Determinants of Innovative Activities: Evidence from Europe and Central Asia Region

Lau, Chi Keung Marco and Yang, Fu Steve and Zhang, Zhe and Leung, Vincent K.K.

Northumbria University, United International College, Eastern Kentucky University

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Lau Chi Keung Marco
Newcastle Business School
Northumbria University
Newcastle, UK
Email: kenlau123@hotmail.com

Yang Fu Steve
Division of Business and Management
United International College
Beijing Normal University-Hong Kong Baptist University
Zhuhai, China
Email: steveyang@uic.edu.hk

Zhe Zhang
Department of Management, Marketing and International Business
School of Business
Eastern Kentucky University
Kentucky, USA
Email: zhe.zhang@eku.edu

Leung Vincent K.K.
Division of Business and Management
BNU-HKBU United International College
Zhuhai, China
vincentleung@uic.edu.hk

Abstract

Recent studies in the innovation literature reveal that Foreign Direct Investment (FDI) promotes the innovation activities in the recipent country through spillover effects. In this paper we extend the existing literature by incooprating the corruption index in the estimation procedure. Using a cross-country analysis from the Europe and Central Asia (ECA) region , covering 57 countries over the period of 1995-2010, we find no evidence of FDI spillover effect on innovative activity. However, corporate corruption and expenditure on education sector are positively related to the number of patents applications. Our study shed light on the national innovation activities and anti-corruption programs.

Keywords: Foreign direct investment; Corruption; Innovation; Technology transfer
JEL classification: O32, O34, O38, F21, D73

1. Introduction

The global economy has yet to shake off the fallout from the crisis of 2008-2009. Based on estimation of the International Monetary Fund, the gross domestic product of eurozone economy will face 0.1% decline in 2013. A long-term policy is needed to promote sustainable economic growth. Innovation has been widely recognized as a key drive of economic growth and identifying the determinants of innovation is a crucial first step for designing effective policies to enhance economic development and growth. However, despite several studies on this topic (for instance, (Anokhin and Schulze 2009)), there is still limited empirical evidence about how countries can promote their innovative capacity.

Corruption is a major obstacle for economic development for developing countries. Corruption impedes FDI, increases transaction cost and limits entrepreneur's market (Anokhin and Schulze 2009). More importantly, corruption delay the permission of licenses and reduce trust of entrepreneur on institution, therefore it impedes the process of innovation. However, some research also shows that corruption can grease the wheel of economic development by speeding the bureaucratic process and jumping policy hurdle (Wang and You 2012; Chen, Liu et al. 2013). With limited and mixed empirical evidence on the influence of corruption on innovation, therefore we need to empirically study what is the impact of corruption on innovation.

The aim of this research is to make a modest contribution towards filling those gaps in existing literature. Our results indicate that research and development expenditures and education expense play a critical role in promoting innovative activity. However, FDI dose not have any influence on innovation, and surprisingly, corruption indeed grease the wheel of economic growth and promote innovative capabilities of countries in ECA region.

Obviously, a single empirical research cannot come up with firm conclusions about what factors influence innovative activity among all countries. However, it can shed some new light on national economic policy issues that are also being investigated in other studies on the subject. Our research will help countries in ECA regions to develop powerful policy to promote regional economic growth, such as focusing on education and R&D. Another contribution of the paper is to reveal the effect of corruption on innovative ability.

The rest of the paper is structured as follows. Section 2 presents the theoretical framework of the research. Section 3 presents the data and methodology. Section 4 describes and discusses the empirical results, and section 5 offers some concluding remarks.

