Innovation and institutional quality: Evidence from OECD countries

Serap Baris*, Faculty of Economics and Administrative Sciences, Department of Economics, Tokat Gaziosmanpaşa University, Tokat, Turkey

Abstract

Focusing the effect of innovations on economic growth, the literature has not adequately cared about what determines the innovations or innovative capacity. However, policy makers and business leaders have accepted the need for creating platforms and institutions that promote innovative activities since it was accepted that innovations were the basic key to economic growth. This study focuses on the effect of institutions or institutional quality on the innovations. In this study where OECD countries have been selected as the sampling (2002–2016 period) and World Bank's Worldwide Governance Indicators represent institutional quality while the number of patent application represents the innovation, the effect of institutional quality on the innovations has been examined through the methods of panel data analysis. Innovation is positively related to voice and accountability, political stability and absence of violence and rule of law while it is negatively related to control of corruption. Moreover, there has been no relationship determined between government effectiveness and regulatory quality and innovation. According to the findings, voice and accountability, political stability and absence of violence and the rule of law are essential for the emergence or increase of innovations in OECD countries.

Keywords: Governance, innovation, institutions, institutional quality, patent, panel data analysis.

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* ADDRESS FOR CORRESPONDENCE: **Serap Baris,** Faculty of Economics and Administrative Sciences, Department of Economics, Gaziosmanpaşa University, Tokat, Turkey. E-*mail address*: serap.baris@gop.edu.tr

1. Introduction

Acemoglu and Robinson start their work titled 'The Origin of Power, Prosperity and Poverty Why Nations Fail' by narrating (depicting) the story of a city – Nogales – which is divided into two by a fence which is very close to but very different from each other. Located in the North of the city, Nogales Arizona is a town where per capita income is around 30,000 Dollars; schooling rate is rather high, healthy population and average life expectancy is long, safety of life and property is available while there are very few robberies or threats which may danger business investments or houses of the residents. Furthermore, it is a city where the rules and institutions of democracy actively operate. On the other hand, Nogales Sonora which is located in the south of the fence has per capita income around 10,000 Dollars, a low level of schooling rate, a high level of infant mortality rate, a shorter average life expectancy, inconvenient health conditions, higher crime rates and risky conditions for establishing a business. It is required to give a bribe even for opening up an enterprise. Moreover, corruption and democracy with incompetent politicians are a new experience for them (Acemoglu & Robinson, 2012). According to the authors, the reason for the difference between these two sides of the city is their 'institutions'. These incentives created by different institutions of two different Nogales and the countries which they belong to bring about the main reason for these differences that are observed in economic welfare levels in two sides of the border.

This example given by the authors provides evidence that good institutions promote entrepreneurship, investment, innovations and also economic growth. Institutions of an economy/country are the main determinants of to what extent the individuals who are closely related to long-term economic growth will desire to make an investment in long-term capital, skill and technology (Jones, 1998). Modern growth theory agrees that innovations are the main power behind the long-term economic growth and sustainable national and international competitive power today (Shefer & Frenkel, 1998, p 187). Focusing on innovation-economic growth relation, literature could not adequately have focused on the factors determining the innovations and institutions which are one of these factors. However, Freeman (1987), one of the oldest works establishing the relationship between institutional quality and innovativeness, indicated that institutional quality is of high importance in the process of creating and spreading technology. Tebaldi and Elmslie (2013) conclude that there are such few studies regarding the effect of institutions on technological innovations because of the deficiencies in describing and measuring institutional quality as well as the econometric problems which are hard to overcome.

