Does institutional quality drive innovation? Evidence from system-GMM estimates

Koçak, Emrah

Erciyes University

1 December 2017

Does institutional quality drive innovation? Evidence from system-GMM estimates

Emrah KOÇAK[1]
Department of Economics, Ahi Evran University, Kirsehir, Turkey

Abstract

This paper investigates the influence of institutional quality on innovation performance in developing countries by employing annual data from 1997-2014. The system- generalized method of moments (GMM) is used as the empirical method. Estimation results reveal that bureaucratic quality, government stability, democratic accountability and law and order indicators that represent institutional quality are a positive influence on innovation performance. These results indicate that improving the institutional structure in the developing countries will have a significant contribution to the innovation process and hence economic development.

Key words: Institutions, Innovation, Panel data, System-GMM.

JEL Classification Number: 043, D02, Q55.

1. Introduction

Innovation promotes productivity in a country, provides a significant competitive advantage and is widely accepted as a driving force for long-term economic growth (Barasa etal., 2014; Laboutkova, 2013). The inclusion of technology as a constant in growth models proves the importance of innovation (Boudreaux, 2017). In addition, there is evidence in the literature that innovation is a major influence on cross-country differences in income or growth rates (Hall, 1994; Freeman, 2002). For this reason, it is very important to design growth policies to show which factors determine the innovation in developed and especially developing countries. Until recently,

[1] Corresponding author. Email: ekocak@ahievran.edu.tr

literature has focused on the impact of innovation on economic growth and factors such as foreign direct investment, trade openness and human capital as determinants of innovation. But there is little debate about the impact of institutions on innovation. Moreover, country experience has shown that different innovation performances may arise in countries with similar technology, labour and capital resources. As an important reason for this situation, the institutional environment differences between countries are shown (Lee and Law, 2016). Therefore, there has recently been an increased interest in research on institutions-innovation relations.

According to theoretical explanations, countries with strong institutions have a democratic regime, independent legal system, functioning state mechanism or bureaucratic structure and public confidence. Such an environment provides the following benefits: (1) Uncertainties are reduced. (2) Commercial relations and contracts occur in a trusting environment. (3) Property rights are guaranteed. (4) Market mechanism works more effectively. (5) Free competition environment is provided. (6) Transaction costs are reduced for all economic actors. Thanks to these benefits, entrepreneurs make the best use of their talents. They are more willing to use new methods in production. They make more inventions. As a result of these efforts, they obtain important returns and protect the product of their effort through property rights. Ultimately, research and development investments increase and more innovation occurs in overall economic life (Gould and Gruben, 1996; Acemoğlu etal., 2003). In addition, it is emphasized that physical capital, human capital and technology are very important for economic development according to the literature, but it is also added that these important factors are not successful in the absence of strong institutions that provide incentives and supports (Eicher and Garcia-Pealosa, 2006).

This paper presents an empirical test on the impact of institutional quality on innovation. In this context, the impact of institutional indicators on innovation performance in developing countries is investigated empirically. The paper contributes to the literature in two respects. Firstly, most of the empirical investigations in this area examine developed countries (Tolbert etal., 2008; Égert, 2016), but there are limited findings for developing countries (Barasa etal., 2014). This study contributes to the literature by providing empirical findings for developing countries. Second, the system-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) is used in the study. This method has significant advantages over other methods (OLS, pooled OLS, fixed effect, random effect) These advantages are: (a) Method reveals dynamic relationships between economic variables. (b) It also solves the problem of endogeneity and autocorrelation by using the instrument variable. For this reason, it produces more reliable and effective results than other estimators. It should also be noted that more effective findings will help authorities to design policies.

The rest of the paper is arranged as follows. Section 2 specifies the methodology. Section 3 describes the data. Section 4 contains findings. Section 5 summarizes the findings and provides suggestions.

2. Methodology

In this study, a dynamic panel data model is estimated as follows:

$$Y_{it} = \delta_1 Y_{it-1} + \delta_2 X_{it} + \delta' Z_{it} + \gamma_i + \varepsilon_{it} \quad (1)$$

$i = 1,2,3,\ldots,N$ and $t = 1,2,3,\ldots,T$

Where Y, X, Z, γ and ε represent dependent variable, explanatory variables, control / addition variables, unobservable country specific effects and error term, respectively. δ denotes the coefficient parameters to be estimated. The standard estimators used for the estimation of Eq. (1) produce biased and inconsistent results. Because adding the lagged values of the dependent variable to the estimation model as the explanatory variable causes some econometric problems. The first of these problems is that the lagged variable (Y_{it-1}) is correlated with the error term. This leads to the problem of autocorrelation. Second, the correlation between country-specific effects and explanatory variables can lead to the problem of endogeneity.

