Some Reflections on the Determinants of ICT Usage

Menbere Workie Tiruneh[1,2(✉)]

[1] Vysoká škola manažmentu,
Panónska cesta 17, 85104 Bratislava, Slovakia
mworkie@vsm.sk
[2] Institute of Economic Research, Slovak Academy of Sciences,
Sancova 56, 811 05 Bratislava, Slovakia

Abstract. This paper sheds some light on the Networked Readiness Index (NRI) compiled by the World Economic Forum and discusses the sources of cross-country variations in the European Union based on the 2013–2014 period. The results based on NRI reveal that the highest variation – measured by standard deviation – is in Economic impacts, Business usage, Political and regulatory environment, and in Infrastructure. There is a clear endogeneity problem though as all the pillars that make-up the NRI are somewhat intertwined. The results seem to signal there is a substantial cross-country variation in both ICT usage and the resulting benefits, which goes against the assumptions that EU is a homogenous economic club with significant convergence criteria. The results also suggest that the catch up process in ICT usage require an improvement in building ICT infrastructure and effective use of ICT primarily by the business sector. This goes against the remarkable success EU has achieved in terms of real income convergence during the past 18 years or so.

Keywords: Information and communication technologies · Network readiness index · Correlation

1 Introduction

The expansion of the ICT sector manifests itself in various ways that include but is not limited to the use of ICT by individuals, businesses as well as governments; the price of ICT, which determine its affordability; and social and economic impacts of ICT usage [3]. While progress has been made in ICT usage both globally in general and in the European Union in particular, there are cross-country variations (as indicated by the World Economic Forum ICT Report) when it comes to the level of ICT usage, the infrastructure to facilitate the use of ICT as well as the subsequent economic benefits. As argued by the World Economic Forum's annual ICT Report, high-quality regulatory and business environment is critical in order to fully leverage ICTs and generate impact. This paper empirically discusses selected determinants of ICT usage in the European Union and points out the complementarity nature of various indicators (pillars) that make up the Networked Readiness Index. In addition the paper also explores the social and economic benefits of investing and using ICT based on a cross-section of 28 EU member states during the 2013–2014 period.

A. Leon-Garcia et al. (Eds.): Smart City 2015, LNICST 166, pp. 551–558, 2016.
DOI: 10.1007/978-3-319-33681-7_46

2 An Empirical Insight into the Determinants of ICT Usage

The benefits of effective ICT usage are broader and multifaceted. The Global Information Technology Report assesses the state of networked readiness of 143 economies using the Networked Readiness Index (NRI). As indicated by the Global Information Technology 2001–2002 Report, Networked Readiness is considered as "*the degree to which a community is prepared to participate in the Networked World*" (p. 11). According to NRI, the ranking is based on a composite indicator made up of four main categories (subindexes), 10 subcategories (pillars), and 53 individual indicators distributed across the different pillars. We summarize the subdexes and subcategories in Table 1.

There are several questions that may arise following the subindexes and corresponding sub-categories summarized in Table 1. First, how accurate the data compilation is given the fact that some of the data are generated through a survey? This may be even a more serious problem for developing countries with significant data quality problem. Second, is it really possible to isolate the subindexes and sub-categories from each other? In fact, the underlined indicators are intertwined with each other which may signal a significant endogeneity problem and therefore measurement error. Nonetheless, the data are still helpful to get some picture on ICT advancement and to make cross-country comparison in ICT performance overtime.

Table 1. Subindexes and corresponding sub-categories in the NBI

A. Environment subindex	B. Readiness subindex	C. Usage subindex	D. Impact subindex
Political and regulatory environment (9 indicators)	Infrastructure (4 indicators)	Individual usage (7 indicators)	Economic impacts (4 indicators)
Business and innovation environment (9 indicators)	Affordability (3 indicators)	Business usage (6 indicators)	Social impacts (4 indicators)
	Skills (4 indicators)	Government usage (3 indicators	

Author's modifications based on The Global Information Technology Report 2015: ICTs for Inclusive Growth (2015)

3 The Determinants of ICT in the European Union

The effective use of ICT is constrained by many factors that include affordability, infrastructure and regulatory environment, among other things. Studies indicate a significant cross-country variation in ICT usage in spite of the overall advancement in the sector in the past decades. As indicated by the World Economic Forum Global ICT Report [3], while "*there are as many mobile subscriptions as (the number of) human beings on the planet, but half of the world's population do not have mobile phones and 450 million people still live out of reach of a mobile signal*". This is something that has

come to be known as the *digital divide* with all the undesirable consequences to the socio-economic advancement of technologically lagging countries.

