ICT subsectors like computers what was the case in Hungary, Czech Republic and finally Poland. Medium sized CEE economies with sufficient absorption capabilities like Slovakia and Estonia joined the group of larger economies in telecom equipment exports, followed by other small economies attempting to catch up. The greatest average progress in RCA improvement was attained in the subsector of electrical appliances where high rate of convergence signifies easy knowledge spillover and technology transfer, perhaps because of relatively less knowledge intensity. The CEE economies took over matured products of the product cycle and supplied them back to the advanced EU economies. The process was intensified due to the EU enlargement and extension of the common market.

Poland is surely not on the top of ICT development trajectory in Europe, but it is well on the way of convergence to the EU mean. However, it is remarkable that after the slowdown of 2009 Poland quickly recovered to the pre-crisis rates of ICT growth, and even during the slowdown Polish ICT exports visibly increased despite of overall demand crash in the Western Europe. The only explanation can be that the quality of Polish ICT products has become comparable with Western standards so that they could become good substitutes for domestic production on old EU-members markets. Thus in some segments of ICT market we can note an appearance of the succeeding phase of PLC when the product is being imported by the country of its prior invention (origin).

The CEE countries differ from the rest of EU mainly in macroeconomic aspects of ICT sector. The value of ICT per capita is poor within the CEE countries, but ICT market is gaining in significance, and its absolute contribution to GDP creation for CEE countries occurs to be higher than for the rest of the EU. As talking about slight differences between CEE and EU countries, they are in e-service area. It seems to be the EU accession and its coherent ICT policy, including international benchmarks and disclosing the weakest practices that forced new comers to match the rest. In two cases the CEE countries don't differ much from the old EU members – in mobile penetration rate and in internet broadband speeds. The first of them are for economic reasons and the investment rate of return (mobile infrastructure is cheaper than the fixed one). The second one is the result of a technological gap that after EU accession is being rapidly squeezed.

Finally, there is no uniform ICT development path across CEE countries. Some of them performed well, leaving behind the rest of EU, and some always stayed in EU tail. The most frequent outliers are Estonia and Poland, Bulgaria and Romania are the others. Partly it is caused by exogenous factors like Finish investments in Estonia, but partly it is a matter of inside ICT policy – like in the Polish case, where some administration initiatives helped improve indexes and the Polish benchmark position. There should also not be overlooked a diversity caused by different specialization patterns in ICT trade across the CEE countries which largely depend on the adequacy between knowledge or scale intensity of a product and the country's innovation system. This may furthermore contribute to a variety of paths for future ICT development in the region.

References

AKAMATSU, K. (1956), A Wild Flying Geese Pattern of Japanese Industrial Development: Machine and Tool Tndustries, *Hitotsubashi Review*, 6 (5): 55-87

BALASSA, B. (1965), Trade Liberalization and 'Revealed' Comparative Advantage, The Manchester School of Economic and Social Studies, Vol. 32: 99-123

BARTOSZEWSKA, B.; OLENDER-SKOREK, M. (2008), Rozwój usług telefonii mobilnej stymulatorem rozwoju społeczeństwa informacyjnego, *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, Seria: Ekonomiczne Problemy Usług, Szczecin, Uniwersytet Szczeciński, No. 27

BORZYCKI, K.; OLENDER-SKOREK, M. (2011), Broadband Internet in Poland, *La Comunicazione - numero speciale BANDA LARGA*

DACHS, B.; MEIJERS, H.; WELFENS, P.J.J. (2008), Internationalisation of European ICT activities - A project carried out for the European Commission and Institute for Prospective Technological Studies (IPTS), Heidelberg New York, Springer-Verlag

DUSZAK, M.; BARTOSZEWSKA, B.; OLENDER-SKOREK, M. (2008), Przyszłość polskiego rynku telefonii mobilnej na tle wybranych krajów UE, *Przegląd Telekomunikacyjny i Wiadomości Telekomunikacyjne*, SIGMA-NOT, No. 10

