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Investigation the effect of ICT and innovation on the total factor productivity in Iran's industry sector

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Abstract

The main purpose of this paper is to study the effect of TCT and innovation on total factor productivity () in Iranian industries from 1996-2014 by using panel data method. Amongst influential factors on productivity increase are ICT, innovation, and spillovers. Implementation of ICT like implementation of new technologies effects all sectors of economy. ICT is not only used as technology of production like traditional forms of capital but it course on increase in productivity and economic growth by substitution with other inputs. The statistical population of this survey is Iranian industries and the size of sample is 140 industries. The result of estimation indicates a positive effect from ICT on TFP. In this model the coefficient of ICT equal 0.02 which shows that a unit of increase in ICT, lead to 0.02 percent increase in TFP. Also we find that the coefficient of innovation (INNO), equal 0.04 which shows that a unit of increase in firm's innovation, lead to 0.04 percent increase in TFP. Moreover the coefficients of LAB and INV are 0.01 and 0.003 respectively, which shows that a unit of increase in LAB and INV, leads to 0.01 and 0.003 percent increase in TFP.

Keywords: Information and communication technology (ICT), Innovation, Total Factor Productivity, Panel data.

1. Introduction

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. Generally Information & Communication Technology (ICT) consists of all the advanced technologies of communication and transformation of data in telecommunication systems. This system can be a telecommunication network, a number of communicated computers and connected to a telecommunication network and also programs used in them. ICT focuses on important place of information, information storage and process devices and devices of transformation and acquiring information. It's obvious that in this way, apart from communicational potentials, other media, like radio and television would be also in the list of communicational devices (information distribution and publication channel). Relaying the structure of ICT prerequisites an informational laying structure in which all communicational devices and equipments like telecommunication equipment's, radio and television would be involved.

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, everywhere 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 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% (Jafari Samimi and Arab, 2011). 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 (1987) 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). Though factors of production, including physical and human capital accumulations, are both certainly critical for economic growth, as a result of the progress in economics, the importance of knowledge, for example in the usage of capital formation and especially skilled labor force, is increasing day by day. In the knowledge-based economy, the specialized labor force is characterized as computer literate and well-trained in handling data, and innovating on processes and systems. Porter (1998) asserts that today‘s economy is far more dynamic and that comparative advantage is less relevant than competitive advantage which rests on making more productive use of input, which requires continual innovation". According to the World Bank Institute's definition, such innovation would further enable the World Bank Institute's vision outlined in their Millennium Development Goals. Though it is not proper to consider information society as interchangeable with knowledge society, i.e., information is usually not equivalent to knowledge and its use is "economy-dependent", the United Nations Commission on Science and Technology for Development (UNCSTD, 1997) reports that for developing countries to successfully integrate ICTs and sustainable development in order to participate in the knowledge economy, they need to intervene collectively and strategically (Flew, 2008).

Science, technology, and innovation have become key factors contributing to economic growth in both developed and developing economies. Developed economies are becoming knowledge-based economies in an increasing scope in the context of generation, using, and dissemination of knowledge because of the fast improvements in science and technology (Seki, 2008). In these countries, knowledge provides the technical expertise, problem-solving, performance measurement and evaluation, and data management needed for the trans-boundary, interdisciplinary global scale of today‘s competition. Consequently, the academic disciplines of science, technology, engineering, and mathematics careers will see continuous demand in years to come. Additionally, well situated clusters including computer scientists, engineers, chemists, biologists, mathematicians, and scientific inventors, who are vital in global economies, connect locally with linked industries, manufacturers, and other entities that are related by skills, technologies, and other common input (Sepehrdoust and Zamani Shabkhaneh, 2015).

In empirical studies; Dewan and Kraemer (2001) 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. Daveri (2002) 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, Ireland, 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 (2004) 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. Jafari samimi and Arab (2011) investigated the relationship between information and communication technology (ICT) and total factor productivity (TFP) from selected countries of the world using panel data regression method for the period 2003-2008. Their 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. Sepehrdoust and Zamani Shabkhaneh (2015) studied the impact of knowledge-based economy on total factor productivity in the member countries of the Middle East and North Africa (MENA) region. For this purpose, the panel data regression analysis has been designed to analyze the effect of knowledge-based economy components on total factor productivity in 14 member countries of MENA region for the period of 1995-2012. The results show that the growth of knowledge-based economy index such as education (coefficient= 0.51), information and communication technology ICT (coefficient= 0.31), innovation (coefficient= 0.62), and economic incentive and institutional regime (coefficient= 1.05) have positive and significant effects on total factor productivity of middle east and North Africa (MENA) member countries for the time period of the study.

