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## The Contributions of Higher Education System to The Innovation Production Performance of Turkey: An Empirical Analysis


**İsmail SEKİ**

*Yrd. Doç. Dr., Çanakkale Onsekiz Mart Üniversitesi Biga İktisadi ve İdari Bilimler Fakültesi, İktisat Bölümü, ismailseki@gmail.com*



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ÖZET

*Bölgesel yenilik sistemleri kalkınma politikaları içerisinde giderek önem kazandıkça üniversitelerin fonksiyonları da değişmektedir. Üniversitelerin ekonomik rolleri iki grup altında sınıflandırılabilir. Bunlar klasik roller ve kompleks rollerdir. Bilgi tabanlı ekonomik sistemlerin en önemli kurumları olarak üniversiteler, özellikle kompleks rolleri vasıtasıyla, bölgesel ve ulusal kalkınmanın belirleyicileridirler. Bu bağlamda çalışmanın amacı üniversitelerin Türkiye'deki yenilik üretim süreçlerindeki rollerini ortaya koymaktır. Bu amaç doğrultusunda yapılan ekonometrik analizde yöntem olarak rassal katsayı modeli kullanılmıştır. Ampirik analize göre, kamu üniversiteleri, teknoloji geliştirme merkezleri ve teknoloji geliştirme bölgeleri Türkiye'nin yenilik üretme seviyesine pozitif katkıda bulunmaktadırlar. Ayrıca analizde yüksek eğitim sektörünün yenilik üretim süreçlerine katkısının diğer faktörlerin katkısından daha fazla olduğu görülmüştür.*



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ABSTRACT

*The functions of universities are changing while the regional innovation systems have a greater importance in development policies. The economic roles of universities can be classified into two groups. These are classical roles and complex roles. Universities, as the most important institutions of knowledge-based economic systems, are determinants of regional and national development, especially by their complex roles. In this context, the aim of the study is to clarify the roles of universities in innovation production processes in Turkey. The study uses random coefficient model as a method for econometric analyse. According to the empirical analyse, public universities, technology development centers and technology development regions have positive contributions to the level of innovation production of Turkey. In addition, the contribution of higher education system is more than the contributions of other factors.*

## INTRODUCTION

The most important production factor is knowledge in knowledge-based economic systems. In these systems, value added is created by knowledge intensive goods. In production processes, knowledge is internalised in high tech products physically and in educated and skilled labor force as human capital. From this point of view, generation and dissemination of knowledge is one of the most important factors for development of regions and countries.

The contribution of higher education institutions, especially universities, to development is a theme that has attracted increasing attention within the knowledge-driven economy. The concept of "Economics of University" is used to identify the roles and the contributions of universities (or in general academic system) in an economy. However, the shift of the economic perspective of development from national level to regional level affects the scale of the "Economics of University" concept. It becomes more "regional" after raising the Regional Innovation Systems (RIS) instead of National Innovation Systems (NIS). We can divide the economic roles of universities into two sub-groups. These are "*classical roles*" and "*complex roles*". Classical roles can be explained by using the tools of classical economics such as tangible production factors while complex roles cannot be definitely explained without the tools of knowledge-based economics. Contributions to the employment, gross output, disposable income and physical infrastructure are the classical roles of a university, however contribution to the knowledge stock, human capital and the acts in the knowledge governance are the complex roles of a university. In this study, we will set up an approach just based on the complex roles of universities.

While the most important production factor is knowledge, universities are the most important institutions of knowledge-based economic systems because the main missions of universities are production and dissemination of knowledge. However, in much of the literature, it is seen that the values of universities are decreased. Because they are introduced as a source of intermediate assets that move into the real economy, like graduates, and then make their impact. However, this impression is changed by triple-helix model (OECD, 2007, pp. 31).

Regional development in triple-helix model is explained in the second part. There is an empirical study about the role of universities in regional innovation production of Turkey in the third part. In the forth and the last part, there is a conclusion of the paper.

