Does Government Effectiveness Spur Technological Innovation? A Cross-Country Empirical Study

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Abstract

The relationship between government effectiveness and economic growth has been widely discussed in academic literature. Though, only a few studies have examined the association between government effectiveness and technological innovation. This research is to analyze the empirical link between government effectiveness and technological innovation by using a panel data set of 58 countries for the period 2002 to 2018. For the empirical testing of hypotheses, we utilized the OLS, Panel negative binomial, and panel quantile regression. The empiricalfindings indicate that government effectiveness has a positive and significant impact on national technological innovation across countries. We further conducted various robustness tests to verify the obtained results. In addition, we divided the selected countries into two groups i.e. OECD and Non-OECD. The results from robustness tests and different groups of countries were found to be in line with the baseline results of this study. The results of this research and recommended policy measures areimportant for policymakers and practitioners.

Keywords: Government effectiveness, Technological innovation, Negative Binomial, Quantile Regression, Panel data

Introduction:

Government effectiveness (GE) is defined as the provision of better public services, good quality of civil services, political freedom, and formulation and implementation of long-term policies which bring peace and prosperity to the country(Kaufmann et al, 2011). Specifically, an effective government is capable and competent in the provision of social security, good infrastructure, rule of law, accountability and transparency, employment opportunities, poverty eradication, and ensuring human and intellectual property rights(Sacks and Levi, 2010).Most economic growth models havebeen basedon three main factors of production i.e. land, labor, and capital, however, other factors also determine the economic growth such as; type of governance, institutional quality, population, and the geographical situation of the country, and trade. Hence in recent research on growth, researchers are

trying to analyze the impacts of these factors on economic growth. Currently, governance has taken the great attention of academicians and policymakers for economic development. Effective government has been proved helpful in boosting businesses and economic activities (Levi 2006).

Effective governance leads a country towards economic prosperity and development through enhancing investment opportunities for domestic as well as foreign investors. GE is necessary for developing countries due to various reasons such as; a more effective government attracts more foreign investment in developing countries to increase capital accumulation. In addition, World Bank provides economic aid to those developing countries that have effective governance to ensure the proper and right use of aid(Friedman et al., 2010). In the existing literature, quality of governance can be measured in terms of economic growth; literacy rate, and infant mortality rate ((Kaufmann et al. 1999). Effective governance and government spending efficiency can be achieved through fiscal transparency and accountability (Montes et al., 2019).

Effective governance increases both physical as well as human capital in the country. A good investment environment requires social security, political stability, pro-business government policies, and trained human capital. An effective government can provide a good investment environment in a country that will not only increase domestic investment but also attracts foreign investment. Foreign companies bring new technologies, new ideas, and trained foreign human capital that can increase innovation activities in the country. Developing countries mostly lack the latest technology and trained human capital to upgrade their economies. Therefore, developing countries seek FDI for capital accumulation, industrial up-gradation, and economic growth. An effective government invests more in R&D to increase innovation activity and sustain a globally competitive environment.

Government innovation policies include; direct subsidies to firms for innovative activities and industrial up-gradation, research and development funds to universities, investing a significant share in higher education to increase the number of scientists,and creation of knowledge management systems in the countries.According to Hewitt Dundas and Roper, (2010) enterprises lack resources for R&D investment, or due to risk on R&D investment, they divert the decision to innovation investment. Hence the government subsidy can reduce the cost and risk of innovation which impacts positively enterprise innovation activity. In contrast, Clausen, (2009) found in the study that government subsidies negatively impact an enterprise's innovation performance due to the crowding out effect of government subsidies. Furthermore, Lin and Luan (2020) analyzed the impact of government subsidies on technological innovation in China's photovoltaic enterprises. Their findings indicate that the provision of government subsidies positively enhances innovation performance.

Effective government and institutional policies ensure the proper labor division to increase labor productivity and provide support to firms in capital accumulation to increase the output (Hall and Jones, 1999). Effective government always encourages firms and individuals for getting new patents and trademarks by offering awards and bonuses. Moreover, the effective government provides knowledge-sharing platforms to firms; buildinga link between academia and industry to implement research output practically. These types of activities boost innovation through the generation of new ideas within the country. Several studies have been conducted on the relationship between GE and economic growth. However, only a few studies have been conducted on the impact of government effectiveness on technological innovation. Among them, most of the studies are atthe firmlevel and in a single country. However, there is scarce literature on cross-country investigation on the impact of GE and technological innovation. Given that, this study aims to analyze the impact of GE on technological innovation on panel data of 58 countries.