Therefore, the main problem in this study is whether the use of modern communication devices and ICT indices can be effective in increase firm's productivity and in turn increase firm's profit and market power. Thus, it is necessary to study the impact of ICT and innovation on Iran' industries productivity. Which for this in a case by case method, Iran's industries has been studied?

This study is guided by the following research questions: What is the relationship between ICT indexes and innovation on Iran's industries total factor productivity?

Accordingly, the following hypotheses are considered:

Hypothesis 1: Improvement in innovation leads to increase in Iran's industries total factor productivity.

Hypothesis 2: Improvement in ICT indexes leads to increase in Iran's industries total factor productivity.

This paper consists of four sections. Section 1, discusses the introduction, in which the background and rationale of the study is outlined. Section 2, covers the details of the data and research methodology employed in this study. Section 3, reports the findings and discussions. The final section contains the conclusions.

2. Data and Methodology

2.1. Model specification

We first start estimating the effects of each independent variables on the dependent variable "total factor productivity" by using pooled and panel ordinary least squares model. We create a pooled data by combining time series and across section data for manufacturer of smart homes and offices industry. The pooled regression model doesn't estimate the impact of variables separately on each firm, but instead yields an overall measure of each variables on the group of firm. If we find large standard errors for variables, the next step is testing the fixed and random effect which are more advanced models if the pooled one was not appropriate.

Panel data provide a large number of point data, increasing the degrees of freedom and reducing the collinearity between regressors. Therefore, it allows for more powerful statistical tests and normal distribution of test statistics. It can also take heterogeneity of each cross-sectional unit into account, and give "more variability, less collinearity among variables, more degrees of freedom, and more efficiency" (Baltagi, 2001).

In this paper, regressions are based on data concerning a group of 140 firms in Iran's industries over the period 1996 - 2014. Data for total factor productivity (TFP), ICT expenditure (ICT), innovation (INNO), investment (INV), research and laboratory expenditure (LAB) for 140 firm in Iran's industries come from the each firm data base.

In this paper we pool cross-section and time series data to study the effect of information and communication technology (ICT) and innovation on total factor productivity in Iran's industries.

2.2. Estimation Procedure

In order to investigate the possibility of panel cointegration, first, it is necessary to determine the existence of unit roots in the data series. For this study we have chosen the Im, Pesaran and Shin (IPS, hereafter), which is based on the well-known Dickey-Fuller procedure.

Im, Pesaran and Shin denoted IPS proposed a test for the presence of unit roots in panels that combines information from the time series dimension with that from the cross section dimension, such that fewer time observations are required for the test to have power. Since researchers have found the IPS test to have superior test power for analyzing long-run relationships in panel data, we will also employ this procedure in this study. IPS begins by specifying a separate ADF regression for each cross-section with individual effects and no time trend:

$$\Delta y_{it} = \alpha_i + \rho_i y_{i,t\,1} + \sum_{j=1}^{pi} \beta_{ij} \Delta y_{i,t\,j} + \varepsilon_{it} \quad (1)$$

Where $i = 1, \ldots, N$ and $t = 1, \ldots, T$

IPS use separate unit root tests for the N cross-section units. Their test is based on the Augmented Dickey-fuller (ADF) statistics averaged across groups. After estimating the separate ADF regressions, the average of the t-statistics for p_1 from the individual ADF regressions, $t_{iTi}(p_i)$

$$\bar{t}_{NT} = \frac{1}{N} \sum_{i=1}^{N} t_{iT} \, (p_i \beta_i) \quad (2)$$

The t-bar is then standardized and it is shown that the standardized *t-bar* statistic converges to the standard normal distribution as N and T $\rightarrow \infty$. IPS (1997) showed that *t-bar* test has better performance when N and T are small. They proposed a cross-sectional demeaned version of both test to be used in the case where the errors in different regressions contain a common time-specific component (Nor'Aznin and et al, 2010).