### 1. Regional Development in Triple-Helix Model

According to Etzkowitz (2002, pp. 2);

*"The triple helix is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization."*

There are three components of the model (Etzkowitz, 2002, pp. 4):

1. Academia
2. State
3. Industry

The Triple-Helix Model is an elastic model. It means there is no order between the stages of development. However, when a completely developed triple-helix model is occurred, it means that whole development stages are achieved. The development stages and characteristics of these stages are summarised in table 1.

**Table 1: Conceptual Framework for Knowledge-Based Regional Economic Development**

| Sage of Development | Characteristics |
|---|---|
| Creation of a Knowledge Space | Focus on "regional innovation environments" where different actors work to improve local conditions for innovation by concentrating related R&D activities and other relevant operations |
| Creation of a Consensus Space | Ideas and strategies are generated in a "triple helix" of multiple reciprocal relationships among institutional sectors (academic, public, private) |
| Creation of an Innovation Space | Attempts at realizing the goals articulated in the previous phase; establishing and/or attracting public and private venture capital (combination of capital, technical knowledge and business knowledge) is central |

**Source: (Etzkowitz, 2002, pp. 7).**

According to Etzkowitz (2002), the Triple-Helix Model has three dimensions. First of all, each helix constitutes an integrity around economic development mission through universities and strategic benefits. Secondly, each helix has an effect to another one. The effect of government policies on the process of universities' knowledge production has been given an example of this situation. Lastly, three helix works interactively as a three dimensioned network. The aim of this network is to create new ideas for innovation based development.

In this complex system, universities can be alive as long-lived institutions. They are long-lived because they can adapt in different and changing conditions very quickly. As a result, universities do never lose their central role for creating and disseminating knowledge. Antonelli (2006) explains the main reasons of having central role in this knowledge process, called knowledge governance. There are two main reasons; first, universities are the only ones that can solve the knowledge trade-off[1] problem. Secondly, universities are the suppliers of well-educated and qualified labor force for the other who is demanded by the other actors of knowledge-based economies.

An efficient and productive higher education system means a higher contribution to innovation production of the region. Innovativeness is directly proportional to the competitive power of the region. Consequently, to determine the contribution of higher education system to the innovative performance of the region is important to have an idea about the competitive power of the region.

## 2. Empirical Analyze

In this part of the study, there is an empirical analysis that has a regional perspective. Also, a parametric approach is used to determine the contributions of higher education system to the innovation production performance of Turkey.

### 2.1 Literature Review for Methodology

Studies that use Random Coefficient Model, which is explained next part of the study, in economic literature are intensed around four main topics. These topics are economic growth, sectoral analysis, R&D and innovation. Literature review is summarized in table 2.

[1] For details about knowledge trade-off look at Antonelli (2006).

**Table 2: Literature Summary for Random Coefficient Model**

| Focus | Researcher | Sample Area | Conclusions |
|---|---|---|---|
| Economic Growth | Grab and Grimm (2008) | Burkina Faso | The regional differences about economic growth and poverty are not changed while the development level of the country increases. |
| | Kim (2008) | Korea South | Economic growth has a capitalization effect on employment and this effect is decreasing while the creative destruction effect is increasing as the time passes. |
| | Dunne and Watson (2005) | OECD Countries | For the time period from 1966 to 2002, military expenditures of countries affect the technology level and it creates a positive contribution to the economic growth. |
| Sectoral Analysis | Salim and Kalirajan (1999) | Banglades h | The firms in the food industry cannot get the maximum utility from the technological improvements. |
| | Oh (2007) | Korea South | The similarities in markets and the learning capacities of the firms affect the sales in the cosmetic sector. |
| | Genakos (2004) | US | Firm marriages in computer industry do not cause a rapid increase in computer prices. These marriages cause different effect in different customer groups. |
| Research and Development (R&D) | Negassi (2004) | France | While the firm scale and R&D intensity of the firms have a positive effect on R&D corporations between firms, market shares of the firms have no effect on it. |
| | Gumprecht (2005) | 22 Developed and Developin g Countries | Regional R&D expenditures create a positive effect on productivity level of national economy. |
| | Xiao (2008) | US | Less price competition in market means more R&D investment |
| | Knott (2008) | US | Firms do not get high level of R&D returns because they make high level of R&D investments. However, they make high level of R&D investments because they get high level of R&D returns. |
| Innovation | Jensen et. al. (2009) | Australia | The patent system of Australia tacitly provides much of bonus to the innovators. |
| | Autio and Acs (2009) | Member Countries of the Global Entrepren eurship Monitor | Behaviors of the entrepreneurs are affected by environment. Also if an intellectual property rights of a country is weak, educated people of this country go towards entrepreneurship. |