Institutions can not only include the laws and legal regulations which regulate the relationships between people and actors forming social structure (for example, state) as well as government agencies enabling democratic process but also such concepts as freedom, trust and social capital when considered from a broader perspective (Unsal, 2007). Although institutions are described by old and new institutional economists in various forms, the common point in these descriptions is that institutions are the restrictions and limitations imposed for the relationships between people. According to Veblen (1899, p 88), who is one of the founders of institutional economics, an institution can be defined as 'The institutions are, in substance, prevalent habits of thought with respect to particular relations and particular functions of the individual and of the community' rules and restrictions imposed by the people for shaping the relationships between people and habits of thinking recognised by the 'majority of society'. The definition of the institutions which is commonly used in the literature today belongs to Douglas North – new institutional economist. North (1990) defines the institutions as 'rules of a game played in a society or restrictions imposed by people in order to shape their relationships and create a framework for their interactions'. Acemoglu and Robinson (2012) state that good institutions have three basic characteristics by highlighting institutional quality (good and bad institutions). First characteristic is the application of property rights which covers a large part of the society. Second characteristic is the prevention of use of revenues and investments of the society by such public officials as politicians and bureaucrats for their own interests. The last characteristic is that good institutions must be developed to have such

characteristics of human capital as innovativeness and rationality in education and consumption and must have the strength to forward them to more efficient areas (Acemoglu, 2003, p 27). Authors suggest that good and exclusive institutions lead to good growth.

The most important characteristic of the institutions is to describe and assure the property rights. Moreover, good operation of rules of law in the society, low level of expropriation risk and existence of economic freedom provide substantial incentives to the entrepreneurs to make investments by decreasing uncertainty for new projects. Because entrepreneurs greatly suffer from uncertainties and risks while making new investments and producing innovations. Van Waarden (2001) suggests that economies that have more efficient legal systems to decrease risk and uncertainty are much more innovative. North (1990) also states that 'The most important role of the institutions is to decrease uncertainty by establishing a stable structure for the interaction between people...'. Economies that are not open and where the legislations, institutions and rules are frequently changed may be a risky area to invest in. Again, North (1990) puts forward that the stability of the institutions does not remove the fact that they have been changed; they are gradually changed in general, not discontinuously. However, it is generally accepted that innovations are based on strong institutions. The cost of introducing new products and uncertainties on the gaining of the innovations is increased when the corruption becomes widespread, rules of law are weakened and bureaucratic transactions are intensive and troublesome (Silve & Plekhanov, 2015). For example, Keefer and Knack (1997) find out that the companies have a very low level of investment in new technologies in the economies where the rules of law are weak and the risk of expropriation is high. Goedhuys, Mohnen and Taha (2016); Mahagaonkar (2008) and Waldemar (2012) reveal that corruption has a negative effect on the innovations. However, the innovation process is possible with the institutions which promote the exclusive property, implement the contracts and enable the establishment of new work areas which will put new technologies into practice as well as providing incentives for this aim (Acemoglu & Robinson, 2012).

Briefly, new institutional economics regard the institutions existing in the society as the promoting structure of technological development (Samuels, 1991, p 4). In this regard, this study will empirically analyse the effect of institutions on the innovation specific to OECD countries for the years 2002–2015. Having a hypothesis expressed as 'There is a positive relationship between the institutional quality and innovation capacity.' Second part is composed of empirical literature explaining the relationship between institutions and innovation; third part is composed of data, econometric method and analysis while fourth part is composed of conclusion and policy suggestions.

2. Literature review

Although endogenous/new growth models achieved an important success in the issue of internalization of technology, they were inadequate to explain the factors/elements which determine technology or innovations in these models. Whereas the main importance of economic institutions for the economic growth is through their effects on technological change which has been debated by Schumpeter and the subsequent economists for a long time (Huang & Xu, 1999, p 438). However; while examining the relationship between institutions and economic growth, *technological innovation* which is the missing link in this relationship (Huang & Xu, 1999; Tebaldi & Elmslie, 2008; Silve & Plekhanov, 2015) has not been included in the models except for a few studies. According to Tebaldi and Elmslie (2013), the small number of studies on the impact of institutions on technological innovations is due to econometric problems that are difficult to define, measure and overcome institutional quality.