The next step is to test for the existence of a long run relationship among the variables. A common practice to test for cointegration is Johansen's procedure. However, the power of the Johansen test in multivariate systems with small sample sizes can be severely distorted. To this end, we need to combine information from time series as well as cross-section data once again. In this context three panel cointegration tests are conducted.

First, we use a test due to Levin and Lin (1993) in the context of panel unit roots, to estimate residuals from (supposedly) long run relations. Levin and Lin (1993) consider the model

$$y_{it} = \rho_i y_{i,t-1} + z_{it}' \gamma + u_{it} \quad (3)$$

Where z_{it} are deterministic variables, u_{it} is iid$(0,\sigma^2)$ and $\rho_i = \rho$. The test statistic is at t-statistic on ρ given by

$$t_\rho = \frac{(\hat{\rho}-1)\sqrt{\sum_{i=1}^{N} \sum_{t=1}^{T} \tilde{y}_{i,t-1}^2}}{s_e} \quad (4)$$

Where

$$\tilde{y}_{it} = y_{it} - \sum_{s=1}^{T} h(t,s) y_{is}, \quad \tilde{u}_{it} = u_{it} - \sum_{s=1}^{T} h(t,s) u_{is} \quad h(t,s) = z_t' \left(\sum_{t=1}^{T} z_t z_t' \right) z_s,$$

$$s_e^2 = (NT)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \tilde{u}_{it}^2,$$

And $\hat{\rho}$ is the OLS estimate of ρ. It can be shown that if there are only fixed effects in the model, then

$$\sqrt{N} T(\hat{\rho} - 1) + 2\sqrt{N} \rightarrow N(0, \sigma^2)$$

Second, we use the unit root tests developed for Eq. (2) by Harris and Tzavalis (1999). It must be noted that Levin and Lin (1993) tests may have substantial size distortion if there is cross-sectional dependence (O'Connell, 1998). Also, Harris and Tzavalis (1999) find that small T yields Levin and Lin tests which are substantially undersized and have low power. A drawback of the Levin and Lin or Harris and Tzavalis tests is that they do not allow for heterogeneity in the autoregressive coefficient, ρ.

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Finally, to overcome the problem of heterogeneity that arises in both tests we use Fisher's test to aggregate the p-values of individual Johansen maximum likelihood cointegration test statistics, see Maddala and Kim (1998). If p_i denotes the p-value of the Johansen statistic for the ith unit, then we have the result $-2\sum_{i=1}^{N}\log p_i \sim \chi^2_{2N}$. The test is easy to compute and, more importantly, it does not assume homogeneity of coefficients in different countries (Christopoulos and Tsionas, 2004).

The next step is to test for the existence of a long-run cointegration market share and the independent variables using panel cointegration tests suggested by Pedroni (1999 and 2004). We will make use of seven panel cointegration by Pedroni (1999), since he determines the appropriateness of the tests to be applied to estimated residuals from a cointegration regression after normalizing the panel statistics with correction terms (Nor'Aznin and et al, 2010).

The procedures proposed by Pedroni make use of estimated residual from the hypothesized long-run regression of the following form:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \cdots + \beta_{Mi} x_{Mi,t} + \varepsilon_{i,t} \quad (5)$$

For t = 1,…..,T; I = 1,….,N; m = 1, …., M,

Where *T* is the number of observations over time, *N* number of cross-sectional units in the panel, and *M* number of regressors. In this set up, α_i is the member specific intercept or fixed effects parameter which varies across individual cross-sectional units. The same is true of the slope coefficients and member specific time effects, $\delta_i t$.

Pedroni (1999 and 2004) proposes the heterogeneous panel and heterogeneous group mean panel test statistics to test for panel cointegration. He defines two sets of statistics. The first set of three statistics $Z_{\hat{v},N,T}$, $Z_{\hat{\rho},N,T\ 1}$ and $Z_{tN,T}$ are based on pooling the residuals along the within dimension of the panel. The statistics are as follows

$$Z_{\hat{v},N,T} = T^2 N^{3/2} \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^2 \hat{e}_{i,t\ 1}^2 \quad (6)$$

$$Z_{\hat{\rho},N,T\ 1} = T\sqrt{N} \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^2 \hat{e}_{i,t\ 1}^2 \quad \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^2 (\hat{e}_{i,t\ 1} \Delta\hat{e}_{i,t} \ \hat{\lambda}_i) \quad (7)$$

$$Z_{tN,T} = \tilde{\sigma}_{N,T}^2 \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^2 \hat{e}_{i,t\ 1}^2{}^{1/2} \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{L}_{11i}^2 (\hat{e}_{i,t\ 1} \Delta\hat{e}_{i,t} \ \hat{\lambda}_i) \quad (8)$$