EUROPEAN COMMISSION, (2010), *The Implementation Report*, Brussels

EUROPEAN COMMISSION, (2011), *Digital Agenda Scoreboard 2011*, Brussels

EUROPEAN COMMISSION, (2011), *Commission Staff Working Paper*, SEC(2011)708, Brussels, May No. 31, 2011

EUROPEAN INFORMATION TECHNOLOGY OBSERVATORY, EITO Reports, No 2005/2006, 2006/2007, 2007/2008, 2008/2009, 2010/201

EUROSTAT, UNCTAD, WTO, World Integrated Trade Solutions WITS, https://wits.worldbank.org/WITS

EUROSTAT statistics

GUS (Central Statistical Office) (2008, 2011), *Społeczeństwo informacyjne w Polsce* (Information Society in Poland)

INTERNET STANDARD (2011), *E-commerce in Poland*, Warsaw

KUBIELAS, S. (2000), Restructuring the Computer and Software Industries in Poland, in Ch. von Chirschhausen, J. Bitzer, (eds), *The Globalization of Industry and Innovation in Eastern Europe*, Cheltenham, Edward Elgar: 283-312

KUBIELAS, S. (2004), Product Fragmentation and Alliances in the Central European Computer and Software Industries, in: S. Radosevic and B. Sadowski, (eds) *International Industrial Networks and Industrial Restructuring in Central and Eastern Europe*, Boston/Dordrecht/London, Kluwer Academic Publishers: 59-77

OECD statistics

OLENDER-SKOREK, M.; CZARNECKI, R. (2007), Pozycja Polski w UE 25 zaawansowaniu w rozwoju społeczeństwa informacyjnego i gospodarki opartej na wiedzy, in H. Babis, A. Brudziewicz-Guźlecka (eds), *Miejsce poczty i*

telekomunikacji w tworzeniu społeczeństw informacyjnych, Materiały Konferencyjne, Szczecin, Uniwersytet Szczeciński, Wydział Zarządzania i Ekonomiki Usług

OLENDER-SKOREK, M.; CZARNECKI, R. (2008), Rola e-usług w kształtowaniu społeczeństwa informacyjnego w Polsce, *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, Seria: Ekonomiczne Problemy Usług, Szczecin, Uniwersytet Szczeciński, No. 27

OLENDER-SKOREK, M., (2009), Perspektywy rozwoju rynku telekomunikacyjnego w świetle kryzysu gospodarczego, *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, Seria: Ekonomiczne Problemy Usług, Rynki przesyłu i przetwarzania informacji - stan obecny i perspektywy rozwoju), Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin, 2009 , No. 35, (t.1)

OLENDER-SKOREK, M.; BARTOSZEWSKA, B.; CZARNECKI, R. (2011), E-commerce w Polsce, *Przegląd Telekomunikacyjny i Wiadomości Telekomunikacyjne*, SIGMA NOT, 2011 , No. 8-9: 1520-1525

VAN ARK, B.; PIĄTKOWSKI, M. (2004), Productivity, Innovation and ICT in Old and New Europe, *International Economics and Economic Policy*, Vol. 1, No. 2-3, December 2004: 215-246

WORLD ECONOMIC FORUM (2011), *The Global Competitiveness Report 2010/2011*

WORLD ECONOMIC FORUM (2011), *The Global Information Technology Report 2010/2011*

EIIW Discussion Papers

ISSN 1430-5445:
Standing orders (usually 13 issues or more p.a.): academic rate 95 Euro p.a.; normal rate 250 Euro p.a.
Single orders: academic rate 10 Euro per copy; normal rate 20 Euro per copy.