While the cross-country variation across EU member states is not as dramatic as one witnesses on the global level, there are nonetheless some noticeable differences in both ICT usage level as well as ICT infrastructure in the EU. Table 2 shows the correlation matrices of the ten pillars that make up the Networked Readiness Index for the panel of EU member States (2013–2014). The list of countries and their codes are in the appendix. While the correlations indicate statistically significant relationships across pillars, the link between pillar four (affordability of ICT) seems to be either not correlated with the rest of the pillars or only partially correlated with them. This may signal that ICT affordability may not be the most difficult challenge for this group of economies.

Table 2. Correlation matrices of NRI (EU cross-section, 2013–2014)

	Pillar_1	Pillar_2	Pillar_3	Pillar_4	Pillar_5	Pillar_6	Pillar_7	Pillar_8	Pillar_9	Pillar_10
Pillar_1	1									
Pillar_2	0.782*	1								
Pillar_3	0.793*	0.608*	1							
Pillar_4	0.334	0.295	0.263	1						
Pillar_5	0.718*	0.722*	0.658*	0.342	1					
Pillar_6	0.859*	0.682*	0.771*	0.338	0.528*	1				
Pillar_7	0.924*	0.734*	0.829*	0.411*	0.712*	0.879*	1			
Pillar_8	0.859*	0.726*	0.618*	0.383*	0.620*	0.758*	0.765*	1		
Pillar_9	0.926*	0.810*	0.819*	0.359	0.732*	0.896*	0.952*	0.825*	1	
Pillar_10	0.823*	0.778*	0.613*	0.335	0.597*	0.765*	0.762*	0.955*	0.816*	1

Author's computations

The asterisk, * indicate significance level at 5 %.

Likewise, the standard deviation in Table 3 suggests that the highest cross-country variation in the European Union has been captured in pillar one (Political and regulatory environment), pillar three (infrastructure), pillar seven (Business ICT usage) and pillar nine (Economic impacts). This may signal EU member states are still heterogeneous in their economic parameters and technological infrastructure in spite of the convergence criteria and EU-wide funds designed to help poor countries to catch up with richer ones.

4 The Economic and Social Impacts of ICT Usage: An Empirical Exploration

It is recognized that widespread ICT usage by businesses, governments, and the population at large is a precondition for all the subsequent benefits and opportunities accompanying the payoffs from ICT usage. This has been confirmed by the nearly perfect correlation between the NRI's usage and Impact subindexes (Table 2). From the correlation matrices we may infer that pillar seven (business ICT usage) has been

Table 3. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
pillar_one	28	4.4760	0.8561	3.1772	5.8176
pillar_two	28	4.8450	0.3508	4.2072	5.4152
pillar_three	28	5.6452	0.8292	4.1143	6.9996
pillar_four	28	5.6141	0.6633	3.8219	6.6898
pillar_five	28	5.7096	0.3436	5.0708	6.5301
pillar_six	28	5.6156	0.6550	4.4566	6.8298
pillar_seven	28	4.4711	0.8664	3.3836	5.9006
pillar_eight	28	4.3972	0.7132	3.1113	5.4704
pillar_nine	28	4.3283	0.8690	3.0709	6.0749
pillar_ten	28	4.8569	0.6630	3.8030	6.0716

Author's computations

statistically significantly correlated with all the other variables. Past studies confirm the powerful economic impact of ICT usage on organization level. ICT enable firms to introduce organizational changes in the areas of re-engineering, decentralization, flexible work arrangements, outsourcing, lean production, and teamwork and customer relation [1]. There is strong evidence that the share of workers using computers is positively related to productivity performance, where a 10 % percentage point increase in the share of workers using computer is associated with a 1 % percentage point increase in probability of productivity improvement.

In the same token, the role of ICT usage on the firm level tends to foster productivity and accelerate efficiency. The research conducted based on a survey of 482 companies of which 148 are listed or traded Over- the- counter (OTC) in Japan confirms that firms with higher level of information technology and higher human capital tend to have higher productivity than those with lower information technology and human capital [2].

On the macroeconomic level there is a bulk of theoretical and empirical literature that deals with the role of human capital accumulation both for effective use of information technology and for long-term growth:

- First, production and diffusion of technology is impossible without human capital accumulation [4].
- Second, a larger stock of human capital makes it easier for nations to imitate new ideas developed elsewhere, which helps to accelerate the catch-up process.

The school of thought that advocates the role of human capital and technological progress for both economic development and competitiveness is classified as Endogenous growth theory. In this regard, Romer [5], Lucas [6], among others argue that human capital is a fundamental input into the research sector, where current research has a positive spillover for the productivity of future research and that technology (such as ICT) is considered as endogenous, therefore complementary to advancement in technology and human capital are highly intertwined. One major conclusion in this respect is that the cost of inventing a new product declines as society accumulates more ideas.