Where $\hat{e}_{i,t\ 1}$ is the residual vector of the OLS estimation of Equation (5) and where the other terms are properly defined in Pedroni. The second set of statistics is based on pooling the residuals along the between dimension of the panel. It allows for a heterogeneous autocorrelation parameter across members. The statistics are as follows:

$$\tilde{Z}_{\hat{\rho}N,T\ 1} = \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{e}_{i,t\ 1}^2{}^{1} \sum_{t=1}^{T} (\hat{e}_{i,t\ 1} \Delta\hat{e}_{i,t} \ \hat{\lambda}_i) \quad (9)$$

$$\tilde{Z}_{tN,T\ 1} = \sum_{i=1}^{N}\sum_{t=1}^{T} \hat{e}_{i,t\ 1}^2{}^{1/2} \sum_{t=1}^{T} (\hat{e}_{i,t\ 1} \Delta\hat{e}_{i,t} \ \hat{\lambda}_i) \quad (10)$$

These statistics compute the group mean of the individual conventional time series statistics. The asymptotic distribution of each of those five statistics can be expressed in the following form:

$$\frac{x_{N,T}\ \mu\sqrt{N}}{\sqrt{v}} \rightarrow N(0,1) \quad (13)$$

Where X_{NT} is the corresponding form of the test statistics, while μ and v are the mean and variance of each test respectively. They are given in Table 2 in Pedroni (1999). Under the alternative hypothesis, Panel *v* statistics diverges to positive infinity. Therefore, it is a one sided test were large positive values reject the null of no cointegration. The remaining statistics diverge to negative infinity, which means that large negative values reject the null (Al-Awad and Harb, 2005).

3. Estimation Result

In order to investigate the possibility of panel regression, it is first necessary to determine the existence of unit roots in the data series. Panel unit root tests are similar, but not identical to unit root tests carried out on a single series. The literature suggests that a panel-based unit root test enhances the power of the unit root test as it allows for greater efficiency by providing more degrees of freedom and for heterogeneity across individual series. For this study we have chosen the Im, Pesaran and Shin (IPS), which is based on the well-known Dickey-Fuller procedure. Investigations into the unit root in panel data have recently attracted a lot of attention.

Table 1 presents the panel unit root tests. At a 5% significance level. The p-values corresponding to the IPS and LLC values calculated for the total factor productivity (TFP), ICT expenditure (ICT), innovation (INNO), investment (INV), research and laboratory expenditure (LAB) are less than 0.05. This indicates that these series of variables are stationary at 5% level of significance and thus these variables are stationary.

Table 1 – Panel unit root tests

Variables	IPS Statistic	Prob
ICT Expenditure (ICT)	-28.14	0.00
Innovation (INNO)	-30.21	0.00
Investment (INV)	-28.94	0.00
Research and Laboratory Expenditure (LAB)	-24.63	0.00
Total Factor Productivity (TFP)	-24.75	0.00

Note: Levels and first order differences denote the IPS t-test for a unit root in levels and first differences respectively. Number of lags was selected using the AIC criterion. We use the Eviews software to estimate this value.

We can conclude that the results of panel unit root tests reported in Table1 reject the hypothesis of a unit root in all variables across industries. The main goal of the paper is to measure the effect of information and communication technology (ICT) and innovation on total factor productivity in Iran's industries using an available panel dataset. The main hypothesis in to test that ICT and innovation has a positive significant on total factor productivity in Iran's industries. If this is true, then we will be able to measure the effect of ICT tools on the total factor productivity.

For our panel data pooled OLS, fixed and random effect estimation techniques will be used. However, there are few important econometric issues which need to be addressed. First, having several proxies of macroeconomic stability may result in the multi-collinearity in the explanatory variables. However, this issue can be tackled by computing the correlation between the corresponding variables. If the correlation is large, it means that these explanatory variables contain similar information and should not be both included in the regression.

