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ICT AND ECONOMIC GROWTH – SHORT TERM CAUSALITY ANALYSIS

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ABSTRACT

Information technologies are often regarded as one of the modern sources of economic growth. They are usually linked to great inventions of the past and marked as a „general purpose technology“. Information technologies should affect whole economy reducing transaction cost and increasing production factors productivity. Companies utilizing information technologies should be more competitive than those which do not do that and countries with higher IT investments should grow faster. This whole story worked fine during 1990s and 2000s but the situation changed with the recession at the beginning of 2008. Although all the benefits from IT were still valid (or even more) companies reduced their IT spending dramatically in 2009. Such unexpected development raises a question if IT sector is not - at least in a short run - a dependent sector which is much more affected by than affecting the overall production.

JEL CLASSIFICATION & KEYWORDS

O14 | Economic Growth | Information Technologies | General Purpose Technology | Business Cycle | Causality

INTRODUCTION

Information technologies have started to attract the economist´s attention approximately 50 years ago when information technologies were believed to be “the biggest technological revolution men have known” [Snow 1966]. Information technologies were believed to reduce transaction cost and increase factor productivity. Despite these great expectations, during the following era of 1970s and 1980s almost no contribution of information technologies to factor productivity, i.e. economic growth, was witnessed. This situation has become to be known as “productivity paradox” introduced by Robert Solow [Brynjolfsson 1993] and other researchers[1] However these unexpected and mostly bitter results were at least partly inaccurate because of unreliable data and small sample sizes [Dedrick et.al. 2003]. In the middle of 1990s the situation has reverted. Kraemer and Dedrick [1994] publish a cross-country study proving positive link between information technologies, GDP and productivity. Schreyer [1999] has found out similarly that information technologies significantly contribute to productivity growth. There were many other studies finding positive relation between IT, factor productivity and economic growth in this decade and during the following 2000s[2]. On the other hand, in ICT industries there was a different relation between labor productivity and labor costs in ICT manufacturing and ICT services [Vltavská, Fischer, 2010]. At the end of 1990s information technologies are regarded as “General Purpose Technologies” [GPT] having the similar effect on economy as great inventions of the past [David 1990 and David, Wright 1999]. Even the dot-com bubble which occurred in 2001 was in line with these findings as information technologies were the driving force of economic decline. Information technologies then have naturally established in the economic growth theory as well, fitting especially into endogenous growth theories framework [Romer 1990, Aghion, Howitt 1998 or Helpman, Trajtenberg 1998].

At the end of 2000s, however, the situation is again not that straightforward. After housing price bubble in 2008 and subsequent recession the situation has changed. Information technologies were substantially affected by the recession they actually did not cause. In addition it seemed that the impact was probably more severe that one of dot-com bubble [IT spending forecast, Gartner 2009]. The Gartner Report on IT Spending (Gartner 2010) exhibits the worldwide IT spending has dropped down by 5,2% in 2009 when it grew by 6% between 2007 and 2008. Quite obviously companies reduced their spending on information technologies dramatically and their need for information technologies turned to be considerably lower. But why did this happen? All the benefits of information technologies were the same during the crisis. So one would expect companies to utilize information technologies even more to gain maximum cost reduction and survive the crisis. On the contrary companies started to see IT services and equipment as expendable part of their structure. Taking this recent development into account we must start to think about the direction of causality between economic growth and information technologies again. Are information technologies really promoting higher competitiveness [i.e. economic growth at the aggregate level] or is their impact on economy questionable? Would it be possible that investment in IT is regarded as risky one and companies therefore tend to invest into IT only during the phases of expansion but are likely to reduce the investment during recessions? And are information technologies really promoting economic growth or could the reality be reversal – that growing economy may afford more unpredictable and risky investments [even with possibly high rate of return]? The purpose of this paper is to analyze the causality direction between information technologies and GDP growth and to answer these quite disturbing questions.

IT AND THE BUSINESS CYCLE

The belief that information technologies promote economic growth is based on assumption that there is one-way causality – from technologies to growth. Almost no one has doubted this assumption yet because it seemed very reasonable[3]. Information technologies utilization yields transaction cost cut, higher efficiency of production factors, better information flows and innovation potential etc. as stated above. But as recent development in IT sector has revealed information technologies are also crucially dependent on the economic development itself. Dewan and Gurbaxani [2007] found out that IT investments contribute

[1] Franke [1987] , Strassmann [1990] or Loveman [1988] for example.

[2] However this relation was proven only for developed countries [see Lal, 2001 or Dewan and Kraemer, 2000].

[3] Some authors also focused on mutual and cumulative relation between IT and economic growth [Lee et. al 2002].

