

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

THE KEY ACTORS OF KNOWLEDGE PRODUCTION FUNCTION IN TURKEY: THE ROLE OF UNIVERSITIES AS A KNOWLEDGE PRODUCER*

TÜRKİYE'DEKİ BİLGİ ÜRETİM FONKSİYONUNUN TEMEL AKTÖRLERİ: BİLGİ ÜRETİCİSİ OLARAK ÜNİVERSİTELERİN ROLÜ

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ABSTRACT

By taking the projects which are carried out in the universities in Turkey and are funded by the Scientific and Technological Research Council (TÜBİTAK) as an output, the paper tries to estimate the knowledge production function of Turkey. In the study, an OLS analysis is made with cross-section data by utilizing the datum of state universities operating in Turkey at the NUTS III level. The dependent variable of the knowledge production function that is developed by using Cobb-Douglas production function is the annual R&D fund transferred to universities by TÜBİTAK for the projects. Other variables in the analysis are the annual R&D expenditures of universities, the number of academic staff, number of postgraduate students and the existence of Technology Transfer Office and/or Technopolis. According to the analysis results there is a positive and significant relationship between R&D fund, and postgraduate students and technology transfer offices/technopolis. However, the relationship between R&D expenditures and the R&D funds transferred to the universities is found to be statistically insignificant. A negative and insignificant relationship is found when R&D funds and academic staff are estimated together, but in the models in which academic staff is decoupled, the results differ.


Keywords: Knowledge Production Function, Turkey, State Universities, Endogenous Growth.


JEL Classification Codes: O30, O31, O40.


ÖZ


Bu çalışmada Türkiye'deki üniversitelerde yürütülen ve Bilimsel ve Teknolojik Araştırma Kurumu (TÜBİTAK) tarafından finanse edilen projeler çıktı olarak ele alınarak, Türkiye'nin bilgi üretim işlevi tahmin edilmeye çalışılmıştır. Çalışmada, Türkiye'de faaliyet gösteren devlet üniversitelerinin NUTS III düzeyinde verileri


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kullanılarak kesit verilerle OLS analizi yapılmıştır. Cobb-Douglas üretim fonksiyonu kullanılarak geliştirilen bilgi üretim fonksiyonunun bağımlı değişkeni, TÜBİTAK tarafından projeler için üniversitelere aktarılan yıllık araştırma ve geliştirme fonudur. Analizdeki diğer değişkenler, üniversitelerin yıllık Ar-Ge harcamaları, akademik personel sayısı, lisansüstü öğrenci sayısı ve Teknoloji Transfer Ofisi ve / veya Teknokent'in varlığıdır. Analiz sonuçlarına göre Ar-Ge fonu ile lisansüstü öğrenciler ve teknoloji transfer ofisleri / Teknokent arasında pozitif ve anlamlı bir ilişki vardır. Ancak Ar-Ge harcamaları ile üniversitelere aktarılan Ar-Ge fonları arasındaki ilişki istatistiksel olarak anlamlı bulunmamıştır. Ar-Ge fonları ve akademik personel birlikte değerlendirilirken negatif ve önemsiz bir ilişki görülmektedir ancak akademik personelin ayrıştığı modellerde sonuçlar farklıdır.

Anahtar Kelimeler: Bilgi Üretim Fonksiyonu, Türkiye, Devlet Üniversiteleri, İçsel Büyüme.

JEL Sınıflandırma Kodları: O30, O31, O40.

1. INTRODUCTION

The knowledge production process should be well understood in order economic growth and innovation to be explained. The solid indicators of economic growth and one of the most crucial sources of it, namely innovation, are the high tech and high value-added products which are the by-product of knowledge. In the basis of all the growth and innovation theories developed in the last decades, the role of knowledge is emphasized both in the regional and national level (Sakalyte and Bartuseviciene 2013). Evolutionary economics also supports the idea that knowledge is a crucial factor in the technologic development and improvement via innovation (Freeman 1988; Lundvall 1988; Nelson 1993; Carlsson 1995; Edquist 1997; Nelson 2002).

