Impact of ICT and innovation on higher education in developed economies

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ABSTRACT: This paper examines the relation between ICT (Information and Communication Technology) and the effect of innovation on higher education during the 2000-2014 periods in the case of developed countries. The cointegration relationship between series was examined by using panel cointegration test developed by Pedroni (1999, 2004) and Kao (1999). As a result of the empirical analysis, cointegration relationship between the series was determined. The results provide also evidence of a positive effect of innovation in tertiary education.

KEYWORDS: ICT, research and development expenditure, expenditure in higher education, panel cointegration, DOLS (Dynamic Ordinary Least Square).

1   INTRODUCTION

The relationship between education and innovation has been the subject of considerable academic research over the past few decades.

Actually, the acceleration of the pace of economic growth is historically accompanied by an increase diffusion of innovation in education. This is proven in several studies such us Charles and Issifu (2015), Vitola and Erina (2015), who believe that innovation is essential for the sector education and therefore has a positive effect on the rate of productivity.

In fact, in countries with advanced and highly specialized economic system is necessary to have a large working population with high intellectual ability and, therefore, a high degree of training, which also translates into higher productivity. Those countries are usually those invest more in human capital, moreover by deploying advanced and efficient training tools, supported by rising investment in both public and private (Krueger and lindahl, 2001).

In this context, we must consider also that these countries are as well investing more in research and development, and thus, they have the most innovative technologies, such as those of information and communication (Bucciarelli et al, 2010).

Indeed, innovation, as a pattern of investment in education, strengthens competitiveness as well as progress and, through them, a sustainable economic growth.

It is known that innovation is an essential element to generate sustained economic growth. However, we cannot talk about innovation without a high level of education or a high standard of living.

Several existing studies on the nexus between ICT, research and development expenditures and education are carried out on a piecemeal basis without a comprehensive model in mind while ignoring the potential interaction between the series.

Our study thus contributes to this existing literature by giving the first integrated approach to examine the three way linkages between higher education, ICT and research and development in 13 developed countries over the 2000-2014 period.

That is to say that, investment in education, and mainly higher education, since it allows quality training by preparing a worker who is better educated and trained and able to produce and realize profit.

This hypothesis is tested using a sample of 13 developed countries.

The econometric analysis of this homogenous panel includes:

First unit root tests to verify the order of integration of the variables. Second, cointegration tests to examine the presence of long term relationship and finally, a DOLS panel model to estimate the impact of innovation on higher education.

This paper proceeds as follows: section 2 briefly reviews the related literature, followed by section 3 that presents the data and the methodology. Section 4 depicts the empirical findings and section 5 concludes.

2 LITERATURE REVIEW

Innovation in education is a difficult concept to define since it is a multidimensional notion which appears in difficult areas. Consequently, the conception of innovation was discussed, defined and developed from the perspective of several disciplines: sociology, psychology, economics, linguistics, management, cognitive science, philosophy, etc. (Popescu & Crenicean, 2012).

In order to identify the innovation variable, several studies, especially in the past, used RD as a measure of innovative activities (Schmookler, 1966). Recently, counts of the number of patents have been used as a proxy for innovation (Ahuja & Katila, 2001). In addition to the pervious indicator, some others have focused on ICT to describe innovation (Charles & Issifu, 2015; Buabeng-Andoh & Yidana, 2015).

2.1 RESEARCH AND DEVELOPMENT EXPENDITURE AND HIGHER EDUCATION

It is known that currency to achieve a high standard of living, a developed nation showed focus on education, research and innovation. For this reason, some studies, such as that of Popescu and Crenicean (2012) stated that existing innovation activities and changes in education for the case of Romania have an impact on economic growth. The research focuses on various educational institutions and modern forms of teaching and learning which promote creativity and strengthen entrepreneurial skills.

Following this seminal study, Teles and Joiozo (2011) evaluate the contribution of human capital to technological innovation applying a panel data from 27 countries for the period 1960 to 2000. Their results significantly revealed that there is a clear long run relationship between human capital stock and the quantity of innovation. This relationship reflects the cointegration between the number of patents and the public spending in tertiary education.

