Middle-East Journal of Scientific Research 10 (6): 768-776, 2011
ISSN 1990-9233

Information and Communication Technology (ICT) & Total Factor Productivity (TFP): Evidence from Selected Countries of the World

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Abstract: Recently, Information and Communications Technology has played an important role in different aspects of human life. In particular, since mid-1990s ICT has increased Total Factor Productivity (TFP) in many countries of the world. ICT through capital deepening has the feature of the so-called knowledge commodity and can increase the factors productivity in the economy. This paper investigates the impact of ICT on TFP using Panel Data regression Method for a sample of selected developing as well as developed countries for the period 2003-2008. Our findings indicate that the impact of investment in ICT and human capital on TFP are both positive and significant for all countries under consideration. Therefore, higher investment in these fields are suggested

Key words: Information and Communication Technology (ICT; Total Factor Productivity (TFP) · Panel Data Method · Human capital

INTRODUCTION

By introduction of computer, a drastic change took place in information transfer and marketing. In fact, use of computer can be regarded as the third huge development after birth of writing and invention of printing. During several last years, IT fast growth and following it development of communication networks have brought about significant changes in every single aspect of human life. Today, every where it is talked about ICT, digital era, computer, mobile and satellite and electronic era. Internet as one of the ITC manifestations, before being considered as an information supply source, is regarded a pervasive medium in which the whole world is present. Great developments such as use of computer, mobile, Internet and websites from second half of the 1990s prepared the grounds for "information and communication revolution" so as emergence of this revolution has differentiated the present era from other periods. In the mid 19^{th} century, railway was considered the newest technology and has changed the ways of doing business. But ICT revolution has immensely affected all economic, social, political, cultural areas, government, security, occupation, hygiene, environment and many other areas. So that today ICT has become the main driving force of global economy and sustainable development without reliance on its application is almost impossible. Studies suggest that in 1965, ICT took 5% of companies' investment costs. This figure in 1980 reached 15% and in early 1990, companies' ICT investment costs increased to 20%. This amount in late 1990 increased to 50% of companies' total investment costs and this course indicates increasing importance of ICT in companies' business. Robert Solow, receiver of the Nobel Prize of 1987, has very well explained the main role of ICT and its impact on economic growth. According to Solow's model, four fifth of each worker's production in the US is obtained from ICT. In addition, the proposed productivity paradox by Solow [1] suggesting that "we see computer ever where except in statistics of productivity", prepared the departure point in comprehensive studies and researches on impact of ICT on productivity. ICT impact on productivity has been among the discussed issues in economics from 1990s on. ICT affects both supply and demand sides; on the demand side, through utility function on consumer's economic behavior and on the supply side, on production function (producer behavior). In this paper, due to the focus on ICT effect on productivity, only the supply side is addressed. ICT is a two-aspect capital. On the one hand, like other traditional forms of capital is used as production technology [2]. It means that ICT price fall leads to replacement of other production factors by ICT and capital deepening so as it affects product growth and labor force productivity.

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On the other hand, ICT attributes are like those of knowledge because part of ICT capital is as a digital commodity (except its hardware parts). Digital goods possess such characteristics as non-competitiveness, unlimited expandability, discontinuity, weightlessness and re-combinability which are the very attributes of knowledge goods. In general, everything which can be stored in computer's memory and transferable via Internet is called digital good. Common attributes of knowledge good and ICT gives rise to three results: 1. Market defeat; 2. Perception of ICT as the technology with general purpose and source of overflows; and 3. ICT impact on consumer's utility. Given this paper's purpose which is estimation of ICT impact on TFP, consequence of overflows and the created external advantages by ICT are the investigation subjects. ICT due to possession of knowledge attributes creates overflows in the sense that the produced knowledge cannot be completely protected by enterprises, industries and the countries producing it and easily spreads among other enterprises, industries and countries [3]. Effects of ICT overflows cause that ICT indirectly through TFP to affect product growth.