Die Zusammenfassungen der Beiträge finden Sie im Internet unter:
The abstracts of the publications can be found in the internet under:

http://www.eiiw.eu

No. 100 **Gavrilenkov, E.:** Macroeconomic Situation in Russia - Growth, Investment and Capital Flows, October 2002

No. 101 **Agata, K.:** Internet, Economic Growth and Globalization, November 2002

No. 102 **Blind, K.; Jungmittag, A.:** Ausländische Direktinvestitionen, Importe und Innovationen im Dienstleistungsgewerbe, February 2003

No. 103 **Welfens, P.J.J.; Kirn, T.:** Mittelstandsentwicklung, BASEL-II-Kreditmarktprobleme und Kapitalmarktperspektiven, Juli 2003

No. 104 **Standke, K.-H.:** The Impact of International Organisations on National Science and Technology Policy and on Good Governance, March 2003

No. 105 **Welfens, P.J.J.:** Exchange Rate Dynamics and Structural Adjustment in Europe, May 2003

No. 106 **Welfens, P.J.J.; Jungmittag, A.; Kauffmann, A.; Schumann, Ch.:** EU Eastern Enlargement and Structural Change: Specialization Patterns in Accession Countries and Economic Dynamics in the Single Market, May 2003

No. 107 **Welfens, P.J.J.:** Überwindung der Wirtschaftskrise in der Eurozone: Stabilitäts-, Wachstums- und Strukturpolitik, September 2003

No. 108 **Welfens, P.J.J.:** Risk Pricing, Investment and Prudential Supervision: A Critical Evaluation of Basel II Rules, September 2003

No. 109 **Welfens, P.J.J.; Ponder, J.K.:** Digital EU Eastern Enlargement, October 2003

No. 110 **Addison, J.T.; Teixeira, P.:** What Have We Learned About The Employment Effects of Severance Pay? Further Iterations of Lazear et al., October 2003

No. 111 **Gavrilenkov, E.:** Diversification of the Russian Economy and Growth, October 2003

No. 112 **Wiegert, R.:** Russia's Banking System, the Central Bank and the Exchange Rate Regime, November 2003

No. 113 **Shi, S.:** China’s Accession to WTO and its Impacts on Foreign Direct Investment, November 2003

No. 114 **Welfens, P.J.J.:** The End of the Stability Pact: Arguments for a New Treaty, December 2003

No. 115 **Addison, J.T.; Teixeira, P.:** The effect of worker representation on employment behaviour in Germany: another case of -2.5%, January 2004

No. 116 **Borbèly, D.:** EU Export Specialization Patterns in Selected Accession Countries, March 2004

No. 117 **Welfens, P.J.J.:** Auf dem Weg in eine europäische Informations- und Wissensgesellschaft: Probleme, Weichenstellungen, Politikoptionen, Januar 2004

No. 118 **Markova, E.:** Liberalisation of Telecommunications in Russia, December 2003

No. 119 **Welfens, P.J.J.; Markova, E.:** Private and Public Financing of Infrastructure: Theory, International Experience and Policy Implications for Russia, February 2004

No. 120 **Welfens, P.J.J.:** EU Innovation Policy: Analysis and Critique, March 2004

No. 121 **Jungmittag, A.; Welfens, P.J.J.:** Politikberatung und empirische Wirtschaftsforschung: Entwicklungen, Probleme, Optionen für mehr Rationalität in der Wirtschaftspolitik, März 2004

No. 122 **Borbèly, D.:** Competition among Cohesion and Accession Countries: Comparative Analysis of Specialization within the EU Market, June 2004

No. 123 **Welfens, P.J.J.:** Digitale Soziale Marktwirtschaft: Probleme und Reformoptionen im Kontext der Expansion der Informations- und Kommunikationstechnologie, Mai 2004

No. 124 **Welfens, P.J.J.; Kauffmann, A.; Keim, M.:** Liberalization of Electricity Markets in Selected European Countries, July 2004

No. 125 **Bartelmus, P.:** SEEA Revision: Accounting for Sustainability?, August 2004

No. 126 **Welfens, P.J.J.; Borbèly, D.:** Exchange Rate Developments and Stock Market Dynamics in Transition Countries: Theory and Empirical Analysis, November 2004

No. 127 **Welfens, P.J.J.:** Innovations in the Digital Economy: Promotion of R&D and Growth in Open Economies, January 2005

No. 128 **Welfens, P.J.J.:** Savings, Investment and Growth: New Approaches for Macroeconomic Modelling, February 2005