The analysis of how knowledge is produced is actually regarded as “black box”. The transformation of inputs to outputs in the knowledge creation process, that is in fact the emergence of new knowledge, is seen as a subject that remains mysterious. The purpose of that is estimated to be those unforeseen variables such as knowledge externalities and spillovers (Charlot, Crescenzi, and Musolesi 2014).

The most accepted method to measure knowledge production is the use of Knowledge Production Function (KPF). In this way, the knowledge production process seen as a black box is tried to be explained with the use of function created. It may be claimed that the KPF approach is not sufficient on itself for the analysis of knowledge production process. However, as the patent and R&D datum are the easiest quantitative indicators that is usually used by KPF as the knowledge output and are the most objective datum that can measure total knowledge flow, the KPF method is still accepted as one of the crucial methods that explain this process (Baumann and Kritikos 2016).

If those studies that utilise knowledge production function are examined, it attracts attention that previously there are many studies focusing on the industry. The literature on knowledge production function has developed in two distinct ways. The first group of studies have concentrated on micro-level studies that utilise survey datum (Acs et al. 2002; Fritsch 2002; Ranga et al. 2003; Conte and Vivarelli 2005; Czarnitzki et al. 2008; Ramani et al. 2008; Ponds et al. 2009), the second group have concentrated on regional level studies that analyse the relationship between regional inputs and local knowledge production (Jaffe 1989; Acs et al. 1992, 1994; Feldman and Florida 1994; Anselin et al. 1997, 2000; Egbu 2002; Riddel and Schwer 2003; Bilbao-Osorio and Rodríguez-Pose 2004).

At this point it is necessary to emphasize that the reflection of the knowledge that is produced by the firms is a subject that has typically been studied by the researches in recent years. Today it is also remarkable that the university emphasis in recent studies on the knowledge production in the regional level has significantly increased. It would not be wrong that the driving force of innovative knowledge in the regional level is the universities as universities recently play pioneering roles in the growth dynamics and regional development of national economies in the context of knowledge production (Lorber 2017).

The objective of the study is to examine the knowledge production of the universities in Turkey by utilising the knowledge production framework that was developed by Griliches (1979, 1985). At this point, it would be beneficial to examine the present situation of higher education sector in Turkey. If the higher education system in Turkey is evaluated it is seen that 60% of the R&D efforts has been executed by the universities. Thus, it may be said that the universities in Turkey have primary role in the knowledge production. The finance of the higher education is to a large extent get from public sources. The number of universities in Turkey has dramatically increased in the last decade. Since 2006, 100 new public universities have been established. As of 2018 there are

201 universities, 129 of which are public while 72 of which are non-profit foundations. The higher education system in Turkey have a huge potential with 7 million students, 157 thousand academic staff and 70 thousand international students (COHE 2018).

2. LITERATURE REVIEW

In most of the KPF based studies that are aiming to measure the effects of knowledge production in the regional scale on both innovation capacity and economic development/growth the role of universities take an important place. The pioneering role of universities in obtaining patent, the procurement of innovative infrastructure, the supply of human resource, the enabling of cooperation with the industry are remarkable. The importance of universities that is increasing gradually reflects on the studies in the literature. In the micro-, macro- and regional-level studies the factors that the universities possess (monetary, infrastructure, human resources etc.) take place among the input and/or output variables in the KPF.

If the literature on KPF is examined, it can be seen that the role of the universities are modelled in two different ways: directly or indirectly. While in those studies in which the effect is indirectly measured, the universities take place as an independent variable among all other variables that produce knowledge; in other studies in which the effect is directly measured, only the self-knowledge production process of universities is focused.

The first study that incorporated universities to KPF indirectly belongs to Anselin, Varga and Acs (1997). In the study, by using the quality and the ranking of the advanced technology centres of universities, total employment and total education expenditures and the advanced technology employment as independent variables the regional innovation capacity is tried to be measured. In the study utilizing the OLS method, it is determined that R&D activities and innovation activities have positive and significant direct and indirect effects on the private sector.

Fischer and Varga (2003) use advanced technology employment, R&D expenditures and the research expenditures of universities as the factors determining the corporate patents that is the output of university-industry cooperation. As the result of spatial lag modelling, it is determined that patent activities are robustly related to university research spillovers and industrial R&D. It is also mentioned that the significance of the relationship is more for advanced technological firms.

