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How do foreign firms' corruption practices affect innovation performance in host countries? Industry-level evidence from transition economies

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ABSTRACT

Using data from the Business Environment and Enterprise Performance Survey (BEEPS), this article investigates how foreign firms' involvement in corruption practices affects the innovation behaviour and performance of their direct competitors in transition economies of Eastern Europe and Central Asia. By unbundling corruption practices into *grand* and *petty* corruption transactions, this paper contributes to deepening the analysis of the 'grease the wheels' versus the 'sand the wheels' effects of corruption on innovation performance. Our empirical results indicate that grand corruption stifles the propensity of firms in the same line of business to conduct R&D activities and to bring new or upgraded products and services to the market, whereas petty corruption of foreign firms tends to foster major innovations in the domestic market. Domestic firms' involvement in petty corruption appears to be detrimental to innovation efforts and incremental innovation, but not to major innovation.

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Transnational corruption; R&D; innovation; discrete choice model

1. Introduction

> Unless the exchange be in love and kindly justice, it will but lead some to greed and others to hunger (Kahlil Gibran (1923), The Prophet).

Innovation has increasingly been recognised as the main driver of long-term firm growth and competitiveness (Audretsch, 1995; Baumol, 2002; Christensen, 1997; OECD, 2007). It is therefore one of the key areas in which corporate managers seek to acquire or retain an advantage over their competitors. Quite often, this kind of competition takes the form of jostling and fencing (potential) innovation adversaries out of lucrative markets and this fencing is not always done with good form. Striving to gain and keep a competitive edge in innovation frequently takes place through unfair methods, sometimes involving large scale corruption practices. This is especially the case for multinational corporations which engage in bribing local officials in their host countries, taking advantage of looser governance standards where anti-corruption laws are less likely to be enforced than in their home markets where corruption is much less accepted (Moran, 2006). This form of corruption practice covertly deployed across national boundaries has been a recurrent phenomenon

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in developing and transition economies, especially in high state capture countries, where foreign firms were found to be almost two times more likely to engage in practices of grand corruption than their domestic counterparts (Hellman, Jones, & Kaufmann, 2002).[1] When powerful foreign firms use cross-border corruption to gain unfair advantages over their competitors, domestic firms are put at a disadvantage and can even be driven out of business altogether.

Corruption is a phenomenon that has afflicted human societies since time immemorial and its effects on growth and economic development have by and large been recognised as being significantly inhibitive (IMF, 2016; Murphy, Shleifer, & Vishny, 1993; Tanzi & Davoodi, 1998; Ugur, 2014; Ugur & Dasgupta, 2011). The International Monetary Fund (IMF) has estimated the global cost of bribery alone to be USD 1.5 to 2 trillion per year in 2015 (2% of World GDP), without taking into account the other social and economic costs of corruption, which are much larger (IMF, 2016). Although a number of studies have argued that bribing opportunity can also speed up business transactions and positively affect economic growth in the so-called 'efficient wheel greasing' argument (Kaufmann & Wei, 1999; Leff, 1964; Lui, 1986),[2] the most commonly held view in the literature is that corruption harms growth by undermining the entrepreneurial climate and thus lowering the investment rate in the economy (Aidt, 2009; Dimant, 2014; Mauro, 1995; Shleifer & Vishny, 1993; Wei, 2000). Given the fact that many countries, especially in East and South-East Asia have managed to enjoy high rates of growth over long periods despite substantial levels of corruption, the mechanism through which corruption affects growth remains puzzling to the accepted wisdom and necessitates further scrutiny.

The adverse effects on investment rates are, moreover, not sufficient to explain the long-run effects of corruption on growth. Indeed, since the emergence of endogenous growth theories, it is generally accepted that what drives economic growth in the long run is not merely the investment rate but rather the rate of innovation in the economy (Aghion & Howitt, 1992; Grossman & Helpman, 1991b; Romer, 1990). In order to better grasp the long-term effects of corruption on economic growth, it is therefore crucial to turn the lens on how it affects the rate of innovation. We posit that the observed stifling effects of corruption on long-term growth run primarily through its inhibitive impact on innovation performance, while the wheel greasing effects of speed money may foster innovation in industries where regulations are cumbersome.[3]

While some theoretical studies, like Shleifer and Vishny (1993), Wei (1997) or Blackburn and Forgues-Puccio (2009), have attempted to model the differences in the effects of corruption on economic outcomes as being explained by the difference in coordination and predictability of corruption practices, there has been little empirical evidence to support these models. A major reason for the lacking empirical evidence may lie in the fact that most of the studies testing the 'wheel greasing' versus the 'wheel sanding' effects on innovation used corruption perception measures or corruption frequency without unbundling the corresponding types of corruption practices and their intensity. Likewise, the measures of innovation used in those studies have rarely attempted to distinguish between various types of innovation or its components.

One of the few exceptions to this is Mahagaonkar (2010), who distinguished between various types of innovation and showed that corruption can indeed stifle organisational and product innovation, while having positive effects on marketing innovation and no significant effect on process innovation. Distinguishing between the various innovation activities can thus hold the key to a closer understanding of the conduits of the 'wheel greasing' and 'sanding' effects. We contribute to deepening the analysis of the 'wheel greasing' versus 'wheel sanding' hypothesis by a triple unbundling of innovation activities and corruption practices. First, we unbundle innovation performance by distinguishing the various components: innovation effort as indicated by R&D investments, incremental innovation measured by the introduction of improved products or services, and major innovations indicated by the introduction of entirely new products or services to the local or global market. Second, we unpack firms' corruption practices by categorising them into acts of *grand corruption* (involving public procurements and other contracts with the government) and *petty corruption* (mainly involving speed money and related bureaucratic bribery to overcome red tape). Furthermore, we analyse the corruption behaviour of firms at the industry level, i.e., we estimate the effects of firms' corruption practices on their direct competitors in the same line of business. We also distinguish between corruption behaviour of foreign firms versus domestic ones. Indeed, on top of the well-known stifling effects of domestic corruption on growth, the phenomenon of transnational corruption may unsettle the entrepreneurial climate in host countries and entail different experiences between domestic and foreign firms with respect to corruption practices in the host country. The latter can indeed feel less constrained in their dealings with local officials in the host economy if they make handy use of loopholes in their home country's anti-corruption regulations as indicated by Moran (2006).[4] This is especially valid in developing and transition economies, where dealings often involve powerful foreign corporations with considerable leverage over local public officials (Carrington, 2010).

As pointed out by Aidis, Estrin, and Mickiewicz (2012) and the World Bank (2011) among others, the privatisation wave that took place in the transition economies of Eastern Europe and Central Asia in the wake of the collapse of the Soviet Union has given rise to an unprecedented opportunity for bribery and instances of state capture. The resulting corruption practices have been perceived ever since as culturally embedded and only very slowly responsive to changes in institutional regulations. After unbundling innovation activities and corruption practices, we test whether foreign corporations operating in such an entrepreneurial environment characterised by entrenched corruption practices ultimately see their innovative strategies suffer from the burden of corruption, or conversely, leverage their advantage in bribing opportunities as a strategy for better innovation efforts and outcomes (thereby greasing the innovation wheels). For that analysis, we use the fourth wave of the Business Environment and Enterprise Performance Survey (BEEPS), a joint initiative of the European Bank for Reconstruction and Development (EBRD) and the World Bank, which collects firm-level data in Transition Economies of Eastern Europe and Central and Western Asia. This rich dataset enables us to analyse not only the effects of corruption occurrence on innovation performance, but also to estimate how innovation behaviour is affected by corruption intensity in any given industry of our analysis. To our knowledge, this is the first time that the effects of corruption on innovation are empirically analysed in a detailed triple decomposition, whereby at the same time a recursive model is applied to mark the interdependence of the different components of innovation performance. We find no stifling effect of grand corruption by domestic firms on the three innovation measures. Transnational *grand corruption*, however, is found to have stifling effects on the propensity of firms in the same industry to conduct R&D activities and to bring upgraded and new products and services to the market. As for acts of *petty corruption*, only domestic firms' participation in corrupt practices appears to be detrimental to innovation efforts and incremental innovation, but not to major innovation.

