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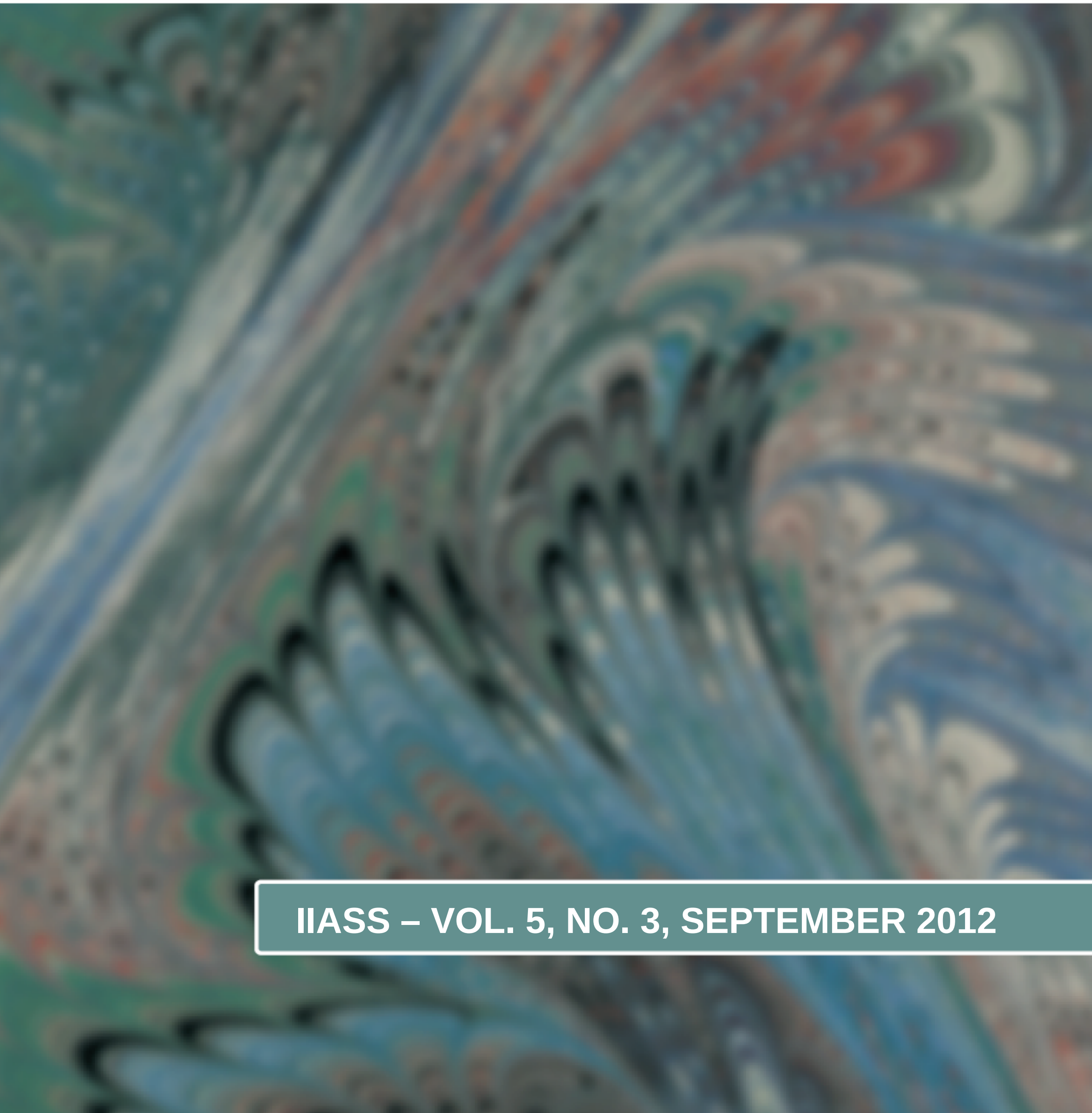

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COMPARISON OF THE ICT IMPACTS BETWEEN CZECH REPUBLIC AND SLOVENIA - PANEL DATA ANALYSIS

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Abstract

This paper compares the ICT impacts occurred in Czech industries during years 1995-2006 to those in Slovenia. We examined whether macro panel data analysis proves significance of ICT capital variable in sense of productivity growth on the whole economy. Unfortunately, there are not many studies observing the ICT impacts from perspective of Central and Eastern European (CEE) countries, even if ICTs are assumed to have potential to enhance economic growth, labour productivity, competitiveness of developing countries and lower income gap within Europe.