The work of Kruss et al. (2015) shows how South African higher education institutions contribute to economic development by drawing on evolutionary economic and the national innovation system approach through two case studies from astronomy and automotives. Therefore, there are counter arguments that point out to limit interactions between the key variables of higher education expansion, productivity and technological change. Moreover, Vitola and Erina (2015) compared higher education performance indicators and their relation with research and development expenditure in the Baltic States. The authors concluded that research and development expenditure in higher education sector is partially related to performance indicators in Latvia and Lithuania, contrary performance indicators are more related to expenditure in Estonia.

In addition, Iacopetta (2010) analyses the transitional dynamics of a growth model utilizing time series data in which both human capital and innovation drive income expansion. This generates a trajectory showing that human capital formation is a first step toward the emergence of a modern economy.

Generally, innovation will play a critical role in education. Some of the most innovative discoveries have their origins in research conducted at universities. Countries with high levels of innovation also tend to have, on average, higher proportions of graduates in their populations and a stronger track record of investment in higher education.

As a consequence, innovation in education system allows several countries to attract new talents and improve the citizen's competences. Besides, it promotes science and research and, in this way, stimulates innovation, productivity, employment and growth.

2.2 ICT AND HIGHER EDUCATION

The use of ICT is a symbol of a new era in education. According to Tezci (2011); Kubiatko and Halakova (2009), ICT has challenged the conventional teaching methods, transformed instructional practices and contributed to the emergence new instructional methods.

In addition, Allahi and Sanayei (2009) showed that "ICT alters thought patterns, enriches existing educational models and provides new training models, those models shares features of a technology-based training and suggest new learning methods in which the learner plays an active role and also emphasizes self directed independent, flexible and interactive learning" [10].

Evidently, ICT should be used to pursue the acquisition of knowledge and the formation of skills which should enable the student to adapt to the demands of society in constant evolution.

In this context, the use of ICT in education has intensely reformed learning and teaching processes. Furthermore, it has expanded new opportunities for learning and accessing to educational resources beyond those traditionally available. In this condition, the use of ICT in education creates a method of training called e-learning. (Talebian et al., 2014).

In this respect, ICT play a key role for the future development of higher education institutions and represent a catalyst for innovation quality and excellence in this sector.

Recent studies, which have examined the relation between innovation and education are, as follows Charles and Issifu (2015). In their study, the authors used a total of 3380 students from 24 public and private schools from four regions in Ghana. Research finding from ICT usage may have important implications for administrators, students and employers and may enhance educational delivery to students, students' learning experience in secondary schools and student's application of knowledge and skills in the real world of work.

Finally, it seems that ICT are a driving force behind much of the development and innovation in many countries.

3   DATA AND METHODOLOGY

3.1   DATA ANALYSIS

The data set consists of cross-country observations, for 13 countries over the 2000-2014 period, obtained from the data base of World Development Indicators (http://data.worldbank.org/indicator); International Telecommunication Union (ITU) (http://www.itu.int/); Organization for Economic Cooperation and Development (OECD) (https://data.oecd.org/) . In this study, we employ data on 13 countries[1]. Countries are chosen according to the availability of their data and specially ICT. The variables are EXP which measures the expenditure on higher education, RD as a proxy of research and development expenditure, PAT as proxy of number of patent applications, ICT is the proxy of ICT investment in tertiary education and GDP is real gross domestic product and ε is the error term.

3.2   METHODOLOGY

In this study, the model is estimated using panel data for 13 countries. The panel data analysis allows the implication of data for N cross-sections (e.g. countries) and T time periods. The combined panel data consist of a time series for each cross-sectional member in the data set and offer a variety of estimation methods (Asteriou & Hall, 2007).

To examine the relationship between higher education and innovation for our sample, we used a Cobb–Douglas production function where the expenditure on higher education (EXP) depends on ICT and innovation.

By taking log, the linearized model can be given as follows:

$$lnEXP_t = \alpha_1 + \alpha_2 lnICT_t + \alpha_3 lnPAT_t + \alpha_4 lnRD_t + \alpha_5 lnGDP_t + \varepsilon_t \qquad (1)$$

The model is then:

$$ln\,EXP_{it} = \alpha_1 + \alpha_2 lnICT_{it} + \alpha_3 lnPAT_{it} + \alpha_4 lnRD_{it} + \alpha_5 lnGDP_{it} + \varepsilon_t \qquad (2)$$

Where the subscript i=1… N denotes the country (in our study, we have 13 countries) and

t= 1…T denotes the time period (our time frame is 2000–2014), ln EXP is the expenditure on tertiary education (% of government expenditure on education), ln ICT is ICT investment in tertiary education, lnPAT is the number of patent

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[1] *Austria, Canada, Denmark, Finland, France, Ireland, Italy, Japan, Netherlands, Spain, Sweden, United Kingdom, United States.*

applications, lnRD is the indicator of research and development expenditure, lnGDP is economic growth and ε is the error term.