The remainder of the paper is structured as follows. Section 2 reviews the theoretical and empirical literature explaining corruption behaviour in a transnational context and examines the nexus between corruption and innovation behaviour from which we derive our arguments. It also builds on these arguments to formulate theoretical hypotheses to elucidate the mechanism through which the observed innovation outputs are generated at industry level. Section 3 describes the firm-level data where the targeted countries and business sectors are listed, and the data cleaning is described. Furthermore, the measures of corruption and innovation are described, and descriptive statistics are presented. Section 4 explains our simultaneous-equations discrete choice model which is estimated by full information maximum likelihood (FIML). The average partial effects that quantify the effects of the explanatory variables on the dependent variables are described in that section. Section 5 discusses the findings and section 6 draws some conclusions regarding the implications of corruption effects on innovation.

2. Corruption and innovation: theoretical background and hypotheses

The literature on the effects of transnational corruption behaviour on the local economy has followed two opposing views, one strand claiming that the presence of foreign firms reduces corruption, the other arguing that foreign firms have more needs and means to exacerbate corruption. The first view posits that foreign-owned firms, especially those from developed countries, improve the local entrepreneurial climate by importing better business practices from their home countries. The second view, however, has tended to show that foreign firms use their higher leverage on local officials to exacerbate corruption climate and gain a competitive advantage on local firms. Vernon (1971) was one of the first studies in this domain to suggest that multinational enterprises (MNEs) have strong incentives to influence host country government policies on an ongoing basis to safeguard their often substantial investments. According to Rodriguez, Siegel, Hillman, and Eden (2006), proactive steps to affect the public policy environment in a way favourable to the firm is indisputably an important aspect of international business for MNEs. Tanzi and Davoodi (1998) argue that large foreign companies have even higher incentives to bribe, since relatively small transactions from their perspective have a sizeable impact on the living standards of local officials, and therefore can be more persuasive.

As for the way corruption affects innovation, it has surprisingly received limited attention, unlike the voluminous number of studies devoted to the effects of corruption on growth. Being the main driving engine of long-term growth, innovation deserves a more prominent place in this corpus of literature. The very few studies that paid attention to this issue have generally suggested that corruption is harmful to innovation and puts innovative firms at a disadvantage (Anokhin & Schulze, 2009; Starosta de Waldemar, 2012). Murphy et al. (1993), for example, argue that innovators are particularly vulnerable to extortion from government officials since they have a high and inelastic demand for government-supplied goods such as permits and licenses. Similarly, Ayyagari, Demirgüç-Kunt, and Maksimovic (2010) find that the odds of having to pay bribes increase significantly for innovative firms compared to non-innovators. As for Aidis et al. (2012), they take the view that innovation is fostered by new entry by entrepreneurs and find the perception of corruption plays a significant role in reducing entrepreneurial aspirations, thus hampering innovation. The underlying argument of these studies asserts that corruption undermines the foundations of the institutional trust needed for the development of entrepreneurial and innovative activity. By negatively affecting the magnitude of the rewards that can be earned from entrepreneurship and innovation, it reduces the incentives to invest in innovative ideas.

Nonetheless, some scholars such as Asiedu and Freeman (2009) have put forward the argument that the negative effects of corruption on innovation can be offset or even neutralised in situations where corruption creates opportunities for illicit private gains for firms, such as paying 'cash for contracts'. Indeed, in many developing countries, firms sometimes pay bribes to win lucrative government contracts, to gain access to raw materials at state subsidised prices, to obtain credit at below-market interest rates, or collude with tax collectors to reduce tax payments, which may boost their investment rate and increase their innovation capacity. Corruption can also act as a facilitator to boost the scope and scale of investments since it acts as a hedge against political risks.

Combining the arguments from the transnational corruption literature and the existing firm-level evidence on the effects of corruption on innovation, it can thus be argued that foreign firms may use corruption as a means to compete in host country markets, thereby impeding innovation or fostering it, depending on the dominant force between the 'greasing' and the 'sanding' effects. Corruption by foreign firms generally creates disincentives for other firms in host countries to invest in innovation and complex economic activities, whose payoffs become difficult or costly to monitor because they become more uncertain. Hence, local firms' motivation to compete on the basis of entrepreneurship and innovation becomes considerably challenged and may wither. One of the many reasons why the stifling effects of corruption might dominate innovation effort and outcomes is that when the rules are effective and the bureaucracy is efficient, the opportunity to bribe results in resource misallocation (Tanzi & Davoodi, 2002; Aidt, 2009; OECD, 2015). This is especially the case for grand corruption involving public procurement, whereby powerful firms (foreign or domestic) may exert their influence on public officials to bend the rules and award the contract to firms that manage to successfully bribe rather than to the most efficient or innovative ones. This will harm the innovation potential of firms competing in the same line of business, especially those that play by the rules, as they lose the market to unfair competitors. Firms that are successful in bribing have also fewer incentives to innovate, since they can substitute corruption for innovation to win contracts. We therefore conjecture that the opportunity to engage in corrupt transactions will distort innovative effort usually associated with public procurement (Aschloff & Sofka, 2009). Such corruption opportunities will more likely give a clear competitive advantage to foreign firms because of their higher leverage over local government officials mentioned above. A high prevalence of foreign firms engaged in corruption practices will thus likely have a larger impact on stifling innovation in the host economy.

Two types of corruption are considered, namely the bribery connected with public procurement, also known as *grand* corruption, and the more traditional bribery to 'get things done' referred to as *petty* corruption. This first form of corruption is found in 'the shaking hand' model of corruption (see for instance, Hellman et al., 2002; Hellman, Jones, & Kaufmann, 2003), where benefits accrue to the bribing firms as well as to the involved government officials. Two corruption variables are then considered, namely the percentage of firms in each 2-digit ISIC industry,[5] taken *separately* for each country, that engage in grand and petty corruption, and the corruption intensity, expressed as the percentage of sales devoted to illicit or facilitation payments to government officials. Because of the perceived difference in persuasive power between domestic and foreign firms in negotiating corrupt transactions (Tanzi & Davoodi, 1998), corruption variables are further broken down into foreign and domestic corruption by using an indicator variable for the foreign status of the firm, so that the corruption indicators are calculated separately for foreign firms and their domestic competitors. We then formulate the hypotheses underpinning the relationships between corruption practices in which foreign and domestic firms engage to compete and the resulting innovation behaviour (effort and output) of their direct competitors in the host country.

Hypothesis H1: In industries where domestic public procurement competition offers opportunities to bribe, both prevalence and intensity of grand corruption among foreign (and domestic) firms are likely to stifle innovation performance of firms in the same line of business in the host economy.

This hypothesis reflects the inhibitive effect of corrupt transactions on innovation in public procurements suggested by Aschloff and Sofka (2009) and the distinction between foreign and domestic firms reflects the special leverage of foreign firms on local officials. As is often the case, however, foreign firms may have access to the advantages of R&D investments made in their parent companies, in such a way that they can still introduce new product/services without having engaged in corresponding R&D effort in the domestic economy. Foreign firms' corruption practices will therefore differently affect the total innovation effort and the total rate of introduction of new products and services in the domestic economy in comparison to their domestic counterparts. For domestic firms, relatively large sums of money spent on securing contracts also reduce the resources available to spend on innovation in such procurements and can even lead to substandard procurement.

The preponderance of petty corruption by domestic (and foreign) firms is often indicative of ineffective rules or cumbersome regulations. Complexity and lack of clarity in regulations usually gives rise to difficult interpretation by bureaucrats, creates inefficiencies that firms tend to overcome by paying speed money. The more firms can get things done through speed money, the more they can have their hands free to innovate. We therefore hypothesise petty corruption to be less harmful to innovation by enabling transaction efficiency for private sector agents.