No. 129 **Pospiezna, P.:** The application of EU Common Trade Policy in new Memberstates after Enlargement – Consequences on Russia's Trade with Poland, March 2005

No. 130 **Pospiezna, P.; Welfens, P.J.J.:** Economic Opening up of Russia: Establishment of new EU-RF Trade Relations in View of EU Eastern Enlargement, April 2005

No. 131 **Welfens, P.J.J.:** Significant Market Power in Telecommunications: Theoretical and Practical Aspects, May 2005

No. 132 **Welfens, P.J.J.:** A Quasi-Cobb Douglas Production Function with Sectoral Progress: Theory and Application to the New Economy, May 2005

No. 133 **Jungmittag, A.; Welfens, P.J.J:** Institutions, Telecommunications Dynamics and Policy Challenges: Theory and Empirical Analysis for Germany, May 2005

No. 134 **Libman, A.:** Russia's Integration into the World Economy: An Interjurisdictional Competition View, June 2005

No. 135 **Feiguine, G.:** Beitritt Russlands zur WTO – Probleme und Perspektiven, September 2005

No. 136 **Welfens, P.J.J.:** Rational Regulatory Policy for the Digital Economy: Theory and EU Policy Options, October 2005

No. 137 **Welfens, P.J.J.:** Schattenregulierung in der Telekommunikationswirtschaft, November 2005

No. 138 **Borbèly, D.:** Determinants of Trade Specialization in the New EU Member States, November 2005

No. 139 **Welfens, P.J.J.:** Interdependency of Real Exchange Rate, Trade, Innovation, Structural Change and Growth, December 2005

No. 140 **Borbély D., Welfens, P.J.J.:** Structural Change, Innovation and Growth in the Context

of EU Eastern Enlargement, January 2006

No. 141 **Schumann, Ch.:** Financing Studies: Financial Support schemes for students in selected countries, January 2006

No. 142 **Welfens, P.J.J.:** Digitale Innovationen, Neue Märkte und Telekomregulierung, März 2006

No. 143 **Welfens, P.J.J.:** Information and Communication Technology: Dynamics, Integration and Economic Stability, July 2006

No. 144 **Welfens, P.J.J.:** Grundlagen rationaler Transportpolitik bei Integration, August 2006

No. 145 **Jungmittag, A.:** Technological Specialization as a driving Force of Production Specialization, October 2006

No. 146 **Welfens, P.J.J.:** Rational Regulatory Policy for the Digital Economy: Theory and EU-Policy Options, October 2006

No. 147 **Welfens, P.J.J.:** Internationalization of EU ICT Industries: The Case of SAP, December 2006

No. 148 **Welfens, P.J.J.:** Marktwirtschaftliche Perspektiven der Energiepolitik in der EU: Ziele, Probleme, Politikoptionen, Dezember 2006

No. 149 **Vogelsang, M.:** Trade of IT Services in a Macroeconomic General Equilibrium Model, December 2006

No. 150 **Cassel, D., Welfens, P.J.J.:** Regional Integration, Institutional Dynamics and International Competitiveness, December 2006

No. 151 **Welfens, P.J.J., Keim, M.:** Finanzmarktintegration und Wirtschaftsentwicklung im Kontext der EU-Osterweiterung, März 2007

No. 152 **Kutlina, Z.:** Realwirtschaftliche und monetäre Entwicklungen im Transformationsprozess ausgewählter mittel- und osteuropäischer Länder, April 2007

No. 153 **Welfens, P.J.J.; Borbély, D.:** Structural Change, Growth and Bazaar Effects in the Single EU Market, September 2008

No. 154 **Feiguine, G.:** Die Beziehungen zwischen Russland und der EU nach der EU-Osterweiterung: Stand und Entwicklungsperspektiven, Oktober 2008

No. 155 **Welfens, P.J.J.:** Ungelöste Probleme der Bankenaufsicht, Oktober 2008

No. 156 **Addison J.T.:** The Performance Effects of Unions. Codetermination, and Employee Involvement: Comparing the United States and Germany (With an Addendum on the United Kingdom), November 2008