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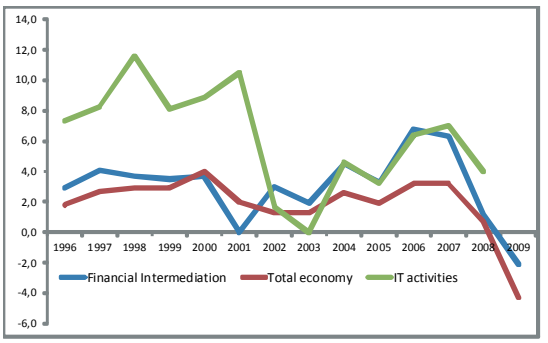
to overall firm risk more than non-IT investments which might explain unusually high valuation of IT capital investments. They are simply investments with high uncertainty and high rate of return. Therefore we could expect that in "good times" companies are more likely to undertake such risky investments and in "bad times" they are quite reluctant to invest in information technologies. To analyze this idea we should compare IT expenditures to business cycle. Figure 1 shows the situation in the case of EU 27 in time period 1996-2009 (2008 respectively)[4] in comparison to other sector – financial intermediation.

Figure 1: IT and Business Cycle



We may find two possible conclusions out of Figure 1. First it is quite obvious that IT sector has very high volatility in comparison to economy average (i.e. total gross value added) or even to financial intermediation as alternative service sector. This might support the idea of information technologies as a risky investment stated above. Also we may see possible delay of information technologies dynamics behind the business cycle. To prove this we should conduct a semi causal model in following section of this paper. Before doing this it would be useful to compare the volatility of information technologies to other service-oriented sectors to see the position of IT among other services from the "risk" point of view. Table 1 in Appendix shows the result; volatility is measured with variation – the higher variation the higher volatility and the higher risk rate of particular type of service. Not surprisingly IT is among those branches with very high volatility indicating that companies really might suppress these activities during recessions more than others.

CAUSALITY MODEL

Higher volatility or risk rate is not necessarily reason for taking information technologies as a sector dependent on the business cycle. On the contrary some economists argue that information technologies are one of important sources of economic growth. Of course if IT was one of the initiators of the cycle than our idea would be wrong. Higher IT investments would initiate growth, cutting these investments down would contribute to recession. It is necessary to analyze the causality between business cycle and information technologies development to prove or deny the hypothesis introduced above. To do this we may use two equation vector autoregressive model. Panel data approach on selected EU countries in period 1996-2008 is used here to get as much observations [and reliability] as possible[5].

[4] EUROSTAT data of gross value added volumes growth in computer and related activities (K72 according to NACE classification) were used. Unfortunately the data availability is very poor – the time series for IT output in most of the EU countries are short or incomplete which is weakening the undertaken analysis.

[1] $$gc_{i,t} = C_{1i} + P_{1j} + \sum_{j=1}^{p} \alpha_{1j}(gc_{i,t-j}) + \sum_{j=1}^{p} \beta_{1j}(y_{i,t-j}) + u_{it}$$

[2] $$y_{i,t} = C_{2i} + P_{2j} + \sum_{j=1}^{p} \alpha_{2j}(gc_{i,t-j}) + \sum_{j=1}^{p} \beta_{2j}(y_{i,t-j}) + v_{it}$$

here *y* represents total output (value added) growth in country *i*, *gc* represents growth of IT value added and *j* represents the lag of variables. *P* and *C* represent period and fixed effects which might take place in estimation. While equation [1] analyzes dependency of information technologies on output equation [2] deals with reversal relationship. After testing for fixed effects only period fixed effects were chosen as significant [see the test results in Appendix] and one period lag [*j=1*] was chosen according to visible time shift in Figure 1. Equations [3] and [4] show the model estimates, t-statistics is in brackets, full representation is in Appendix.

[3] $$gc_{i,t} = \underset{[4,21]}{7,59} - \underset{[-2,74]}{0,15}(gc_{t-1}) + \underset{[3,24]}{1,35}(y_{t-1})$$

[4] $$y_{i,t} = \underset{[3,45]}{0,98} + \underset{[0,39]}{0,003}(gc_{t-1}) + \underset{[10,32]}{0,68}(y_{t-1})$$

Not surprisingly it is quite obvious that at least in a short run, information technologies are probably dependent on total economy development and not vice versa. We can say that we have proven our hypothesis of IT as a mainly "pushed" sector which is corresponding to partial conclusions taken above.