3.3 PANEL UNIT ROOT TESTS

In order to understand whether there is a long run relationship between all the variables, applying cointegration test, should check nether all the variables are stationary at level or not. If these series are not stationary at level, it should be preceded by first difference to get stationary positions. When all the series become stationary at first difference level, we can use co-integration test (Dickey and Fuller, 1981; Phillips and Perron, 1988).

Therefore, we begin our work by performing the panel unit root test proposed by Levin et al. (LLC) (2002) and Im et al. (IPS) (2003). Both tests are based on the Augmented Dickey- Fuller principle.

Levin et al. (2002) considered the following basic Augmented Dickey–Fuller model:

$$\Delta X_{i,t} = \alpha i + \beta_i X_{i,t-1} + \sum_{j=1}^{P_i} \mu_{i,j} \Delta X_{i,t-j} + \varepsilon_{i,t} \qquad (3)$$

Where Δ is the first difference operator, $X_{i,t}$ is the dependent variable i over period t, and $\varepsilon_{i,t}$ is a white-noise disturbance with a variance of σ_i^2.

Both β_i and the lag order μ in this equation are permitted to vary across sections (countries). Hence, it is assumed that:

$$\begin{cases} H_0: \beta_i = 0 \\ H_1: \beta_i < 0 \end{cases}$$

According to LLC test, compared with the single-equation Augmented Dickey-Fuller test, the panel method sensibly raises power in finite samples. The proposed model is as follows:

$$\Delta X_{i,t} = \alpha i + \beta X_{i,t-1} + \sum_{j=1}^{P_i} \mu_{i,j} \Delta X_{i,t-j} + \varepsilon_{i,t} \qquad (4)$$

It is also assumed that:

$$\begin{cases} H_0: \beta_1 = \beta_2 = \cdots = \beta = 0 \\ H_1: \beta_1 = \beta_2 = \cdots \beta < 0 \end{cases}$$

where the statistics of the test is $t_\beta = \frac{\beta}{\sigma(\beta)}$; β is the OLS estimate of β in Eq.(4) and $\sigma(\beta)$ is its standard error.

Im et al. (2003) proposed a testing procedure based on the mean group approach and also on the Augmented Dickey-Fuller regression presented by Eq.(3). By contrast, the null and alternative hypotheses are not similar to the LLC test, where the rejection of the null hypothesis indicates that all the series are stationary.

Now, we have: H_0: β_1 = β_2 =……= β_N =0   vs.   H1: Some but not necessarily all β _i < 0

The IPS test is calculated as the average of the t-statistic with and without trend. Alternative t-bar statistics for testing the null hypothesis of the unit root for all individuals (β_i = 0) is as follows:

$$\bar{t} = \frac{\sum_{i=1}^{N} t\beta_i}{N} \qquad (5)$$

Where t is the estimated Augmented Dickey-Fuller statistics from individual panel members; N is the number of individuals. Using the Monte Carlo simulations, this test shows that the t-bar ($\bar{t}$) is normally distributed under the null hypothesis. Accordingly, the estimate of its mean and variance is used to convert t-bar ($\bar{t}$) into a standard normal z-bar ($\bar{z}$) statistic which is given by:

$$\bar{z} = \frac{\sqrt{N}(\bar{t} - E[\bar{t} \backslash \beta_i = 0])}{\sqrt{var[\bar{t} \backslash \beta_i = 0]}} \to N(0,1) \qquad (6)$$

Where E [$\bar{t}$ / β _i = 0] and var [$\bar{t}$ / β _i = 0] are the mean and variance of t_{it}.

Moreover, the IPS study shows that the standardized statistic converges weakly to the standard normal distribution, which allows the comparison with critical values of the distribution N (0, 1).