Hypothesis H2: In industries whose bureaucratic regulations are prone to petty corruption, the prevalence and intensity of speed money transactions by domestic and foreign firms may result in net positive effects on innovation performance of firms in the same line of business in the host economy.

We group firms in various business activities according to their 2-digit ISIC code and analyse how the prevalence of corrupt (foreign and domestic) firms in each business sector affects their direct competitors' innovation (effort and output) in the host countries.

3. Data

3.1. Data and their sources

The data are derived from the fourth wave of the EBRD-World Bank Business Environment and Enterprise Performance Survey (BEEPS), which was launched in 2008–2009 to collect information for the year 2007 or the period 2005–2007 on approximately 12,000 enterprises in 30 countries from Eastern Europe and Central and Western Asia.[6] The BEEPS data are collected through a stratified random sampling where the strata are defined according to the industry, the size and the region of the establishment. To collect the data, three different questionnaires are used, namely a core questionnaire that includes common questions put to establishments from all sectors, and two questionnaires for manufacturing and services with additional manufacturing- and services-specific questions that are directed only to establishments in those sectors.

Table 1 gives an overview of the targeted number of interviews for each surveyed country and, for each type of questionnaire, the achieved number of interviews resulting in a sample (before cleaning) of 11,998 establishments. The last column of the table shows for each surveyed country the number of establishments of the sample of analysis obtained after cleaning: Turkey and Russia alone represent one fifth of the cleaned sample while Albania, Bulgaria and Montenegro, for instance, represent together less than 4% of the sample.

The cleaning process leading to the sample of analysis is described in Table 2. It consists mainly in dropping those establishments for which non-responses or refusals to respond have been observed in the dataset. These problems are particularly pronounced for firms' sales and corruption behaviour where over one third of the original sample has been

Table 1. Targeted and completed number of interviews, and the sample of analysis after cleaning.

	Number of establishments					
		Completed				
Country	Target	All	Manuf.	Services	Core	Analysis sample
Albania†	200	175	65	47	63	55
Armenia	360	374	113	154	107	236
Azerbaijan	360	380	120	144	116	168
Belarus	360	273	84	126	63	142
Bosnia & Herz.	360	361	124	127	110	185
Bulgaria†	270	288	95	150	43	105
Croatia†	270	159	71	55	33	116
Czech Republic	270	250	94	90	66	149
Estonia	270	273	90	124	59	187
FYR Macedonia	360	366	115	142	109	232
Georgia	360	373	121	139	113	123
Hungary	270	291	103	105	83	229
Kazakhstan	600	544	181	203	160	288
Kosovo	270	270	98	63	109	165
Kyrgyz Republic	360	235	92	82	61	131
Latvia	270	271	89	111	71	147
Lithuania	270	276	97	113	66	173
Moldova	360	363	110	149	104	210
Mongolia	360	362	132	86	144	296
Montenegro	120	116	37	44	35	56
Poland	540	533	172	175	186	220
Romania	540	541	193	192	156	208
Russia	1260	1256	734	207	315	562
Serbia	360	388	132	158	98	245
Slovak Republic	270	275	86	97	92	129
Slovenia	270	276	102	101	73	227
Tajikistan	360	360	116	151	93	204
Turkey	1160	1152	860	165	127	702
Ukraine	840	851	487	182	182	338
Uzbekistan	360	366	121	160	85	280
Total	12,280	11,998	5034	3842	3122	6509

†Establishments in these countries were first surveyed in 2007 and then asked additional questions in 2008–2009.

Table 2. Description of the data cleaning and the resulting sample of analysis.

Cleaning criteria	Number of establishments dropped in cleaning	Number of establishments after cleaning
Sample before cleaning	11,998	
Non-response or refusal		
Innovation	281	11,717
Foreign status	116	11,601
Business activities	30	11,571
Sales	2137	9434
Exports	20	9420
Competition	525	8895
Subsidies	61	8834
Gvt. contract	63	8771
Corruption	2058	6713
Employees	13	6700
Univ. degree of emp.	174	6526
Insuf. obsv. in indus.	17	6509
Sample of analysis	6509	

dropped because of these issues.[7] Unfortunately, we can only acknowledge these problems as the actual reasons for non-response or refusal to respond are unknown. These issues should therefore be borne in mind when interpreting the results.

3.2. Firm characteristics, sector categories and country groups

Firm characteristics, sector categories and country groups, as well as the measures of innovation and corruption, are listed and described in Table 3. The firm characteristics include indicators for government contract, competition, exports and subsidies, as well as continuous variables for employment (head counts), university degree of labour force and market share. Four categories of business activities, namely manufacturing, construction, wholesale and retail trade, and services are identified according to 2-digit ISIC, and five groups of country are defined according to their corruption perception index (see Table 3 for how the groups were formed).

3.3. Descriptive statistics

Table 4 reports descriptive statistics on innovation and corruption activities of the firm in 2007 or during 2005–2007. A quarter of the firms have had R&D activities during the period 2005–2007, three quarters have upgraded existing product lines or services and 53% have introduced new products or services during that period. The table shows that 10% of the firms, that is (657/6509) ×100, are foreign firms of which 19%, that is (126/657) ×100, secured or attempted to secure a contract with the government in 2007. The mean across 2-digit ISIC industries of the rate of foreign firms that engaged in public procurement bribery (grand corruption) in 2007, given the existence of a government contract, is 29%. Half of these foreign firms had no grand corruption activities in 2007. As for petty corruption, the average industry rate of corrupt foreign firms is 20%. The grand and petty corruption figures of domestic firms can be read in a similar manner in the table.

Table 5 reports descriptive statistics on firm characteristics (other than innovation and corruption), sector categories and country groups. The firms had on average 107 employees,

Table 3. Description of the variables of the analysis.

Variable	Type	Definition
Innovation		
R&D spending	binary	1 if firm has spent on R&D activities during 2005–2007
Upgraded products or services	binary	1 if firm has upgraded existing product lines or services during 2005–2007
New products or services	binary	1 if firm has introduced new products or services during 2005–2007
Grand corruption, if gvt. Contract		
Percent firms with PPBs†	continuous	percent firms in each 2-digit ISIC industry with public procurement bribery in 2007
Petty corruption		
Percent firms with petty bribes†	continuous	percent firms in 2-digit ISIC industry with petty bribery activities in 2007
Firm characteristics		
University degree	Continuous	percent labour force with a university degree in 2007
Employment, head counts	Continuous	number of employees in 2007 that had worked for one or more fiscal years
Market share	Continuous	firm sales over sales of 2-digit ISIC industry of the firm, both taken in 2007
Export	binary	1 if firm had positive exports in 2007
Subsidies	binary	1 if firm was subsidised by the government or by the European Union during 2005–2007
Contract with government	binary	1 if firm secured or attempted to secure a government contract in 2007
Competition‡	binary	four dummies, 1 if pressure from competitors in affecting decisions to develop new products or services was unimportant, fairly important, important or very important during 2005–2007
Sector categories		
Manufacturing	binary	1 if firm belongs to ISIC (Rev. 3.1) 15–36 industries
Construction	binary	1 if firm belongs to ISIC 45 industry
Wholesale and retail trade	binary	1 if firm belongs to ISIC 50–52 industries
Services	binary	1 if firm belongs to ISIC 55, 60–64 and 72 industries
Country groups		
CPI*, rank 143–175	binary	1 if country's 2007 CPI lies between 143 and 175, the most corrupt countries
CPI, rank 79–118	binary	1 if country's 2007 CPI lies between 79 and 118
CPI, rank 61–69	binary	1 if country's 2007 CPI lies between 61 and 69
CPI, rank 39–51	binary	1 if country's 2007 CPI lies between 39 and 51
CPI, rank 27–28	binary	1 if country's 2007 CPI lies between 27 and 28, the least corrupt countries

†These variables are calculated separately for domestic and foreign firms. PPBs stands for public procurement bribes. Petty bribes are informal payments made to public officials to 'get things done' with regard to customs, taxes, licenses and regulations.
‡These variables apply to domestic and foreign competitors.
*CPI stands for corruption perception index.