In their study, Buesa, Hejris, Pellitero and Baumert (2006) analyse the R&D system of Spain at the regional scale by utilising multivariate data analysis. They assessed regional innovation capacity with 4 different factors. These factors are public administration, environment, enterprises and university. An emphasis is laid on that special R&D policies for each region where innovative inequalities exist should be applied.

Abdih and Joutz (2006) incorporate the number of scientists and engineers who are employed in the R&D departments of the universities to the KPF model as an independent variable in their study. They determine that in order to increase total factor productivity and magnitude a policy that give weight to R&D supports is necessitated.

Chen and He (2014) realise a panel data application by utilising the data for eastern-western and central regions of China for the period 2000-2005. They reveal that the R&D staff and the R&D expenditures of universities have significant effect on patent activities.

Perret (2016) examines the knowledge production process, which he thinks as the key for national innovation system, for the USA and Russian Federation. Knowledge production is thought as an element that reveals the efficiency of innovation system. He proves that there is a nonlinear relationship between the input and outputs of knowledge. While examining the relationship he utilises the regional data such as the R&D expenditures and patents of universities. In both countries, small sized research systems exhibit more dynamic results. In the USA and Russian Federation KPF exhibits separate yields according to the size of the research system. The study derives policy recommendations for the USA and Russia.

The first pioneering research in which the universities are put in the centre of KPF is the paper published by Varga in 1997. Varga determines that the research expenditures of universities have positive effects on the innovation output of economics activities in metropolitan regions. As the reason of the effect he indicates that local academic knowledge transfers produce agglomeration effects in metropolitan regions.

In 2003, Andersson and Ejermo included the industrial R&D, university research and the index of geographical coincidence between university and industry research as independent variables into the model where patent is the dependent variable and realised a panel pooled OLD analysis with the 1993-99 data. Different from previous studies, the index of geographical coincidence is utilised in the study in order to decrease the effect of geographical discrepancies. They determined that university research has positive and significant effects on patent activities.

On the other hand, in their study in 2007 Ohuallachain and Leslie they found that R&D expenditures of universities have no effect on patents in the USA. They made a regression analysis for knowledge production in the regional scale in order to analyse the relationship between R&D and innovation by utilising the 2002-4 data. They determined a positive relationship between industrial R&D expenditures and institutional patents. However, they also revealed that human capital provides an advantage in the increase of knowledge flows and in taking patents.

In their study, Gurmu, Black and Stephan (2010) build a model on the patent activities of universities. In the study that encompasses the USA data for the period 1985-99, the R&D expenditures and the fields of study of the universities and the existence of TTOs in the universities are included as variables. The fields of study are divided into 5 distinct disciplines. Besides, the researchers in the universities are also categorised according to their departments, level of education and visa status of this level. A positive and significant relationship is determined between the patent output, and the stock of R&D expenditure and the existence of TTOs. Also, a positive and significant relationship is also determined between human resource and the number of patents. A positive and significant relationship also prevails between all researches and patents. It is also determined that all Ph.D. graduate students and Post-docs have equivalent contributions to obtain patents, but this may differ according to the visa status. At this point, it is seen that the field of study and visa status have distinct effects on patenting activities. The competition between the residents and immigrants is emphasized to be effective on this situation. It is confirmed that there is a positive and significant relationship between resident Ph.D. students and the number of patents but a negative relationship between immigrant Ph.D. students and the number of patents. On the other hand, it is stated that among post-docs those who are immigrant have positive and significant effect on the number of patents.

Conti and Liu (2014) is a study that focuses on the knowledge produced by the graduate and post-doc students in the academic community. The knowledge performance in the Department of Biology, MIT is tested by using 1970-2000 data. It is revealed that previously produced knowledge, a stock variable, has crucial and significant contributions to the studies to be made and to the knowledge to be produced in the future. Therefore, it is a crucial study in terms of the measurement of the contributions of universities to knowledge production.

Chatterjee, Dinar and Gonzalez-Rivera made a regression analysis in 2016 on the University of California by using 2007-2013 data. In the KPF model the variables of full-time equivalent extension positions, expenditures on salaries per unit FTE and expenditures on infrastructure per unit FTE were used. As a result, it is determined that all these variables have positive and significant effects on knowledge production.