It is seen that many variables are used as the indicators of institutions or institutional quality in the studies which examine the relationship between institutions and innovation. This is because of the difficulty in measuring the institutions. Because there are various comprehensions and perceptions regarding to what the institutions are in each country or region. Berthelier, Desdoigts and Aoudia (2004) divided institutional framework into 9 parts regarding the content of the institutions: (i)

political institutions, (ii) law and order, (iii) public governance, (iv) markets' operating freedom, (v) preparation for the future, absorption of technology, aptitude for reform, (vi) security of transactions and contracts, (vii) regulation, (viii) openness to the outside World, (iv) social cohesion. Some studies focused on the effects of regulations on innovations and Research & Development (R&D). For example, Blind (2012) examined the effect of regulations on innovation as an indicator of institutional quality in 21 OECD countries. Results indicate that the effects of different regulations (economic and social) on innovation are also various. Bassanini and Ernst (2002) found out that there is a negative correlation between product market regulations and the density of R&D expenditures in OECD countries. Koch, Rafiquzzaman and Rao (2004) identified that antitrust regulation has a positive effect on R&D density in old G7 countries. Blind (2012) emphasizes that the effect of regulations on innovations varies depending on type of regulations, difference of short term and long term effects of the regulations and finally alterability of these effects over time. Previous studies find out that regulations negatively affect the innovations while recent studies suggest that regulations – which are mostly environmental regulations – positively affect the innovations (Blind, 2012).

Another parameter/indicator which comes to mind considering the institutions or institutional quality is the corruption. The differences in the innovation and growth performance of firms and countries are explained by the quality of management of the institutions and especially by corruptions (Goedhuys et al., 2016; Mo, 2001). The old institutional theory suggests that corruption, bribery and efforts of having contacts with the bureaucrats increase the operation costs, so it prevents making investment in R&D and other productive activities. Additionally, it increases the distrust and uncertainty in government agencies and business environment in general (Anokhin & Schultze, 2009). However; there is a need for a practical environment for the investment and innovation activities of the entrepreneurs. In the countries which have a high level of corruption, more talented people/ entrepreneurs will tend towards rent seeking which is more appealing, so the creation of human capital will be taken under pressure for the innovation and growth (Murphy, Shleifer and 1993; Shleifer and Vishny, 1993). This direct and negative effect of corruption on the company's innovation is called as the hypothesis of "sand the wheels" in literature. Contrary to this view, it is suggested that it serves as "grease of bureaucratic mechanism" in the economies which have a low level of corruption, especially governance quality, with regard to the fact that it removes the public rigidities for preventing the investments – by facilitating the procedures in order to obtain the required bureaucratic permits – and it can compensate the wrong decisions taken in public administration. On the other hand; the determination suggesting that the corruption has a positive effect on the operation of economic system (on the innovation, growth and income inequality) (Goedhuys et al., 2016; Meon & Sekkat, 2005) is known as the hypothesis of "grease the wheels". In addition to the findings which support both views, there are also results in literature suggesting that there is no relationship between these two variables. DiRienzo and Das (2015); Goedhuys, et al. (2016) and Huang and Yuan (2016) found out that corruption prevents or negatively affects the innovations while Habiyaremye and Raymond (2013) put forward that corruption has a direct and positive effect on the innovation only for the foreign companies. Anokhin and Schulze (2009) concluded that corruption does not have any substantial effect on the innovations in his sampling of 64 countries.

The relationship between corruption and innovation is related to development level of the countries. Natario, Couto, Tiago and Braga (2011) searched for the determinants of innovation capacity by dividing European Union countries into two with regard to their innovation levels. In the study finding that there is a strong link between corruption and innovation, it is also suggested that more innovative capacity has been linked to much more control of corruption while less innovative capacity has been linked to a low level of control of corruption. Heo, Hou and Park (2017) put forward that corruptions have a positive relationship with the innovations in developed countries while they have a negative relationship in developing countries.

In fact, more than one indicator/variable is used in many studies to represent the institutions. Tebaldi and Elmslie (2013) searched for the effect of institutional regulations on the innovation which is measured as the number of patent by using transnational data and instrumental variable method.

They also included average index values of expropriation risk, rules of law and World Bank's Governance Indicators (regulatory quality (RQ), rule of law (RL), control of corruption (CC), voice and accountability (VA), political stability (PS) and government effectiveness (GE)) that they calculated in regression in order to represent institutional regulations. The findings of the study set forth that institutional regulations positively reveal the changes in patent production. Boudreaux (2016) also focused on the impact of institutional quality on innovation, using cross-country data. In the study where institutional quality is represented by the data of Fraser Institute's Economic Freedom of the World Index (EFW) and innovation is represented by the data of Global Innovation Index (GII), it was concluded that the increase in economic freedom also increases the innovations. Furthermore; the authors state that this relationship mainly arises out of both creative and informative inputs and consequently market organizations promote much more innovation.