Research objectives

1. To analyze the impact of GE on national technological innovation
2. To fillup the literature gap onthis promising issue
3. To provide the policy measures for enhancing technological innovations through effective governance

In the second section of this study, we analyze the related literature and thethird section of the study will discuss the data and methodology. The fourth section is to discuss the empirical results of the study and the fifth section is discussion, the conclusion, and policy implication. In the end, we present the references and appendix.

Literature review

Government effectiveness

The word effectiveness has been interchangeably used with quality of service, performance, and improvement. Governance means managing the formal and informal institutes by a governing authority to enhance the economic and social prosperity of the country (Hunter & Shah, 1998). Effective governance can be described as a well-managed administration to increase the welfare of society (Rainey &Steinbauer, 1999). In concrete words,an effective government is a government that provides better public services to its citizens such as; health, education, security, and infrastructure (Hunter & Shah, 1998). The quality of governance varies in countries due to certain reasons for example; government structure, electoral systems, and the type of government (Hoffman and Gibson, 2005). In addition, effective government boosts economic activities by ensuring security stability, political stability, rule of law, accountability and transparency, and pro-business fiscal policies to increase domestic investment and attract talent and FDI (Boswell & Richardson, 2003). Lower autonomy decreases the quality of government (Fukuyama, 2013).

Technological innovation

Innovation is defined as the adoption of novel techniques, technology, or system to increase productivity and competitiveness (Maranville, 1992). Innovation can be divided into three parts, production, process, and system. Firms always try to be more innovative in production to decrease the cost of production and increase productivity. Innovation is considered a key driving factor for economic activities. Patents are generally called innovation output, and in economic literature, it is explained as the production of novel knowledge that increases productivity or output.

In the existing literature on innovation, patents and trademarks are often associated with innovation and technological progress. These two variables have become reliable indicators to measure national innovation. Patents and trademarks remain the most suitable indicators for measuring innovation levels as employed in many studies such as; Jalles, (2010), Hsu, et al., (2014), Wang et al. (2019), and Wen et al., (2018). The patent refers to a technology or invention that is protected by national law. Specifically, it relates to the exclusive right to the technology or creativity granted by the state's examination and approval authority to the applicant within the stipulated time. Technological innovation is the embodiment of resource input and efficiency, allowing the patent applications representing intermediate outputs to reflect better the innovation performance (Hsu et al., 2014; Jalles 2010). Trademark differentiates the products and services of a specific company from other corporates (WIPO 2017). Millot (2009) depicts that the trademark contains some vital innovation that is not reproduced by traditional R & D and patents, predominantly non-technological innovations that attract much attention in service-intensive economies. More specifically, compared to a patent, the trademark is more closely linked to commercialization, covering a more extensive range of activities from manufacturing to services (Graham and Hancock 2014).

Nexus between government effectiveness and technological innovation

An effective government enforces the legislation to ensure copyrights and intellectual property rights protection which encourages firms to be innovative (Li, 2006). Moreover, government fiscal policies can increase firm innovation through subsidies and public-private partnerships(Nie, 2011). Fiscal policies improve firm internal incentives and innovation through technical support by the government. Government support in the shape of financial and non-financial surges a firm's innovative capabilities. Financial support by the government in the shape of subsidies and credits to firms for the purchase of new technologies and plants can increase the innovative capacity of firms. Whereas, non-financial support such as; training to employees, provision of certificates on innovative activities, and increases the firm innovative capacity.Firms alone cannot achieve the level of innovation except through

government involvement. According to Gander (1985), government involvement in various ways has a positive impact onthe timing of innovation. Industrial policy through public R&D funding increases open innovation outcomes with the collaboration between public research institutes and firms (Cheaha and Ho, 2020). Moreover, GE increases both economic growth and innovation activities (Alam et al., 2017; Furman et al., 2002).