Key words: ICT, Czech Republic, Slovenia, Panel Data Analysis

Introduction

Numerous researches since the 1990s have focused on topic of the ICT impacts in sense of GDP or labour productivity growth but in particular from the view of the US or other developed countries. However, not many studies pay attention to how to alleviate income disparities between countries by improving the ability of developing countries to adopt and use ICTs.

Clarke (2002) highlighted the potential of new technologies (such as Internet) if they are implemented into business sector of developing countries. He assumed that it might lead to the development of their business processes and increase their overall competitiveness in comparison with more developed economies.

Moreover, Indjikian and Siegel (2004) in their research compared the impact of ICTs on economic growth in developed and developing countries. In general, studies from developed countries show a strong positive relationship between ICTs and economic performance. ICTs

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also induce positive organisational changes as well as changes in the structure of the workforce (better educated and trained labour). On the other hand emerging countries have shortcomings in terms of knowledge and best practices related to the use of ICTs but also in ICT-skilled workforce. Therefore these countries should try to adopt technologies and adjust business environment so that they will enhance their long-term economic growth.

The authors pointed out that the state should play an important role to improve the knowledge and best practices of local companies in the ICT use in their perspective industries; create an enabling environment for investment in ICTs and also build inevitable infrastructure, which contributes to gaining access to broadband at lower cost and supports the use of free software (open source). Fast and reliable connection helps to build confidence in the “impersonal” transactions, exchange of information online and creation of electronic services etc. Moreover, the state should also ensure improvement in ICT skills and qualification of workforce.

However, they assumed that the state itself cannot effectively overcome all these shortcomings and it is also necessary to establish proper cooperation between public and private sectors. Such cooperation would be able to bring benefits such as better access to financial capital, which might stimulate ICT investment; human capital development in order to ease implementation of new technologies; development and expansion of networks, which serve to improve the private (business level) and the societal benefits of ICTs, e-commerce or information sharing etc.

Another study by Fuss, Meschi and Waverman (2005) examined the growth potential of investment in telecommunications infrastructure in both developed and developing economies and found out that a country with an average of 10 more mobile phones for every 100 people would have enjoyed a per capita GDP growth higher by 0.59 percent annually. The effect of mobiles was twice larger in developing countries then in developed ones. It indicates great perspectives of mobile infrastructure and services in order to improve their economic development.

A World Bank´s econometric analysis of 120 countries (2009) also suggests that an increase of broadband access in countries by 10 subscribers per 100 inhabitants might induce a 1.3 percent increase in per capita GDP growth. According to this study the growth effect of broadband is stronger in developing countries than in developed ones but also higher than that reached by telephones or the Internet. The main conclusion of this study is that broadband has a significant impact

on growth and deserves a central role in country development and competitiveness strategies.
Unfortunately, there is lack of similar studies which examine these issues from perspective of Central and Eastern European (CEE) countries. Only in 2003 Piatkowski provided the first estimates of the ICT capital contribution to economic growth and labour productivity in Bulgaria, Czech Republic, Hungary, Poland, Slovakia, Slovenia, Romania and Russia. The results of this paper show that contribution of investment in IT hardware, software and telecommunication equipment to output growth and labour productivity between 1995 and 2000 in most countries included into the study was much higher than what might be expected on the basis of the level of their GDP per capita. This might mean that the transition economies are able to increase their growth rates in output and labour productivity through the use of ICTs and hence accelerate the process of catching-up more developed countries. The last results of his co-work with Van Ark (2007) show that labour productivity growth in most New Member States of the EU accelerated in 2004 and continued to grow fast in 2005 and 2006. Manufacturing industries in the these states contributed between 0.4 and 1.9 percentage points to the aggregate labour productivity growth between 1995 and 2004 that is substantially more than in the EU-15 and the US.

