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4. DOES TECHNOLOGY MATTER IN ECONOMIC DEVELOPMENT AND WHY?

Keywords

economic development (O10, O11), technological change (O3)

Introduction

Economic development is a complex area determined by lots of different and often interdependent factors. It is broadly defined as a process of improving people`s life. In recent years it has become crucial to identify the potential role that information and communication technologies can play in it. Now, many countries – especially these less developed – are undergoing a revolution in information and communication technologies (ICTs), and it has been widely recognized that these technologies have great implications for current and future social and economic situation[1] of many economies. Although there is much evidence that ICTs have influenced positively the performance of national economies, we still lack any quantitative proof that ICTs really contribute to the development level. But identifying which areas of life (social, economic, political) can benefit most from proper application and use of ICTs, remains a fundamental issue for planning national development policies.

So the question arises: is there any relationship between ICTs development and economic development? And if there is one, is this relationship positive or negative, and what is its strength?

Economic development concept and its measurement

There are number of ways to define economic development. It is also very often taken for economic growth and that is why, at the very beginning these two ideas should be distinguished. Economic growth is a process of increasing national income, and consequently national income *per capita*[2]. Economic growth means quantitative changes, so according to that definition, an economy is growing when its output is growing. Economic development is defined as a process of structural changes but also of increasing national income. It stands for quantitative and qualitative changes. Distinguishing between the notion of economic growth and economic development seems to be the crucial factor for planning national strategies to foster these two processes.

Economists traditionally[3] distinguish four desirable factors that let a country develop. They are also called "four wheels to the development vehicle[4]". Among these are:

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[1] Report of the meeting of the high-level panel of experts on Information and communication Technology (New York, 17-20 April 2000)
[2] If birth rates are lower than GDP growth rates
[3] According to Samuelson P.A., Nordhaus W.D.: Economics; McGraw-Hill Inc., 1995, International Edition;
[4] Beardshaw J.: Economics. A student`s guide, Pitman, London 1992

- Natural resources – this refers to such resources as land (especially arable land), minerals, fish, forests, metals, oil, gas; generally considered as helpful but not a critical factor for economic development.
- Human resources – this refers to people who staff and operate an organization; it also means skills, labour, wisdom, experience; closely related to "human capital" which also concerns quality of human resources; for economic development this seems to be a critical factor in many cases, that is why most governments implement programmes aimed to improve general health and nutrition, education, reduce illiteracy and improve labor skills.
- Capital formation – generally it refers to financial and fixed capital; nowadays considered as a necessary condition that enables a country to develop.
- Technological change and innovation[5] - nowadays considered as the most important factor determining economic progress; in most countries perceived as a prerequisite for further development

Having defined economic development and briefly characterized its major determinants, we shall consider the aspect of its measurement. In many cases national income *per capita* is treated as a measure of development, but definitely it is not the proper one. Why? Mostly because GNP does not show a precise picture of people`s welfare. GNP does not reflect real conditions that a person is living in, does not say anything about freedom one enjoys (if any), and what possibilities one has to be creative and benefit from using his vital skills.

In 1990 United Nations Development Programme (UNDP) introduced a new measure, that tries to express what economic development really is. It goes far beyond the income, in order to assess the level of people's long-term well-being. Bringing about development of the people[6], the indicator emphasizes that the goals of development are choices and freedoms, not just income. The measure, a non-monetary indicator, is Human Development Index (HDI). It is regularly calculated to assess progress in achieving general welfare of nations and its concept is broader than any other measure of human well-being[7]. HDI measures country`s achievement in 3 basic dimensions[8]: long and healthy life (measured by life expectancy at birth), knowledge (measured by adult literacy rate and the combined gross enrolment ratio for primary, secondary and tertiary schools), and standard of living (measured by GDP per capita in purchasing power parity). HDI value varies from 0 to 1, where 1 is the best score.

The table below shows a few examples of HDI value for chosen economies and values of HDI components.