In the words of Zhang et al. (2019a) a good quality of governance improves the national innovation system and enhances innovation capacity. In addition, Jiao et al., (2015) concluded that GE is positively related to the firm product, process, and management innovation in the case of Chinese firms.Buffart et al., (2020) analyzed the effects of government entrepreneurship programs on innovative ventures. Results of their study show that government support in entrepreneurship programs increases innovation outcomes in firms. Moreover, the quality of government is positively related to the number of patents in both private and public-owned firms; however, this relationship is stronger in the case of public-owned firms (Clò et al., 2020). Some studies have investigated the impact of technological innovation on GE, such as; the application of the internet, telephone, and copier in the public sector has improved the quality of governance (Brown 2001). Zang and Xiong (2019) investigated the relationship between technological innovation and GE. The findings of their study indicate that there is U-shaped relation between technological innovation and GE. Moreover, this impact is diverse according to the demographic situation and level of development of countries.

Data and methodology

Data and variables

We used a panel data set for 58 economies from2002 to 2018. The dependent variables of this study are the total number of patent applications and trademarks which represents the technological innovation. The independent variable is government effectiveness and the control variables are R&D expenditure, high technology export,total labor, the share of the manufacturing industry, trade openness, population density, FDI,and domestic investment. Data for all variables were taken from world development indicators except GE which was taken from World Bank's world governance indicators (WGI).

Dependent variables

To measure the technological innovation we have used the number of patent applications and trademark applications. We adopted the data for patents and trademarks from world development indicators for 58 countries from 2002 to 2018.

1. Patents:

This refers to a technology or invention that is protected by national law. Specifically, it refers to the exclusive right to the technology or invention granted by the state's examination and approval authority to the applicant within the stipulated time. Technological innovation is the embodiment of resource input and efficiency, allowing the patent applications representing intermediate outputs to better reflect the innovation performance (Hsu et al., 2014; Jalles 2010).

2. Trademarks:

This serves two important functions. In addition, a trademark differentiates the products or services of a particular enterprise from others (WIPO 2017). Millot (2009) shows trademark contains some important innovation that is not reflected by traditional R&D and patent data, particularly non-technological innovations that attract much attention in service-intensive economies. More specifically, compared to a patent, the trademark is more closely linked to commercialization, covering a wider range of activities from manufacturing to services (Graham and Hancock 2014). Thus, we follow the relevant literature and employ patents and trademarks in our basic regression.

Independent variable

We used GE as an independent variable for this study. The data for GE was downloaded fromthe World Bank world governance indicator (WGI). The indicator for GE ranges from -2.5 (weak effectiveness) to 2.5 (strong effectiveness). The index is anexceptionalmeasure of GE that revealsinsightsregarding the worth of public services, the value of the civil service and level of political freedom, the quality of policy designing and enactment, and the reliability ofthe commitment of the government towards its policies(Kaufmann et al. 2008).

Control variables

We have used different control variables which may affect technological innovation. Based on the literature on innovation, we have identified the following control variables for this study.

1. Research and development expenditure

In available literature on innovation, it has been noticed that R&D expenditure is positively correlated with innovation output such as patents and trademarks, and R&D is considered as innovation input (Pradhan et al., 2018). Hence, we have included the R&D expenditure as a ratio of GDP as a control variable for this study.

2. Export of high technology

High technology export specifies the country's innovation level. Therefore increase in high technology export increases competition in domestic firms which leads to an increase country's number of patents and trademarks. Thus, we have taken high technology export as a control variable in this study.

3. Share of manufacturing industry

The industrial structure significantly increases the innovation level in the country (Frías et al., 2012), following the study of Wang et al. (2019). We have used the proportion of the manufacturing industry to GDP as an industrial structure that may affect several patents and trademarks.

4. Total labor

Availability of more labor has a positive impact on innovation in two ways; first, more labor means lower cost of input which may increase productivity Wang et al. (2019), and second, the more labor and communication between them can generate new ideas and knowledge (Dong and Martin, 2017). Therefore, we have added total labor as a control variable in this study.

5. Domestic investment

Domestic investment increases the industrial up-gradation which may lead to increased innovation activities. Domestic investment either by firms themselves or by public investment in industries stimulates the innovation activities in firms

6. Foreign direct investment (FDI)

Foreign direct investment (FDI) plays a cruel role in technology transfer and improving domestic technology through the spillover effect (Perri and Peruffo, 2016). FDI affects domestic innovation activity; hence, FDI is used as a control variable in our study.