All these studies support the assumption that ICTs have potential to enhance economic growth, productivity and competitiveness of developing countries and lower income gap between developed and developing countries. Therefore we consider necessary to study the ICT impacts and their future growth prospects for CEE countries.

Consequently, the aim of this paper is to assess the ICT impacts on productivity growth in Czech Republic and Slovenia during years 1995 – 2006 by using EU KLEMS Growth and Productivity Accounts.

Data

To analyse the ICT impacts we employed available annual data series of Czech Republic and Slovenia from 1995 to 2006. Data inevitable for our analysis were obtained from released EU KLEMS database and consists of variables - ICT-capital stock (coded in this analysis as *ict*), non-ICT capital stock input (*noict*), Production or Gross output (*prod*), Total hours worked by employees (*hours*), Number of employees (*emp*). For better comparison of two countries the capital and output values are expressed in millions of USD and number of employees and total worked hours in million units. We used time series of 29 industry branches of every country classified by the European NACE revision 1 method. (Table 1 provides overview of analysed industries and their codes used in the further analysis for simplification).

Table 1: Industries overview

INDUSTRIES OVERVIEW (with coding)	
TOTAL INDUSTRIES	195
AGRICULTURE, HUNTING, FORESTRY AND FISHING	105
MINING AND QUARRYING	1014
TOTAL MANUFACTURING	D
FOOD , BEVERAGES AND TOBACCO	1516
TEXTILES, TEXTILE , LEATHER AND FOOTWEAR	1719
WOOD AND OF WOOD AND CORK	20
PULP, PAPER, PAPER , PRINTING AND PUBLISHING	2122
CHEMICAL, RUBBER, PLASTICS AND FUEL	E
Coke, refined petroleum and nuclear fuel	23
Chemicals and chemical	24
Rubber and plastics	25
OTHER NON-METALLIC MINERAL	26
BASIC METALS AND FABRICATED METAL	2728
MACHINERY, NEC	29
ELECTRICAL AND OPTICAL EQUIPMENT	3033
TRANSPORT EQUIPMENT	3435
MANUFACTURING NEC; RECYCLING	3637
ELECTRICITY, GAS AND WATER SUPPLY	4041
CONSTRUCTION	45
WHOLESALE AND RETAIL TRADE	F
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	50
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
Retail trade, except of motor vehicles and motorcycles; repair of household goods	52
HOTELS AND RESTAURANTS	55
TRANSPORT AND STORAGE AND COMMUNICATION	G
TRANSPORT AND STORAGE	6063
POST AND TELECOMMUNICATIONS	64
FINANCE, INSURANCE, REAL ESTATE AND BUSINESS SERVICES	H
FINANCIAL INTERMEDIATION	6567
REAL ESTATE ACTIVITIES	70
RENTING OF M&EQ AND OTHER BUSINESS ACTIVITIES	7174
COMMUNITY SOCIAL AND PERSONAL SERVICES	I
PUBLIC ADMIN AND DEFENCE; COMPULSORY SOCIAL SECURITY	75
EDUCATION	80
HEALTH AND SOCIAL WORK	85
OTHER COMMUNITY, SOCIAL AND PERSONAL SERVICES	9093
PRIVATE HOUSEHOLDS WITH EMPLOYED PERSONS	95
EXTRA-TERRITORIAL ORGANIZATIONS AND BODIES	X

Source: EU Klems (2007)

As a measure of productivity we defined logarithm of production (gross output) per employee. Final model, which assess the ICT impacts, is based on Cobb-Douglas production function. The next section presents applied methodology and the final model.

Methodology

In this paper we attempt to assess the ICT impacts in sense of productivity growth of Czech Republic in comparison to Slovenia by using panel data analysis. Using panel data we can control for variables that vary across subjects but not over time or are unobserved or unmeasured and therefore cannot be included in regular OLS regression. This method requires data in which each observational unit or entity is observed at two or more time periods. Our panel is balanced which means that all subjects (29 industries) are observed in all determined time periods (1995-2006)[2].