Arellano and Bond (1991) propose a difference-GMM method to solve these problems. The difference-GMM method applies the econometric model to the first difference transform and all lagged variables are used as the instruments variable. Thus, the econometric problems cease to exist and the country-specific effects in equation (1) are eliminated. Equation (2) represents this process.

$$\Delta Y_{it} = \delta_1 \Delta Y_{it-1} + \delta_2 \Delta X_{it} + \delta' \Delta Z_{it} + u_{it} \quad (2)$$

$u_{it} = e_{it} - e_{it-1}$

Conversely, if the explanatory variables are persistent over time, the lagged levels of these variables can be very weak instruments for the first differences. This limitation of the difference-GMM method may cause estimators to be biased and inconsistent. Arellano and Bover (1995) and Blundell and Bond (1998) propose the system-GMM method to reduce the likelihood of biased and inconsistent in the difference-GMM method. The system-GMM approach deals with the difference and level equations together so that the estimator becomes more efficient.

The performance of the GMM estimators depends on the validity of the two assumptions. First, there should not be second-order autocorrelation even if there is first-order autocorrelation among the error terms in the model. Arellano and Bond (1991) test the null hypothesis "no autocorrelation" with AR(1) and AR(2) tests for the residuals of the first difference model. AR(1) and AR(2) determine whether there is autocorrelation in first-order and second-order respectively. The second is the assumption that the instrumental variables are valid. The validity of this hypothesis is investigated by the Sargan (Hansen-J statistic) test. The Sargan test examines the null hypothesis that "instrumental variables are valid". Ultimately, the null hypothesis is decided on the basis of the statistical significance of the test result.

3. Data

This paper uses a cross-country panel data of 23 developing countries (Algeria, Argentina, Bangladesh, Brazil, Chile, China, Colombia, Egypt, Guatemala, India, Indonesia, Iran, Malaysia, Mexico, Pakistan, Peru, Philippines, Sri Lanka, Romania, Russia, Singapore, South Africa and

Turkey). The data are annual and cover the period 1997-2014. The dependent variable is innovation and is represented by the total patent application. The explanatory variables representing institutional quality are bureaucratic quality, government stability, democratic accountability and law and order. Other explanatory variables added to the model to increase the reliability of estimation results are economic growth, trade, foreign direct investment and credit. The natural logarithms of all variables are taken. Table 1 summarizes the explanations for all variables.

Table 1: Definitions of variables and data sources

Variable	Unit	Source	Definition
Innovation	Number of thousand applications	World Intellectual Property Organization	Innovation is measured by the total number of patent applications. (residents and non-residents)
Economic growth	US$	World Bank	GDP per capita (Constant 2010)
Trade	Percent (%)	World Bank	Trade is the sum of exports and imports of goods and services measured as a share of GDP.
Foreign Direct Investment	Percent (%)	World Bank	Foreign direct investment is net foreign capital inflows as a share of GDP.
Private sector credit	Percent (%)	World Bank	Private sector credit is represented by domestic credits to the private sector. (As a share of GDP).
Bureaucratic quality	Index (between 0-4)	International Country Risk Guide (ICRG)	Bureaucratic quality is measured by the bureaucracy's political repression immunity and power of domination. The increase in the index score indicates bureaucratic quality improvement.
Government stability	Index (between 0-12)	ICRG	Government stability measures the government's ability to carry out its announced program and its ability to stay in office. The increase in the index score

			indicates government stability improvement.
Democratic accountability	Index (between 0-6)	ICRG	Democratic accountability is a measure of the level of government sensitivity to its people. The increase in the index score indicates democratic accountability improvement.
Law and Order	Index (between 0-6)	ICRG	Law and order measure the impartiality of the legal system and the influence of the legal system on the people. The increase in the index score indicates law and order improvement.

Note: The table is prepared by the author.