Table 4. Descriptive statistics: innovation and corruption.

Variable	# firms	Mean	Median	(*SD*)	Min.	Max.
Innovation						
R&D spending	6509	0.252	–	–	0	1
Upgraded products, services	6509	0.743	–	–	0	1
New products, services	6509	0.525	–	–	0	1
Grand corruption, if contract						
Percent firms with PPBs						
foreign	126	29.365	0	(44.842)	0	100
domestic	1262	22.425	16.667	(26.396)	0	100
Petty corruption						
Percent firms with petty bribes						
foreign	657	20.244	0	(32.474)	0	100
domestic	5852	19.173	14.286	(18.292)	0	100

of which 23% had a university degree in 2007, and an average market share of 8%. One fifth of the firms secured or attempted to secure a contract with the government in 2007, 28% had export activities and 10% were subsidised by the government or by the European Union (EU), and 60% and almost 80% of the firms deem foreign competition and local competition, respectively, at least fairly important. The majority of the firms belong to the manufacturing (45%) and the wholesale and retail trade (34%) sectors.

Table 6 shows pairwise correlations between corruption and innovation taken at 2-digit ISIC industry level. The figures show that innovation effort decreases significantly in uncertain environments created by the presence of corrupt firms. In other words, the correlations between industry percentage of R&D performers and industry percentage of corrupt firms are all negative and statistically significant. The presence of foreign firms with public procurement bribery is the most detrimental to R&D activities. Comparing foreign and domestic firms with respect to their corruption behaviour, grand corruption of the former and petty corruption of the latter cause the most harm to R&D effort. Grand corruption, especially by foreign firms, and petty corruption are also detrimental to the upgrading of existing product lines or services (incremental innovation). However, the relation between corruption and the introduction of new products or services (major innovation) is not unambiguous as the correlations are both positive and negative, and mostly insignificant.

The pairwise correlations do not isolate the effect that other variables correlated with corruption might have on innovation, which is done by estimating partial correlations in a simultaneous-equations discrete choice model described in the next section.

Table 5. Descriptive statistics: Firm characteristics, sector categories and country groups.

Variable	Mean	Median	(*SD*)	Min.	Max.
Firm characteristics					
University degree	22.903	15	(25.033)	0	100
Employment, head counts	107.406	27	(419.402)	1	20,843
Market share, in percent	7.647	0.714	(18.538)	8.45×10^{-6}	100
Export	0.280	–	–	0	1
Subsidies	0.096	–	–	0	1
Contract with government	0.213	–	–	0	1
Foreign competition					
Not important	0.404	–	–	0	1
Fairly important	0.179	–	–	0	1
Important	0.216	–	–	0	1
Very important	0.201	–	–	0	1
Local competition					
Not important	0.133	–	–	0	1
Fairly important	0.165	–	–	0	1
Important	0.356	–	–	0	1
Very important	0.346	–	–	0	1
Sector categories					
Manufacturing	0.453	–	–	0	1
Construction	0.095	–	–	0	1
Wholesale and retail trade	0.344	–	–	0	1
Services	0.108	–	–	0	1
Country groups					
CPI, rank 143–175	0.273	–	–	0	1
CPI, rank 79–118	0.329	–	–	0	1
CPI, rank 61–69	0.208	–	–	0	1
CPI, rank 39–51	0.127	–	–	0	1
CPI, rank 27–28	0.064	–	–	0	1
# firms				6509	

Table 6. Pairwise correlations between the percentage of R&D performers and innovators, and the percentage of corrupt firms in each 2-digit ISIC industry.

	Innovation variables		
Corruption variables	Percent R&D performers	Percent incremental innovators	Percent major innovators
Grand corruption, if gvt. Contract			
Percent firms with PPBs			
foreign	−0.274**	−0.300**	−0.061
domestic	−0.129**	−0.009	−0.036
Petty corruption			
Percent firms with petty bribes			
foreign	−0.125**	−0.074†	0.048
domestic	−0.206**	−0.073**	−0.025†

Significance levels: † : 10% * : 5% ** : 1%.

4. Empirical strategy

4.1. Specification

In order to study the effects of corruption on innovation, we use three binary measures of innovation input and output as our dependent variables. They include the occurrence of R&D spending, the upgrading of existing products or services and the introduction of new products or services. The explanatory variables of primary interest are grand and petty corruption. Grand corruption is measured as the percentage of foreign and domestic firms in each 2-digit ISIC industry that are involved in public procurement bribery. Likewise, petty corruption is measured as the percentage of foreign and domestic firms in each 2-digit ISIC industry that are involved in petty bribe activities. We control for various determinants of innovation such as firm size and market share, skills of employees, export behaviour, competition, subsidies and the existence of contracts with the government. We also control for sector and country effects by including dummies for sectors of activity and country corruption groupings, defined according to 2-digit ISIC and the 2007 CPI, respectively (see Table 3).

According to Schumpeter (1942), firm size is expected to positively affect innovation behaviour as larger corporations have more and better resources to invest and wield more monopolistic power that enables them to capture the benefits of their innovation output. Likewise, market share is a measure of a firm's ability to capture the innovation rents and is expected to be positively correlated with innovation effort and innovation outcome. Human capital or research capacity, as measured by the percentage of employees with a university degree, is also an indicator of firms' ability to deploy innovative efforts. It can therefore be argued that skilled employees will more likely constitute the R&D personnel and hence play an important role in the firm's innovation efforts. As a result, the relative share of skilled employees in the firm's personnel is expected to be positively correlated with the firm's innovation behaviour. The export status of the firm is also an important factor for innovation. Firms producing for the export market are expected to be more innovative as a result of knowledge spillovers (Aghion & Howitt, 1992; Grossman & Helpman, 1991a). Various studies have, however, indicated that the causality can be bidirectional, with innovative firms also more likely to be exporters in international markets (see, e.g., Krugman, 1979).

As for the effects of competition on innovation, there are still divergent views and the relationship is not unambiguously determined. According to Arrow (1962), a perfectly competitive market is more likely to foster innovation than a monopoly market. That view is shared by Li and Vanhaverbeke (2009), who assert that under foreign competition in their domestic market, local firms may seek to explore innovation opportunities to bring new or improved products or services to the market in order to stay ahead of their competitors. It is also supported by empirical evidence, such as Porter (1990) and Geroski (1990, 1994). However, some theoretical studies have advanced the opposite argument, namely that reduced rents as a result of increased competition discourage investment in R&D and lead to a decrease in product innovation (Aghion & Howitt, 1998; Grossman & Helpman, 1991a; Romer, 1990).

Combining these apparently opposing views, Aghion, Bloom, Blundell, Griffith, and Howitt (2005) find an inverted-U relationship between innovation and competition in a model in which competition discourages laggard firms from innovating, while it encourages the technological leaders competing neck-and-neck to innovate. In our study we focus on a measure of perceived importance of foreign and domestic competitive pressure in the firm's decision making regarding innovation. We expect firms that give a higher importance to competitive pressure in their innovation decisions to respond more vigorously to this pressure by engaging in innovative activities.

Firms attempting to secure contracts with the government are also more likely to innovate since competing for public procurement often involves the elaboration of products and services that are a new acquisition by the government. In the EU and in the US, public procurement has long been regarded as one of the most important drivers of innovation and a study carried out by Ernst and Young in 2011 as reported in the Technopolis Group Report (2011) has shown that 74% of respondents perceive public procurement as creating demand for innovation. We therefore expect firms attempting to secure these contracts to be more likely to have developed innovative capacity to respond to this demand.

Access to EU or government subsidies acts as a reduction in the costs of innovation and gives the firm more incentives to innovate. If subsidies are attached to an innovation policy, they stimulate firms' innovative behaviour. Hence, subsidies are likely to be positively correlated with innovative activities (Aschloff & Sofka, 2009; Nemet, 2009).