7. Population density

Asthe labor force, the population is also considered a factor for technological innovation. According to studies, more people can have more ideas and knowledge generation opportunities. Moreover, some studies have found that population and technological innovation has a nonlinear relation such as the study byCoccia (2014) and Dong et al. (2016). Therefore, we have taken the population density as a control variable that can affect innovation.

8.Trade openness

Trade openness is said to be the main stimulator for innovation activity domestically as well as internationally. Because of trade openness, the competition will increase, which pushes firms to adopt the latest technologies and innovations to meet the market standards.Countries achieve advantages of technology transfer through openness and gaining a prolonged base of knowledge, which upsurges their internal output. This practice is expedited through foreign trade, which is the main channel of modern technological diffusion and defines the application of international know-how in internal manufacturing processes. These activities can auxiliary enhance the quality of the supply chain in the market and lead to the production of the latest goods and services and improve competitiveness in the existing business atmosphere. (Wacziarg, 2001)

Empirical model

Our bench mark empirical model is given below:

$$Inov_{i,t} = \beta_1 + \beta_2 GEF_{i,t} + \beta_3 HTX_{i,t} + \beta 4\ IND_{i,t} + \beta_5 RD + \beta 6\ TO_{i,t} + \beta 7 POPD_{i,t} + \beta 8\ FDI_{i,t} + \beta 9\ GFCF + \varepsilon_{it} (1)$$

Where Inovt,i represents the innovation, which is measured in the total number of residents and non-resident patents and trademarks in the country (i) at the time (t). GEF is representing government effectiveness, HTX is high

technology export, TO stands for trade openness, IND is a share of the manufacturing industry, FDI is a foreign direct investment and GFCF is gross fixed capital formation which is used as a proxy for domestic investment. εi,t is an error term. We took a natural log of all variables.

Modified form of our basic model after taking natural log

$$lnInov_{i,t} = \beta_1 + \beta_2 ln\ GEF_{i,t} + \beta_3 lnHTX_{i,t} + \beta_4\ lnIND_{i,t} + \beta_5 lnRD + \beta_6\ lnTO_{i,t} + \beta_7 lnPOPD_{i,t} + \beta_8 ln\ FDI_{i,t} + \beta_9 ln\ GFCF + \varepsilon_{it} \quad (2)$$

Methods of estimation

We first estimate our baseline model using a simple OLS model. Later, we employed negative binomial estimation adopted from the study ofHausman et al. (1984). Negative binomial estimation is used when the distribution is generated by a Poisson-like method, such as non-negative event counts, but the distribution is too scattered to use Poisson estimation. Poisson is the proper form of estimation where the mean and variance of the dependent variable are almost equal (Hausman et al., 1984).Perceptibly, our data is more dispersed.If the model is stable, negative binomial coefficients are equivalent to Poisson estimates but with more stringent significance checks in the form of greater standard errors. The statistically significant alpha estimate shows over dispersion and the consequent suitability of the negative binomial distribution.

Empirical results

Results of descriptive statistics and correlation coefficients

The results of descriptive statistics are presented in Table 1. According to the results, the mean and standard deviation of patents are 7.653 and 2.480 respectively. However, the mean and standard deviation of trademarks are 9.672 and 1.459 respectively. These two variables are the main dependent variables of our model to measure technological innovation. The mean and standard deviation of our main independent variable which is GE are -0.261 and 1.012 respectively.

Table 1.Discriptive statistics and correlation coefficients

Variable	Obs	Mean	Std. Dev.	Min	Max	COR I	COR II
Patent	933	7.6533	2.4808	1.0986	14.248		
Trademark	944	9.6729	1.4598	6.2344	14.559		
Government effectiveness	847	-0.2615	1.0126	-6.466	0.8907	0.045	0.012
High-tech	967	2.3190	1.2145	-8.859	4.5000	0.293	0.137
Industry	964	2.6037	0.4852	-0.024	3.5428	0.213	0.109
Labor	985	15.628	1.7915	11.975	20.483	0.848	0.912
R&D	809	-0.0295	0.9513	-4.140	1.5158	0.468	0.312
Trade openness	958	-0.1699	0.5689	-1.575	1.4875	-0.467	-0.53
Population density	985	4.5411	1.461	0.939	8.9813	0.141	0.076
FDI	933	1.1917	1.2363	-6.3937	6.1128	-0.409	-0.412
Domestic investment	958	3.1167	0.2108	2.348073	3.8218	0.177	0.097

Notes: COR=Correlation, COR I is the correlation coefficient between explanatory variables and Patent; COR II is the correlation coefficient between explanatory variables and Trademark.