After the 1980s, the KPF literature has turned into a topic that exhibits a development with an interaction with the disciplines of economic growth, development and economic geography. Assessed in this context, the literature has developed in two distinct branches: micro and regional level analyses. The studies from both branches, regardless of their level of analysis, draw attention to the important role of universities in the KPF. Therefore, in this study, although the distinction between these two branches is accepted, the literature is assessed by focusing on the role of universities. In the study, the KPF method is utilised, as used in Varga (1997), Andersson and Ejermo (2003), Ohuallachain and Leslie (2007), Gurmu, Black and Stephan (2010), Conti and Liu (2014), Chatterjee, Dinar and Gonzalez-Rivera (2016), in order to analyse the KP process of universities among Turkish universities.

3. METHOD

KPF identifies the relationship between the knowledge inputs and knowledge outputs like the traditional production functions identifying the relationship between input and output. As knowledge can be subsidised and as it has no maximum theoretically similar to the production factors, the knowledge production function may be assessed as a substitutional production function.

The concept of knowledge production function was brought to the literature by Griliches (1979) based on the aggregate production function. This function is based on Cobb-Douglas production function that actually reflects a traditional production function. In the aggregate production function;

$$Y = F(K, L, A) \quad (1)$$

Y represents the input related outputs; K, L and A represent capital, labour and the level of technological knowledge, respectively. In the function the relationship between the level of technological knowledge and knowledge production is correlated with R&D investments. Like the total production function, Griliches also bases the relationship between the knowledge and R&D investments while generating the knowledge production function;

$$\dot{A} = R \quad (2)$$

In the function above \dot{A} represents the new knowledge output and R represents the knowledge attained as a consequence of R&D expenditures. According to Griliches cumulative R&D expenditures constitute the knowledge stocks. The stock variables determined in this context are shows in the following equation:

$$A_t = \sum_{i=-\infty}^t \dot{A}_i = \sum_{i=-\infty}^t R_i \quad (3)$$

While attaining knowledge stocks from knowledge production function, it is probable knowledge depreciations to occur. As a result of knowledge to lose its currency in due course, previous R&D expenditures contribute less to the knowledge stocks v-compared to current R&D expenditures. At this stage, Griliches identifies technological knowledge stocks as a function of R&D expenditure flows.

$$A_t = G(W(B)R, v) \quad (4)$$

Although the above equation is named as knowledge function, in fact it defines the knowledge accumulation. While A represents the technological knowledge accumulation in the equation, W(B)R is the indicator of current and lagged R&D expenditures. The G(W(B)R) function can be redefined as follows:

$$A_t = R_t + (1-\gamma) A_{t-1} \quad (5)$$

In the above equation Perpetual Inventory Method (PIM) is utilised for the measurement of stock variables. In the PIM equation calculated for the current knowledge stocks R_t represents the total of current period investments while $(1-\gamma) A_{t-1}$ represents the previous period value adjusted for depreciation. In Equation 4, variable v represents residual factors. These residual factors do not have direct influences on the formation of R&D stocks.

Following Griliches, Romer (1990) and Jones (1995) (by modifying Romer's ideas) use knowledge production function as an explanatory variable of the economic growth in Endogenous Growth Theory. Particularly the creation of new ideas has been included in the model depending on the size of funds devoted to knowledge accumulation, R&D expenditures and R&D activities such as the number of scientists and researchers.

In this context, the main purpose of the study is to analyse the knowledge produced by Turkish universities by using knowledge inputs. If the KPF studies in the literature are examined, the outputs in the knowledge production process are seen mostly to be those variables such as patents, R&D expenditures and scientific projects. The output of this study is R&D expenditures. In contrast to common use, the main purpose of non-using the number of patents in Turkey as an output is that patent tracking system is inefficient, patenting is not common traditionally and therefore patents are not thought as an innovation indicator on the basis of universities in Turkey.

In the study, as input the variables of R&D budgets of universities, number of various education staff, R&D staff, Technopolis and Technology Transfer Offices are used in accordance with the literature. These variables are analysed with the logarithmic regression modes OLS method by using 2016 cross-section data for 108 public universities.

All the variables used in the model are grouped and given in Table 1 and Table 2.