Silve and Plekhanov (2015) analyzed the relationship between the quality of economic institutions and innovation which they measured by using Worldwide Governance Indicators. Their results indicate that the countries which have stronger economic institutions specialize in the sectors dealing with the innovations more intensively. The study also proves that there are more innovations in countries which have stronger economic institutions and these countries relatively grow much more quickly. Clarke (2001) examined the relationship between institutions and economic factors and innovation in developing countries. In the study where panel data analysis was used, innovation was represented by the ratio of R&D expenditures in GDP while institutional quality was represented by expropriation risk, rule of law and the protection of property rights. Estimates indicate that the countries which have weak economic institutions make less R&D expenditures than the countries which have strong institutions. These results are also very strong in various measurements of institutional quality. Akcomak and Weel (2006) examined the relationship between social capital, innovation and economic growth for 102 European regions in the years 1990-2002. Innovation is modelled and described as an important mechanism which turns the social capital into higher income levels in this study. Econometric estimates indicate that trust which is an important factor of social capital has a significant effect on the number of patent applications. Social capital affects the increase of per capita income not directly, but indirectly by promoting the innovations. Effect of social capital on innovations is not limited to Akcomak and Weel (2006). Kaasa, Kaldaru and Parts (2007) analyzed the effect of institutional quality on innovations by using social capital as an indicator of institutional quality in 29 European Union countries. In the study where clustering analysis was preferred, Worldwide Governance Indicators were used as the indicator of institutional quality. Analysis findings indicate that different representations of good governance and social capital have a positive effect on innovation activities.

Some studies also examine this relationship in company level. Srholec (2011) found out that democratic institutions have a relationship with the company innovations but there are less innovations in tax regimes that have higher tax rates. Having examined the corruption-innovation relationship in the sampling of African companies, Mahagaonkar (2008) determined that corruption has a negative effect on product innovation and organizational innovation of the companies but no effect on process innovation. Mahendra, Zuhdi and Muyanto (2015) focused on the variables of institutional quality and the access to financial sources which are the determinants of company innovations in Indonesia. In the study where binary logit, ordered logit and poisson regressions analyses were used, it was found out that institutional quality was rather related to innovations. Moreover; access to financial sources is important for SMEs while institutional quality is important for the big companies.

Some studies in literature also examined institutions/institutional quality innovation relationship by dividing the institutions into two as formal and informal institutions. Thus, North (1990) stated that institutions are composed of restrictions; and these restrictions are also composed of formal and informal restrictions. According to North (1990), "(…) restrictions are composed of informal restrictions (sanctions, taboos, traditions, customs, codes of conduct) and formal rules (constitutions, laws and property rights)." Lee and Law (2016) dealt with the institutions as formal and informal

unlike many studies in the issue of the effect of institutions on innovation level of the countries. In the study where data of 62 countries was analyzed through Ordinary Least Squares (OLS) estimates, the findings indicated that both formal and informal institutions are effective on innovation level of the countries. However; formal institutions are of high importance for the high innovation level of a country. Wang (2013) researched the effect of institutional quality, especially political risk indicators, on innovation density. He used five instrumental variables for the institutions. He reported that institutions have a direct and significant effect on innovation density of the countries based on empirical analysis. Furthermore; his studies suggest that there are no differences between formal and informal institutions with regard to affecting innovation levels of the countries.

In the context of the literature explained here, there is no consensus yet in terms of the effect of institutional quality on innovations. Therefore; the effect of institutions on innovations is still controversial. However; theoretical expectations are as such that improvements in institutional quality will promote the innovations of good institutions. We can express the main hypothesis of the study in accordance with theoretical expectations as follows:

$H_1 = $ There is a positive relationship between institutional quality and innovation.