3.4   PANEL COINTEGRATION

The concept of cointegration introduced by Granger (1969) is relevant to the problem of determining long-run relationships between variables. The basic idea that supports cointegration is simple. If the difference between two non stationary series is itself stationary, then the two series are cointegrated. If two or more series are cointegrated, it is possible to interpret the variables in these series as being in a long-run equilibrium relationship (Engle and Granger, 1987). By contrast, a lack of cointegration suggests that the variables have no long-run relationship-thus, in principle, the postulated variables can arbitrarily move far away from one another. Therefore, Panel cointegration test is used to investigate the long-run equilibrium relation between the dependent variable and all the independent variables as a group in the model.

In fact, there are numerous cointegration tests such as those of Engle and Granger (1987), Johansen (1991) and Philips and Ouliaris (1990), which documented in the time series literature. However, these tests fail to take advantage of information across countries, which lead to the loss of efficiency in estimation. Recently, several authors, such as Pedroni (2004), Kao and Chiang (2000) and Kao (1999) have developed cointegration tests with panel data. In this article, we employ the Panel cointegration tests proposed by Pedroni (2004) and Kao (1999) to test whether a cointegration exists in the estimated equations.

To test the null hypothesis of non cointegration, Pedroni (1999, 2004) proposed seven cointegration tests of two types: Four within the model and three between models. This study employs the ADF statistic and the ADF statistic for groups since Pedroni (1999) showed that the ADF tests work better than others when applied to small samples, such as the present panel. Following Pedroni (1999), the heterogeneous panel and group of the mean panel cointegration statistics are calculated as follows (Lee, 2005)

Panel ADF-statistics:

$$\tilde{Z}_t^* = \left(\hat{S}^{*2}\right) \sum_{i=1}^{N} \sum_{t=1}^{T} \left(\hat{L}_{11i}^{-2} \hat{e}_{it-1}^{*2}\right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \left(\hat{L}_{11i}^{-2} \hat{e}_{it-1}^* \Delta \hat{e}_{it}^*\right) \qquad (7)$$

Group ADF-statistics:

$$\tilde{Z}_t^* = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{S}_i^2 \hat{e}_{it-1}^{*2}\right)^{-1/2} \sum_{t=1}^{T} (\hat{e}_{it-1}^* \Delta \hat{e}_{it}^*) \qquad (8)$$

Where e_{it} is the estimated residual from Eq. (1) and L^2_{11i} is the estimated long run covariance matrix for $\widehat{\Delta e_{it}}$ Likewise, $\hat{\sigma}_i^2$ and $\hat{S}_i^2$ $(\hat{S}^{*2})$ are, respectively, the long run and contemporaneous variances for individual i. The other terms are appropriately defined by Pedroni (1999) with the property lag length determined by the Newey-West method. Despite the fact that co-integrated test was already proposed more than one decade ago, it is use is still very much used. The reasons are that the principles at the basis of the survey, the design of the seven cointegration tests in their two types, between and within the models, entail a certain strength in their results, due to the fact that they combine time series and cross sectional data obtaining more degrees of freedom, which improves properties of the estimators and corrects non observer heterogeneities (Robledo and Olivares, 2013). The panel Cointegration technique is still active and used in several studies as the main method (Cetin et al. 2014) or in a complementary way (Adhikari & Chen, 2012; Jebli & Youssef, 2015).

However, Kao offered two types of tests to examine panel cointegration, which are the Dickey Fuller (DF) and the augmented Dickey Fuller (ADF) tests. Besides, others used the Fisher type test to aggregate the p values of the individual Johansen maximum likelihood cointegration test statistics. Because the OLS, which is used to estimate the panel cointegration vectors, are a biased and inconsistent estimator, hence, the Panel Dynamic Ordinary Least Squares (DOLS) estimator was introduced by Pedroni (2000); Phillips and Moon (1999) and developed by Kao and Chiang (2000) which is allowed to take serial correlation and endogeneity of the regressors into the conventional OLS estimator.

Additionally, we used the DOLS technique developed by Kao and Chiang (2000) to estimate the long-run panel cointegrated model. DOLS builds upon the time series analysis of Stock (Stock & Watson, 1993; Saikkonen, 1991). Kao and Chiang's (2000) Monte Carlo simulations showed that DOLS outperforms both the OLS and FMOLS estimators on all counts. The estimated coefficients of the DOLS converge to the same coefficients as the FMOLS estimation. Mark and Sul (2003) evaluated the panel DOLS estimator by Monte Carlo simulation. They concluded that panel DOLS provides much more precise estimates and has standard asymptotic distributions that provide reasonably close approximations to the exact sampling distributions in small samples.