The results of the correlation matrix are given in Table 1. Results of correlation coefficients show that government effectiveness is positively related to both numbers of patents and trademarks. Hence we can assume that GE is positively related to overall technological innovation.

Empirical results of the basic model

The empirical results from OLS and negative binomial estimation indicate that GE significantly increases both the number of patents and trademarks at a 1% level of significance (see Table 2).

Table 2: OLS and negative binomial estimation

	OLS		Negative binomial	
Variable	Patents	Trademarks	Patents	Trademarks
Government effectiveness	.456(.074)***	.0962(.030)***	.050(.007)***	.012(.002)***
High-tech	.153(.108)	.018(.024)	.026(.009)***	.0009(.002)
Export				
Industry	-.362(.118)***	-.322(.036)***	-.058(.013)***	-.034(.003)***
Labor	1.179(.042)***	.730(.017)***	.154(.006)***	.075(.001)***
R&D	.453(.079)***	.091(.036)**	.073(.009)***	.008(.003)***
Trade openness	-.245(.139)*	-.246(.050)***	.023(.018)	-.016(.005)***
Population density	.146(.040)***	.053(.015)***	.008(.005)*	.004(.001)***
FDI	-.109(.046)**	.025(.016)	-.020(.006)***	.0006(.001)
Domestic investment	1.059(.216)***	1.169(.099)***	.068(.030)**	.109(.009)***
Constant	13.912(.743)***	-4.784(.427)***	-.546(.115)***	.824(.042)***
Observations	651	659	651	659
R^2	0.8	0.8	0.13	0.03

* Significance at 10% level. ** Significance at 5% level. *** Significance at 1% level, robust standard errors are in parentheses.

Robustness analysis

The previous techniques only summarize the average relationship between GE and technical innovation on the bases of conditional mean function given the standard normality assumption. Furthermore, this strategy only provides a partial view of the association between the variables under control, mainly when the data concentrate at dissimilar points in the conditional distribution of the outcome variable. Moreover, the quantile regression is capable of addressing such concerns by describing the full distribution of the given dependent variables (Koenker and Bassett, 1978). Hence we employed quantile regression as the robustness of our previous empirical results. The empirical results from panel quantile regression also confirm that government effectiveness has a positive and significant impact on technological innovation (see Table 2). Figure A illustrates how the coefficients (for the baseline model) vary with quantiles.

Table 3: Panel quantile regression to estimate impact of government effectiveness on technological innovation

Variable	*Q (0.10)*	*Q (0.25)*	*Q (0.50)*	*Q (0.75)*	*Q (0.90)*
Panel A: Patent	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Government effectiveness	0.228(.051)***	0.267(.085)***	0.389(.084)***	0.529(.088)***	0.490(.077)***
High-tech					
Export	0.530(.0413)***	0.516(.068)***	0.325(.068)***	0.273(.071)***	-0.029(.062)
Industry	0.789(.0791)***	0.379(.131)***	-0.583(.130)***	-0.641(.137)***	-0.309(.119)**