4.2. Simultaneous-equations discrete choice model

The three measures of innovation we use, namely R&D effort, the upgrading of products and the introduction of new products/services, are available as binary outcomes. Given this binary nature, we estimate the corruption effects by considering a simultaneous-equations discrete choice model with observed binary endogenous regressors. Formally:

$$rd_i = 1[\beta_1' \mathrm{corrupt}_i + \delta_1' x_{1i} + \varepsilon_{1i} > 0], \tag{4.1}$$

$$upgrade_i = 1[\gamma rd_i + \beta_2' \mathrm{corrupt}_i + \delta_2' x_{2i} + \varepsilon_{2i} > 0], \tag{4.2}$$

$$newpdt_i = 1[\vartheta upgrade_i + \lambda rd_i + \beta_3' \mathrm{corrupt}_i + \delta_3' x_{3i} + \varepsilon_{3i} > 0], \tag{4.3}$$

where 1 denotes the indicator function which takes the value 1 if its argument is positive, and zero otherwise.

Equation (4.1) explains the firm's decision to engage in R&D activities, which depends upon some latent R&D incentive that can be expressed as a function of corruption activities of foreign and domestic firms in each 2-digit ISIC industry, $\mathbf{corrupt}_i$, firm, industry and country characteristics, x_{1i}, and other unobserved variables summarised in the error term ϵ_{1i}. If the firm's R&D incentive is positive,[8] the firm is observed to be an R&D performer. Thus rd_i is a binary variable taking the value 1 if firm i has had positive R&D spending during 2005–2007, and zero otherwise. The coefficients to be estimated are β_1 that captures the effect of corruption activities by foreign and domestic firms on R&D and δ_1 that captures the effect of firm, industry and country characteristics.

Equation (4.2) explains incremental innovation in the form of upgrading existing product lines or services. The ability to achieve these innovations is unobserved but defined as a function of observed variables such as R&D, corruption in the sector of activity, firm, industry and country characteristics, and unobserved variables ϵ_{2i}. The observed binary dependent variable, $upgrade_i$, indicates whether or not the firm has upgraded existing product lines or services during 2005–2007. The coefficients to be estimated are γ which captures the effect of R&D on incremental innovation, and β_2 and δ_2 that capture respectively the *direct* effect of corruption and that of the control variables on incremental innovation. Like equation (4.1), the control variables encompass firm, industry and country characteristics.

Equation (4.3) explains major innovation in the form of introduction of new products or services. The ability to achieve so is also unobserved but defined as a function of incremental innovation, R&D, control variables that are similar to those of Equation (4.2), and unobserved variables ϵ_{3i}. The observed dependent variable, $newpdt_i$, takes the value 1 if the firm has introduced new products or services into the market during 2005–2007. The parameters to be estimated are ϑ that captures the effect of incremental innovation on major innovation, and λ, β_3 and δ_3 that capture respectively the direct effect of R&D, corruption and control variables on major innovation.

Before turning to the estimation strategy, a few points are worth mentioning. First, the various stages of the model would probably be more realistic if time was explicitly modelled. For instance, R&D is more likely to affect the upgrading of existing products or services and the introduction of new ones only after a certain period of time. Unfortunately, we are unable to use panel data because the variables of interest and the sampling scheme are different over the various waves of the BEEPS. Second, for the sake of parsimony, we consider a recursive model where various stages of the innovation process are clearly identified. In other words, R&D leads to incremental and major innovation output as in a knowledge production function, and incremental innovation yields major innovation as in a *learning-by-doing* framework. Finally, since the model has nonlinear conditional means, the coefficients of Equations (4.1) through (4.3) only pick up the sign and significance of the effects of the explanatory variables. To quantify these effects, we need to calculate average partial effects. Because of the simultaneous-equations characteristic of the model, direct, indirect and total average partial effects (APEs) can be computed. For instance, corruption has a direct effect on incremental innovation, captured by β_2, and an indirect effect which operates through the effect of R&D on incremental innovation captured by γ and through the effect of corruption on R&D captured by β_1. The total effect of corruption on incremental innovation is the sum of the direct and the indirect effect.

4.3. Estimation

We estimate the model using full information maximum likelihood estimation (FIMLE) techniques. In other words, Equations (4.1) through (4.3) are *jointly* estimated by maximum likelihood, which requires distributional assumptions regarding the error terms ϵ. The maximum likelihood estimator is essentially unbiased (even in the presence of endogenous regressors) and as pointed out by Freedman and Sekhon (2010), is to be preferred to a two-step correction (with instrumental variables) for taking care of endogeneity. Given the regressors, the error terms are assumed to be normally distributed with mean 0 and covariance matrix Σ.

$$\Sigma = \begin{matrix} 1 & 0 & 0 \\ \rho 12 & 1 & 0 \\ \rho 13 & \rho 23 & 1 \end{matrix}$$

where ρ_{12}, ρ_{13} and ρ_{23} are also to be estimated. The log-likelihood consists of $2^3 = 8$ components calculated over various subsamples defined by Equations (4.1) through (4.3), that is

$$lnL = \sum {}_{000} lnL_{000} + \cdots + \sum {}_{111} lnL_{111}. \tag{4.4}$$

where $\ln L_{jkl}$, (j,k,l ∈{0,1}), denotes the individual contributions to the log-likelihood and Σ_{jkl} defines the observations of the various subsamples. The individual likelihoods for which l = 0 are calculated as:

$$\int_a^b \int_c^d \int_{-\infty}^{A3i} \phi_3\left(\varepsilon_{1i}, \varepsilon_{2i}, \varepsilon_{3i}\right) \mathrm{d}\varepsilon_{1i} \,.\, \mathrm{d}\varepsilon_{2i} \,.\, \mathrm{d}\varepsilon_{3i} \tag{4.5}$$

where ϕ_3 denotes the density function of the trivariate standard normal distribution, the integral bounds a, b, c, and d are defined as:

$$(a, b) \quad = \begin{cases} (-\infty, -A_{1i}) \text{if } j = 0 \\ (-A_{1i}, \infty) \ \text{if } j = 1 \end{cases}$$

$$(c, d) \quad = \begin{cases} (-\infty, -A_{2i}) \text{ if } k = 0 \\ (-A_{2i}, \infty) \ \text{if } k = 1 \end{cases}$$

and A_{1i}, A_{2i} and A_{3i} are defined respectively as:

$$A_{1i} = \beta_1' \mathbf{corrupt}_i + \delta_1' \mathbf{x}_{1i}, \tag{4.6a}$$

$$A_{2i} = \gamma rd_i + \beta_2' \mathbf{corrupt}_i + \delta_2' \mathbf{x}_{2i}, \tag{4.6b}$$

$$A_{3i} = \vartheta upgrade_i + \lambda rd_i + \beta_3' \mathbf{corrupt}_i + \delta_3' \mathbf{x}_{3i}. \tag{4.6c}$$

Similarly, the individual likelihoods for which l = 1 are calculated as

$$L_{jk1} = \int_a^b \int_c^d \int_{-\infty}^{A_{3i}} \phi_3\left(\varepsilon_{1i}, \varepsilon_{2i}, \varepsilon_{3i}\right) \mathrm{d}\varepsilon_{1i} \,.\, \mathrm{d}\varepsilon_{2i} \,.\, \mathrm{d}\varepsilon_{3i} \tag{4.7}$$

The multiple integrals of Equations (4.5) and (4.7) involve multivariate cumulative distribution functions which are evaluated using the Geweke-Hajivassiliou-Keane simulator so that the resulting log-likelihood to be maximised is a simulated log-likelihood.