The Theoretical Basics: For study of ICT impact on TFP, there are different methods. The studies which so far for investigation of ICT role on productivity in production have been done have extracted their indices from implicit production functions or Distribution Theory or from explicit production functions from among of which implicit production functions have been employed the most. Kendrick's studies in 1950s which were based on implicit production functions for productivity estimation, significantly contributed to applicability of TFP concept in economy. Also, in this regard, Abromovitz [4] estimated a residue which is known in his name. In his study, the residue was the difference of production factors combination growth from production growth which was introduced as productivity [4]:

$$(dY / Y) - \alpha\,(dN / N) - \beta\,(dK / K) = residual$$

In which, α and β is share of capital and labor, K represents capital and N labor force. Also Kendrick [5] for TFP estimation used an implicit production function and calculated TFP through division of actual production on weighted mean share of production factors. Assumptions of Kendrick's model were Homogeneous Production Function and Euler Theory. In this model, Kendrick has introduced labor as total hour of workers' labor and capital as capital asset. In his extensive studies on the US productivity growth, attributed productivity growth to progress in technical knowledge and technology. Since Solow's studies was in a novel way in position to explain and justify some of economic events for which there was no explanation before then, they became the basis of many later researches by scientists. For effect of technology on productivity, Solow profited from an implicit production function and the relation [6] assuming Hicks-Neutral Technical change (progress). Solow's method to a great extent is similar to Abromovitz's residue. The reason for this similarity is use of the first order homogeneous production factor in both methods. In Solow's method, the production function was implicit and do not has an explicit form. Therefore, the Theory of Constant productivity relative to scale and perfect competition can be investigated. Solow's residue is defined as follows:

$$\theta_{it} = V\dot{\partial}_{it} - \sum S_{j.it}\dot{X}_{j.it} \qquad (j \bullet inputs)$$

Where $S_{j.it}$ is added value with cost-share index, input j as weight, $V\dot{\partial}_{it}$ added value growth and $\dot{X}_{j.it}$ production factors growth. Positive relation between Solow's residue and investment in ICT leads to productivity improvement and this model is based on inputs Linear Homogeneous Model with assumption of perfect competition. To calculate Solow's residue or the very TFP, we need to calculate inputs cost share. For flow variables such as labor force, inputs price multiplied by inputs amount is used. But for reserve (substitute) variables such as ICT capital or non-ICT capital, renting rate should be calculated. In this method, share of inputs with assumption of perfect competition and constant efficiency relative to scale gives a correct measurement of production function elasticity and by calculation of this elasticity; productivity growth rate with deduction of the used inputs multiplied by production elasticity is obtained from increases in product. Another estimation method of ICT effect on TFP is Dual approach method. In this method, within accounting framework of early growth, the neoclassical production function as Cobb-Douglas production function is used. In Dual approach method, which is in fact Solow's extended production function, has been used in most of the important empirical researches such as studies of Jorgenson *et al* [7] and Ark and Piatkowski [8] and the function generally looks as follows [8]:

$$Y = F\,(A, K, H, S, T, L)$$

In this function, K, H, S, T, L, A and Y represent non-ICT capital level, hardware, software, ICT capital, labor force, total factors productivity and product (production), respectively. TFP growth, assuming that Neutral Technical Progress is of Hicks type and payoff to production factors is to the amount of their social marginal production is defined as follows [9]:

$$\frac{\hat{A}}{A} = \frac{r_k K}{Y}\frac{\hat{r}_k}{r_k} + \frac{r_s S}{Y}\frac{\hat{r}_s}{r_s} + \frac{r_H H}{Y}\frac{\hat{r}_H}{r_H} + \frac{r_T T}{Y}\frac{\hat{r}_T}{r_T} + \frac{wL}{Y}\frac{\hat{w}}{w}$$