Variable	*Q (0.10)*	*Q (0.25)*	*Q (0.50)*	*Q (0.75)*	*Q (0.90)*
Panel A: Patent	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Labor	1.047(.0325)***	1.091(.054)***	1.215(.053)***	1.111(.056)***	1.032(.049)***
R&D	0.789(.0612)***	0.533(.102)***	0.477(.100)***	0.415(.106)***	0.585(.092)***
Trade openness	-0.77(.106)***	-0.773(.177)***	-0.502(.174)***	-0.564(.184)***	-0.198(.160)
Population density	0.059(.0301)***	0.007(.050)	0.122(.049)**	0.216(.052)***	0.139(.045)***
FDI	-0.107(.0331)***	-0.057(.055)	-0.006(.054)	-0.049(.057)	-0.070(.050)
Domestic investment	-0.601(.180)***	0.056(.301)	1.128(.297)***	1.624(.312)	1.684(.272)***
Observations	651	651	651	651	651
Pseudo/ R – square	0.66	0.62	0.61	0.62	0.66
Panel B: Trade mark	(1)	(2)	(3)	(4)	(5)
Government effectiveness	.218(.042)***	.182(.030)***	.090(.028)***	.066(.037)*	-.005(.044)
Obser., Countries	659	659	659	659	659
Pseudo R – square	0.65	0.67	0.69	0.69	0.70

Note: Results of control variables in panel B are not presented but can be available on request.Standard errors are reported in parenthesis. * Significance at 10% level. ** Significance at 5% level. *** Significance at 1% level.

Table 4: Additional robustness tests using negative binomial estimation

Variable	Patent	Trademark
Panel A: adding additional controls		
Government effectiveness	.070***(0.009)	.016***(.003)
Constant	-.633***(.216)	.856***(.076)
Panel B: Removing outlier base patent		
Government effectiveness	.040 ***(.006)	.008 **(.003)
Constant	-.240***(.089)	.752 ***(.052)
Panel C: Removing outlier base Trademark		
Government effectiveness	.053 ***(.008)	.007**(.003)
Constant	-.435***(.102)	.738***(.051)
Panel D: Removing outlier base Government effectiveness		
Government effectiveness	.052 ***(.008)	.006 **(.003)
Constant	-.587 ***(.123)	.714***(.050)

Notes: The regressions are estimated using a negative binomial estimation froma dataset of 58economies from 2002 to 2018. The table provides additional robustness tests of the estimated impact of terrorism on innovation panel A to panel D. Columns (1) is for patents as the dependent variable whereas Columns (2) is for trademarks as the dependent variable. Control variables are not reported but are available upon request. Robust standard errors are reported in parenthesis.

* Significance at 10% level. ** Significance at 5% level. *** Significance at 1% level.

Table 4 shows the results of additional robustness tests including adding more control variables and removing outliers from dependent and independent variables. As shown in panel A of Table 4 after adding additional control variables we found the positive and significant impact of GE on patents with a coefficient of 0.070 and significant at 1%. Similarly, after adding more control variables the GE shows a positive and significant impact on trademarks with coefficients of 0.016 with a 1% significant level. Moreover, the further robustness results in panel B of Table after removing outliers from number patents application indicate that government effectiveness is significantly positively

related to number of patents and trademarks with coefficients of 0.040 and 0.008 at 1% and 5% levels of significance respectively. Additionally, the results in panel C of Table 4 show that GE has a positive and significant impact on both the number of patent applications and trademarks after removing the outliers from trademark applications. The finding further shows that after removing outliers from the independent variable GE is also consistent with our baseline results as shown in panel D of Table 4.

Robustness test through different groups of countries

We divided all 58 countries into two groups i.e. OECD countries and Non-OECD countries to test the impact of GE on technological innovation.

Table 5: Negative binomial estimation to investigate the impact of GE on technological innovation in OECD and Non-OECD countries

	OECD countries		Non-OECD countries	
Variable	Patents	Trademarks	Patents	Trademarks
Government effectiveness	0.016(.011)	0.010***(.003)	0.034***(.015)	0.004(.006)
High-tech				
Export	0.050***(.007)	-0.007***(.003)	-0.008(.011)	0.0087(.003)
Industry	0.052***(.018)	-0.029***(.008)	-0.029*(.017)	-0.028***(.004)
Labor	0.139***(.006)	0.076***(.002)	0.157***(.014)	0.077***(.003)
R&D	0.100***(.014)	0.009***(.004)	0.057***(.013)	0.020***(.006)
Trade openness	-0.085***(.019)	-0.029***(.008)	0.061(.038)	-0.018(.013)
Population density	-0.012***(.004)	0.001(.001)	0.050***(.015)	0.010***(.004)
FDI	-0.003(.003)	0.001(.001)	-0.054***(.023)	0.009(.004)
Domestic investment	0.059*(.031)	0.141***(.014)	-0.023(.081)	0.091***(.022)
Constant	-0.605***(.135	0.712***(.069)	-0.464***(.181)	0.799***(.097)
Observations	446	448	187	183
R^2	0.12	0.03	0.17	0.02