To calculate the APEs, let us write the exogenous linear indexes as:

$$\boldsymbol{\pi}'_m \mathbf{z}_{mi} \equiv \beta'_m \mathbf{corrupt}_i + \delta'_m \mathbf{x}_{mi},\ m \in \{1, 2, 3\}$$

The conditional mean associated with Equation (4.1) is straightforwardly derived as

$$\mathbb{E}(rd_i | \boldsymbol{z}_{1i}) = \Phi_1(\boldsymbol{\pi}'_1 \boldsymbol{z}_{1i}) \tag{4.8}$$

where Φ_1 denotes the univariate cumulative distribution function (CDF) of the normal distribution. The conditional mean associated with Equation (4.2) requires using the *law of iterated expectations* (LIE), that is:

$$\mathbb{E}(upgrade_i | \mathbf{z}_{1i}, \mathbf{z}_{2i}) = \mathbb{E}_{rdi} \mathbb{E}(upgrade_i | \mathbf{z}_{1i}, \mathbf{z}_{2i,}\ rd_i)$$

Since rd_i is a binary variable,

$$\begin{aligned}\mathbb{E}(upgrade_i | \mathbf{z}_{1i}, \mathbf{z}_{2i}) &= \mathbb{P}(rd_i = 1)\mathbb{E}\left(upgrade_i | \mathbf{z}_{1i}, \mathbf{z}_{2i, rd_i=1}\right) \\ &+ \mathbb{P}(rdi = 0)\mathbb{E}(upgrade_i | \mathbf{z}_{1i}, \mathbf{z}_{2i}, rd_i = 0)\end{aligned}$$

which, using the standard normal CDF, is written as:

$$\mathbb{E}(upgrade_i | \mathbf{z}_{1i}, \mathbf{z}_{2i}) = \Phi(\boldsymbol{\pi}'_1 \mathbf{z}_{1i},)\Phi(\gamma + \boldsymbol{\pi}'_2 \mathbf{z}_{2i}) + \Phi(-\boldsymbol{\pi}'_1 \mathbf{z}_{1i})\Phi(\boldsymbol{\pi}'_2 \mathbf{z}_{2i}) \tag{4.9}$$

The conditional mean associated with Equation (4.3) also requires using the LIE, that is,

$$\mathbb{E}(newpdt_i | \mathbf{z}_{1i}, \mathbf{z}_{2i}, \mathbf{z}_{3i}) = \mathbb{E}_{rdi}[\mathbb{E}_{upgrade_i}[\mathbb{E}(newpdt_i | \mathbf{z}_{1i}, \mathbf{z}_{2i,}\ rd_i,\ upgrade_i)] | rd_i]$$

which, using similar derivations yields:

$$\begin{aligned}\mathbb{E}(newpdt_i | \mathbf{z}_{1i}, \mathbf{z}_{2i}, \mathbf{z}_{3i}) &= \Phi(\boldsymbol{\pi}'_1 \mathbf{z}_{1i})[\Phi(\gamma + \boldsymbol{\pi}'_2 \mathbf{z}_{2i})\Phi(\vartheta + \lambda + \boldsymbol{\pi}' \mathbf{z}_{3i})] \\ &+ \Phi(-\gamma - \boldsymbol{\pi}'_2 \mathbf{z}_{2i})\Phi(\lambda + \boldsymbol{\pi}'_3 \mathbf{z}_{3i})] + \Phi(-\boldsymbol{\pi}'_1 \mathbf{z}_{1i})[\Phi(\boldsymbol{\pi}'_2 \mathbf{z}_{2i})\Phi(\vartheta + \boldsymbol{\pi}'_3 \mathbf{z}_{3i}) \\ &+ \Phi((-\boldsymbol{\pi}'_2 \mathbf{z}_{2i})\Phi(\boldsymbol{\pi}'_3 \mathbf{z}_{3i})]\end{aligned} \tag{4.10}$$

We obtain the APE of a *continuous* exogenous regressor z by taking the derivatives of the conditional means of Equations (4.8), (4.9) and (4.10) with respect to z, and by averaging these individual derivatives over the estimation sample. For a binary exogenous regressor, say q, the APEs are obtained by evaluating the conditional means at $q = 1$ and $q = 0$ and by taking differences of the evaluated expressions. These APEs capture total effects that can be decomposed into direct and indirect effects (see Appendix A). Standard errors are obtained by the delta method.

5. Results

Table 7 shows FIML estimates of the determinants of R&D, incremental and major innovation. Total average partial effects are reported for all explanatory variables with the exception of sector categories and country groups.[9] The APEs are further decomposed into direct and indirect effects for the corruption regressors, and reported in Table A1 in the Appendix.

5.1. Effects of corruption on innovation

The results of our estimation suggest that grand corruption by foreign firms is detrimental to innovation efforts and to incremental and major innovation, while we find no stifling effect of grand corruption by domestic firms on the three innovation measures. Our results also point to a 'wheel greasing' effect of foreign petty corruption on the successful development of new products, but this effect tends to decrease as the level of corruption increases. More specifically, a one percentage point increase of foreign firms with public procurement bribery activities in the same line of business decreases the likelihood of performing R&D, improving existing lines of products and services, and introducing new products or services by 0.15%, 0.28%, and 0.26%, respectively. Hypothesis H1 is therefore confirmed for foreign firms engaging in transnational grand corruption, while similar practices by domestic firms do not seem to significantly support this hypothesis. Foreign firms are thus shown to have a stronger effect on stifling innovation through grand corruption than domestic firms, potentially because of their greater leverage of local officials. Surprisingly, whereas manufacturing could be expected to stand out, no significant differences between various industry categories were observed in these patterns.

As for petty corruption, bribing practices by local firms have a stifling effect on R&D and incremental innovation which both decrease by 0.13% with a one point increase in the percentage of local corrupt firms in the industry. The stifling effect of foreign grand corruption and local petty corruption on incremental innovation operates directly, but also indirectly through reducing innovation efforts, while the negative effect of foreign grand corruption

Table 7. FIML estimates of the determinants of R&D, incremental and major innovation‡.

	R&D		Upgraded products		New products	
Variable	APE	SE	APE	SE	APE	SE
Upgraded products	–	–	–	–	0.4089**	0.0130
R&D	–	–	0.1920**	0.0106	0.1955**	0.0136
Grand corruption						
Percent foreign firms	−0.0015†	0.0008	−0.0028**	0.0008	−0.0026**	0.0009
Percent local firms	0.0002	0.0004	0.0003	0.0005	0.0002	0.0005
Petty corruption						
Percent foreign firms	−0.0006	0.0005	0.0002	0.0005	0.0019**	0.0006
Percent local firms	−0.0013**	0.0004	−0.0013**	0.0004	0.0001	0.0004
Univ. degree	0.0011**	0.0002	0.0002**	0.0000	0.0003**	0.0001
Employment	0.0350**	0.0043	0.0102*	0.0046	0.0059	0.0052
Market share	0.0070**	0.0026	0.0081**	0.0027	0.0104**	0.0031
Export	0.0931**	0.0141	0.0628**	0.0137	0.0904**	0.0161
Subsidies	0.0889**	0.0188	0.0742**	0.0176	0.0915**	0.0211
Gvt. contract	0.0937**	0.0166	0.0947**	0.0156	0.1549**	0.0186
Competition						
Foreign						
Fairly important	0.0234	0.0146	0.0277†	0.0147	0.0249	0.0167
Important	0.0681**	0.0148	0.0307*	0.0149	0.0222	0.0169
Very important Local	0.1141**	0.0160	0.0178	0.0169	0.0121	0.0186
Fairly important	0.0147	0.0190	0.0568**	0.0175	0.0628	0.0190
Important	0.0047	0.0168	0.0764**	0.0161	0.0977**	0.0176
Very important	0.0317†	0.0171	0.0705**	0.0169	0.1074**	0.0184
#observations			6059			
Log-likelihood			−10248.535			

‡Three dummies for sector categories and four dummies for country groups are included in each equation, and employment and market share are log−transformed in the estimation.
Significance levels : † : 10% * : 5% ** : 1%.

on major innovation operates mainly indirectly through reducing innovation efforts and incremental innovation (see Table A1). We find no stifling effect of foreign petty corruption on R&D and incremental innovation. The effect of petty corruption on major innovation output is decomposed into a positive and significant direct effect and a negative indirect effect. In the case of local petty corruption, both effects offset each other, resulting in an insignificant total effect, while in the case of foreign petty corruption, the indirect effect is too small to offset the larger positive effect, resulting in a net positive and significant total effect. Speed money paid by foreign firms to local officials to facilitate transactions therefore appears to lead to better innovation outputs, but that of domestic firms yields no such effect. Our hypothesis H2 is therefore only partially supported by BEEPS data, since similar practices by local firms fail to yield the same effects. This 'wheel greasing' effect suggests that foreign firms are more efficient in circumventing cumbersome regulations and bureaucratic rigidities, but this advantage decreases as the percentage of bribing firms in the industry increases (see Figure 1). Fairly similar results are obtained when bribing intensity is used as a measure for corruption (tables not displayed for space parsimony), confirming hypotheses H1 and H2 for foreign firms but failing the same for domestic firms. This means that corruption practices by local firms produce largely negative effects in innovations, leading ultimately to undermining long-term growth performance.