In relation [9], ˆ rate of time change and r_H, r_S, r_T and r_K are rental prices of hardware, software, ICT capital and non-ICT capital, respectively. This method can use for study of ICT and non-ICT capital share in TFP [10]. Another method used for this purpose is the method of Production Function or Preliminary Method. Also, in this method like previous method, production function is as Cobb-Douglas function and production relative to traditional inputs has constant yield relative to scale. In this method, assuming perfect competition, product's elasticity relative to factors is equal to their share in income. In such a condition, an index can be extracted for TFP (i.e. to obtain TFP changes from difference of production changes and changes of the factors labor force and capital). Next, ICT share in TFP is obtained by the following equation [11]:

$$\frac{\hat{TFP}}{TFP} = \lambda + \alpha\frac{\hat{K}_{ICT}}{K_{ICT}} + \varepsilon$$

In this equation, K_{ICT} is ICT capital, α represents production elasticity relative to ICT capital and ε denotes surplus effect of ICT capital. Since one of the assumptions of this method is perfect competition, therefore ICT elasticity is equal to its income share. Based on this relation we have [12]:

$$\alpha\frac{\hat{K}_{ICT}}{K_{ICT}} = \frac{\partial Y}{\partial K_{ICT}}\frac{K_{ICT}}{Y}\frac{\hat{K}_{ICT}}{K_{ICT}}$$

$$\rightarrow \qquad \alpha\frac{\hat{K}_{ICT}}{K_{ICT}} = \sigma\frac{\hat{K}_{ICT}}{Y}$$

Where $\sigma = \partial Y/\partial K$ is ICT efficiency rate and by assuming that there is no depreciation and considering it close to zero, we may consider ICT investment as an approximation of ICT capital. As a result, in place of using equation [5] for estimation of ICT share in TFP growth, equation can be used as follows:

$$\frac{\hat{TFP}}{TFP} = \lambda + \sigma\frac{ICT}{Y} + \varepsilon$$

In this relation, ICT represents ICT investment and σ denotes efficiency of production surplus relative to ICT investment. Thus, it can be concluded that ICT in addition to increase of production growth and labor force efficiency, through its income share due to the surplus effects it creates leads to increased TFP and through this increased product growth. To investigate surplus effect of ICT, first, TFP should be calculated. Next, ICT effect on TFP is estimated. In empirical researches on ICT impact on productivity, in addition to Cobb-Douglas Function (which in this study is used for calculation of TFP), other forms of production function are used. Among these functions Transcendental Production Function which for the first time was proposed by Halter *et al*. [13] and Translogue Production Function can be referred to but these functions were primarily applied for estimation of ICT effect on labor force productivity. Hence, due to focus on TFP we dispense with further description of these production functions.