* Significance at 10% level. ** Significance at 5% level. *** Significance at 1% level, robust standard errors are in parentheses

The empirical results in Table 5 indicate that GE has a positive and significant impact on trademarks however it has a positive but insignificant impact on a number of patent applications in the case of OECD countries. Furthermore, the results indicate that GE in Non-OECD countries is positively and significantly increases the number of patent applications, whereas it has a positive yet insignificant impact on trademarks.

Discussion

This study empirically and theoretically analyzed the relationship between GE and technological innovations. The findings of this study confirmed that government effectiveness significantly enhances technological innovation in countries.

The number of patent applications and trademarks is considered a quantitative measure of innovation in academic literature. National innovation can be increased through effective government policies regarding innovation and new technologies. Effective government enhances innovation activity through productive government policies such as: providing innovation subsidies to firms, awarding firms for achieving new patents or trademarks, and providing technical support. Proper enforcement of rules and regulations, ensuring the protection of intellectual property rights and copyrights encourages firms to involve in innovative activities.

A safe and good investment environment can be developed by an effective government which in turn increases domestic investment and attracts both foreign talent and FDI. Moreover,domestic investment and FDI are considered key factors for innovation adoption.Most the developing countries have a lack efficiency to produce high

technology, even having more natural resources; henceforth, these countries seek FDI for technology transfer. In addition, countries fascinate FDI to achieve new technology, skilled labor, and other reverse engineering processes. MNCs have the potential to produce high technology, which increases competition in the world market. MNCs invest more in R&D, which creates the latest ideas, new methods of production, and processes, which enhances innovation and technological advancement in the host country.Effective government boosts economic activities by ensuring security stability, political stability, rule of law, transparency, and pro-business fiscal policies to increase domestic investment and attract FDI (Boswell & Richardson, 2003).

Besides that, an effective Government allocates more budgets toR&D for innovation and higher education to produce more researchers and technicians. These activities enhance the overallresearch and development activities in the country which in turn increases national technological innovation. However, there are mixed results on the impact of government subsidy on firm innovation. According to HewittDundas and Roper, (2010) enterprises lack resources for R&D investment and the risk of R&D investment diverts the firm decision for innovation investment. Hence the government subsidy can reduce the cost and risk of innovation which impacts positively enterprise innovation activity. In contrast, Clausen, (2009) found in the study that government subsidy negatively impacts an enterprise's innovation performance due to the crowding out effect of government subsidies. Furthermore, Lin and Luan (2020) analyzed the impact of government subsidies on technological innovation in China's photovoltaic enterprises. Their findings indicate that the provision of government subsidies positively enhances innovation performance. Our study empirically confirmed that GE enhances innovation activity in countries.

Conclusion

We empirically analyzed the impact of GE on technological innovation by using a panel data set of 58 countries. The empirical results from OLS and negative binomial estimation confirm that GE enhances technological innovation through effective government policies. Furthermore, the results of robustness analysis from panel quantile regression support our results. The empirical findings from additional robustness tests and different groups of countries (OECD and Non-OECD) are also in line with the baseline results of this study.

Policy implications

Based on the empirical results of this study following policy measures are suggested to boost innovation activity through effective governance.

Governments should focus on pro-business policies, ensuring political and security stability for sustainable domestic and foreign investment in the country. Moreover, governments should invest more in R&D. In addition; the cooperation mechanism between universities and industries should be strengthened.Providing modern training to the worker to increase trained human capital. Furthermore, it is also necessary to ensure intellectual property rights, copyrights, proper enforcement of rule of law, and transparency. Through these efforts, the national innovation activity can beraised in the countries.