2. Theoretical Framework

It has been well established in the literature that innovation promote economic growth, and an increasing number of researchers start to investigate what factors determine the innovative ability of a country in the last few years. One stream of literature focuses on the importance of inputs in the production of knowledge, such as research and development expense, and number of scientists (Acs, Anselin et al. 2002; Furman, Porter et al. 2002). However, new knowledge cannot be produced in vacuum, institutional factors, stated by national innovation system theory, are another strong determinants for innovation ability (Edquist 1997). Social and economic institutions demonstrate the variance of innovation ability among countries, for example, economic development (Grande and Peschke 1999), patent rights protection (Varsakelis 2001) ,and quality of education (Varsakelis 2006).

FDI has been well recognized as an important factor in national innovation system to promote innovative activities through spill-over effect (Baskaran 2008). Local firms in host country benefit FDI from a number of ways. First of all, local firms can imitate the designs of the new developed product of foreign companies by reverse engineering, and build up new innovative product. Secondly, employment and training supplied by foreign firms can enhance the quality of human resource, and those skilled labors will move to other factories in host countries, and therefore knowledge is transferred to other domestic companies. Thirdly, FDI can produce "demonstration effect". The foreign products in market can stimulate domestic competitor's innovation to generate ideas for innovative product. Lastly, FDI can promote technological know-how transfer vertically from foreign investing firms to local suppliers through knowledge exchange and training. Then local suppliers can develop innovative products based on vertically spillover knowledge.

The outcome of innovation activities is difficult to measure, however the number of patent is a good proxy to reflect innovation activities in each countries(Acs, Anselin et al. 2002). In this paper, we focus on the definition on the OECD manual (OECD 2005), and broadly innovations can be categorized into four different types: *Product Innovations:* Introduction of a good or service that is new or significantly improved with respect to its characteristics and intended uses. *Process Innovations:* Implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. The process innovations can be intended to decrease unit costs of production or delivery. *Marketing Innovations:* Implementation of a new marketing method involving significant changes in product placement, promotion etc. Examples of marketing innovations include introduction or obtaining new product licensing. *Organisational Innovations:* Implementation of new organisational method in firm's business practices, workplace organisation and external relations.

Another important factor which influences innovative activities is the efficiency of political institutions (Varsakelis 2006). In national innovation system, dynamic networks of policies and institutions influence knowledge transfer among different countries and also within each country's domestic industries. In order to absorb knowledge from foreign countries, an institution needs to implement policies that facilitate domestic firms to use and diffuse these technologies within domestic industry. Previous research has shown that the intellectual property protection framework influences a country's innovation ability (Varsakelis 2001). A country's ability to enact a law bases on the quality of institutional agencies such as political stability and judiciary system. Efficient judiciary system can provide better protection on patents and therefore, entrepreneurs have higher incentive to innovate. However, countries with high corruption and low enforcement of law will affect diffusion of knowledge and impede innovation. Research shows that corruption and abuse of public power undermines the foundations of institutional trust and consequently hinder the innovative ability of entrepreneurs (Anokhin and Schulze 2009). In the literature, corruption has been widely used as a proxy for the efficiency of political institutions (Mauro 1995; Varsakelis 2006).

Despite the fact that a growing number of studies demonstrate importance of national innovation system in developed countries, limited research has been conducted to investigate national innovation system approach specific to developing countries. Therefore in this study, we choose European and Central Asia (ECA) regions to study country specific effect of national innovation system. One reason for choosing ECA region is the fact that spatial proximity is an important force which facilitate flow of information and knowledge, as documented in the literature on innovative activity (Jaffe 1989; de Dominicis, Florax et al. 2012). It has been well accepted that geographic proximity aid learning processes through mechanisms of knowledge spillovers, especially sticky knowledge. Tacit knowledge is un-codified and can only be acquired through the process of social interaction. The chance that tacit knowledge is transferred from one region to another region decreased when the geographic distance increase. Therefore, the closer a country to other innovative countries, the more chance of knowledge transfer between two countries and the more likely recipient countries exhibit a high capacity to introduce new products or processes.