Empirical Studies: Early studies done at macro level using the data of 1980s, reached tha conclusion that there is negative relationship between productivity at macro level and ICT [14]. Oliner and Sichel [15] investigated some other aspects of econometric estimations in 1980s and early 1990s suggest trivial share of ICT in economic productivity. The studies by Stiroh and Jorgenson [16] report an approximately moderate share of ICT on productivity growth during 1973 – 1995. Most of studies on relationship of ICT with productivity and economic growth during 1970s and 1980s were done in the United States and result of a majority of these researches suggested reduction of the US national productivity. Some scholars called this situation productivity paradox. Robert Solow in 1987 described productivity paradox by this phrase: you can see computer everywhere except in productivity statistics. This finding and studies during 1980 which suggested there is no relationship between ICT and productivity of American economy for some time was subject of debate in most scientific circles. However, by revival of the US productivity growth in the mid 1990s, studies with focus on ICT took higher pace. According to studies of Oliner and Sichel [15] and Jorgenson and Stiroh [17], the acceleration in productivity and growth of American economy was attributed to the significant and crucial impact of ICT. Dewan and Kraemer [18], using Panel Data Method of 36 countries during 1985-1993 in two groups of developed and developing countries estimated effect of ICT on productivity and reached the conclusion that in wealthier industrial countries, there is a strong, significant and positive association between ICT and productivity growth, whereas such association is not significant in developing countries. The studies of Oulton [19] and Kodres [20] in late 1990s in England indicate that total productivity and labor force productivity is affected by ICT capital deepening. Pohjola [21] using Panel Data Method estimated ICT effect for 24 developing countries and 24 countries with high income in the period 1985-1999 and found that effect of this variable in the countries with high incomes significant and positive but in developing countries is insignificant and positive. The study by Haacker and Morsink [22] in the two time spans of 1985-1995 and 1996-2000 in 20 European countries using Panel Data Method indicates that ICT has had positive effect on TFP and economic growth. Bassanini and Scarpetta [5] investigated growth and productivity performance among OECD countries during 1980-2000. According to their results, there is positive relationship between investment in ICT and TFP. Daveri [23] by comparing ICT contribution in growth of total productivity and labor force productivity in some European countries such as Germany, France, Finland, Sweden, Italy, Spain, Ireleand, Denmark and Greece in the second half of 1990s relative to the first half of this decade demonstrated that this share in these countries except Greece and Ireland in the second half relative to the first half of this decade in showed no increase. According to results of this study, share of ICT in economic growth and productivity in great European countries such as Germany, France, Italy and Spain has decreased. Davery argues that productivity paradox in absence of strong correlation between ICT investment and productivity growth intensifies in these countries. Papaioannou [24] in a study investigates ICT effects on productivity and economic growth in developed and developing countries for the period 1993-2001 and reached the conclusion that ICT has positive and significant effect on economic growth and productivity in the studied countries, but this effect in developing countries is greater. Moshiri and Jahangard [25] have investigated of ICT effects on growth and productivity of Iran during 1969-2000. The obtained results from their assessment which however have had more emphasis on economic growth, suggest positive and significant effect of ICT. Study of ICT role in total productivity and economic growth of Eastern and Central European countries compared to 15 European countries and the United States is a research carried out by Ark and Piatokski [8]. The obtained results from this study indicate that ICT has had a very prominent and crucial role in productivity increase in Eastern and Central European countries and this factor has the most effect on countries' convergence in 1990s. Jorgenson and Motohashi [26] with emphasis on ICT role investigated the sources of economic growth in Japan and America. According to their findings ICT contribution in growth and total productivity after 1995 has increased. Lee, Gholami and Tong [27] investigated causal relationship between investment in ICT and TFP for 20 developed and developing countries in the period 1980-2000. Result of their study indicate that the countries which steadily have made more long terms investment on ICT, infrastructural sectors, supplementary investments in communication and human resources, are more considerably in position to absorb benefits of ICT capital. Therefore, it can be concluded that probably complementary factors of ICT have crucial role in difference of the obtained efficiencies from ICT capital in developing and developed countries. Heshmati and Shiu [28] investigated TFP growth as a result of ICT application in 30 provinces of China for the period 1993-2003 using Panel Data Method. According to their findings, ICT has a positive and significant effect on production growth and TFP growth but this effect is small. Rahmani and Hiati [10] have investigated ICT effect on TFP growth using Panel Data Method for 69 countries in the period 1993-2003. Results of this study suggest that both internal investment in ICT and ICT international overflows have positive and significant effect on TFP growth both in the sample of developed countries and the sample of developing countries. However, this effect in developed countries is stronger compared to developing countries. In a study, Mahmoudzadeh [29] investigates ICT effects on TFP in the selected developing countries for the period 1995-2003. The obtained findings from this research indicate ICT capital and human capital, openness of economy and saving rate has a positive and significant effect on total productivity.