| | | | |
|---|---|---|---|
| | | (GEM) Survey | |
| | Cerulli and Poti (2010) | Italy | The firms whose economic activities are based on their innovation capacity are more successful than the firms whose economic activities are based on their experiences. |
| | Cerquera (2008) | Germany | There is no empirical evidence about Information and Communication Technology (ICT) consulting increase the level of innovation talent of firms. |
| | Eizenberg (2008) | US | The rapid innovation in Central Processing Units (CPU) results an increase in computer prices and also an increase in computer sales. |

Literature review shows that random coefficient model can be used for micro level and regional analysis. The main inferences from literature review are an increase in regional R&D expenditure creates positive effect in productivity level of national economy and there is a negative effect of price competition on R&D investments especially in developed countries. Although there is an increase in national development level, it does not mean that there will be a convergence between regions in developing countries. There are unexpected results about innovation. First of all, there is a negative relationships between weakness of intellectual property rights and educated entrepreneur level of then country. If the intellectual property rights system of a country is weak, educated people try to use their intellectual capital as entrepreneurs. Secondly, there is no sufficient evidence about the link between ICT consulting and innovation talent of firms.

### 2.2. Empirical Model and Data Set

The data set that is used for the econometric estimation is NUTS3 level unbalanced panel data, and it contains 15 years, between 1995 and 2009.

The econometric model can be shown as;

$$PS1_{it} = \alpha_o + \alpha_1 US_{it} + \alpha_2 AK_{it} + \alpha_3 D_{it} + \varepsilon_{it} \qquad i=1,\ldots,81;\ t=1,\ldots,15. \qquad (1)$$

PS1 = number of patents in a nation divided to the number of firms in manufacturing industry[2],

US = number of state university[3],

AK = number of patents that includes a university or academician contribution,

D = number of technology development centers and technology development regions.

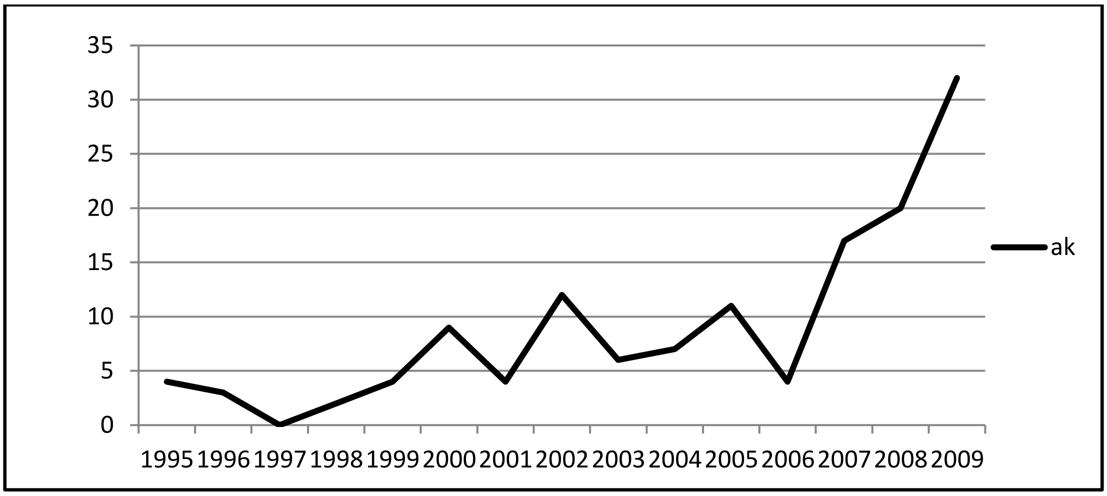
PS1 data is organized from Turkish Patent Institute and Turkish Statistical Institute. US data is organised from Turkish Higher Education Council. D data is organised from Turkish Statistical Institute and a nongovernment organisation called Science, Technology and Innovation Platform. AK data is organised by researcher. To collect that data a survey is applied to the patent owners. There is only one question in the survey that is *“Is there any university or academician contribution in your patent?”* There is a data constraint especially about variable AK. The data set is composed in 2010 and unfortunately there is no chance to enlarge it to nowadays. Because Turkish Patent Institute has not generated the AK data series yet.