Table 1. HDI value for chosen countries, 2005

Country	HDI value	Life expectancy at birth (in years)	Adult literacy rate	Gross combined enrolment ratio	GDP per capita (USD PPP)
Norway	0,963	79,4	99%	100%	37 670
Iceland	0,956	80,7	99%	96%	31 243
United States	0,944	77,4	99%	93%	37 562
Poland	**0,858**	**74,3**	**99,7%**	**90%**	**11 379**
Slovakia	0,849	74,0	99,6%	75%	13 494
Mexico	0,814	75,1	90,3%	75%	9 168

[5] Samuelson P. *op. cit.*
[6] http://hdr.undp.org/aboutus/
[7] Human Development Report 2005, www.un.org
[8] *ibidem*

Belarus	0,786	68,1	99,6%	88%	6 052
India	0,602	63,6	61,0%	60%	2 892
Burkina Faso	0,317	47,5	12,8%	24%	1 174
Niger	0,281	44,4	14,4%	21%	835

Source: Human Development Report 2005

Information and communication technologies – definition, measurement and their role in development

Information and communication technologies (ICTs), broadly defined, are tools used by most of governments to achieve some economic and social targets. They are tools that facilitate – by electronic means – the creation, storage, management and dissemination of information and knowledge[9]. ICTs can be understood as industry but also as a tool, or set of tools, and only if they are regarded as tools they can potentially become an enabler of social and economic development. But why are these ICTs assigned such importance in the development context? Mostly it is because of their unique characteristics, opportunities they offer and benefits they create. They are relatively cheap tools that can be implemented and used practically everywhere. ICTs have great impact on individual user`s welfare, change the way business is run, transform societies, enable knowledge sharing and free from the so called "tyranny of physical distance". ICTs infrastructure create economies of scale[10] and by stimulating building social and economic networks they spillover benefits. They enable overcoming distance, promote social inclusion, foster information and knowledge sharing, offer new services, health care information and learning opportunities. They also enhance job creating and local entrepreneurship. "ICTs reduce transactions costs, change the structure of markets and of public services and institutions, entrap human resources, and immediately increase potential values of human capital[11]". Much evidence from all around the world has shown that enormous benefits can be derived from ICTs, if they facilitate mainstreaming of information and knowledge. Full and effective use of ICTs requires transparent environment, including policy and legal frameworks, and what is even the most important – ICTs should be available at an affordable cost so that almost everyone could use them.

ICTs if deployed and used properly, can solve many problems that many economies are struggling with. Now, almost everyone would agree that technology has always been, and still is a great and powerful tool for human development.

Trying to measure technological achievements of nations one should realize that usually they are much more extensive and complex than any index – even the most sophisticated – could capture. But having in mind a necessity of being able to monitor countries progress in implementing and using ICTs, but also making international rankings to compare their achievements, there is an essential need for such index. Until now there have been introduced three methods to measure ICTs development in a country. United Nations Development Programme and International Telecommunication Union (ITU) have elaborated three indices which try to measure overall achievements of countries and nations in implementing ICTs, but also nation`s ability to benefit from multiple opportunities that ICTs offer. These three mentioned indices are:

- Technology Achievement Index (TAI) – introduced by UNDP

[9] Gester & Zimmermann, Information and communication Technologies for poverty reduction: discussion paper, Swiss Agency of Cooperation & Development, 2003

[10] Torero M., Braun von J.: ICTs for the poor; International Food Policy Research Institute, 2006

[11] Specne R.: ICTs, Internet, Development and poverty reduction, 2005, www.developmentgateway.org

- Digital Access Index (DAI) – introduced by ITU
- Digital Opportunity Index (DOI) – introduced by ITU

Technology Achievement Index is a measure which tries to show how well a country is creating and diffusing technology, and building human skill base[12]. TAI focuses on four dimensions which are thought to be crucial for getting benefits that ICTs offer. It is calculated on the base of indicators of four dimensions: creation of technology (patents granted per capita, receipts of royalty and license fees from abroad *per capita*), diffusion of recent innovation (internet hosts *per capita*, high- and medium-technology exports as a share of all exports), diffusion of old innovations (logarithm of telephones *per capita*, logarithm of electricity consumption *per capita*), human skills (mean number of years of schooling, gross enrolment ratio at tertiary level in science, mathematics and engineering). TAI value ranges from 0 to 1, where 1 is the best possible score. Up till now estimates of TAI have been prepared for 72 countries[13]. In order to reflect to the great disparities between countries, nations for which TAI has been calculated, are divided into 4 groups: leaders (for TAI above 0,5), potential leaders (for TAI from 0,35 to 0,49), dynamic adapters (for TAI from 0,34 to 0,20) and marginalized (for TAI below 0,20).