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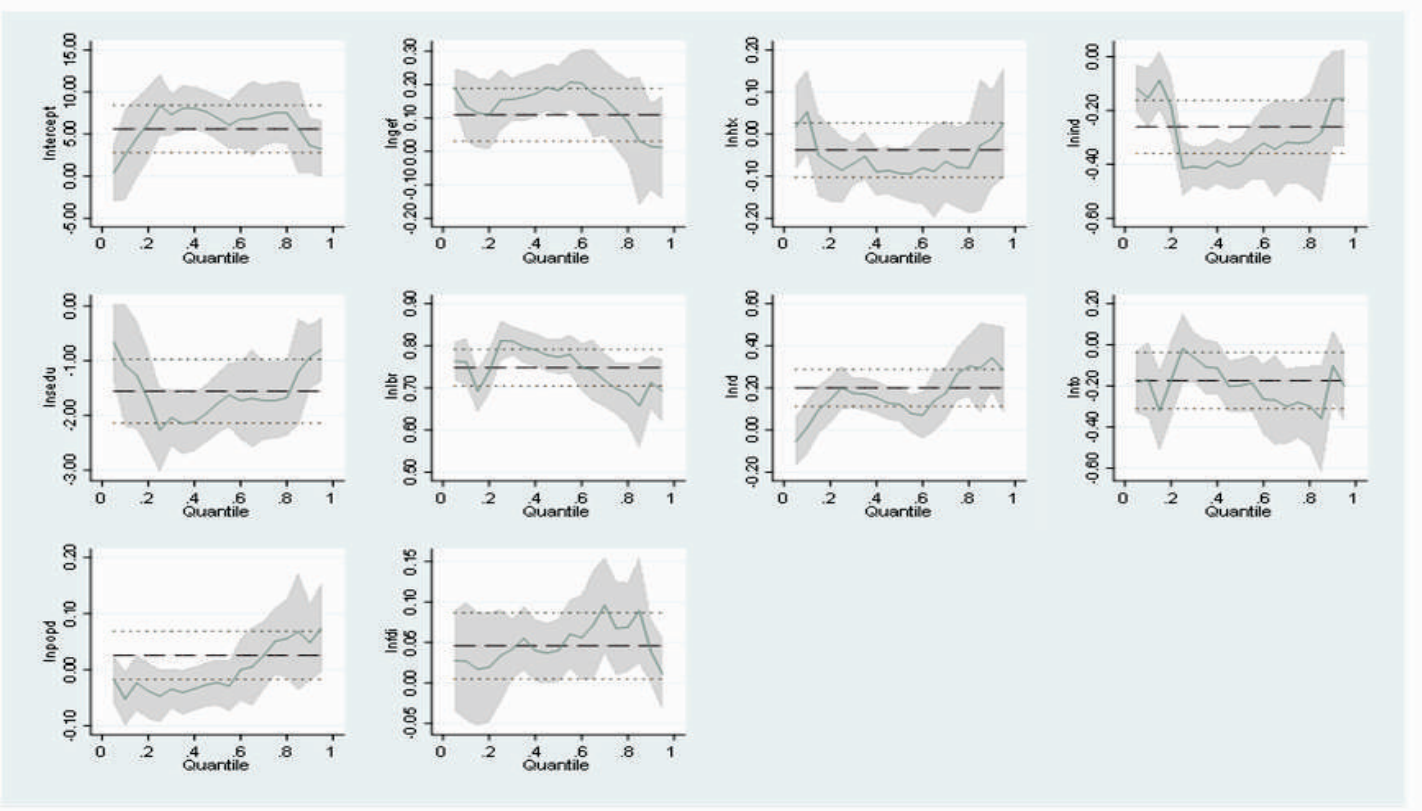
Appendix

Figure A: Estimates across quantiles (baseline).



List of countries

Country name	Country name	Country name	Country name
Australia	Estonia	Japan	Slovak Republic
Austria	Ethiopia	Korea, Rep.	Slovenia
Belgium	Finland	Latvia	South Africa
Brazil	France	Lithuania	Spain
Brunei Darussalam	Georgia	Malaysia	Sweden
Bulgaria	Germany	Malta	Switzerland
Canada	Greece	Mauritius	Thailand
Chile	Hong Kong SAR, China	Mexico	Trinidad and Tobago
China	Hungary	New Zealand	Tunisia
Colombia	Iceland	Norway	Turkey
Costa Rica	India	Panama	United Kingdom
Croatia	Ireland	Philippines	United States
Cyprus	Israel	Poland	Uruguay
Czech Republic	Italy	Portugal	
Denmark	Jamaica	Singapore	