The regression model is defined as follows:

$$Y_{i,t} = \beta_0 + \beta_1 X_{i,t} + \beta_2 \eta_i + u_{i,t} .$$

Where $Y_{i,t}$ is dependent variable, $X_{i,t}$ is observed regressor, η_i is unobserved variable that varies from one industry to the next but does not change over time (for example in our case it could be openness towards new technologies). Because η_i does not vary over time the regression model can be interpreted as having n intercepts α_i, one for each industry:

$$\alpha_i = \beta_0 + \beta_2 \eta_i .$$

Then equation of the regression model becomes:

$$Y_{i,t} = \alpha_i + \beta_1 X_{i,t} + u_{i,t} .$$

Using this method we can study changes (differences) in the dependent variable over time and therefore the omitted variables (that does not change over time) are dropped out from equation. We can control for all time-constant differences between individuals:

$$Y_{i,t} - \breve{Y}_i = (\beta_0 + \beta_1 X_{i,t} + \beta_2 \eta_i + u_{i,t}) - (\beta_0 + \beta_1 \breve{X}_i + \beta_2 \eta_i + \breve{u}_i) =$$
$$= \beta_1 (X_{i,t} - \breve{X}_i) + (u_{i,t} - \breve{u}_i)$$

.

Where $\breve{Y}_i, \breve{X}_i, \breve{u}_i$ are means of $Y_{i,t}$, $X_{i,t}$ and $u_{i,t}$ over time.

We can rewrite equation in the form that is similar to the regression function in OLS, if we define $\widetilde{Y}_{i,t} = Y_{i,t} - \breve{Y}_i$ and similar for $\breve{X}_i, \breve{u}_i$:

[2] Stock, J. H., & Watson, M.W. (2007)

$\widetilde{Y}_{i,t} = \beta_1 \widetilde{X}_{i,t} + \widetilde{u}_{i,t}$.

We have N.T observations. Our original variables were transformed and this transformation caused that we have a model specification without intercept.

Our final model is based on Cobb-Douglas production function:
$Y = A.ICT^{\beta 1}.L^{\beta 2}.K^{\beta 3}$.

Where *Y* is output per employee, *A* is a constant representing other factors of production (eg increased level of education, improved skills of workers etc.), *ICT* is ICT capital variable, *K* is non-ICT capital variable and *L* represents hours worked by employees. $\beta_1, \beta_2, \beta_3$ are elasticities of the production resources.

For the further analysis the equation is transformed into linear form:
$\ln(Y_{it}) = a + \beta_1 \ln(ICT_{it}) + \beta_2 \ln(K_{it}) + \beta_3 \ln(L_{it})$.

Using the panel data methodology our final model is constructed as followed:
$\ln(\widetilde{Y}_{i,t}) = \beta_1 \ln(\widetilde{ICT}_{i,t}) + \beta_2 \ln(\widetilde{K}_{i,t}) + \beta_2 \ln(\widetilde{L}_{i,t}) + \widetilde{u}_{i,t}$.