TFP Calculation Method and Data Sources: TFP is the Solow's residue which using Cobb-Douglas Function is presented in relation [30] and is defined as relation [31]:

$$Y = A K^{\alpha} L^{\beta}$$
$$A = Y / (K^{\alpha} L^{\beta})$$

In the above function, Y is gross domestic production (GDP), K denotes total capital reserve, L denotes labor force, A represents TFP, $0 < \alpha < 1$ denotes production elasticity to capital and $0 < \beta < 1$ denotes production elasticity to labor force. In addition, in Cobb-Douglas Function, $\alpha + \beta = 1$. By having GDP data, capital reserve and labor force data, TFP can be calculated. In many prior inter-country studies, researches mostly consider α (capital income share) equal to 0.3 and β (labor force income share) equal to 0.7 [22, 32] identically for all countries. In this research too, α is consider equal to 0.3 and β equal to 0.7 and TFP is calculated based on the relation [8]. GDP is in US dollar the data of which is extracted from WDI [33]. L is number of labor force and its respective data is extracted from WDI [33]. K is capital reserve (physical reserve). Physical capital comprises equipment and tools inventory which is used for production of various goods and services. Physical capital data for the under study countries are not available. Therefore, first, physical capital should be calculated for the countries in question. One calculation method of physical capital utilized in this article is use of ratio of gross fixed capital formation to GDP as the physical capital. The data concerning gross fixed capital accumulation and GDP in US dollar have been taken from WDI [33].

Description of Model's Explanatory Variables: In addition to the determinants of TFP introduced above, here and other variables which have been used in the under study model of this research are described:

ICT Internal Capital: ICTD is internal capital of ICT. ICT internal capital is a production factor which has a critical role in production of different goods and services. Division of total ICT capital into ICT and non-ICT has drawn researchers' attention since 1990s. ICT internal capital is divided into the four following sections: software capital, hardware, services and relationships. But since services are not considered part of investments, consistent with Schreyer [34], Pohjola [35], the figures related to ICT internal capital are eliminated. In addition, due to lack of statistics concerning the other sub-divisions in some of countries as a time series, in this study like majority of prior research on this topic, ICT expenses are considered as a substitute for ICT internal capital. The data concerning. The data concerning ICT expenses are in US dollar extracted from WD [33].

ICT External Capital (ICT Overflow): ICT has a double role in the modern economy; on the one side, ICT products such as computer and mobile as physical capital participate in production process next to other production factors. Given fast improvement in quality of ICT equipments and very large reduction in their price, profit maximizing producers replace other inputs by them and this process of input replacement is called capital deepening. ICT's second role is its effect on TFP increase. With increase of investment in ICT, through change in production organization, labor force combination, management and establishment of network relationships TFP increases as well and this indirect effect is called overflow. Neoclassical growth models lay stress on direct effect of ICT inputs, whereas endogenous growth models take overflow effect individually into account. It should be noted that the under study model in present research is of endogenous growth models type. Study of overflow presence was introduced to economics by Alfred Marshal in the 19th century. ICT overflow comes into circulation through international trade between countries. International trade enables a country to possess more diverse intermediate goods and capital equipments. It also prepares the grounds for establishment of relationship channels which induce learning of production methods from other countries, products design, organizational methods and market condition and eventually by providing the ground for imitation from other technologies and inverse engineering it can allow development of new technologies and products [30]. Therefore, international trade can be considered a path for technology transfer. To measure ICT overflow and to assess its impact in the estimation model in the paper, the variable ICTF which represents ICT investment in other countries or ICT overflow has been used and in calculation of ICTF, the relation [23] used in the study by Seo and Lee [36] has been profited:

$$ICTF_{tj} = (TIT_t - IT_{tj}) / (TI_t - I_{tj})$$

In which, $ICTF_{tj}$ denotes investment of country j (any given country) in year t, TIT_t, total investment of all countries in ICT in year t, IT_{tj}, investment of country j (any given country) in ICT in year t, TI_t total internal investment of all countries in year t and I_{tj}, internal investment of each country (any given country) in year t. In present paper, the data of ICT expenditures have been used as countries' investment in ICT and the data regarding countries' total investment and ICT expenditures have been extracted from WDI [33].