This goes against the neoclassical assumption where the steady state of output per worker depends on savings and growth rate of population, while the growth rate of output per worker depends only on technological progress that is determined exogenously [7]. Therefore, economic policy does not play any substantial role in the catch up process and poor countries unconditionally converge to the income per capita of richer ones due to the declining marginal productivity of capital.

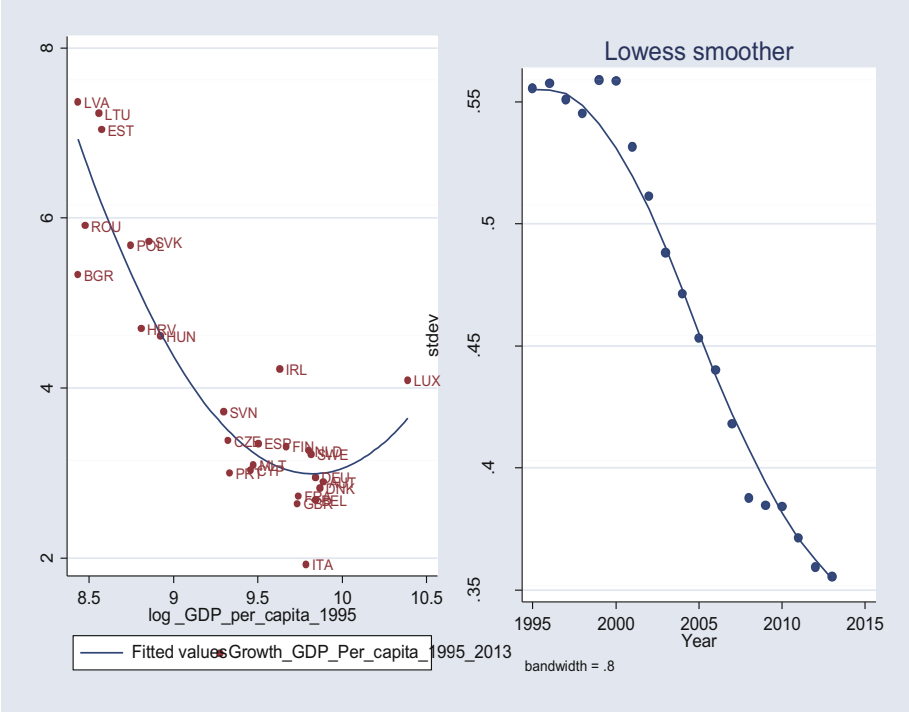

Fig. 1. Real GDP per capita convergence in the European Union (1995–2013) (Color figure online)

However, the empirical evidence for unconditional convergence for a larger group of world economies has been rather weak and there is an empirical evidence for conditional convergence, hence controlling for initial conditions and investment into both physical as well as human capital and vector of policy variables. The results for EU member states indicate a successful convergence in real income per capita, hence poorer EU members having grown faster than richer ones in the past 18 years or so (Fig. 1, left quadrant). This has also been confirmed by declining standard deviation in real income per capita indicating a decline in the dispersion of income per capita across EU member states in the same years (Fig. 1, right quadrant).

The success story in remarkable income convergence in the European Union does seem to be the case when it comes to technology readiness index. From Fig. 2 and

Table 2 it is possible to infer that the level of ICT usage tend to have a significant subsequent economic benefits, while the social impact of ICT usage does not seem to have a clear relationship. The link between ICT usage both by individuals, businesses and governments has on average a strong (and almost linear) relationship with subsequent economic benefits as indicated in Table 1 and Fig. 2.