Figure 2 shows the dynamics of the partial effects of foreign grand corruption over various levels of corruption in the firm industry. Different dynamics are observed for the three measures of innovation. More specifically, the negative effects on R&D and incremental innovation initially worsen with the sudden presence in the firm industry of foreign firms

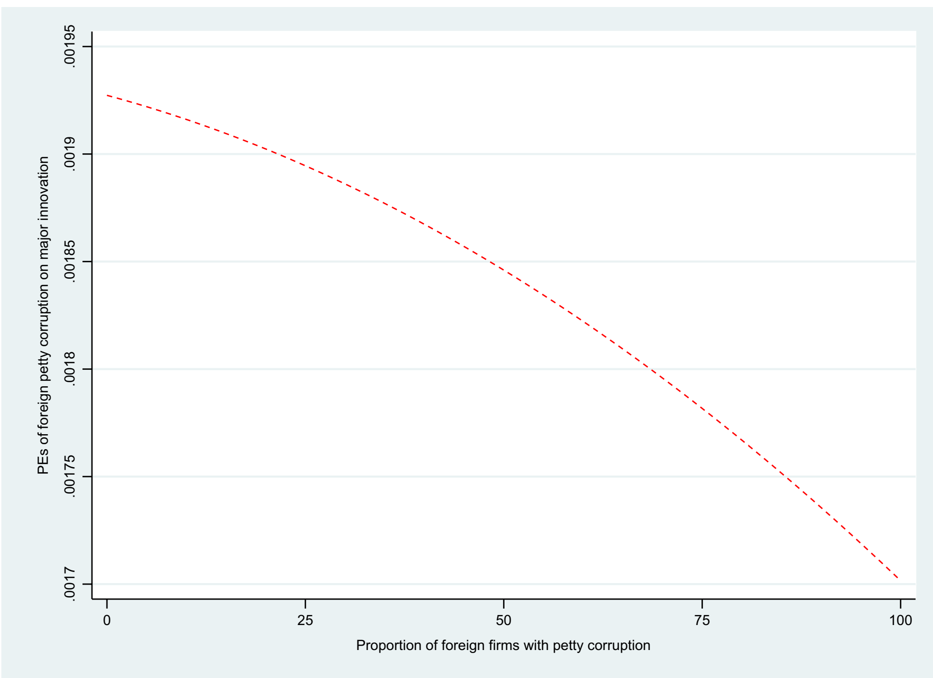

Figure 1. Partial effects of petty corruption of foreign firms on major innovation for different levels of corruption.

with grand corruption activities up to a certain percentage of corrupt firms. Beyond that level, which is around 50% for R&D and 60% for incremental innovation, the negative effects tend to stabilise (incremental innovation) or even improve (R&D). As for major innovation, the negative effects remain constant over the different levels of corruption.

Similarly, we show in Figure 3 the partial effects of local petty corruption on the three measures of innovation for different levels of corruption. The negative effects on R&D now improve immediately, even if they remain negative. Likewise, the partial effects on incremental innovation stabilise and improve much faster than in Figure 2. These two results indicate that the firms get acquainted more quickly with (and react much faster to) local petty corruption than foreign grand corruption. As for the effects on major innovation, they also remain constant over the different levels of corruption, except that they are now positive, albeit not significantly different from zero.

5.2. Effects of other determinants of innovation

As usually found in the literature, the most important input to innovation output is R&D. In other words, R&D performers are more likely to improve existing lines of products and services and to introduce new products or services. Improving existing products or services constitutes an important step towards the introduction of new products or services. Other things being equal, succeeding in improving existing products increases the likelihood of introducing new ones by 0.41, which is rather substantial. The likelihood of innovation efforts increases significantly with the firm size and the skills of its employees. Furthermore,

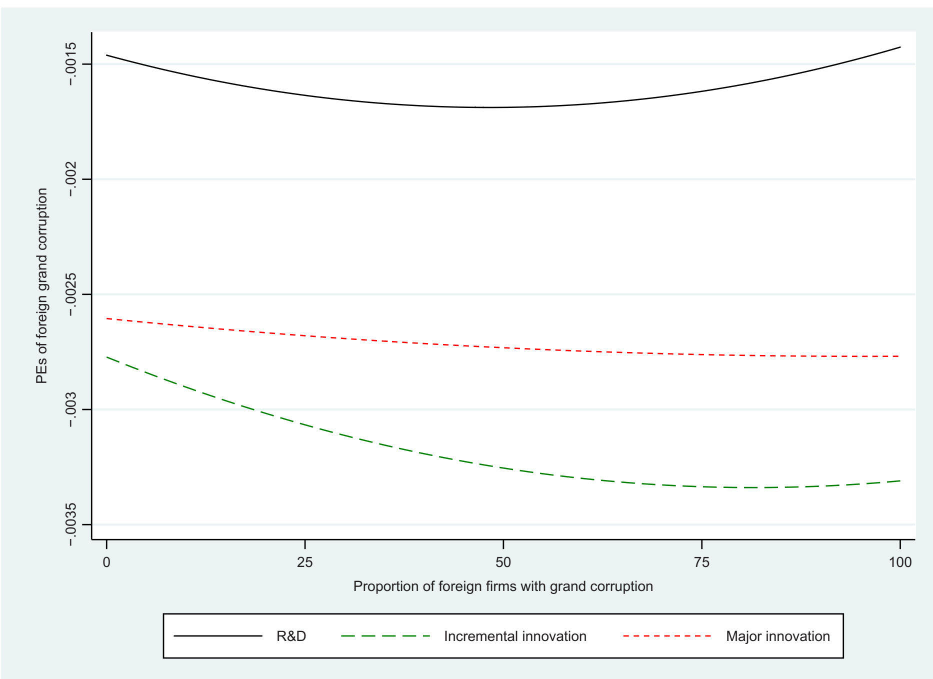

Figure 2. Partial effects of grand corruption of foreign firms on R&D, and incremental and major innovation for different levels of corruption.