No. 157 **Welfens, P.J.J.:** Portfoliomodell und langfristiges Wachstum: Neue Makroperspektiven, November 2008

No. 158 **Welfens, P.J.J.:** Growth, Structural Dynamics and EU Integration in the Context of the Lisbon Agenda, November 2008

No. 159 **Welfens, P.J.J.:** Growth, Innovation and Natural Resources, December 2008

No. 160 **Islami, M.:** Interdependence Between Foreign Exchange Markets and Stock Markets in Selected European Countries, December 2008

No. 161 **Welfens, P.J.J.:** Portfolio Modelling and Growth, January 2009

No. 162 **Bartelmus, P.:** Sustainable Development – Has It Run Its Course?, January 2009

No. 163 **Welfens, P.J.J.:** Intégration Européenne et Mondialisation: Défis, Débats, Options, February 2009

No. 164 **Welfens, P.J.J.:** ЭКОНОМИЧЕСКИЙ РОСТ, ИННОВАЦИИ И ПРИРОДНЫЕ РЕСУРСЫ, February 2009

No. 165 **Welfens, P.J.J.; Vogelsang, M.:** Regulierung und Innovationsdynamik in der EU-Telekommunikationswirtschaft, February 2009

No. 166 **Welfens, P.J.J.:** The International Banking Crisis: Lessons and EU Reforms, February 2009

No. 167 **Schröder, C.:** Financial System and Innovations: Determinants of Early Stage Venture Capital in Europe, March 2009

No. 168 **Welfens, P.J.J.:** Marshall-Lerner Condition and Economic Globalization, April 2009

No. 169 **Welfens, P.J.J.:** Explaining Oil Price Dynamics, May 2009

No. 170 **Welfens, P.J.J.; Borbély, D.:** Structural Change, Innovation and Growth in the Single EU Market, August 2009

No. 171 **Welfens, P.J.J.:** Innovationen und Transatlantische Bankenkrise: Eine ordnungspolitische Analyse, August 2009

No. 172 **Erdem, D.; Meyer, K.:** Natural Gas Import Dynamics and Russia´s Role in the Security of Germany´s Supply Strategy, December 2009

No. 173 **Welfens P.J.J; Perret K.J.:** Structural Change, Specialization and Growth in EU 25, January 2010

No. 174 **Welfens P.J.J.; Perret K.J.; Erdem D.:** Global Economic Sustainability Indicator: Analysis and Policy Options for the Copenhagen Process, February 2010

No. 175 **Welfens, P.J.J.:** Rating, Kapitalmarktsignale und Risikomanagement: Reformansätze nach der Transatlantischen Bankenkrise, Februar 2010

No. 176 **Mahmutovic, Z.:** Patendatenbank: Implementierung und Nutzung, Juli 2010

No. 177 **Welfens, P.J.J.:** Toward a New Concept of Universal Services: The Role of Digital Mobile Services and Network Neutrality, November 2010

No. 178 **Perret J.K.:** A Core-Periphery Pattern in Russia – Twin Peaks or a Rat´s Tail, December 2010

No. 179 **Welfens P.J.J.:** New Open Economy Policy Perspectives: Modified Golden Rule and Hybrid Welfare, December 2010

No. 180 **Welfens P.J.J.:** European and Global Reform Requirements for Overcoming the Banking Crisis, December 2010

No. 181 **Szanyi, M.:** Industrial Clusters: Concepts and Empirical Evidence from East-Central Europe, December 2010

No. 182 **Szalavetz, A.:** The Hungarian automotive sector – a comparative CEE perspective with special emphasis on structural change, December 2010

No. 183 **Welfens, P.J.J.; Perret, K.J.; Erdem, D.:** The Hungarian ICT sector – a comparative CEE perspective with special emphasis on structural change, December 2010

No. 184 **Lengyel, B.:** Regional clustering tendencies of the Hungarian automotive and ICT industries in the first half of the 2000's, December 2010

No. 185 **Schröder, C.:** Regionale und unternehmensspezifische Faktoren einer hohen Wachstumsdynamik von IKT Unternehmen in Deutschland; Dezember 2010