CONCLUSION

Information technologies are often perceived as a dynamic sector which is significantly contributing to the overall output growth. Lots of studies prove positive correlation between IT and GDP [or other output measure] growth however the question of causality has still remained open. As we witnessed during the financial crisis and subsequent recession, companies surprisingly dramatically reduced their spending on IT. They did it in spite of general knowledge that information technologies are reducing transaction cost and increase efficiency of inputs. The possible answer to this question is quite disturbing – companies probably perceive IT as a risky investment and the risk aversion is naturally increasing during the recession. This is quite visible if we compare the IT development to business cycle and its volatility to other services. Information technologies like new software may bring cost reduction but it is not guaranteed and it takes time and adaptation so companies rather prefer to hold scarce liquidity [money] to making any risky investment. Such thinking brings us back to the question if the causality must be from IT to output growth as usually regarded or if the causality might be reversal. We have made a simple model simulating the causal dependency of total output and information technologies development and prove that the causality is, at least in a short run, really reversal. This might shed a new light on information technologies and their role in economic growth.

[5] Unfortunately not all EU 27 countries provide the IT data in sufficiently good quality [missing observations, very short series]. Therefore we had to make a selection of countries which were put in analysis simply under data availability criteria. Selected countries are Belgium, Czech Republic, Denmark, Germany, Estonia, Italy, Lithuania, Hungary, Netherlands, Slovenia, Slovakia, Finland and Sweden.

REFERENCES

Aghion, P., Howitt, P. [1998], "the Macroeconomic Effects of Major Technological Change" In *General Purpose Technologies and Economic Growth*, E. Helpman, ed., Cambridge, MA: MIT Press. pp. 121-144.

Brynjolfsson, E. [1993]. "The Productivity Paradox of Information Technology." *Communications of the ACM.* pp. 67-77

David, P.A. [1990]. "dynamo and the computer: An historical perspective on the modern productivity paradox". American Econonic Review 80, 2 (May), pp. 35–61.

David, P.A., Wright, D. [1999], Early Twentieth Century Production Growth Dynamics: An Inquiry into the Economic History of "Our Ignorance". Discussion Papers in Economic and Social History no.33. University of Oxford.

Dedrick, J., Gurbaxani, V., Kraemer, K.L. [2003], "Technology and Economic Performance: A Critical Review of the Empirical Evidence." *ACM Computing Surveys*, vol.35, no.1, pp.1-28.

Dewan, S., Kraemer, K. L. [2000], "technology and productivity: Preliminary evidence from country-level data". *Managerial Science*46,4 (April). pp. 548–562.

Dewan, S., Gurbaxani, V [2007], "Investigating the risk-return relationship of information technology investment: Firm-level empirical analysis". *Management Science* (12). pp 1829-1842.

Franke, Richard H. [1987], "Technological Revolution and Productivity Decline: Computer Introduction in the Financial Industry," *Technological Forecasting and Social Change*, Vol. 31. pp. 143-154.

Gartner Report on IT Spending [2010].

Gordon, R. [2009], "will be worse than 2001". IT Spending Forecast, Gartner 2009.

Helpman, E., Trajtenberg, M. [1998]," Diffusion of general purpose technologies". In *General Purpose Technologies and Economic Growth*, edited by E. Helpman. Cambridge: MIT Press.

Kraemer, K. L., Dedrick,J. [1994], "from Investment in Information Technology: Lessons from Asia-Pacific Region". *World Development*, 22 (12), pp. 1921-31.

Lal, K. [2001], "determinants of the adoption of information technology: A case study of the Indian garments industry". In *Information Technology, Productivity, and Economic Growth: International Evidence and Implications for Economic Development*. Pohjola, M. Ed. Oxford University Press, Cambridge, U.K.. pp. 149–174.

Lee,Y., Oh, J.,Seo, H.[2002], "Digital Divide and Growth Gap A Cumulative Relationship." Discussion Paper No. 2002/88. United Nations University, WIDER.

Loveman, G.W.[1988]. "Assessment of the Productivity Impact on Information Technologies". *Management in the l990s.*Working Paper no.88-054. The MIT Press July 1988.

Romer, P. [1990]. Endogenous Technological Change'. *Journal of Political Economy*, 98: pp. S71-S102.

Schreyer, P. [1999]. "contribution of information and communication technology to output growth". Statistical Working Paper No. 99:4. OECD, Paris, France.

Strassmann, P. A. [1990], *The Business Value of Computers: An Executive's Guide*. Information Economics Press New Canaan, CT, 1990.

Vltavská, K., Fischer, J. (2010). Labour Productivity and Total Factor Productivity in the Czech ICT. Jindřichův Hradec 08.09.2010 – 10.09.2010. In: *IDIMT-2010 Information Technology – Human Values, Innovation and Economy*. Linz : Trauner, 2010, s. 251–257. ISBN 978-3-85499-760-3.