4. Estimation results

Table 2 illustrates the difference and system-GMM estimations results for institutional quality indicators. Columns (1-2), (3-4), (5-6) and (7-8) explain the effect of bureaucratic quality, government stability, democratic accountability and law and order on innovation, respectively. The difference and system-GMM estimations results show that institutional quality indicators have a positive and significant effect on innovation performance. In other words, institutional developments in developing countries have an increasing influence on patent applications. In addition, coefficient estimates of other explanatory variables (economic growth, trade, foreign direct investment and private sector credit) added to the model are also considerably in line with the economic expectations. As emphasized earlier, the effectiveness of the GMM estimators depends on the validity of the two assumptions. Hansen and second-order autocorrelation tests show the validity of these assumptions. Firstly, the Hansen test results for all estimated models reveal that the instruments are valid. Secondly, AR(2) test results indicate that there is no second order autocorrelation.

Table 2: Baseline results (1997-2014)

Dependent variable: Innovation as total patent application

Independent variables	Diff-GMM (1)	Sys-GMM (2)	Diff-GMM (3)	Sys-GMM (4)	Diff-GMM (5)	Sys-GMM (6)	Diff-GMM (7)	Sys-GMM (8)
Innovation (t-1)	0.14* (0.00)	0.39* (0.00)	0.01 (0.82)	0.36* (0.00)	0.01 (0.81)	0.37* (0.00)	0.16* (0.00)	0.41* (0.00)
Economic growth	0.34 (0.24)	0.66* (0.00)	0.89* (0.00)	0.83* (0.00)	0.86* (0.00)	0.81* (0.00)	0.92* (0.00)	0.63* (0.00)
Trade	0.43* (0.00)	0.21** (0.03)	0.54** (0.01)	0.20** (0.04)	0.56** (0.01)	0.21** (0.04)	0.56* (0.00)	0.20** (0.04)
Foreign Direct Investment	0.06 (0.71)	0.10* (0.00)	0.01 (0.63)	0.09* (0.00)	0.01 (0.60)	0.09* (0.00)	0.04** (0.02)	0.09* (0.00)
Private sector credit	0.53* (0.00)	0.11** (0.02)	0.57* (0.00)	0.11* (0.00)	0.60* (0.00)	0.11* (0.00)	0.26* (0.00)	0.09** (0.01)
Bureaucratic quality	0.28* (0.00)	0.22* (0.00)						
Government stability			0.41* (0.00)	0.19** (0.02)				
Democratic Acc.					0.85* (0.00)	0.33** (0.03)		
Law and Order							0.26* (0.00)	0.03* (0.00)
#Countries	23	23	23	23	23	23	23	23
Hansen J-test	19.68	20.64	17.92	19.97	18.03	20.20	20.62	21.49
Hansen p-value	0.29	0.24	0.39	0.27	0.38	0.26	0.24	0.20
AR(2) test	-1.14	-1.50	-0.78	-0.76	-1.14	-0.75	-1.57	-1.30
AR(2) p-value	0.35	0.13	0.44	0.44	0.35	0.45	0.11	0.19

Notes: (a) P-values are indicated in parentheses.
(b) *, ** denote significance at the 1% and 5%, respectively.

Finally, in order to check robustness, analysis is repeated with an alternative innovation indicator. For this purpose, the number of industrial design registration applications is considered as an indication of innovation. Data is obtained from World Intellectual Property Organization for 22 countries from 2000-2014. Table 3 illustrates the estimation results for robustness check. Accordingly, estimation results obtained for industrial design as an alternative innovation indicator support baseline findings. The robust control findings show that improvements in institutional quality have a positive effect on industrial design registration applications. The Hansen and AR(2) test results show that the instruments are valid and there is no second-order autocorrelation in the estimated models.