No. 186 **Emons, O.:** Innovation and Specialization Dynamics in the European Automotive Sector: Comparative Analysis of Cooperation & Application Network, October 2010

No. 187 **Welfens, P.J.J.:** The Twin Crisis: From the Transatlantic Banking Crisis to the Euro

Crisis?,January 2011

No. 188 **Welfens, P.J.J.:** Green ICT Dynamics: Key Issues and Findings for Germany, March 2012

No. 189 **Erdem, D.:** Foreign Direct Investments, Energy Efficiency and Innovation Dynamics, July 2011

No. 190 **Welfens, P.J.J.:** Atomstromkosten und -risiken: Haftpflichtfragen und Optionen rationaler Wirtschaftspolitik, Mai 2011

No. 191 **Welfens, P.J.J.:** Towards a Euro Fiscal Union: Reinforced Fiscal and Macroeconomic Coordination and Surveillance is Not Enough, January 2012

No. 192 **Irawan, Tony:** ICT and economic development: Conclusion from IO Analysis for Selected ASEAN Member States, November 2013

No. 193 **Welfens, P.J.J.; Perret, J.:** Information & Communication Technology and True Real GDP: Economic Analysis and Findings for Selected Countries, February 2014

No. 194 **Schröder, C.:** Dynamics of ICT Cooperation Networks in Selected German ICT Clusters, August 2013

No. 195 **Welfens, P.J.J.; Jungmittag, A.:** Telecommunications Dynamics, Output and Employment, September 2013

No. 196 **Feiguine, G.; Solojova, J.:** ICT Investment and Internationalization of the Russian Economy, Septemper 2013

EIIW Economic Policy Analysis:

No. 1 **Welfens, P.J.J.:** Globalisierung der Wirtschaft und Krise des Sozialstaats: Ist die Wirtschaftswissenschaft am Ende?, April 1997

No. 2 **Welfens, P.J.J.:** Nach der D-Mark kommt die E-Mark: Auf dem Weg zur EU-Währungsunion, Juli 1997

No. 3 **Welfens, P.J.J.:** Beschäftigungsförderliche Steuerreform in Deutschland zum Euro-Start: Für eine wachstumsorientierte Doppelsteuerreform, Oktober 1998

Fordern Sie den EIIW Newsletter an: www.eiiw.eu

Please subscribe to EIIW Newsletter: www.eiiw.eu

Weitere Beiträge von Interesse:
Titels of related interest:

Most recent books also see the last page.

WELFENS, P.J.J. (2013), Social Security and Economic Globalization, Heidelberg: Springer.

PERRET, J.K. (2013), Knowledge as a Driver of Regional Growth in the Russian Federation, Heidelberg: Springer.

WELFENS, P.J.J. (2013), Nachhaltige Überwindung der Euro-Krise, Stuttgart: Lucius & Lucius.

SCHULZ, M. (2013), Der gefesselte Riese – Europas letzte Chance, Reinbek: Rowohlt Verlag.

WELFENS, P.J.J. (2012), Die Zukunft des Euro, Berlin: Nicolai Verlag.

WELFENS, P.J.J., HENNICKE, P. (2012), Energiewende nach Fukushima, München: Oekom Verlag.

WELZER, H.; WIEGANDT, K. (2012), Perspektiven einer nachhaltigen Entwicklung: Wie sieht die Welt im Jahr 2050 aus?, Frankfurt am Main: Fischer Verlag.

WELFENS, P.J.J (2011), Cluster- und Innovationsdynamik in Europa: Neue Perspektiven der Automobil- und IKT-Wirtschaft, Stuttgart: Lucius & Lucius.

WELFENS, P.J.J.; EMONS, O.; SCHRÖDER, C. (2011), Europäische Innovations- und Spezialisierungsdynamik im Gesundheitssektor, Stuttgart: Lucius & Lucius.

ISLAMI, M. (2010), Interdependenz zwischen Devisen- und Aktienmärkten in ausgewählten EU-Ländern: Theorie und empirische Analyse, Hamburg: Verlag Dr. Kovac.