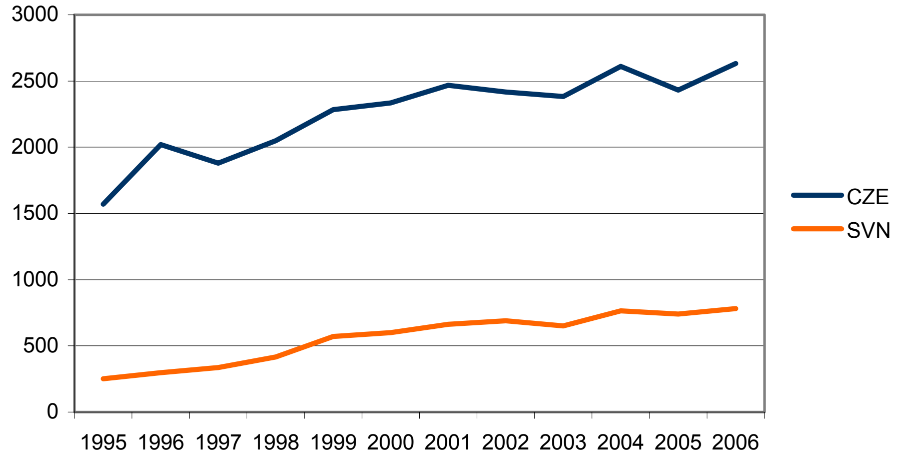
Empirical results

As mentioned before our ambition in this paper is to assess the ICT impacts by using panel data of 29 industry branches of Czech Republic and Slovenia. The graph 1 indicates growth of ICT capital in both countries during 1995 – 2006. There is significantly higher volume but also higher volatility of the Czech ICT capital. The total volume of ICT investment in Slovenia during the same period is on average four times smaller then in Czech Republic but its trend seems to increase constantly and more stable.

If we look at the graph 2 we can compare average percentage share of ICT capital to total capital for individual industries. It is not surprising that the highest share of ICT capital is in Post and Telecommunications industry (64) and Financial Intermediation sector (6567) where its share is about 40-60%. The pattern of ICT capital distribution is very similar for both countries (but in most cases its percentage share is higher in Slovene industries). It might reflect differences in the real ICT capital needs and heterogeneity of individual industries. For instance Mining and Quarrying (1014) requires only about 5% of ICT capital in both countries, however, Post and Telecommunications industry (64) requires about 60% on average.

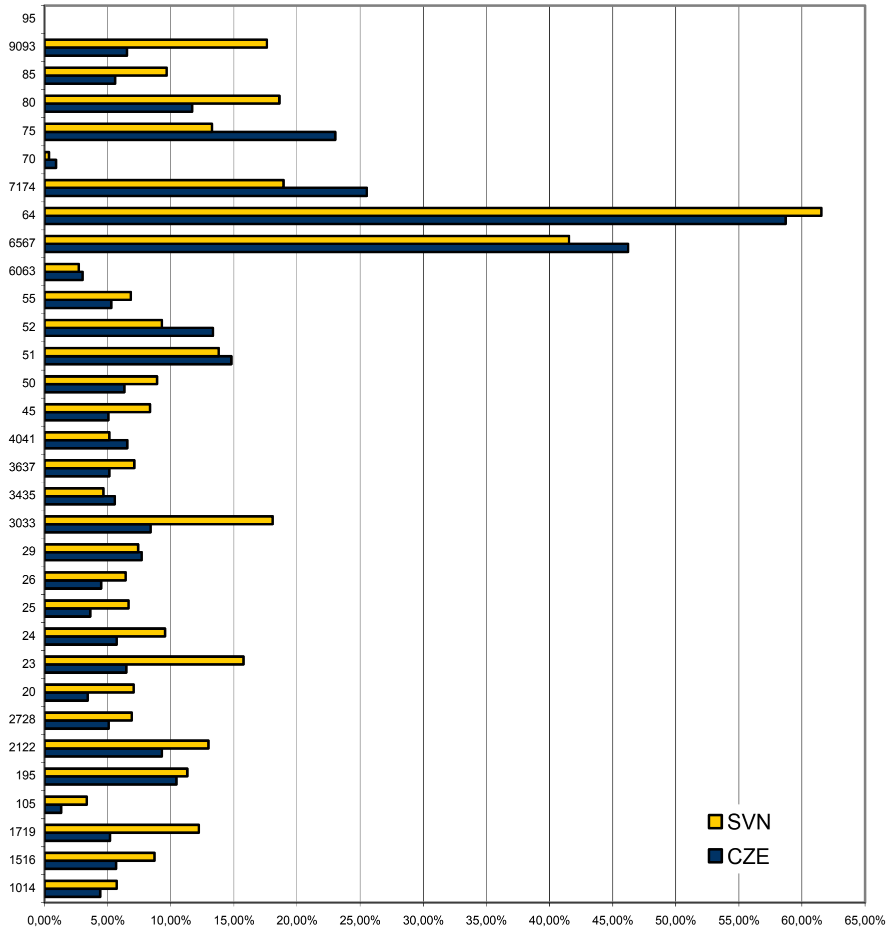
Huge development and implementation of technologies is expected to bring benefits in form of enhanced productivity, higher profits, lower cost, quality improvements as well as new product or process innovations. Believing that ICTs are an important driver of economic growth and employment, it is necessary to examine real impacts of investment in ICTs and more precisely determine specific technology needs for each industry branch. Unfortunately, in this case we are not able to assess each single industry because we have access only to aggregate industry level data but not to micro level ones. The available observations are for 12 years and 29 industries. But such a small dataset might not be able to provide reliable estimates.