[2] PS shows the number of patent numbers in a certain year for a certain nation. Patents generally become dense in İstanbul, Ankara and İzmir. Also the number of state universities are higer in these cities. Because of that condition, if PS is used for dependent variable and US is used for explanatory variable, there will be “scale effect problem” (Lenger, 2007, pp. 16). To avoid this problem, PS1 is used as dependent variable.

[3] Bilkent University is taken into consideration as a state university despite it is a private foundation university. Because it is the oldest private university in Turkey, and it has a big effect on the scientific development of the country on the contrary of other private univesities.

It is clear in figure 1 that the level of university or academician contribution in patents is very low. However, after 2006, there is a significant increase. The nations that can get higher contribution from higher education sector are İstanbul, Kocaeli and Ankara. There are two reasons beside this table. First, there is university-industry cooperation between technical universities in İstanbul and Arçelik[4]. Secondly, the biggest innovation center in Turkey called Marmara Research Center is in Kocaeli.

**Figure 1: Number of Patents that includes a University or Academician Contribution**




**Source: Turkish Patent Institute Data Base and Author's Survey**

For using these data sets, it is aimed to determine the factors of innovation production in Turkey and also to determine the contribution of Turkish higher education system in innovation processes.

### 2.2.1 Methodology: Random Coefficient Model[5]

Consider the linear regression model of the form

$$Y = \beta' x + u \qquad (2)$$

where *Y* is dependent variable and *x* is a Kx1 vector of explanatory variables. The variable *u* denotes the effects of all mother variables that affect the outcome of *Y* but are not explicitly included as independent variables. The standard assumption is that *u* behaves like a random variable and is uncorrelated with *x*. One of the most important issues in panel data analysis is how the differences in behavior across individuals and/or through time that are not captured by *x* should be modeled (Hsiao and Pesaran, 2004, pp. 2).

Multilevel Regression Model is summarised by Pirili and Lenger (2012);

$$Y = X\beta + X\mu_i + \varepsilon_{it} \qquad i = 1,\dots,N; t = 1,\dots,T \qquad (3)$$

In equation (3), $X$ denotes the matrix of explanatory variables; $\beta$ denotes fixed effect coefficient estimations vector; $\mu_i$ denotes random effects. $\varepsilon$ denotes error term. Under the assumption of there is only one explanatory variable in the model, equation (4) is obtained from equation (3).

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \mu_{0i} + \mu_{1i} X_{it} + \varepsilon_{it} \qquad (4)$$

[4] Arçelik is the biggest firm in Turkey that produces durable goods such as TV, washing machine etc..
[5] Methodology part of the study is a brief summary of Hsiao and Pesaran (2004) and Lenger and Pirili (2012). For details about Random Coefficient Model look at also Baltagi (2005).

$\beta_0$ represents the beginning point of regression trend curve, $\mu_{0i}$ represents the deviation of cross section units from the beginning point. $\mu_{1i}$ represents the deviation of units from the slope of regression trend line. $\mu_{0i}$ and $\mu_{1i}$ are independent from each other in cross section dimension. Maximum Likelihood (ML) technique is used to estimate Random Coefficient Model.