Table 1. Variables According to KPF Approach

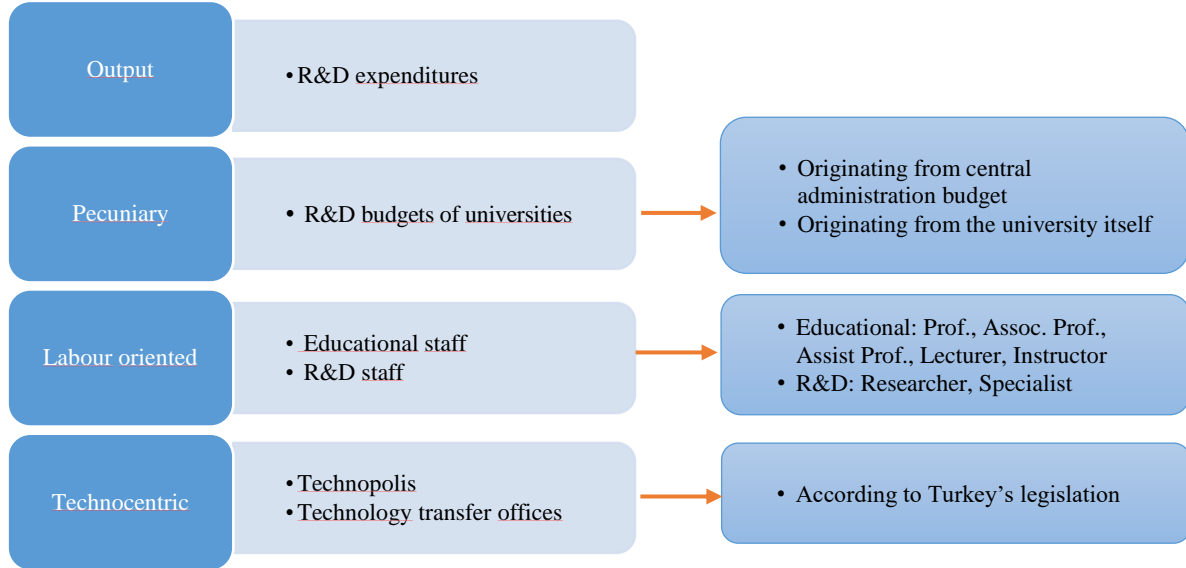


Table 2. Explanation of Variables Used in OLS Model

VARIABLES	EXPLANATION
R&D_2016CUM	Cumulative R&D expenditures of universities for the last 4 years
R&D_2016	R&D expenditures of universities for 2016 (appropriation transferred)
R&D_BUDGET	Total university budget allocated for R&D
PROF	Number of professors
ASSIST_PROF	Number of assistant professors
ASSOC_PROF	Number of associate professors
LECT	Number of lecturers
INSTRUCT	Number of instructors (for only compulsory courses)
SPECIALIST	Number of specialists
ACAD_STAFF	Total number of academic staff above
STUD_MS	Number of students at master level
STUD_PHD	Number of doctoral students
STUD_GRAD	Total number graduate students above
TTO	Technology transfer offices (Yes or no)
TECHP	Technopolis (Yes or no)

4. MODELS

In the study, eight different models are used as shown in Table 3. While in the first 4 models the dependant variable is cumulative R&D expenditures, in the last 4 models it is the R&D figure for the year 2016. Although the analysis is cross-sectional, the reason of including cumulative dependant variable in 4 models is that, as Griliches states, the formation of knowledge output is not the accumulation of a single year, but instead it is the accumulation of a retrospective knowledge accumulation. In order to see the cumulative effect, 4-year R&D expenditure that is available retrospectively is utilised.

In all models for KPF, as the K variable (pecuniary) R&D budget of the universities is used and as the A variable (technocentric) the existence of Technology Transfer Office and/or Technopolis is used. The L variable (labour oriented) is included into the analyses in 8 models both as all together and as separate groups. Here, the aim is to measure the research and educational effects individually.