One of major obstacles currently faced by ECA countries is corruption, which is common among emerging countries. Substantial research has demonstrated detrimental effect of corruption on economic development. It is well recognized that corruption increases agency costs, limits firm's revenues, undermine institutional trust (Mauro 1995) (need to add a new one). However, due to the complex relationships and associated data limitations for conducting studies[1], the direct impact of corruption on innovative activity is still not clear based on current empirical studies. Especially, entrepreneurs in developing countries often encounter corruption problems, and resource was allocated based on the relationship with government, usually through bribing. Therefore, it is even more important to investigate whether and to what extent

[1] Only few studies have been related to this issue, and these provide mixed evidence. For example, Anokhin et al. (2008) find that countries with higher control of corruption (derived from World Bank's Worldwide Governance Indicators) are associated with higher number of patents application. Mahagaonkar (2008) find that corruption has a positive effect on marketing innovation and negative effect on product innovation and organization innovation.

corruption adversely affect the innovation activity in emerging countries. To date, this research topic has rarely been tested in empirical studies, and our study will fill some gaps in the current literature.

The Corruption Perception Index (CPI) is calculated by Transparency International and has been widely used as a measure for corruption (Varsakelis 2006). CPI is based on survey of business people and industry expert over hundred countries. It measures those persons' perception about the level of corruption in particular country. However, this subjective measure may not truly reflect the local situation. Instead of using perception, we adopt a real measurement which is collected by World Bank. We use firm's informal payments to government as a measurement of corruption. This variable measures the percentage of firms that pay informal payments or gift to the public officials in a particular country.

Previous studies on national innovation system have analyzed the impact of corruption and FDI on innovation in separate but parallel research paths. In this study, we explore how the corruption and FDI together affect the innovation activities in ECA countries. This approach distinguishes our study from all previous empirical research which only investigate on each factor. To our knowledge, this paper is the first one to investigate the impact of FDI and corruption on innovative activities in ECA regions.

3. Data and methodology

3.1 The Sample

The World Bank collection of development indicators covers 256 countries, with seven regions over the world. Judged from the demographic distribution of the seven regions, we decided to focus on Europe and Central Asia (ECA) region because of its abundant data available that enable us to form a more balanced panel data, as compared to other regions. More importantly ECA region represent an interesting study on the positve spillover effect of FDI on product innovation (measured as the number of patents application in the home country) due to its local proximity nature.[2]

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[2] The diverse yet highly interdependent economies of Europe and Central Asia are a natural experiment in seeing how the emerging economies can learn from the developed European countries. In our sample, advanced European countries including: Austria, Belgium, Germany, Denmark, Spain, France, Finland, Iceland, Norway, Portugal, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Switzerland, Sweden and the United Kingdom.

Table 1. 57 Countries included in the analysis (1995–2010)

Albania	Faeroe Islands	Latvia	Serbia
Andorra	Finland	Liechtenstein	Slovak Republic
Armenia	France	Lithuania	Slovenia
Austria	Georgia	Luxembourg	Spain
Azerbaijan	Germany	Macedonia, FYR	Sweden
Belarus	Greece	Moldova	Switzerland
Belgium	Greenland	Monaco	Tajikistan
Bosnia and Herzegovina	Hungary	Montenegro	Turkey
Bulgaria	Iceland	Netherlands	Turkmenistan
Channel Islands	Ireland	Norway	Ukraine
Croatia	Isle of Man	Poland	United Kingdom
Cyprus	Italy	Portugal	Uzbekistan
Czech Republic	Kazakhstan	Romania	
Denmark	Kosovo	Russian Federation	
Estonia	Kyrgyz Republic	San Marino	

Our study is based on data from ECA and European countries for the period of 1995-2010. Number of patent application was used as a measure of innovative activity. ECA countries encountered series of transition process from late 1980s to early 1990s. Since then, inventive activity has shown a clear increasing trend and this generally positive trend has been maintained up to the most recent years for which data are available (Figure 2.1). Especially, Russian and Poland shows stronger increase in the number of patent application in this period of time.