VOGELSANG, M. (2010), Digitalization in Open Economies, Heidelberg: Springer.

WELFENS, P.J.J.; et al. (2009), A Europe of achievements in a Changing World, European Commission.

WELFENS, P.J.J.; BORBÉLY, D. (2009), Europäische Integration und Digitale Weltwirtschaft, Band 4: EU-Ostererweiterung, IKT und Strukturwandel, Stuttgart: Lucius & Lucius.

BLEISCHWITZ, R.; WELFENS, P.J.J.; ZHANG, Z. (2009), Sustainable Growth and Resource Productivity, Sheffield: Greanleaf.

WELFENS, P.J.J.; ADDISON, J.T. (2009), Innovation, Employment and Growth Policy Issues in the EU and the US, Heidelberg: Springer.

WELFENS, P.J.J.; RYAN, C.; CHIRATHIVAT, S.; KNIPPING, F. (2009), EU-ASEAN, Facing Economic Globalisation, Heidelberg: Springer.

WELFENS, P.J.J. (2009), Transatlantische Bankenkrise, Stuttgart: Lucius & Lucius.

WELFENS, P.J.J.; WOLF, H.C.; WOLTERS, J. (eds., 2008), International Economics and Economic Policy, Heidelberg: Springer.

WELFENS, P.J.J.; WALTHER-KLAUS, E. (eds., 2008), Digital Excelence, University Meets Economy, Heidelberg: Springer.

WELFENS, P.J.J. (2008), Digital Integration, Growth and Rational Regulation, Heidelberg: Springer.

WELFENS, P.J.J. (2007), Innovation in Macroeconomics, Heidelberg: Springer.

WELFENS, P.J.J.; WESKE, M. (eds., 2007), Digital Economic Dynamics, Innovations, Networks and Regulations, Heidelberg: Springer.

WELFENS, P.J.J., WESKE, M. (eds., 2006): Innovations, Digital Economic Dynamics and Regulatory Policy, Heidelberg: Springer.

WELFENS, P.J.J., KNIPPING, F., CHIRATHIVAT, S., RYAN, C. (eds., 2006): Integration in Asia and Europe: Historical Dynamics, Political Issues and Economic Perspectives, Heidelberg: Springer.

BROADMAN, H.G., PAAS, T., WELFENS, P.J.J. (eds., 2006): Economic Liberalization and Integration Policy Options for Eastern Europe and Russia, Heidelberg: Springer.

BORBÉLY, D. (2006): Trade Specialization in the Enlarged European Union, Heidelberg/Berlin: Springer.

JUNGMITTAG, A. (2006): Internationale Innovationsdynamik, Spezialisierung und Wirtschaftswachstum in der EU, Heidelberg: Physica.

WELFENS, P.J.J., WZIATEK-KUBIAK, (eds., 2005): Structural Change and Exchange Rate Dynamics – The Economics of EU Eastern Enlargement; Heidelberg: Springer.

WELFENS, P.J.J., ZOCHE, P., JUNGMITTAG, A. (et al. 2005): Internetwirtschaft 2010 (final Report for the German Federal Government; joint study EIIW and Fraunhofer Institute for System Dynamics and Innovation, Karlsruhe), Heidelberg: Physica.

GRAHAM, E., ODING, N., WELFENS, P.J.J., (2005): Internationalization and Economic Policy Reforms in Transition Countries, Heidelberg: Springer.

GAVRILENKOW, E., WELFENS, P.J.J., (2005): Infrastructure, Investments and Economic Integration: Perspectives for Eastern Europe and Russia, Moscow: HSE.

APOLTE, T.; CASPERS, R.; WELFENS, P.J.J. (2004), Ordnungsökonomische Grundlagen nationaler und internationaler Wirtschaftspolitik, Stuttgart: Lucius & Lucius.

GAVRILENKOV, E.; WELFENS, P.J.J.; WIEGERT, R. (2004), Economic Opening Up and Growth in Russia, Heidelberg and New York: Springer.