In 2003 ITU has launched Digital Access Index, which tries to measure an overall ability of nations to access and use new ICTs[14]. DAI is estimated by using data from 5 different fields: infrastructure[15] (fixed telephone subscribers *per* 100 inhabitants, mobile cellular phone subscribers *per* 100 inhabitants), affordability (Internet access price as percentage of Gross National Income per capita), knowledge (adult literacy, combined primary, secondary and tertiary school enrolment level), quality (international Internet bandwidth (bits) *per capita*, broadband subscribers *per* 100 inhabitants) and usage (Internet users *per* 100 inhabitants). DAI value ranges from 0 to 1, where 1 is the best score. DAI calculations cover 178 countries[16], which are divided into 4 categories (according to the DAI value): high access (for DAI above 0,70), upper access (for DAI from 0,50 to 0,69), medium access (for DAI from 0,30 to 0,49) and low access (for DAI below 0,29).

In February 2005 ITU and the Korea Agency for Digital Opportunity and Promotion (KADO) announced a new index to measure ICTs. DOI is a composite index that allows the tracking and comparison of countries in ICTs infrastructure capabilities, access path and device, affordability and coverage, and quality[17]. DOI methodology utilizes 11 core indicators categorized in 3 groups: opportunity (percentage of population covered by mobile cellular telephony, mobile cellular tariffs as a percentage of *per capita* income, Internet access tariffs as a percentage of *per capita* income), infrastructure (proportion of households with a fixed line telephone, mobile cellular subscribers *per* 100 inhabitants, proportion of households with Internet access at home, (mobile) Internet subscribers *per* 100 inhabitants, proportion of households with computers) and utilization (Internet users *per* 100 inhabitants, ratio of (fixed) broadband Internet subscribers to total Internet subscribers, ratio of (mobile) broadband Internet subscribers to mobile Internet subscribers). DOI value ranges from 0 to 1, where 1 is the best score. So far DOI has been calculated for 40 leading economies[18].

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[12] Making New Technologies Work For Human Development; UNDP, Human Development Report 2001

[13] Only for that number of countries there have been sufficient, valuable data necessary to calculate TAI value. Full list of countries is available in Human Development Report 2001

[14] http://www.itu.int/ITU-D/ict/dai/, 2006

[15] http://www.itu.int/newsarchive/press_releases/2003/30.html

[16] Full list of countries is available at: http://www.itu.int/newsarchive/press_releases/2003/30.html

[17] http://www.itu.int/osg/spu/statistics/DOI/background.phtml

[18] Full list of countries is available at: http://www.itu.int/osg/spu/statistics/DOI/results.phtml or in Measuring Digital Opportunity, ITU 2005

Table 3. Comparison of three indices values for chosen countries

Country	TAI[19]	DAI[20]	DOI[21]
Sweden	0,703	0,85	0,65
United States	0,733	0,78	0,60
Israel	0,514	0,70	0,60
Spain	0,481	0,67	0,55
Hungary	0,464	0,63	0,47
Poland	0,407	0,59	0,45
Mexico	0,389	0,50	0,35
China	0,299	0,43	0,31
Peru	0,271	0,44	0,17
India	0,201	0,32	0,14

Source: Author's own specification based on data from www.un.org and www.itu.int, 2006

Is economic development related to ICTs diffusion in a country? – some evidence

It is difficult to prove that ICTs diffusion and technological progress have positive influence on GDP growth and economic development. It is because of the fact, that ICTs influence on country's economy and society is mostly a qualitative one. ICTs programmes are usually "built to last", which means that positive effects are supposed to be noticed in the future and not today. Technology implementation and usage is closely related to the so called "technology spillover effect" – which means that it is hardly possible to assess the quantitative impact of technology on economy's condition; and to the "network effect" – the more people use technology the more benefits can be derived from its usage. The only thing that can be assessed precisely is the kind of relationship between technological advancement and economic development of a country.