3. Econometric methodology

32 OECD countries, data set of which we can regularly have an access to, were selected as the sampling in this study in order to analyze the relationship between institutional quality and innovation econometrically. Panel data analysis methods are used in the study, the research period covers the years 2002-2016. Worldwide Governance Indicators which is annually published by World Bank were used to represent institutional quality while total number of patent applications was used to represent innovation. The method and variables used in the research are explained detail below.

3.1. Method

The panel data analysis to be used in the study will be briefly explained here. Panel data analysis; individuals, countries, households, firms, regions such as horizontal cross-sectional observations of the units are collected together in a certain period (Baltagi, 1995, p 1). Thus, panel data analysis combines cross-sectional analysis and time series analysis.

In panel data analysis, N units for dependent variable and T-period time series data of these units are analyzed. In general, the linear panel data equation is represented by equation (1) (Kaya ve Yılmaz, 2006, p 69):

$$Y_{it} = \beta_{1it} + \beta_{2it}X_{2it} + \beta_{3it}X_{3it} + \varepsilon_{it} \quad t = 1 \dots T \text{ ve } i = 1 \dots N \tag{1}$$

The simplest form of panel data analysis is to keep the coefficients in the model constant for all horizontal cross-sectional units. This assumption is shown by equation (2):

$$Y_{it} = \beta_1 + \beta_2X_{2it} + \beta_3X_{3it} + \varepsilon_{it} \tag{2}$$

Equation (2) predicts that all independent variables affect the horizontal section units equally. However, assuming that independent variables affect each of the units differently, this equation is insufficient. In this case, the starting point can be kept constant for all units, or it can be allowed to have different starting points for each of the horizontal cross-section units without limitation. Accordingly, there are two different methods for the starting point the fixed effects model and the random effects model (Yuce Akıncı et al., 2013, p 86). Since fixed effects model is used in this study, this model is explained here.

In the panel data analysis, models that coefficients are assumed to differ by units or units with time are called "fixed effects" model. In the fixed effects model, it is assumed that individual differences between units can be captured by differences in fixed terms. Therefore, only the fixed

term changes in the model and the fixed term varies according to the cross-section, not time (Pazarlioglu and Kiren Gurler, 2007, p 37).

The fixed effects model is usually expressed as in equation (3):

$$Y_{it} = \beta_1 + \beta_2 X_{2it} + \ldots + \beta_k X_{kit} + \varepsilon_{it} \quad i = 1,2,\ldots,G \quad t = 1,2,\ldots,N \tag{3}$$

In the equation, Y_{it} is a dependent variable β_1, X_{it} independent variables, i individuals, countries, such as the horizontal section, t represents the time dimension and ε_{it} indicates the error term.

3.2. Variables

3.2.1. Dependent variables

Although the importance of innovation is recognised with regard to economic growth and competitive power of the nations, there are still ongoing discussions in the issue of measuring these concepts. Total amount of R&D expenditures, the ratio of R&D expenditures in GDP, number of R&D staff, number of patent applications, number of patents, number of patents per capita, various innovation surveys and innovation indexes (European Innovation Index, GII, etc.) are commonly used in both national and international literatures as the indicators of innovation. The total number of patent applications obtained from World Development Indicators was used in this study to represent innovation. According to World Bank, patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention – a product or process that provides a new way of doing something or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years.

3.2.2.Independent variables

Governance indicators that are annually published by World Bank were used to represent institutional quality which is the independent variable of this study. WGI are a long-term research project established for developing transnational governance indicators. WGI are composed of six composite indicators that have been covering large dimensions of governance in more than 200 countries since 1996. Universal governance indicators that are developed within the scope of WGI are composed of six indexes as RQ, RL, control of corruption, VA, PS and GE. These indicators are based on several hundreds of variables which are gathered from 31 different data sources such as governance perceptions obtained from survey results, non-governmental organisations, commercial business information suppliers and public sector organisations across the world (Kaufmann, Kraay & Mastruzzi, 2010, p 2). Governance indicators which were firstly published in 1996 and biennially published until 2002 have started to be published annually since 2002. Thus, the period of examination has been started from 2002. Data of 214 countries are included in the last update of governance indicators published by World Bank in 2016. Each index has a numeric value between +2.5 and −2.5. The highest governance score is indicated as +2.5, whereas the lowest governance score is indicated as −2.5. Index score of a country in a specific year indicates the status of that country with regard to the relevant governance indicator. These six indexes which indicate universal governance indicators can be briefed as follows based on the studies of Kaufmann, Kraay and Mastruzzi (2004, p 2):