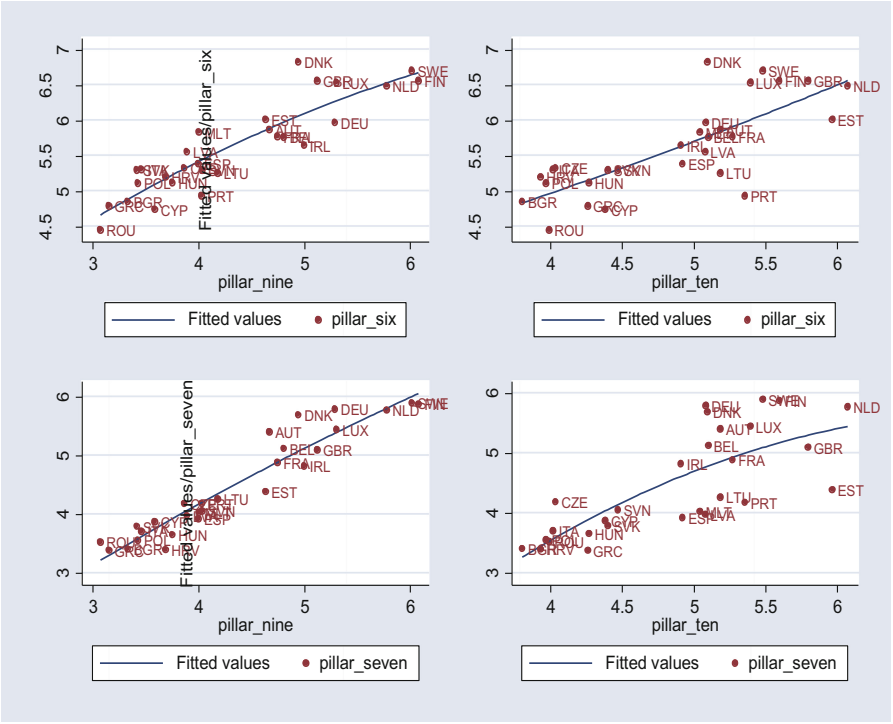

Fig. 2. ICT Individual Usage (pillar_six) and Business Uage (pillar_seven) and Economic and Social Impacts (2013–2014) (Color figure online)

Table 4. ICT Usage and economic and social impacts (based on a cross-section of EU member states, 2013–2014)

	Pillar_six	Pillar_seven	Pillar-eight	Pillar_nine	Pillar_ten
Pillar_six	1				
Pillar_seven	0.8794*	1			
Pillar_eight	0.7584*	0.7655*	1		
Pillar_nine	0.8965*	0.9526*	0.8254*	1	
Pillar_ten	0.7658*	0.7628*	0.9552*	0.8160*	1

The asterisk, * indicate significance level at 5 %.
Author's computations

From Fig. 1 and Table 2 it is possible to infer that the level of ICT usage tend to have a significant subsequent economic benefits, while the social impact of ICT usage does not seem to have a clear relationship. The link between ICT usage both by individuals, businesses and governments has on average a strong relationship with subsequent economic benefits as indicated in Table 1 and Fig. 1. However, the results also suggest business use of ICT (pillar_seven) has a more powerful economic impact (pillar_nine) while government use of ICT (pillar_eight) has a significantly higher social impact (pillar_ten). The results seem to be intuitive as much of government use of ICT is primarily to deliver public service and the social impact is a desired outcome (Table 4).

5 Concluding Remarks

This brief empirical discussion and previous other studies suggest that global competition is likely to be determined primarily by competitive rather than comparative advantages. In this regard, innovation and use of technology that include ICT remain the major source of sustaining competitiveness. The results also seem to indicate that the pillars of the global Networked Readiness Index are complementary and intertwined and therefore could be misleading if not handled and interpreted with appropriate amount of caution. The results also suggest that while EU seems to be quite a homogeneous economic club from various perspectives, including real income convergence, it appears the degree of cross-country variation is significantly high when it comes to Networked Readiness Index suggesting the prevalence digital divide in the European Union albeit its relatively smaller scale compared to the global digital divide. This may signal possible new convergence criteria in Networked Readiness Index for EU member states in order to reduce the scale of the current *digital divide* across countries.

Appendix

Table: List of countries and their codes included in the study

Country	Code	Country	Code	Country	Code
Austria	AUT	Germany	DEU	Poland	POL
Belgium	BEL	Greece	GRC	Portugal	PRT
Bulgaria	BGR	Hungary	HUN	Romania	ROU
Croatia	HRV	Ireland	IRL	Slovak Republic	SVK
Cyprus	CYP	Italy	ITA	Slovenia	SVN
Czech Republic	CZE	Latvia	LVA	Spain	ESP
Denmark	DNK	Lithuania	LTU	Sweden	SWE
Estonia	EST	Luxembourg	LUX	United Kingdom	GBR
Finland	FIN	Malta	MLT		
France	FRA	Netherlands	NLD		

References

1. Surendra, G., Wulong, G.: The effect of organizational innovation and information and communications technology on firm performance. Int. Prod. Monit. **9**, 37–51 (2004)
2. Bresnahan, F.T., Boynjolfsson, E., Lorin Hitt, H.L.: Information technology, workplace organization and the demand for skilled labor: firm-level evidence. Q. J. Econ. **117**(1), 339–376 (2012)
3. Dutta, S., Geiger, T., Lanvin, B.: The Global Information Technology report (2015). http://reports.weforum.org/global-information-technology-report-2015/
4. Nelson, R.R., Phelps, S.P.: Investment in humans, technological diffusion, and economic growth. Am. Econ. Rev. **56**(1/2), 69–75 (1966)
5. Romer, M.P.: The origins of endogenous growth. J. Econ. Perspect. **8**(1), 3–12 (1994)
6. Lucas, E.R.: On the mechanics of economic development. J. Monetary Econ. **22**, 3–42 (1988)
7. Solow, R.: A contribution to the theory of economic growth. Q. J. Econ. **70**(1), 65–94 (1956)