Human Capital: In addition to ICT capital, one of the other determinants of TFI is human capital or education (EDU). According to the definition, when one says a person is skilled it means that the person is capable of doing a suitable job that matches his skills [37-38]. Human capital includes the accumulated skills during official and in official training programs in the course of individual's life both during childhood and adulthood. Education includes all the trainings in school period and technical training. In addition to education, individual characteristics and personality traits are manifested in abilities of each individual and enhance human capital level. However, measurement of human capital level is difficult and usually involves estimation error, therefore, in analysis of human capital's performance one acts cautiously. Theoretically, human capital, like physical capital, enhances a country's abilities for production of goods and services. Most economists are of view that investment on human and the expenditures made in occupational training and labor force hygiene has positive effect on productivity and this effect in total productivity is more rather than in growth. Disregarding human capital (qualitative changes in labor force) leads to total productivity overestimation. For this reason, Mankiw, Romer and Weil [39] introduced investment in human capital as a variable in Cobb-Douglas Production Function. They considered educational achievements as a substitute for capital accumulation. Studies of Baliamoune Lutz and Mahmoodzadeh [29] have emphasized on importance of human capital for achieving ICT and its distribution. Based on these studies, education at middle school and high school has a critical role in reception and diffusion of technology. In this study, gross registration rate in high school has been used as substitute for human capital the date of which has been extracted from WDI [33].

Research Methodology: This research intends to investigate ICT effect on TFP based on econometric models using panel data for the time period 2003-2008. Panel Data Method can measure effect of independent variables both through the time and across the countries. Present study in terms of purpose is of applied type and in terms of method it is a causal research in the sense that it intends to investigate ICT effect on TFP. The countries in this study have been selected based on the available information regarding ICT and data evaluation during the time period 2003-2008 and include 45 countries 30 0f which are developing and the remaining 15 belong to developed countries.

Model Specification: As was stated in theoretical principles and empirical studies, ICT has impact on TFP. This impact is both due to investment inside country and ICT overflows at international and inter-country levels. Therefore, the variables ICTD and INTF which are ICT internal and external capital or ICT overflow are included in the estimation Model. In addition to ICT capital, one of the other determinants of TFP is human capital. Human capital, on the one hand, is regarded as one of the essential infrastructures for enjoying ICT internal and external investments and on the other hand, growth literature has introduced human capital as one of TFP determinants [30]. Therefore, to ensure ICT net effect, the variable human capital is individually introduced into the model. In this research, for introduction of human capital into the model, views of Nelson and Phelps [40] based on endogenous growth models have been used. The model to be tested in this paper has been estimated as follows [2]:

$$Log\ TFP_{it} = \alpha_0 + \beta\ log\ ICTD_{it} + ä\ log\ ICTF_{it} + \gamma\ log\ EDU_{it} + \varepsilon_{it}$$

In the above model, $logTFP_{it}$ is logarithm of TFP. $logICTD_{it}$ is logarithm of ICT internal capital. $logICTF_{it}$ is logarithm of ICT external capital (overflow). $logEDU_{it}$ is logarithm of human capital. α_0 is intercept. β is coefficient of ICT internal capital logarithm. ä is coefficient of ICT external capital logarithm. γ is coefficient of human capital logarithm. ε is disruption component. I = 1, …, n is number of countries and t = 1, …, t is number of years. Based on the suggestion in theoretical principles and empirical studies, it is expected that effect of the model's independent variables on TFP to be positive. The presented model is estimated based on availability of ICT statistics first for 45 selected countries for the time period 2003-2008.

Model Estimation: For model estimation, relation (10) and panel data methods were used. The equation was estimated for 45 under study countries. At first, for specification of the model type, F-test and Hausman. Test were performed based on which the under study model is found to be of constant effect type. Therefore, based on results of F-test which was performed for the purpose of choosing between Ordinary Least Squares Method and Constant Effect Method and based on Hausman. Test which was performed for selecting from among two methods of Constant Effects and Random Effects, the model was estimated through Constant Effects Method. Results regarding the model estimation are gathered in Table (1). Dependent variable in the under study model is TFP. The model's independent or explanatory variables are: ICT internal capital, ICT external capital (ICT overflow) and human capital.