Figure 1. Number of patent applications (1995-2010)

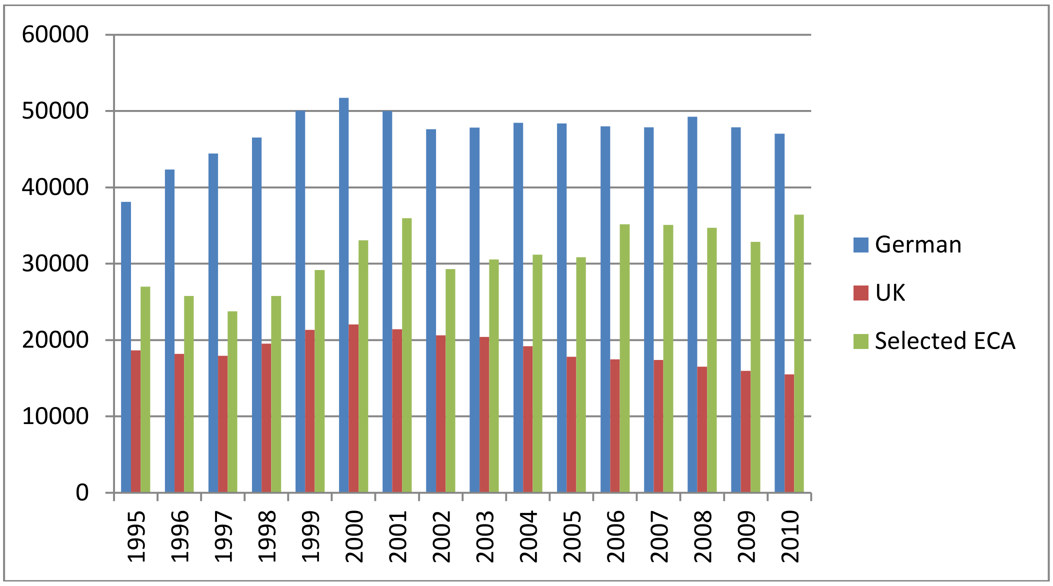

Figure 2.1 shows a long-run perspective on ECA patenting by tracking all patent applied to State Patent Office (data from World Bank indicator). Selected ECA includes: Russia, Hungary, Poland, Czech Republic, Slovenia and Ukraine.

An interesting question that which emerging countries copy innovation from European countries is usually lacked in the literature. And the number of patents applications in the well developed European countries may impose positive externality on ECA countries. In order to answer an interesting question of which emerging countries receives positive external benefits from which group of EU countries we therefore conduct granger causality test. The variable of interest is the number of patent applications. Table 2 shows the empirical findings after examining all countries in our sample, detailed statistics are available upon request. The result shows that Hungary, Czech Republic, Ukraine, Slovenia, and Estonia all benefits from the innovation activities that are initiated by Spain.

Table 2 Granger Causality Test

Spain	Germany	Belgium
Hungary	Ukraine	Turkey
Czech Republic	Rusia	Czech Republic
Ukraine	Hungary	
Slovenia		
Estonia		

Note: Evidences are based on 5% significance level

Figure 2 Maps of Granger Causality Test Results

Table 3 Summary statistics

Variable	Mean	Std. Dev.	Min	Max
Ln (Patent)	5.60	1.82	0.69	10.27
Ln (R&D Exp/GDP)	0.61	0.38	0.02	1.86
Ln (Number of Researchers)	7.12	0.74	4.12	8.24
Ln (Trade)	99.31	31.83	36.55	199.68
Ln (Education Expenditure)	22.95	1.70	19.22	27.08
Ln (FDI Inflow)	1.36	0.95	-1.77	3.95
Corruption (% of firms)	36.54	18.92	3.70	77.42