Graph 1: The ICT capital growth, all industries, 1995-2006



Source: EU Klems (2007)

Graph 2: Average percentage share of ICT capital to total capital, all industries 1995-2006



Source: EU Klems (2007)

Assuming that only industries with higher proportion of ICT capital might benefit from using it, we excluded industries with the lowest average percentage share of ICT capital to total capital – Real Estate Activities (70), Transport and Storage (6063), Agriculture, Hunting, Forestry and Fishing (105) and Private Households with Employed Persons (95). Industries with too low ICT capital in comparison to non-ICT capital could bias our analysis and lower potential results of the ICT effects. By excluding the least ICT-intensive industries (from this point of view) we could more precisely indicate significance of ICT investment to productivity growth. Afterwards we conducted panel data analysis of such reduced panels.

As mentioned in previous section panel data analysis is controlling for omitted variables, which does not change over time. Moreover, we added also time dummy variables, which control for omitted variables that change over time. The final regression model structure consists of logarithm of gross output per employee as dependent variable and logarithm of total hours worked, logarithm of ICT capital, logarithm of non-ICT capital and time dummies as independent variables.

To test whether the fixed effects (FE) or random effects (RE) model is more appropriate for the panel data analysis, we conducted Hausman test. The fixed effects model assumes that individual heterogeneity (or individual effects by which entities differ from each other) is captured only by the intercept term α_i, which means that every individual entity (in this case industry) gets its own intercept while the slope coefficients are the same. On the other hand the random effects model assumes that individual effects are captured by the intercept but also by a random component $\varepsilon_{i,}$ which is not correlated with the regressors on the right side and part of the error term. The intercept becomes $\alpha_i + \varepsilon_{i,}$. Considering this test Slovenia follows random effects model and for Czech Republic fixed effects model is more suitable. Picture 1 and 2 present obtained results of panel analysis:

Picture 1: Slovenia – panel data analysis

```
Random-effects GLS regression                   Number of obs      =       324
Group variable: id                              Number of groups   =        27

R-sq:  within  = 0.8882                         Obs per group: min =        12
       between = 0.0012                                        avg =      12.0
       overall = 0.1573                                        max =        12

Random effects u_i ~ Gaussian                   Wald chi2(14)      =   1333.42
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000

                                    (Std. Err. adjusted for 27 clusters in id)
------------------------------------------------------------------------------
             |               Robust
         LPQ |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    loghours |   .0539103   .1537772     0.35   0.726    -.2474875    .3553082
      logict |   .1332555   .0686751     1.94   0.052    -.0013451    .2678562
    lognoict |   .0900878    .047752     1.89   0.059    -.0035044      .18368
         y96 |   .1316465   .0172259     7.64   0.000     .0978842    .1654087
         y97 |    .243541   .0347361     7.01   0.000     .1754595    .3116225
         y98 |   .2879403   .0577787     4.98   0.000     .1746961    .4011846
         y99 |   .3108287   .0763307     4.07   0.000     .1612232    .4604342
         y00 |   .4361227   .0726247     6.01   0.000     .2937808    .5784645
         y01 |   .4903033    .093848     5.22   0.000     .3063646     .674242
         y02 |    .593283   .0943831     6.29   0.000     .4082955    .7782705
         y03 |   .6464294   .1046842     6.18   0.000     .4412522    .8516065
         y04 |   .7245104   .1001098     7.24   0.000     .5282988    .9207221
         y05 |   .7775669   .1047149     7.43   0.000     .5723294    .9828044
         y06 |   .8607681   .1018081     8.45   0.000      .661228    1.060308
       _cons |   2.532778   .4736091     5.35   0.000     1.604522    3.461035
-------------+----------------------------------------------------------------
     sigma_u |  .48456385
     sigma_e |  .12975472
         rho |  .93309334   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Source: Author

Looking at p-value we can consider all dependent variables as significant at 10% significance level. The results explain that 1% increase of ICT investment would yield a 0.13% increase in the productivity (holding all other variables constant). Moreover, 1% increase of non-ICT capital would yield a 0.09% increase and 1% increase of hours worked would increase productivity by 0.05%. All dummy variables are significant which means that we omitted some variables that change over time. The Wald test that the coefficients on the regressors are all jointly zero is rejected. In this paper we are estimating a within-effects model, therefore the within R^2 is relevant and its value 88.82% implies that our model is quite well specified.

Picture 2: Czech Republic - panel data analysis