The model of the DOLS is as follows:

$$Y_{it} = \alpha_i + X_{it}\beta_i + u_{it}^* \qquad (9)$$

$$X_{it} = X_{it-1} + V_{it} \qquad (10)$$

With the regressors Y_{it} is the expenditure on tertiary education at time t, X_{it} is the indicators of ICT investment, research and development expenditure, number of patent applications, real output, and being integrated of order 1, then cointegrated with slopes βᵢ.

4 EMPIRICAL RESULTS

4.1 RESULTS OF PANEL UNIT ROOT TESTS

To investigate the stationarity of the series used, we applied the unit root tests on panel data (LLC, IPS) .The results of these tests are presented in the following table:

Table 1: Results for panel unit root tests (Level and First Differences)

Variables	LLC test				IPS test			
	Level		First difference		Level		First difference	
	T-Statistics	p-value	T-Statistics	p-value	T-Statistics	p-value	T-Statistics	p-value
EXP	-2.52450	0.0058	-12.7438	0.0000	-1.01952	0.1540	-8.76580	0.0000
ICT	-3.16016	0.0008	-10.0446	0.0000	-0.25675	0.3987	-6.24091	0.0000
PAT	1.29053	0.9016	-5.55852	0.0000	1.90584	0.9717	-5.18205	0.0000
RD	1.21833	0.8885	-9.24605	0.0000	0.56698	0.7146	-5.54045	0.0000
GDP	-3.07948	0.0010	-11.6383	0.0000	-0.57597	0.2823	-6.33292	0.0000

From the results of the unit root tests performed for the seven panels of the study, we can draw the following conclusions: All the statistics are not significant at 1% level for all series. After differentiation into first degree data, we noticed a significant way that all data are stationary for all the variables. Thus, all the series are integrated of order one I(1).These results led us to a logical way to test for the presence or absence of a long-term relationship between them by applying Co-integration.

4.2 RESULTS OF COINTEGRATION TESTS

According to the results of Table 1, we confirm that all the variables are I (1), and then we start the long-run analysis, that is to use panel cointegration tests examining the relationship between the five variables. Besides, considering the analysis of sensitivity and robustness, we employed two kinds of panel cointegration tests, those of Pedroni and Kao panel cointegration tests.

- Pedorni's residual cointegration test result

  Cointegration requires that all the variables are integrated of the same order.

  The results of panel unit root test indicate that our variables are first order integrated I(1). Then, we proceed to test cointegration panel, by relying on Pedroni's Residual-Based Panel Cointegration Tests (1999, 2004), which refer to seven different statistics for this test.

The results are as follows:

Table 2: Results for Pedroni's panel cointegration tests

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob	Weighted Statistic	Prob
Panel v-Statistic	-0.877025	0.8098	-1.359897	0.9131
Panel rho-Statistic	0.289966	0.6141	0.431629	0.6670
Panel PP-Statistic	-3.765558	0.0001	-6.234605	0.0000
Panel ADF-Statistic	-3.950715	0.0000	-5.204526	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	1.671781	0.9527		
Group PP-Statistic	-12.48387	0.0000		
Group ADF-Statistic	-5.317752	0.0000		

From table 2, out of the total seven statistics, four statistics that include Panel PP-statistics, Panel ADF-statistics, Group PP and Group ADF- statistics are significant at 1% level, which indicates the rejection of the null hypothesis of no cointegration. Generally, evaluating according to the results of these four tests, it can be reported that Pedroni's cointegration test results show a cointegration relationship between the analyzed variables.

- kao's residual cointegration test results

Table 3: Results for Kao panel cointegration tests

	t-Statistic	Prob.
ADF	15.89674	0.0000
Residual variance	1.441108	
HAC variance	0.955406	

Table 3 provides results for the Kao (1999) panel cointegration test, which rejects the null hypothesis of no cointegration for the economic growth and other variables at 1% significance level; therefore there is existence of cointegration.