To accomplish the required analysis, the author tries to estimate simple linear correlation (which measures the relationship between two variables) and consequently correlation coefficient[22] in three cases: between TAI and HDI, DAI and HDI, DOI and HDI. In each case the correlation coefficient (Pearson r) was estimated for all of the countries for which indices were available[23]. There have also been estimated coefficient of determination – r^2, which represents the proportion of common variation in the two variables. In other words: coefficient of determination explains to what extend value of dependent variable is explained by variation of independent variable. r^2 ranges from 0 to 1, where $r^2 = 1$ would mean that independent variable in 100% explains variation of dependent variable. There have also been estimated "statistical significance" (p-value) in each case. Statistical significance of a result tells about the degree to which the result is "true" or "representative of the population". The higher the p-value, the less we can believe that the observed relation between variables is a reliable indicator of the relation between the respective variables in the whole population. For

[19] Data for 2001
[20] Data for 2003
[21] Data for 2005
[22] Correlation coefficients can range from -1.00 to +1.00. The value of -1.00 represents a perfect negative correlation while a value of +1.00 represents a perfect positive correlation. A value of 0.00 represents a lack of correlation; in http://www.statsoft.com/textbook/stbasic.html#Correlationsa
[23] HDI value are available for almost all of the countries.

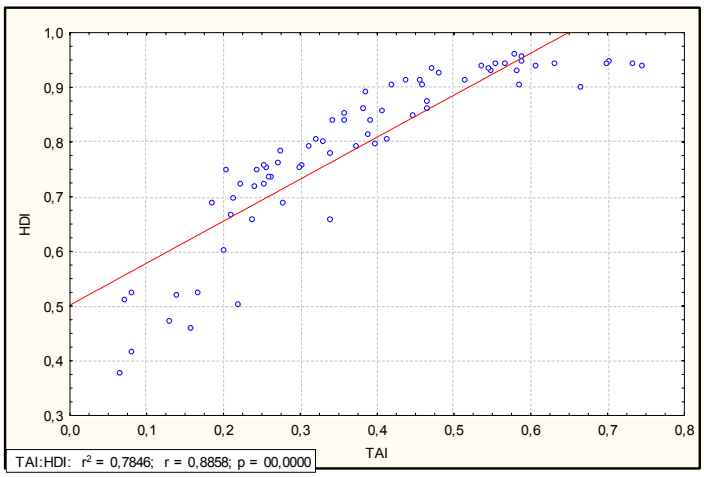
example, a p-value of 0,05 indicates that there is a 5% probability that the relation between the variables found in our sample is false. Usually results with p ≤ 0,01 level are considered statistically significant, and p ≤ 0,005 or p ≤ 0,001 levels are often called "highly" significant.

Findings of all three cases are presented below:

- TAI and HDI (HDI as dependent variable)

Estimates have been done for 72 observations[24].

Figure 1. HDI vs. TAI, scatter plot



Source: author's own calculations using data from Human Development Report 2001 and www.itu.int

In this case correlation coefficient is r = 0,8858 which means that there is high relationship between two cited variables – Technology Achievment Index and Human Development Report. Coefficient of determination equals r^2 = 0,7846 what indicates that variation of HDI is explained by variation of TAI in 78,46%. That suggests that these two variables are highly related to each other. P – value is 0,0000 what means that this relationship is statistically significant and these results could be generalized in the whole population.

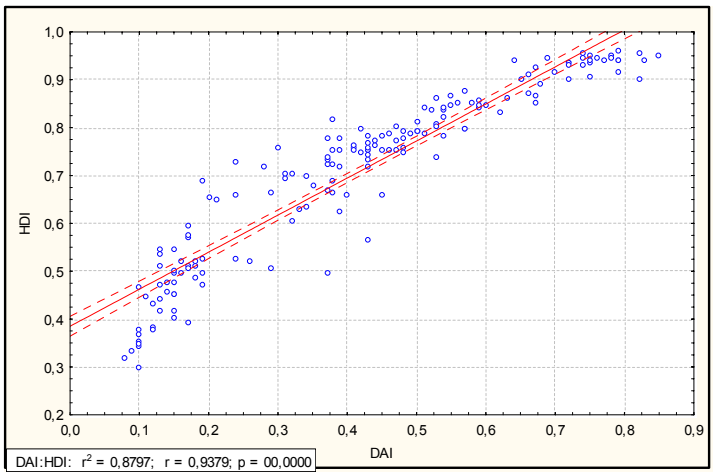
According to the findings in the current analysis it is correct to state that creation of technology, diffusion of recent innovation, diffusion of old innovations and human skills, do have great impact on level of economic development of a country.