APPENDIX

Table: Services volatility

NACE_R1	VAR
Water transport	68.9271
Air transport	57.06899
Renting of machinery and equipment without operator and of personal and household goods	14.48379
Activities auxiliary to financial intermediation	13.61633
Insurance and pension funding, except compulsory social security	647151
Computer and related activities	2077409
Post and telecommunications	6.735148
Recreational, cultural and sporting activities	5.914556
Research and development	5.36071
Supporting and auxiliary transport activities; activities of travel agencies	5.33787
Financial intermediation, except insurance and pension funding	3.205562
Financial intermediation	3.145562
Wholesale trade and commission trade, except of motor vehicles and motorcycles	3.049467
Other business activities	2.845325
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	2.133254
Other community, social and personal service activities	2.094083
Land transport; transport via pipelines	2.055976
Hotels and restaurants	1.939763
Sewage and refuse disposal, sanitation and similar activities	1.78071
Other service activities	1.756095
Transport, storage and communication	1.751716
Activities of membership organization n.e.c.	1.582485
Real estate, renting and business activities	1.371598
Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	1.203905
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	0.839053
Real estate activities	0.725444
Activities of households	0.644852
Health and social work	0.585325
Public administration and defence; compulsory social security	0.211361
Education	0.120237

Table : Test cross-section and period fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	1.561 531	-12.13	0.110 8
Cross-section Chi-square	21.006 090	12	0.050 3
Period F	5.322 251	-11.13	0.000 0
Period Chi-square	58.000 955	11	0.000 0
Cross-Section/Period F	3.838 141	-23.13	0.000 0
Cross-Section/Period Chi-square	80.844 121	23	0.000 0

Table: A1 Equation [4] estimates, full representation

Dependent Variable: GC?

Method: Pooled Least Squares

Date: 11/25/10 Time: 14:12

Sample (adjusted): 1997 2008

Included observations: E1:E512 after adjustments

Cross-sections included: 13

Total pool (balanced) observations: 156

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.593 136	1.802 608	4.212 307	0.000 0
Y?(-1)	1.347 703	0.415 787	3.241 330	0.001 5
GC?(-1)	-0.156 251	0.057 037	-2.739 466	0.006 9
Fixed Effects (Period)				
1997--C	14.17 977			
1998--C	9.901 712			
1999--C	1.508 444			
2000--C	2.212 652			
2001--C	5.312 325			
2002--C	-7.076 635			
2003--C	-10.14 756			
2004--C	-3.902 127			
2005--C	-3.896 431			
2006--C	-0.483 328			
2007--C	-0.330 596			
2008--C	-7.278 231			

Effects Specification	
Period fixed (dummy variables)	
R-squared	0.285552
Adjusted R-squared	0.220144
S.E. of regression	12.09614
Sum squared resid	20776.96
Log likelihood	-602.9104
F-statistic	4.365749
Prob(F-statistic)	0.000004
Mean dependent var	10.59038
S.D. dependent var	13.69745
Akaike info criterion	7.909108
Schwarz criterion	8.182813
Hannan-Quinn criter.	8.020275
Durbin-Watson stat	1.639341

Table: Equation [4] estimates, full representation

Dependent Variable: Y?

Method: Pooled Least Squares

Date: 11/25/10 Time: 14:12

Sample (adjusted): 1997 2008

Included observations: 12 after adjustments

Cross-sections included: 13

Total pool (balanced) observations: 156

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.982 136	0.284 326	3.454 258	0.000 7
Y?(-1)	0.677 435	0.065 582	10.32 954	0.000 0
GC?(-1)	0.003 569	0.008 996	0.396 680	0.692 2
Fixed Effects (Period)				
1997--C	0.951 826			
1998--C	-0.445 497			
1999--C	-0.889 548			
2000--C	1.691 468			
2001--C	-0.996 196			
2002--C	-0.318 918			
2003--C	-0.098 167			
2004--C	1.020 923			
2005--C	0.211 687			
2006--C	1.669 181			
2007--C	0.267 583			
2008--C	-3.064 341			

Effects Specification	
Period fixed (dummy variables)	
R-squared	0.538067
Adjusted R-squared	0.495777
S.E. of regression	1.907930
Sum squared resid	516.9077
Log likelihood	-314.7991
F-statistic	12.72335
Prob(F-statistic)	0.000000
Mean dependent var	3.514103
S.D. dependent var	2.686896
Akaike info criterion	4.215373
Schwarz criterion	4.489078
Hannan-Quinn criter.	4.326540
Durbin-Watson stat	1.909723