3.2.2.1. Voice and accountability

VA includes the free participation of the citizens of a country in political elections without being exposed to any oppression as well as freedom of expression and organisation of the public and their perceptions on freedom of press (Kaufmann et al., 2010, p 223). This index includes a series of indicators including political processes and various aspects of civil freedom and political rights.

3.2.2.2. Political stability and absence of violence

In this category, perceptions regarding some probabilities such as destabilisation of the ruling government through some methods against the constitution or through terrorism and/or violence are measured by combining various indicators. This index supports the view that the probability of

destabilisation of a democratic government through some methods against the constitution will endanger the governance quality in a country. This case undermines the capabilities of all the citizens to elect and change the ruling government peacefully in addition to its effect on the sustainability of direct policies.

3.2.2.3. Government effectiveness

Data regarding such issues as public service delivery, quality of bureaucracy, civil service quality, independency of these services from political oppressions and confidence in the policies which are guaranteed by the government were combined within the scope of GE. This index mainly focuses on the inputs which are needed by the government in order to make and implement good policies in the delivery of public goods.

3.2.2.4. Regulatory quality

This index measures the competency of the government to develop and implement good working policies and regulations that permit and promote the development of the private sector. It also includes the measurement of heavy loads which are leaded by excessive regulations in the fields of foreign trade and business development as well as the measurement of negative effects of such issues as a high level of price controls or inadequate bank audits on the market.

3.2.2.5. Rule of law

This index indicates the trust of the citizens in social rules, quality of the implementation of contracts, property rights, quality of police and courts as well as their perceptions on the probability of crime and violence. It also includes various indicators which measure the level of citizens, institutions and public officials in a country to respect and obey to social rules. These indicators are composed of such perceptions of crime rates, judicial reliability and predictability as well as applicability of the contracts.

3.2.2.6. Control of corruption

Control of corruption index indicates the perceptions regarding the use of public power for deriving private benefits and the use of public resources for the elites and private benefit groups starting from the smallest type of corruption to the biggest type of corruption. Control of corruption index measures the precautions taken against corruptions and the perceptions regarding the use of public authority for deriving private benefits.

3.3. Model and summary statistics

We investigated how the institutions effect innovations in the 32 OECD countries during the 2002–2016 period. Our dependent variable is patent application that sum of resident and nonresidents. Therefore, we consider the following model:

$$\text{Patent}_{it} = \beta_0 + \beta_1 \text{VA}_{it} + \beta_2 \text{PS}_{it} + \beta_3 \text{GE}_{it} + \beta_4 \text{RQ}_{it} + \beta_5 \text{RL}_{it} + \beta_6 \text{CC}_{it} + \varepsilon_{it}$$

In the model, Patent_{it} is the total number of patents applied by the residents and non-residents in 'i' country in 't' year. This parameter is also the dependent variable of the model whose relationship with the independent variables is examined. VA_{it}, one of independent variables, represents the VA in 'i' country in 't' year; PS_{it} represents the PS; GE_{it} represents the GE; RQ_{it} represents the RQ; RL_{it} represents the RL; CC_{it} represents the control of corruption and and ε_{it} indicates the error term. We use Stata 14.0 software Packages Programme for the analysis. The descriptive statistics of the variables in this study are presented in Table 1.

Table 1. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Patent	495	37,838.7	104,693.5	24	605,571
VA	495	1.166823	0.4163658	−0.6348642	1.800992
PS	495	0.7109678	0.6694245	−199.828	1.755.193

GE	495	1.362.471	0.5445892	0.0088391	2.353.998
RQ	495	1.316.861	0.4281165	0.0437174	2.038.402
RL	495	1.323.941	0.6064055	−0.6678741	2.100.273
CC	495	1.323.055	0.7936667	−0.7661818	2.469.991

4. Estimate results and discussion

Analysis has been started with the selection of estimator. It is required to check the existence of individual effects for the selection of estimator in the first phase of the analysis. If units (countries) or time (years) regarding data set which we use have no unique effect, the valid model will be classical model (pooled OLS); while it will be more appropriate to prefer fixed or random effect models if the units or time have an individual effect.