Source: World Bank Indicator

3.2 Methodology

We now turn to the empirical parts; we focus on panel regression analysis to examine the detrminanats of product innovations. Following Cheung and Lin (2004) the innovation production function in its empirical form can be represented as:

$$Patent_{i,t} = \beta_0 + \beta_k X_{i,t} + FDI_{i,t} + Corrup_{i,t} + v_i + v_t + \eta_{it} \quad (1)$$

where $Patent_{i,t}$ is the number of patent application to quantify the innovation level for country i at timet; the larger the number of patent application, the higher the innovation level. $X_{i,t}$ is the matrix for the country's inputs into the R&D activities.

v_i is the fixed effect for province i, v_t is the time dummy, and η_{it} is the idiosyncratic disturbance. The idiosyncratic disturbances are assumed to be uncorrelated across the countries. Innovation is a knowledge creation process, the more the inputs the hihger the chance of success. Therefore the measure of inputs to R&D activities ($X_{i,t}$) includes:

1. NUMBER OF R&D RESEARCHERS

The variable measures the number of personnel (experts) in the R&D sector, it proxy the labour input to the R&D activity. We expect positive association bewteen this control variable and the number of patents applications.

2. R&D EXPENDITURE PER CAPITA GDP

This variabe measures the R&D intensity, it proxy not only the quantity of resources deveotd into the R&D activities but also the quality of capital and human resources into R&D processes. Following Cheung and Ping (2004) we use the amount of expenditures spend on R&D sectors to poxy the resources, such as technicians, equipments and scientists that used to create new knowledge. We again expect positive association between this variable and innovation.

3. EXPENDITURE ON EDUCATION

Since general eduxation is the foundation of any innovation activities, therefore we use exenditures on education , which was genrally ignored in the literature to proxy the positive externality effect of genral education as a public goods. We expect postive relatiohsop between this variable and the inoovation outcome.

4. OPENNESS

Here we also include the variable "OPENESS" , defined as the summation of imports and exports, to test if domestic firms can benenfit in domestic innovation from participating in the ovrseas markt. Hoever we expect this effect is week and even negative. Cheung and Ping (2004) finds that FDI firms with larger export–output shares cannot signigicantly benefit from intrnational trade because the FDI firms come to China only to utilize its cheap labor, and hence the technologies they bring in are mostly labor intensive and the spillover effects on domestic innovation is not strong. In our study FDI firms's export to GDP ratio is generally not avaible for ECA coutnries. Therefore we expect even a negative effect assocaited with innovation and openss becuase most of these emerging markets only perform labor intensive process and lack of incentive to do its own nnovation if their economy is too much relie on exporting labor-intensive peoducts. Moreover, trade can pose negative impact on innovation through competition[3].

Turning to FDI, as we discueed extensively spillover effects of FDI may have positive influence on the number of domestic patent application. However the uncertainty of this hypothsis come from two sources. First this assumed association all depends on the form of ownership structure of the enterprises. Obviosuly, foreign joint ventures and cooperative businesses are able to gnerate positve spillover effect than exclusively foreign-owned enterprises for instance. More importantly corruption may trigger FDI and hence the effect of FDI on innovation may be biased when the vaiable of corruption is ommited. Therefore in our empirical regression model we include the variable of corporate corruption ($Corrup_{i,t}$), which measures the percentage of firms that pay informal payment or gift to the public officials in a particular counry. As we emphasized in the literature, there is lack of research on the association of corporate corruption and innovation activities, espcially for the emerging markets, where resource allocation is often shaped by political connection. As a result, it is important to know whether and to what extent corruption is adversely affect the innovation activity of in emerging countries. To date, the impacts of corruption on innovation have rarely been empirically tested. In this paper, we aim to fill some gaps in the existing literature by focusing on whether corruption can adversely affect the innovation ability of firms in ECA region. In contrast to emerging markets, anti-corruption programs and regulations are well-established in the developed countries alike Western Euoropen countries like Germeny and France. Unfortunately the corporate corruption data is not avaible for developed countries, otherwise it would be interesting to conduct a compartive study to compare the impact of corporate corruption for emerging and developed markets.