- DAI and HDI (HDI as dependent variable)

Estimates have been done for 178 countries.

[24] That is the whole population of countries for which TAI has been calculated

Figure 2. HDI vs. DAI, scatter plot



Source: author's own calculations using data from www.itu.int

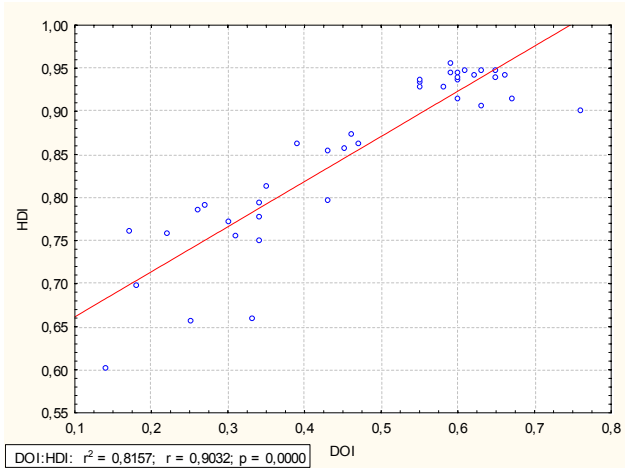
The correlation coefficient is r = 0,9379 and it suggests high, positive relationship between Digital Access Index and Human Development Index and with p = 0,0000 it appears to be statistically significant. At the same time value of coefficient of determination is r^2 = 0,8797 what says that variation of HDI is explained in 87,97% by variation of DAI.

According to the findings in the current analysis it is correct to say that such factors as: infrastructure, affordability, knowledge, quality and usage of ICTs have a significant impact on economic development.

- DOI and HDI (HDI as dependent variable)

Estimates have been done for 40 economies.

Figure 3. HDI vs. DOI , scatter plot



Source: author's own calculations using data from www.itu.int

In the last case the correlation coefficient equals r = 0,9032, what also suggests high and positive relationship between DOI and HDI. These findings are statistically significant (p = 0,0000). R^2 = 0,8157 determines that variation of DOI explains variation of HDI in 81,57%. According to the findings in the current analysis it is correct to state that such factors as: opportunity of using ICTs, ICTs infrastructure and its utilization do have strong and positive impact on economic development.

Summary

Table 3. Specification/list of findings

	Pearson r	Coefficient of determination – r^2	Statistical significance - p
HDI vs. TAI	0,8858	0,7846	0,0000
HDI vs. DAI	0,9379	0,8797	0,0000
HDI vs. DOI	0,9032	0,8157	0,0000

Source: Author's own research

All obtained results illustrate strong and positive relationship between one of the indices that measure use and diffusion of ICTs in a country and the level of economic development the respective country enjoys. Broadly speaking – regardless of the way ICTs are measured, findings are mostly the same. We would also state that the level of economic development is closely related to nations` ability to access and utilize ICTs and that economic development is a function of ICTs development. This is exactly what was expected at the very beginning, when we hypothesized that information and communication technologies are the crucial factor which determines economic performance of countries. But it is also important to realize that countries differ widely, and it is seen in the Figures 1, 2 and 3 where the following scatter plots show scores on one variable plotted against values of a second variable. There are many dots (each one representing a country) situated above or below the regression line, which means that in many cases the average level of development is higher or lower than it would be expected by the given ICTs development level. To explain these cross-country differences wider and more detailed analysis would be required. But generally speaking, it is clear that ICTs are great tools for development, and their proper application and usage can raise the quality of life in almost every country of the world.

Comprehension check

1. Calculate correlation coefficient and coefficient of determination for HDI vs. DAI, but first categorize countries by DAI value. According to the findings obtained try to explain in which group of countries ICTs seem to be the most important factor determining the level of development and why? Is the correlation high and positive in each case? If not draw some conclusion.
2. Choose as case study one of the developing countries and try to identify some barriers to development.
3. Try to think what possible and desirable, positive outcomes could use of ICTs bring both in developed and in developing countries?

4. Describe all four factors of economic development. Try to think about some others. What, do you think, in a country like Bolivia, mainly determines economic development and what set of development tools would you propose for such a country to enable it to develop faster.

Recommended readings

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