We must apply three tests to make this check. First of all is Analysis of variance (ANOVA) F test. This test compares classical model and fixed effect model as well as checking the existence of individual effect based on the fixed effect model. Second test is Breusch-Pagan Lagrange Multiplier (LM) where the hypothesis suggesting that correlation matrix of all the residuals of cross-section units is the unit matrix is checked with the main hypothesis of non-correlation between the units in other words (Yerdelen Tatoglu, 2013, p 215). If both tests (or at least either of them) indicate that individual effects do exist, Hausman test which is the third test must be applied in order to compare fixed and random effect models in the selection of estimator. In accordance with the results of F Test and LM test where individual effects were checked for unit (cross section) and time, it was understood that the units have unique effects but no effect of time. Thus, Hausman test was applied to make a choice between fixed effect model and random effect model. Hausman test results indicate that H_0 hypothesis suggesting 'difference in coefficients not systematic' was rejected. So, it was concluded that consistent model is fixed effect model. Results of these three tests are indicated in Table 2.

Table 2. Tests Determining Cross Section and Time Effect

	Cross section	Time	Both
ANOVA F	459.76 (0.0000)	0.34 (0.9882)	451.79 (0.0000)
LM	2,925.27 (0.0000)	0.00 (1.0000)	2,955.06 (0.0000)
Hausman		22.03 (0.0012)	

Validity of econometric assumptions is required to be tested in order to be able to state that fixed effect model is both effective and consistent. These assumptions are as follows: variances are homoscedastic depending on the units ($H_0 : \sigma^2_i = \sigma^2$), auto correlation coefficient equals zero ($H_0 : \rho = 0$) and there is no correlation between the units. Firstly, Modified Wald test was applied in order to test whether or not variances are homoscedastic depending on the units. At the end of the test, H_0 hypothesis suggesting that there is no variance varying depending on the units was rejected. Durbin-Watson and Baltagi-Wu local best invariant tests were applied in order to test auto correlation. If test results are close to 2, it is interpreted that there is no auto correlation, and if it is far from 2, it is interpreted that there is a problem of auto correlation. Test results indicate that both values are far from 2. This result can be interpreted as auto correlation is significant. Finally, Pesaran (2004) CD test was applied in order to test the assumption that there is no correlation between the units (since N>T). Test result indicates that there is a correlation between the units. In accordance with the test results checking the validity of econometric assumptions in panel data, there are varying variance, auto correlation and correlation between the units. So, the analysis was conducted with the help of Driscoll and Kraay estimator which is estimated by resistant standard error in order to remove these problems. Results are indicated in Table 3.

Table 3. Panel regression estimations

Panel A: Summary statistics

Regression with Driscoll-Kraay standard errors			Number of obs.	= 495	
Method: Fixed-effects regression			Number of groups	= 33	
maximum lag: 2			F (6, 14)	= 18.65	
			Prob > F	= 0.0000	
			within R-squared	= 0.1256	

Panel B. Panel regressions estimations

Patent	Coef.	Driscoll-Kraay Std. Err.	t	P > t	[95% Conf. Interval]	
VA	27,005.64	5.928.051	4.56	0.000	39,720.04	14,291.23
PS	18,252.36	4,238.33	4.31	0.001	9.162.043	27,342.67
GE	−7,716.017	7,809.65	−0.99	0.340	−24,466.05	9.034.016
RQ	−5,793.94	3.377.031	−1.72	0.108	−13,036.95	1,449.07
RL	32,386.92	13,217.94	2.45	0.028	4.037.257	60,736.59
CC	−31,978.59	11,631.27	−2.75	0.016	−56,925.18	−7,031.989
_cons	73,946.38	5.850.741	12.64	0.000	61,397.79	86,494.97
Wald Test	55,553.83			0.000		
Durbin-Watson	0.15058465					
Baltagi-Wu	0.44194889					
Pesaran (2004) CD	9.296			0.000		