```
Fixed-effects (within) regression               Number of obs      =       324
Group variable: id                              Number of groups   =        27

R-sq:  within  = 0.9152                         Obs per group: min =        12
       between = 0.5714                                        avg =      12.0
       overall = 0.6188                                        max =        12

                                                F(14,26)           =    353.12
corr(u_i, Xb)  = 0.2627                         Prob > F           =    0.0000

                                  (Std. Err. adjusted for 27 clusters in id)
```

LPQ	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loghours	-.39458	.1765507	-2.23	0.034	-.757485	-.0316749
logict	.0153768	.0287617	0.53	0.597	-.0437437	.0744974
lognoict	.0136477	.0474301	0.29	0.776	-.0838462	.1111416
y96	.0856369	.0230148	3.72	0.001	.0383293	.1329446
y97	.0604179	.0289833	2.08	0.047	.0008419	.119994
y98	.1389832	.0348211	3.99	0.000	.0674073	.210559
y99	.145045	.0428825	3.38	0.002	.0568986	.2331913
y00	.1515661	.0485579	3.12	0.004	.0517538	.2513783
y01	.2185207	.0530013	4.12	0.000	.1095748	.3274665
y02	.3900242	.0561904	6.94	0.000	.2745231	.5055252
y03	.6006887	.059631	10.07	0.000	.4781154	.723262
y04	.7891531	.0584565	13.50	0.000	.6689941	.9093122
y05	.9138624	.0558268	16.37	0.000	.7991087	1.028616
y06	.9155874	.056998	16.06	0.000	.7984263	1.032748
_cons	5.427013	.9490322	5.72	0.000	3.476249	7.377777
sigma_u	.4923456					
sigma_e	.11645038					
rho	.94702129	(fraction of variance due to u_i)				

Source: Author

Looking at p-value of the second reduced panel for Czech Republic we can also confirm that all dependent variables are significant at 10% significance level. The results indicate that 1% increase of ICT capital variable would lead to 0.015% increase in productivity (holding all other variables constant), 1% increase of non-ICT capital would increase productivity by 0.014% and 1% increase of hours worked would decrease productivity by 0.4%. All dummies are significant therefore we can assume that there are other omitted variables that change over time and our model does not include them. The F statistic tests that the coefficients on the regressors are all jointly zero is rejected. The within R^2 is 91.52% which implies that our model is quite well specified.

We can compare our results also with previous study of Piatkowski and Van Ark from 2004, when they examined the ICT effects in CEE countries during 1995-2001 and concluded that ICT capital growth leads to 0.87% average growth of output in four CEE countries (Czech Republic, Hungary, Poland and Slovakia). Average contribution of ICT capital in these countries was higher than average of EU-15 (0.73%), which indicates that ICTs might contribute to convergence process between CEE and EU-15. Our results show lower impacts but it may be caused by differences in methodology, datasets or longer time period. After longer time ICTs are more adopted and diffused in the country and their marginal ICT effects are getting lower.

In our model the ICT effects of Slovene industries seem to be significantly higher than in Czech Republic. Looking closely on correlation coefficients between productivity per employee and ICT capital there is significant positive correlation (above 0.7) for almost all industries (except for Textiles, Textile, Leather and Footwear industry (1719), Coke, Refined Petroleum and Nuclear Fuel industry (23) and Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail sale of Fuel (50)), which might mean that almost all industries reach considerable benefits of using ICTs. They might have proper establishment of ICT capital and also other complementary factors that improve the ICT effects might be well adjusted such as infrastructure, suitable economical and political environment, ICT-skilled workforce etc.

On the other hand Czech industry correlation coefficients of productivity and ICT capital are mainly insignificant or negative. The highest correlation slightly above 0.7 is reached only in Wood and of Wood and Cork industry (20), Electrical and Optical Equipment (3033) and Renting of M&EQ and Other Business Activities (7174)). The highest negative correlation is in Mining and Quarrying industry (0.42), but in this case we did not even expect high correlation according to the industry character.