Table 3: Robustness check results

Dependent variable: Innovation as total Industrial design application								
Independent variables	Diff-GMM (1)	Sys-GMM (2)	Diff-GMM (3)	Sys-GMM (4)	Diff-GMM (5)	Sys-GMM (6)	Diff-GMM (7)	Sys-GMM (8)
Innovation (t-1)	0.01 (0.89)	0.58^{*} (0.00)	0.01 (0.35)	0.63^{*} (0.00)	0.08^{***} (0.06)	0.63^{*} (0.00)	0.05 (0.71)	0.68^{*} (0.00)
Economic growth	1.39^{*} (0.00)	0.63^{*} (0.00)	1.25^{*} (0.00)	0.65^{*} (0.00)	1.58^{*} (0.00)	0.64^{*} (0.00)	1.32^{*} (0.00)	0.43^{*} (0.00)
Trade	0.67^{*} (0.00)	0.17^{*} (0.00)	0.38^{*} (0.00)	0.11^{*} (0.00)	0.37^{**} (0.01)	0.17^{*} (0.00)	0.66^{*} (0.00)	0.13^{*} (0.00)
Foreign Direct Investment	0.10 (0.85)	0.005 (0.74)	0.024 (0.10)	0.03^{**} (0.02)	0.01^{*} (0.00)	0.03^{*} (0.00)	0.05^{*} (0.00)	0.07^{*} (0.00)
Private sector credit	0.05 (0.81)	0.29 (0.35)	0.09 (0.51)	0.25^{*} (0.01)	0.008^{**} (0.04)	0.25^{**} (0.01)	0.11 (0.17)	0.13 (0.13)
Bureaucratic quality	0.19 (0.15)	0.14^{***} (0.08)						
Government stability			0.14^{**} (0.03)	0.11^{**} (0.07)				
Democratic Acc.					0.24^{*} (0.00)	0.22^{**} (0.03)		
Law and Order							0.40^{*} (0.00)	0.23^{*} (0.00)
#Countries	22	22	22	22	22	22	22	22
Hansen J-test	25.02	21.25	15.60	20.59	16.63	20.65	21.24	18.87
Hansen p-value	0.10	0.14	0.48	0.19	0.40	0.19	0.16	0.28
AR(2) test	-0.57	-1.00	-0.97	-0.89	-1.05	-1.26	-1.05	-1.43
AR(2) p-value	0.56	0.31	0.32	0.37	0.29	0.20	0.29	0.15

Notes: (a) P-values are indicated in parentheses.
(b) *, **, *** denote significance at the 1%, 5%, and 10%, respectively.

5. Conclusion

In this study, the influence of institutional quality on innovation in 23 developing countries of 1997-2014 period was investigated by system-GMM method. The results of the analysis show that the institutional quality is a strong influence on the innovation performance. These results provide empirical evidence on relevant literature about the importance of institutions in the innovation process for developing countries. The basic recommendation of working within this context is that, while preparing economic growth and innovation incentive policies, a strong institutional environment must first be provided. Otherwise, incentive policies will only yield short-term results, and there will be no meaningful change in the long-term.

References

Acemoğlu, D., S. Johnson, J. Robinson and Y. Thaicharoen, 2003, Institutional Causes, Macroeconomic Symptoms: Volatility, Crises and Growth, Journal of Monetary Economics, 50(1), 49-123.

Arellano, M. and S. Bond, 1991, Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations, The Review of Economic Studies, 58(2), 277-297.

Arellano, M. and O. Bover, 1995, Another Look at the Instrumental Variable Estimation of Error-components Models. Journal of Econometrics, 68(1), 29-51.

Barasa, L., P. Kimuyu, P. Vermeulen, J. Knoben and B. Kinyanjui, 2014, Institutions, Resources and Innovation in Developing Countries: A Firm Level Approach. DFID Working Paper.

Blundell, R. and S. Bond, 1998, Initial Conditions and Moment Restrictions in Dynamic Panel Data Models. Journal of Econometrics, 87(1), 115-143.

Boudreaux, C. J., 2017, Institutional Quality and Innovation: Some Cross-country Evidence. Journal of Entrepreneurship and Public Policy, 6(1), 26-40.

Égert, B., 2016, Regulation, Institutions, and Productivity: New Macroeconomic Evidence from OECD Countries. The American Economic Review, 106(5), 109-113.

Eicher, T. S. and C. García-Peñalosa, 2006, Institutions, development, and economic growth. Mit Press.

Freeman, C., 2002, Continental, National and Sub-national Innovation Systems—Complementarity and Economic Growth, Research Policy, 31(2), 191-211.

Gould, D. M. and W. C. Gruben, 1996, The Role of Intellectual Property Rights in Economic Growth, Journal of Development Economics, 48(2), 323-350.

Hall, P. H., 1994, Innovation, Economics and Evolution: Theoretical Perspectives on Changing Technology in Economic Systems. Harvester Wheatsheaf.

Laboutkova, S., 2013, The Impact of Institutional Quality on Regional Innovation Performance of EU Countries, Proceedıngs of The 11th International Conference on Liberec Economic Forum, Sychrov, Czech Republıc, Sep16-17, 353-362.

Lee, W. C. and S. H. Law, 2016, The Roles of Formal and Informal Institutions on Innovations Activity. Jurnal Ekonomi Malaysia, 50(2), 167-180.

Tolbert, C. J., K. Mossberger and R. McNeal, 2008, Institutions, Policy Innovation and E-Government in the American States, Public Administration Review, 68(3), 549-563.