Table 1: Output of Eviews

Dependent Variable: LTFP				
Method: Pooled Least Squares				
Sample: 2003 2008				
Included Observations: 6				
Cross-sections included: 45				
Total Pool (balanced) observations: 270				
Variable	Coefficient	Std. Error	t-statistic	prob
C	-4.8969161	0.677922	-7.223490	0.0000
LICTD	0.708046	0.026669	26.54952	0.0000
LICTF	0.089610	0.013665	6.557502	0.0000
LEDU	0.231115	0.068850	3.356770	0.0077
Effects Specification				
R-squared	0.997702	Mean dependent var	49.63751	
Adjustmen R-squared	0.996962	S.D dependent var	45.89676	
S.E. of regression	0.078232	Sum squared resid	0.893551	
F-statistic	1348.614	Durbin-Watson stat	0.933784	
Prob(F-statistic)	0.000000			

According to Table (1), it can be concluded that effect of ICT internal capital, ICT external capital and human capital on TFP to positive and highly significant. This positive effect is inferred from positive coefficients of the model's independent variables. In addition, given the t-statistic, it can be found that all the three independent variables of the model are significant. Based on table (1), if ICT internal capital changes 1%, TFP changes 0.71% in the same direction. Also, a one-percent increase in ICT external capital leads to 0.09% increase in TFP and one percent increase in human capital results in 0.23% increase in TFP. By casting eye on the column of coefficients in table (1), it can be found that coefficient of the first explanatory variable (ICT internal capital) is greater than that of the two other explanatory variables indicating stronger effect of this variable on TFP relative to two other variables. This positive effect which given its significance level of 99% is significant as well is a result consistent with many claims stated in the literature and researchers' empirical findings. The second explanatory variable is ICT external capital or ICT overflow. As was expected, this variable too had a positive and significant effect on TFP. The third independent variable under study is human capital and as was expected effect of this variable too was found positive and significant. According to Nelson and Fleps, the higher the education level, the greater the labor force's ability in creation, implementation and reception of new technologies and the more it is able to adapt itself with new imported technologies which consequently leads to greater TFP. R^2 of the estimated Model is equal to 0.996 and its R^2 is 0.997. Proximity of these two statistics indicates the more confidence one may have in correctness of the model specification. In addition, R^2 value states that 99% of changes in the dependent variable TFP are explained by the model's independent variables. Probability of F-statistic in this model is explained by the model's independent variables. Probability of F-statistic in this model is zero which indicates the model's significance.

Finding and Conclusion: In this paper, ICT effect on TFP was investigated at level of 45 selected sample countries. The obtained results from the model's estimation using panel data method confirm the theoretical models and empirical findings of other researchers. A summary of the obtained results is as follows:

- Coefficient of the independent variable ICT internal capital logarithm for the sample of 45 countries is 0.708 and based on this finding, effect of this explanatory variable on TFP is positive and significant. Thus, increase in the independent variable.

ICT internal capital increases the dependent variable TFP in positive direction.

- Effect of the variable ICT overflow logarithm, on TFP, given coefficient of this independent variable, at sample of selected countries is positive and significant. Therefore, increase in ICT external capital leads to increase in TFP.
- The third explanatory variable is human capital. Coefficient of human capital logarithm at sample of the 45 under study countries -developing and developed countries- is positive and significant.

ICT through capital deepening can lead to increased labor force productivity and eventually economic development and through its overflows pave the ground for TFP growth and production growth. Therefore, investment in this new technology is crucial for countries in achieving sustainable growth. Given significant effect of human capital (education level) on TFP, governments should utilize maximum educational and research potentials for appropriate planning in UCT application in education and training of trained technical, skilled and specialized human force.

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