Table 3. Eight Different Model About Knowledge Production Functions

MODELS	DV	PECUNIARY IV'S	LABOUR ORIENTED IV'S	TECHNOCENTRIC IV'S
1	R&D_2016CUM	R&D_BUDGET	ASSIST_PROF, PROF, ASSOC_PROF, LECT, INSTRUCT, SPECIALIST, STUD_MS and STUD_PHD	TTO and TECHP
2	R&D_2016CUM	R&D_BUDGET	ASSIST_PROF, PROF, ASSOC_PROF, LECT, INSTRUCT, SPECIALIST and STUD_GRAD	TTO and TECHP
3	R&D_2016CUM	R&D_BUDGET	ACAD_STAFF, STUD_MS and STUD_PHD	TTO and TECHP
4	R&D_2016CUM	R&D_BUDGET	ACAD_STAFF and STUD_GRAD	TTO and TECHP
5	R&D_2016	R&D_BUDGET	ASSIST_PROF, PROF, ASSOC_PROF, LECT, INSTRUCT, SPECIALIST, STUD_MS and STUD_PHD	TTO and TECHP
6	R&D_2016	R&D_BUDGET	ASSIST_PROF, PROF, ASSOC_PROF, LECT, INSTRUCT, SPECIALIST and STUD_GRAD	TTO and TECHP
7	R&D_2016	R&D_BUDGET	ACAD_STAFF, STUD_MS and STUD_PHD	TTO and TECHP
8	R&D_2016	R&D_BUDGET	ACAD_STAFF and STUD_GRAD	TTO and TECHP

The results of the first 4 models in which the cumulative R&D expenditures are used as a dependent variable are given in Table 5 below. The reason of low R² in all models is thought to be the use of cross-sectional analysis. The reason of using cross-sectional data is the lack of regular available time series data in Turkey for the variables used in the model. The F-test results reveal that all the variables in the models are jointly significant.

Unexpected negative coefficients may generally be caused by strong correlations between independent variables. For example, as the correlations between prof. and assoc. prof. or assoc. prof. and assist. prof. are around 90%, the use of these two variables in the same model may cause a positive coefficient for one and negative for the other (See Table 4).

Table 4. Correlation Matrix for Labour Oriented Variables Used in the Study

	Total	STUD_MS	STUD_PHD	PROF	ASSOC_PROF	ASSIST_PROF	LECT	INSTRUCT	SPECIALIST
Total	1,000								
STUD_MS	0,399	1,000							
STUD_PHD	0,527	0,893	1,000						
PROF	0,398	0,506	0,512	1,000					
ASSOC_PROF	0,309	0,477	0,388	0,899	1,000				
ASSIST_PROF	0,213	0,447	0,272	0,674	0,865	1,000			
LECT	0,097	0,389	0,200	0,512	0,670	0,758	1,000		
INSTRUCT	0,453	0,550	0,474	0,855	0,814	0,674	0,623	1,000	
SPECIALIST	0,451	0,526	0,493	0,898	0,856	0,666	0,623	0,868	1

* The threshold value for cells marked with grey is 0.75.

These 4 models indicate that graduate and Ph.D. students have significant effects on the knowledge production in Turkey. It may also be possible to claim that the existence of Technopolis and TTOs have significant effects on the knowledge production.

Table 5. Cumulative R&D Expenditures Dependent Variable Four Models

DV	LNR&D_2016CUM							
R²					0,43	0,41	0,42	0,38
Adjusted R²					0,37	0,35	0,39	0,36
F - Test					7,38***	7,43***	14,5***	15,83***
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
	Coefficients	Coefficients	Coefficients	Coefficients	t Stat	t Stat	t Stat	t Stat
Constant term	10,19	8,94	7,76	5,37	4,85***	4,18***	3,85***	2,85***
LNR&D_BUDGET	0,07	0,09	0,08	0,09	0,94	1,20	1,22	1,33
LNSTUD_MS	0,06		-0,06		0,19		-0,18	
LNSTUD_GRAD	0,63	0,63		0,61		2,77***		2,81***
LNSTUD_PHD	0,57		0,59		2,21**		2,68***	
LNPROF	-0,06	0,33			-0,14	0,90		
LNASSOC_PROF	0,14	0,07			0,32	0,16		
LNASSIST_PROF	-0,13	-0,44			-0,22	-0,81		
LNACAD_STAFF			0,40	0,40			1,40	1,37
LNLECT	-0,17	-0,15			-0,67	-0,60		
LNINSTRUCT	-0,16	-0,23			-0,50	-0,71		
LNSPECIALIST	0,50	0,45			1,76*	1,58		
TTO_TECHP	0,77	1,07	0,90	1,39	1,20	1,68*	1,47	2,33**

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

The results for the constant term reveal an interesting point that R&D expenditures are made without any input. Output may be the result of another knowledge spillover in which no R&D effort exists or is a result of an increase in the stock of knowledge capital. High level of significance in the first 4 models increases the probability of second option.