Insignificant or negative correlations in some industries might be explained by wrong cost policy, time-consuming process of new technologies adoption (for instance employees training, adjustment of internal and external processes of companies etc), unqualified or insufficiently trained employees, inefficient computerization, obsolescence and low flexibility of business processes, incorrect bookkeeping of ICT capital, incorrect management of ICT investment (for instance “maverick spend”) etc.

Moreover, other reasons might be for instance that some industries (or companies) invest into ICT but their core processes do not necessarily require significant ICT support and increase in ICTs would not lead to higher productivity anyway or some industries still have low level of ICT investment and therefore their productivity may be also low. But in this case we can assume that higher increase in the usage of ICTs but also improvement and modernisation of business processes and management would improve their productivity results.

Unfortunately, we analysed only available aggregated data on the industry level therefore we miss a lot of information about individual firms in each industry and their characteristics (number of companies, their size etc). Moreover, we do not have also detail information about the concrete forms of ICTs used in individual companies, which might be very important to assess the real ICT impacts. For instance report about the ICT impacts "Information Society: ICT impact assessment by linking data from different sources" concluded that some technologies are more beneficial for certain industries. Inappropriate even huge investment in ICTs in the industry will not bring expected effects, which could also partly explain insignificant results in some examined industries of our research.

Conclusion

The main aim of this paper is to study the ICT impacts of Czech Republic and Slovenia during 1995-2006. We believe that more studies focused on CEE countries and higher interest in this region would lead to its further economic growth. By improving methodologies and more precise analyses in this field we might potentially lower income gap within Europe as well as lower negative impacts of the crisis.

For the purpose of the ICT impacts assessment we conducted panel data analysis, which controls for variables that vary across subjects but not over time or are unobserved or unmeasured and therefore can not be included in regular OLS regression.

Czech results from macro analysis did not prove significance of ICT investment in sense of productivity growth, which is measured by logarithm of gross output per employee. In comparison to Slovenia which shows significant ICT effects without any reduction of whole economy panel. Taking into account heterogeneity of industries and the fact that not all the industries need to implement ICTs into their production, we performed analysis which excluded industries with the lowest average ICT capital share from both countries. Afterwards also Czech Republic proved importance of ICT capital to productivity growth. But looking separately on individual industry correlation coefficients between productivity and ICT capital, majority of Czech industries demonstrate low or negative correlations. We cannot confirm that ICT investment in Czech Republic significantly contribute to productivity growth in every industry. But it might be also caused by other factors such as for instance unqualified or insufficiently trained employees, inefficient computerization, obsolescence and low flexibility of business processes or incorrect management of ICT investment etc.

Unfortunately, we have to admit that our analysis lacks detail data about industry structures (number of companies or their size involved in an industry) which would help us better detect the ICT impacts in individual industry branches, effective distribution of ICT capital or suitable form of technologies that matches industry or company individual needs. We are also aware of insufficient length of the time series in our analysis what could lead to biased results. Therefore we consider our analysis as eventual model or proposal for further research in this field more than explicit evaluation of the ICT impacts. Our main ambition was to point out on inevitability to pay more attention to potential benefits of ICTs in CEE countries and development of our region.

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