### 2.2.2 Empirical Results

NUTS2 level regions are taken as group variable in estimation. In other words, it is considered that the values of the nations which are in the same NUTS2 region are not independent from each other. In addition, it is assumed that all explanatory variables are random. STATA computer program is used to estimate the model. Table 3 shows the estimation results. And the estimated model is represented in equation (5).

$$PS1 = 0.00000361 + 0.0000127\, US + 0.0002329\, AK + 0.0000405\, D \quad (5)$$

LR statistics shows that the estimated model is significant. As a result, the linear model is acceptable. According to the estimation results of the model, all variables are positive as expected before.

**Table 3: Random Coefficient Model Estimation Results**

| Number of Obs. = 1215 | | Wald chi2 = 36.38 | | |
|---|---|---|---|---|
| Number of Groups = 12 | | Prob > chi2 = 0.0000 | | |
| Variable | Coef. | Std. Err. | z | p>\|z\| |
| us | 0.0000127** | 3.56e – 06 | 3.57 | 0.000 |
| ak | 0.0002329* | 0.0000991 | 2.35 | 0.019 |
| d | 0.0000405** | 0.0000108 | 3.77 | 0.000 |
| cons | 3.61e - 06 | 3.11e - 06 | 1.16 | 0.245 |
| Random-Effects Parameters | | Estimate | Std. Err | |
| sd (us) | | 5.39e – 06 | 6.18e – 06 | |
| sd (ak) | | 0.0002777 | 0.0000782 | |
| sd (d) | | 0.0000316 | 9.36e – 06 | |
| sd (cons) | | 3.72e – 06 | 6.54e – 06 | |
| sd (Residual) | | 0.0000687 | 1.41e - 06 | |
| LR Test | | chi2 = 717.61 | Prob > chi2 = 0.0000 | |

Note: * Statistically significant at 5% level.
** Statistically significant at 1% level.

As to the estimation results, state universities, technology development centers and technology development regions have positive effects on the innovation production process of NUT3 level regions in Turkey. In addition, the contributions of higher education sector, especially academicians, are positive and relatively higher than other factors.

## CONCLUSION

*Knowledge Governance Approach* is a term used for explaining the system that aims to increase the level of production and dissemination of knowledge. The main institution of this approach is university. University as an institution and higher education system as a sector are getting more importance in economic literature over time. Universities are long lived and dynamic institutions that are also very important for scientific, economic and social life. The Triple Helix Model makes the universities a key factor for economic and social life. Generally knowledge based economies and knowledge society; privately innovation and learning processes give central roles to the universities.

Under these new conditions, it is needed to reorganise the roles of universities. It is possible to subdivide the economic roles of universities into two groups as *classical roles and complex roles*. Classical roles can be explained by using the tools of classical economics such as tangible production factors while complex roles cannot be definitely explained without the tools of knowledge-based economics. Contributions to the employment, gross output, disposable income and physical infrastructure are the classical roles of a university, however contribution to the knowledge stock, human capital and the acts in the knowledge governance are the complex roles of a university. Complex roles have big effects on innovation processes.

Empirical analysis proves that the key role of universities in knowledge-based economies is valid for Turkish economy. Like developed countries, higher education system affects innovation production processes more than other factors relatively. Under these circumstances, making higher education sector stronger causes an increase in speed of the country for transforming into the knowledge-based economic system. As a result, if Turkey makes its higher education system stronger, it will create a high level catching-up effect. To make the higher education system stronger means to invest in the complex roles of universities instead of classical roles. There are some suggestions for investing in complex roles of universities in Turkey:

- To establish more autonomous administrative systems for universities. To achieve this goal, the Council of Higher Education should be annihilated.
- Scientific supporting policies should be more transparent.
- Technopark system should be revised.
- Postgraduate education system should be modernized and interdisciplinary studies and institutes should be supported.

Unfortunately, there is a data constraint especially for innovation data sets such as R&D consumption. If Turkish Patent Institute collect data related with not only the innovation but also the innovation production processes such as AK, there will be more efficient empirical studies about innovation performance.

For future studies, it can be better to measure efficiency and productivity levels of innovative actors and innovation policies in Turkey.

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