[3] As noted by Onodera (2008), an increase in competition can have both positive and negative effects on innovation depending on levels of existing competition, nature of the industry, and existing levels of technology.

4. Empirical Result

Several estimation methods are considered in this study. Column 1, 3, and 5 of table 4 shows the baseline random effect estimation[4] of determinants of innovation activities countries from ECA region. Several empirical findings are apparent. Column 1 shows the baseline modeling of the determinants (control variables) of product innovation. In general we observe positive correlation between R&D personnel and innovation activities, even though only model 3 is statistically significant at 10% level, while the coefficient in model 1 is marginally significant. For all random effects models, the expenditure on R&D intensity has positive impact on product innovation, indicating that the success rate of innovation becomes higher when the country devotes larger amount of resources to the sector, and the results are expected and consistent with the existing literature. However, there is no guarantee of having more innovations even when more human capital, as measured by the number of researchers is working in the sector. The estimate for public expenditure on education is positive and statistically significant at 1% level, supporting the hypothesis that the higher the investment of a society in general education, the more efficient the innovation sector will become, as positive externality exists. The negative impact of openness on innovation activities is observed, and this finding implies that the negative effect on innovation raised from increase in competition outweighs its positive contribution to innovation activities. As suggested by Onodera (2008), the mixed effects of openness on innovation depending on levels of existing competition, nature of the industry, and existing levels of technology.

Table 4: Determinants of Innovation

	(1) RE	(2) SGMM	(3) RE	(4) SGMM	(5) RE	(6) SGMM
Number of R&D Researchers	0.466	-0.0707	0.460*	-0.378	0.191	0.548
	[1.64]	[-0.14]	[1.69]	[-1.02]	[0.59]	[0.42]

4 We use heteroskedasticity-robust standard errors clustered at the country level, such that the computed t-values have been taken into account of the within-country but between-year correlation. The Hausman specification test indicates that the random effect model should be used. Results are not shown here to save space.

R&D EXPENDITURE	0.422**	0.105	0.469***	0.325	1.080***	-0.380
	[2.27]	[0.30]	[2.71]	[0.78]	[2.67]	[-0.10]
OPENESS	-0.00996***	-0.0214**	-0.0105***	-0.0207***	-0.00985	0.00924
	[-4.00]	[-2.21]	[-3.88]	[-2.73]	[-1.57]	[0.58]
EXPENDITURE ON EDUCATION	0.384***	0.824***	0.365***	0.803***	0.738***	1.138***
	[3.85]	[5.85]	[3.65]	[6.29]	[7.14]	[3.06]
FDI INFLOW			0.0583*	0.0889	0.0891	-0.254
			[1.94]	[1.22]	[0.88]	[-0.30]
CORRUPTION OF FIRMS					0.0132*	0.0438***
					[1.92]	[2.94]
Constant	0.394	-9.667***	1.068	-7.562*	-6.494***	-20.05
	[0.21]	[-3.75]	[0.61]	[-1.86]	[-3.13]	[-1.48]
Observations	401	380	392	371	51	51
Adjusted R^2	0.570		0.505		0.815	
AR(2) p-value		0.178		0.138		0.143
Hansen p-value		0.418		0.639		0.539