Summary statistics to assess the model are reported in Panel B of Table 3. F-statistic values show that model is significant as a whole. Panel A of Table 3 reports the coefficient estimates and significance of independent variables. These results show that the total number of patent applications is positively related to VA and PS in 1% significance level. This result indicates that one unit of increase in the level of VA and PS increases the number of patent applications. VA includes a series of indicators including political processes and various aspects of civil freedom and political rights. The perception that there are political rights and political freedom in a country can increase the desires of the investors to make investment and produce innovations. PS has also a positive effect on innovations. Previous literature reveals results in conformity with the findings here. Waguespack, Birnir and Schroeder (2005) put forward that stable political environments will be much more practical for both national and international patent activities. In their studies where they use international patent rates as an indicator in the sampling of 27 Latin America and Caribbean countries, the authors find out that PS is of high importance for the innovation. Wang (2013) also states that institutional quality, especially political risk indicators have a positive effect on innovation density. RL also has a positive effect on the innovations like political risk variable, as expected. RL positively affects patent applications in 5% significance level. Van Waarden (2001) finds out that economies which have more efficient legal systems to decrease risk and uncertainty are much more innovative while Keefer and Knack (1997) conclude that the companies have a very low level of investment in new technologies in the economies where the rules of law are weak and the risk of expropriation is high.

Control of corruption variable negatively affects patent applications in 5% significance level. It means that an increase in the control of corruption in OECD countries decreases the innovations. As can be noted, the variable here is the control of corruption, not the corruption level. So, the indicator expected from the regression estimate – with regard to increase of the innovations by the control of corruption – should be positive. Hence, this result, which also means that corruptions increase the

innovations, supports the 'grease the wheel' hypothesis as in some previous studies (Habiyaremye and Raymond, 2013; Nguyen, Doan, Nguyen and Tran-Nam 2016). Theoretical and empirical literature suggests that corruption can have a negative or positive effect and sometimes do not have any effect on the innovations, as mentioned in previous sections.

Finally, coefficient of GE and RQ variables is negative and insignificant.

5. Conclusion and Recommendations

According to Schumpeter, who made the first and utmost contribution to innovation literature, the most important factor in the growth of capitalist system is entrepreneurs and their innovations. Entrepreneurs will not be willing to make investment or produce innovation in an environment where it is difficult to establish a business, laws and rules are constantly changed, property rights are not taken under assurance, there is no economic freedom, there are widespread activities such as corruption, bribery, robbery and expropriation may have dangerous effects on revenues. So, institutional quality of an economy becomes an important factor in determining the level of innovation.

This study searches for the relationship between institutional quality and innovation. Data of 32 OECD countries, data set of which we can regularly have an access to, were used in the study for the years 2002-2016. Worldwide Governance Indicators which are composed of 6 indexes published by World Bank were included in the model to represent institutional quality while the total number of patent applications of the countries was included in the model to represent innovation. Using panel data analysis methods, it has been found that there is a relationship between innovation and four of six indexes representing institutional quality. Innovation is positively related to voice and accountability, political stability and rule of law while it is negatively related to control of corruption. It has been determined that government effectiveness and regulatory quality have no relation with the innovation. These findings show that voice and accountability, political stability and the rule of law are the determinants of innovation. In other words, it is important to establish freedom of expression and the rule of law in order to promote innovation. in other words, it is important to establish freedom of expression, public choice and the rule of law in order to promote innovation.

This study which will contribute to the institutions and innovation literature have surely have some restrictions. Firstly, it covers only OECD countries as the sampling which can be extended in the following studies. Secondly, different variables which will represent institutional quality can be included in analysis in this study where World Bank's Worldwide Governance Indicators are used to represent institutional quality. Finally, the number of patent application was used to represent the innovations, which is the dependent variable of the study. Apart from this, separate models can be created for such variables as R&D expenditures, total number of R&D staff and high-tech product export to represent innovation. In this respect, further research is needed to clarify the relationship between innovation and corporate quality.

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