The results of the last 4 models in which R&D expenditures for the year 2016 are used as the dependent variable are given in Table 6 below. As in the first 4 models, it is striking that Ph.D. and graduate students are significant in these 4 models. However, in these 4 models it is found that assist. prof. have negative and significant effect. Besides, unlike the first 4 models, the positive and significant effects of assoc. prof. and prof. is remarkable. Unlike the first models, the existence of TTO and Technopolis is not significant in these models. All the findings for R², F statistics and constants in the first 4 models are also valid for these 4 models.

Table 6. R&D Expenditures Dependent Variable Four Models

DV	LNR&D_2016							
R ²					0,51	0,48	0,49	0,42
Adjusted R ²					0,46	0,43	0,46	0,40
F - Test					10,27***	9,91***	19,41***	18,7***
	Model 5	Model 6	Model 7	Model 8	Model 5	Model 6	Model 7	Model 8
	Coefficients	Coefficients	Coefficients	Coefficients	t Stat	t Stat	t Stat	t Stat
Constant term	8,29	6,27	4,78	0,38	3,33***	2,44**	1,98*	0,16
LNR&D_BUDGET	0,08	0,11	0,07	0,09	0,97	1,27	0,83	0,97
LNSTUD_MS	0,19		0,04		0,48		0,09	
LNSTUD_PHD	0,90		1,08		2,91***		4,08***	4,70***
LNSTUD_GRAD		1,09		1,26		3,96***		
LNPROF	0,24	0,84			0,50	1,89*		
LNASSOC_PROF	0,91	0,79			1,72*	1,45		
LNASSIST_PROF	-1,20	-1,68			-1,79*	-2,56**		
LNACAD_STAFF			0,13	0,12			0,38	0,34
LNLECT	-0,07	-0,04			-0,24	-0,14		
LNINSTRUCT	-0,28	-0,38			-0,74	-0,99		
LNSPECIALIST	-0,01	-0,08			-0,03	-0,23		
TTO_TECHP	0,07	0,53	0,19	1,06	0,10	0,69	0,26	1,43

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

5. CONCLUSION

In the study in which the results of KPF, which is attained for Turkey with the 2012-2016 data, are assessed 8 models are built. The variables used are categorised under 3 groups, namely pecuniary, labour oriented and technocentric. While building the models, the effects of all variables on both the cumulative and annual R&D expenditures for the year 2016 are examined.

In all models it is determined that graduate and Ph.D. students have positive and significant effects on output. In line with the findings in the studies of Stephan, Black and Gurmu in the literature, the effects of graduate and Ph.D. students on output are found as expected. It may be thought that crucial part of the graduate and Ph.D. level students in Turkey maintain a project-based process in order to complete their thesis and this may cause such an effect. Recently, the funds for graduate students increase gradually with the supports of internal or external units/institutions such as the Coordinatorship of Scientific Research Projects in the universities and Scientific and Technological Research Council of Turkey (TÜBİTAK). Therefore, it is thought that the support of graduate student would positively affect the knowledge production process. At this point the encouragement and support of post graduate education may be presented as a policy recommendation.

In the last 4 models in which the dependant variable is not cumulative, the insignificance of the existence of TTOs and Technopolis is an expected result. This, in turn, do not indicate that TTOs and Technopolis have no effect on knowledge production. It is known that due to their structures the positive effects of TTOs and Technopolis occur following a certain period of time. Therefore, the significance of TTOs and Technopolis in the model in which cumulative variable is used affirms this prediction.

In the study, it is thought that those models with cumulative variables give closer results to the expectations. The study is the first effort for Turkey and would shed light to future studies to be made with comprehensive and longer data. Hence, the universities in Turkey would be compared with those in other countries.

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