Another more important problem is the possible problem of endogeneity between the capital flight and growth, as we cannot state for sure which variable determines which. Even though the regressions are very likely to have country- or region specific effects, we will start the estimation from the OLS procedure. The coefficients for the Pooled OLS regression have the expected sign. However, we know that the Pooled OLS is very restrictive. Choosing between Pooled OLS and fixed effect procedure is based on F test, we analyzed the statistics from the F-test for common intercept, which favored the fixed effect estimation.

As we have noted earlier, all explanatory variables are stationary in level. As was noted above, we discuss the results, obtained with the fixed effect model. After we estimate the model by using Pooled and fixed effect we use F test. Our model based on assumptions about how the fixed term is are used so as to predict the relationship between the variables. These are "pooled regression" (pooled OLS) and "fixed effects". The first phase in choosing the correct method is carrying out the F test which tests the homogeneity of the firm's effects. The null hypothesis in which fixed effect model is redundant versus pooled regression model. After completing the Leamer F Test, the results suggest the need to estimate the model using panel data. Since Prob is less than 0.05 at the 5% significant level, then null hypothesis based on homogeneous cross sections is rejected and therefore it is concluded that the panel method would be an accurate method for the estimation. Results of Leamer F Test are shown in Table 2.

Table 2- Results of Leamer F test

Statistic	Prob	Result
17.42	0.000	Pnale data (Fixed effect)

In what follows, to determine whether the random effect or the fixed effect performance is sufficient for a good estimation of the models, Hausman test is designed. The results of Hausman test are shown in Table 3. According to the results of Hausman test, the fixed effect method is suitable for the model.

Table 3- Results of Hausman test

Statistic	Prob	Result
0.000	1.000	Pnale data (Fixed effect)
Rho	0.28	Cross-section random
	0.72	Idiosyncratic random

According to the results of test, fixed effects model provides reliable predictions and we use panel data (Fixed effect) model.

Table 4- Panel Regression Results

Dependent variable: TFP				
Independent variables	Coefficient	Std. Error	t-Statistic	Prob
Intercept	311.23	7.982	43.95	0.00
ICT	0.02	0.004	5.52	0.00
INNO	0.04	0.006	7.21	0.00
LAB	0.01	0.002	6.38	0.00
INV	0.003	0.002	1.60	0.10
R-squared=0.55 F-statistic=21.92 Prob(F-statistic)=0.00 Durbin-Watson stat=1.89				

Each industries we are studying have some individual characteristics which may influence the independent variables. Therefore, we can assess the net effect of each independent variable on TFP. We estimate the above regression with fixed effect model. The result of estimation indicates a positive effect from ICT on TFP. In this model the coefficient of ICT equal 0.02 which shows that a unit of increase in ICT, lead to 0.02 percent increase in TFP. Also we find that the coefficient of innovation (INNO), equal 0.04 which shows that a unit of increase in firm's innovation, lead to 0.04 percent increase in TFP. Moreover the coefficients of LAB and INV are 0.01 and 0.003 respectively, which shows that a unit of increase in LAB and INV, leads to 0.01 and 0.003 percent increase in TFP. The Durbin Watson statistic showed error terms are uncorrelated. The R-squared index in model indicates the good fitting of the model. In addition, F statistics indicates that regression is significant.

4. Conclusion

This paper is an empirical study on the effect of information and communication technology (ICT) and innovation on total factor productivity in Iran's industries. For that reason, the unit root test is used to confirm the stationarity of all variables. After confirming that all variables are stationary at level, the panel fixed effect is applied. Results obtained indicate the positive and significant effect of ICT and innovation on total factor productivity in Iran's industries for 140 industry. The result of estimation indicates a positive effect from ICT on TFP. In this model the coefficient of ICT equal 0.02 which shows that a unit of increase in ICT, lead to 0.02 percent increase in TFP. Also we find that the coefficient of innovation (INNO), equal 0.04 which shows that a unit of increase in firm's innovation, lead to 0.04 percent increase in TFP. Moreover the coefficients of LAB and INV are 0.01 and 0.003 respectively, which shows that a unit of increase in LAB and INV, leads to 0.01 and 0.003 percent increase in TFP. According to the results it seems necessary to giving high priority to science and technology, it is recommended that the countries particularly increase the use of ICT in formulating the national educational plans and programs. It is recommended that the members cooperate in technological activities and development programs to promote, expand and develop ICT.

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