It is clear that in all the panel data sets, there is a long run relationship between tertiary education expenditure, RD expenditure, patent applications, ICT investment and economic growth for our panel of continents. Since there is cointegration between tertiary education expenditure and the other variables of our model, the equation model is estimated through the Dynamic Ordinary Least Square (DOLS) method.

In fact, the DOLS method has a feature of resolving deviations in the static regression (particularly problems arising from endogeneity), including dynamics elements to the model (Kök et al., 2010).

4.3 THE DOLS ESTIMATION

After confirming the existence of a Co-integration relationship between the series, we have to move to the estimation of the long term relationship.

There are different available estimators to estimate a vector Co-integration panel data, including with and between groups such as OLS estimates, fully modified OLS (FMOLS) estimators and estimators dynamic OLS (DOLS).

In this part of the study, the long run individual cointegration coefficients will be estimated using the DOLS which was developed by Kao and Chiang (2000).

The DOLS estimations and the results are presented in Table 4.

Table 4: Results for Panel DOLS

Dependent Variable: EXP
Method: Dynamic Least Squares (DOLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ICT	0.156814	0.083796	1.871369	0.0630
PAT	-0.076081	0.015163	-5.017581	0.0000
R_D	0.228130	0.077460	2.945127	0.0037
GDP	0.004368	0.148606	0.029396	0.9766
C	3.206619	1.569812	2.042677	0.0426
R-squared	0.521296	Mean dependent var		3.194870
Adjusted R-squared	0.477529	S.D. dependent var		0.218578
S.E. of regression	0.157993	Sum squared resid		4.368308
Durbin-Watson stat	0.265839	Long-run variance		0.100102

From table 4, the elasticity of ICT across the panels was calculated as 0.156. This means that a 1% increase in ICT in the 13 countries generates approximately 0.156% increase of expenditure on tertiary education in the long-run. Elastic coefficients of R&D are calculated as 0.228%. Therefore, an increase of 1% in R&D constitutes a positive effect on economic growth at the rate of approximately 0.228%. On the other hand, a 1% increase in GDP growth causes 0.004 % increases of expenditure on tertiary education in the long-run. However, a 1% increase in patent application in our panel countries causes approximately 0.076 % decreases of expenditure on tertiary education in the long-run.

According to the test results of the DOLS estimation, ICT and R&D in the long-run affect tertiary education expenditure significantly both in a positive and statistical way as expected. Furthermore, the findings indicate a positive relationship between GDP growth and tertiary education expenditure, but statically non significant.

However, we find that patent application affect negatively the tertiary education expenditure in the long-run.

The above sections analyze the feedback effect between higher education, ICT, RD and economic growth. Our model organizes and estimates such effects, and the analysis shows that technology and research share a positive relationship with higher education, although they don't lead to patent applications.

5 CONCLUSION AND DISCUSSIONS

Nowadays, to achieve a competitive economy, the focus should be oriented on some key factors, such as human capital, technologies and innovation. In this context, education is the powerful way to develop right skills for knowledge economy which increase competitive performance and long term state development.

In fact, the development of higher education quality depends mainly by focusing on innovation activity. Actually, ICT and R&D play a key role for the future development of higher education institutions and represent a catalyst for innovation and excellence in this sector.

The aim of this study is to investigate the link between ICT, innovation and higher education in 13 developed countries over the period 2000-2014 while applying the DOLS method.

Our results provide evidence that expenditure on tertiary education influenced positively by the following factors: ICT, R&D expenditure and GDP.

In short, a 1% increase in ICT, RD and GDP affects expenditure on tertiary education by 0.15%, 0.22% and 0.004% successively in the long run.

The main findings show that the most important contribution to expenditure on tertiary education has been made by RD expenditure. Nevertheless, there is a negative effect of patent applications on higher education spending. That is to say that, ICT policies and R&D are clearly beneficial to higher education. However, the application of these factors doesn't foster the number of patent applications. As a consequence, the increase of RD expenditure in higher education sector cannot increase the number of patent applications. This show that the contribution of higher education sector in the production of patent is less active than others sectors. Nonetheless, in order to rising patent performance, higher education sector must have been encouraged by public sector by using fiscal policy instruments.

This finding, suggest that, universities besides being promoted quality and excellence of students, they should lead them to engage in research and patent activity in order to enhance the performance in higher institutions.

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