t statistics in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We now turn our focus to the spillover effect of FDI on innovation. It seems that the positve spillover effect of FDI exists; however, this effect disappears once we include the variable of corporate corruption. Conlumn 5 reveals the fact that the higher the percentage of firms that pay informal payment or gift to the public officials in a particular counry, the higher is the number of patents applications. This finding is not surprising since resource allocation is often shaped by political connection, and firm's innovation is no exception. Therefore, we conclude that innovation activities in the ECA region cannot truly reflect the innovation outcomes because the numbers of patents applications is connected to corruption activities. Corruption can adversely affect the innovation ability of firms in ECA region. The job of patent exminers is to examine whether the claimed innvenion application should be granted the patent. The quality of patents applications are adversely affected because the salary of the patent examiners are not high in emerging countries. Also, the growth of corruption , nepotim, non-transparent practices, and non-accountability of admistractive officers who are in power also cause inefficieny of the patent office in assessing and approving patent applications. Therefore it is important to establish an effective anti-corruption compliance program in order to prevent and detect patents applications which are not up to standard. We can conclude that R&D intensity is the most important determinat of innovaton actvity, followed by expenditure on education.

For robustness check of findings for the estimates reported in Table 4 using random effects method (column 2,4, and 6 in table 4), we adopt Windmeijer (2005) general method of moment (SGMM) system panel data estimator, with the two-step finite-sample correction, to deal with the handle possible endogenity of the independent variables, raised possibly from simultaneity bias, reverse causality and omitted variables. In our case the more open is the international trade (openness), it may stimulate more domestic innovation in face of intense competition. However the reverse causality can happen; whereas more innovations may create more trade opportunities. The same may happen for the relationship between corporate corruption and innovation. It may be in the direction that more patent applications attract more frequent bribery activity. And the use of GMM estimation can overcome the endogeneity bias, and control for fixed effects and time effects, and multiple endogenous variables. In our paper we use system GMM because the conventional dynamic GMM coefficients will be biased for small samples if the series are near unit root processes, and the instruments variables are weak.

In order to check for the consistency of the GMM estimator, we use Hansen test to detect overall validity of the instruments, under the null hypothesis that the residuals and instrumental variables are not correlated. In our model we also perform a second order autocorrelation test for the residuals, to test whether second order serial correlation exists in the estimation models. As we can see the presence of the lagged dependent variable gives rise to autocorrelation, with correlation of 0.991 between patents applications and its first lag. We used the "xtabond2" Stata routine developed by Roodman (2005). The explanatory power of the random effects model is quite satisfactory, with R^2 of 0.815 after taking into the effect of corporate corruption. (See column 5, table 4) However, the results for GMM estimates are also provided for robustness checking because of the potential endogeneity problem. This study uses a two-step estimator, which is asymptotically efficient and robust to any pattern of cross-correlation and heteroskedasticity (Roodman, 2006). Even though there seems no prior knowledge regarding exogeneity of regressors we use the number of telphone line as the IV. The corrleation coefficient between numbers of telephone lines and corruption is -0.573 while the correlation coefficient between numbers of telephone lines and patents applications is 0.222. The result of the SGMM estimation is shown in the column 2, 4 and 6 of Table 4. The validiy if IVs are checked by using Autocorrelation AR(2) test, and Hansen test. The instruments used in the model are valid as we can see from the results of the above two tests. When we compared the results of SGMM (column 6) with the FE results (column 5) we find that expenditure on R&D activity and numbers of personnel are not significant for the number of patents applications. Interstingly the coefficient and its statistical significance increases in the SGMM estimation, and this result futher concide with our argument that the numbr of patents applications are not an accuartate indicator of innovation activities. Instead higher number of patents applications in emerging economy is associated with bribery. Our empirical results regarding the relationship between patents applications and corporate corruption is robust for a variety of models.

5. Conclusion

As the world becomes flat, the interests in entering global markets have surged phenomenally. Since markets differ significantly in their business environments, firms are cautious in choosing which market to enter. In this study, we attempt to provide a deeper understanding of how countries differ with respect to their innovations. Specifically, we investigated the effects of FDI, corruption and educational expenditure on innovation. Using World Bank's archival dataset that contains 57 countries, we found that FDI, educational expenditure, and corporate bribery are positively related to innovations. The interesting finding of positive effect of bribery on patents applications posts caution on the fact that corruption hinders the real innovation activities.

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