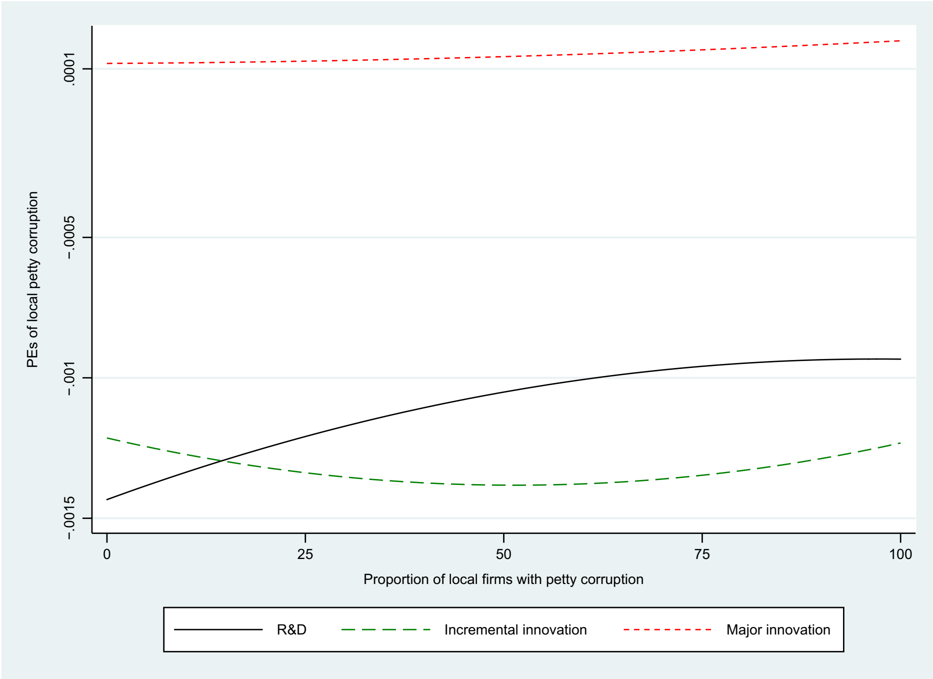

Figure 3. Partial effects of petty corruption of local firms on R&D, and incremental and major innovation for different levels of corruption.

market share, having export activities, receiving government subsidies and securing contracts with the government are all important determinants of innovation efforts and innovation success as they increase the likelihood of performing R&D, improving existing products and introducing new products. Finally, the results show that the likelihood of innovation efforts increases monotonically with foreign competition, while that of innovation success increases monotonically with local competition, thereby supporting the view advanced by Arrow (1962).

6. Conclusion

Given the fundamental role innovation plays as a determinant of long-term growth and competitiveness of firms, it is undoubtedly also one of the most important channels through which corruption may undermine economic growth. In order to elucidate the mechanism through which corruption may stifle growth, we have made use of two forms of distinctions to help get a closer look at this phenomenon at industry level: grand corruption versus petty corruption and domestic firms versus foreign firms in the host economy. We then estimated the firms' likelihood to engage in innovative activities in the presence of foreign and domestic corrupt corporations operating in their line of business.

Our estimation results indicate that no significantly negative direct effect of corruption on major innovation, be it from foreign or domestic firms, was observed. In contrast, an increase in the proportion of foreign firms engaging in grand corruption in a given industry discourages investment in research and development, reduces the likelihood of upgrading existing lines of products and/or services, and stifles the development of new products or services for all firms in the same industry. Likewise, an increase in the proportion of domestic firms with petty corruption activities decreases the likelihood of R&D activities and that of incremental innovation success. Speed money paid by foreign firms, on the other hand, goes together with better innovation output, without significantly affecting R&D effort or incremental innovation.

In light of these results, we note that transnational corruption is detrimental to innovation in host countries, but benefits foreign firms involved in it. Since their corruption behaviour in host countries affects primarily innovation efforts and incremental innovation, this puts non-corrupt domestic firms in host countries at a disadvantage as R&D is the most important input to new and improved products. Especially subsidiaries of MNEs can rely on their access to foreign technologies for their innovative outcomes in their host countries and reap the benefits of corruption without bearing its full costs. While foreign firms can avoid the indirect negative effects of low R&D spending by tapping into foreign sources of knowledge in their home countries, local firms will bear the indirect cost of diminished ability to create and successfully market new products and services. These insights could be enriched by testing similar hypotheses on data from developing countries if available, especially in Africa, where bribing opportunities in public procurement are reputed to be high, as reflected by their consistently low ranking on Transparency International's corruption perception index.

Even though speed money paid by foreign firms to quicken transactions in the presence of rigid regulations in the host economy may appear to facilitate their innovation performance, the corresponding effects by local firms on innovation effort and incremental innovation remain largely negative. Despite its localised short-term gains, corruption thus remains an undesirable phenomenon *in fine*, as it both undermines the reliability of governance institutions and jeopardises long-run economic growth by lowering investment rate. Efforts to tackle corruption must therefore be directed not only towards local officials but also towards foreign corporate managers who are likely to cash positive payoffs and without bearing the externalities of corruption.

Notes

1. Grand corruption refers to large-scale corrupt acts involving officials at the highest levels of government and decision making, often in transactions linked, but not limited, to public procurement contracts.
2. The 'grease-the-wheels' argument postulates that an inefficient bureaucracy constitutes a major impediment to business transactions so that some 'speed money' or 'grease' may help 'get things done'. Proponents of the 'greasing wheels' hypothesis argue that corruption facilitates business transactions that would otherwise not take place because of inefficient bureaucracy or complex regulations. The 'efficient grease' hypothesis asserts therefore that corruption can improve economic efficiency and that fighting bribery would be counterproductive.
3. Aidt and Dutta (2008) and Aidt (2009) argue that cumbersome regulations can be seen as part of the corruption problem since corrupt government officials are likely to maintain them and oppose reform because of the corruption potential they represent.
4. Moran (2006) points out that anti-corruption laws, such as the US Foreign Corrupt Practices Act (FCPA) or the OECD convention against bribery (1997), do not prohibit facilitation payments to foreign officials, whose purpose is to grease the bureaucracy in order to expedite

the acquisition of permits or speed up the process of conducting their business. To circumvent the interdiction of payments to foreign politicians, firms often resort to forming advantageous partnerships with the latter's friends or relatives. Batzilis (2015) also found no evidence that laws against foreign bribery affect corporate conduct in the host country.

5. This paper does not focus on the effects of a firm's (domestic or foreign) corruption behaviour on its own innovation activities where both corruption measures and innovation performance would be taken at the firm level. Instead, we aim to explain innovation activities of firms operating in host countries when faced with corruption activities coming from their direct competitors, especially foreign ones, hence the use of industry-level analysis.
6. The first wave of the BEEPS was launched in 1999–2000 and utilised, for instance, by Hellman et al. (2002, 2003). The second and third waves were launched in 2002 and 2005 respectively, and utilised by Brown, Jappelli, and Pagano (2009). Unlike the first three waves, the fourth one has hardly been utilised. However, it is very difficult to use all of them in a panel setting because the periods are unequally spaced, and the sampling design and the variables are different across waves.
7. The EBRD and the World Bank were aware of the potential non-responses or refusals to respond to questions involving sensitive issues such as 'informal payments'. Therefore, every effort was made to assure respondents that their answers would be treated confidentially. For instance, questions were phrased indirectly regarding 'informal payments' made by 'establishments like this one', and respondents were assured that responses would be aggregated and not attributable to themselves or their establishments.
8. There is no loss of generality in assuming a zero threshold in lieu of any threshold, say c, as long as the R&D equation includes an intercept.
9. The estimates for sector categories and country groups are not reported in order to save space. They can be obtained upon request.

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Disclosure statement

The authors declare that they are not aware of any conflict of interest related to this study.

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Appendix A. Direct, indirect and total average partial effects

The APEs in the R&D equation (Equation (4.1)) are obtained by differentiating $\mathbb{E}\left(rd_i|\mathbf{z}_{1i}\right)$ with respect to a certain continuous regressor z. Formally,

$$\partial(\mathbb{E}(rd_i|\mathbf{z}_{1i}))/\partial\mathbf{z} = \pi_{1z}\varphi(\pi'\mathbf{z}_{1i}), \tag{A.1}$$

where ϕ_1 denotes the univariate standard normal density function. These APEs capture the direct effect, which is also the total effect, of z on the conditional mean.

The APEs in the incremental innovation equation (Equation (4.2)) are obtained as

$$\begin{aligned}&\partial\mathbb{E}(upgrade_i|\mathbf{z}_{1i},\mathbf{z}_{2i})/\partial z\\ &= \pi_{2z}[\varphi_1(\gamma+\boldsymbol{\pi}_2'\mathbf{z}_{2i})\,\Phi(\boldsymbol{\pi}_1'\mathbf{z}_{1i}) + \varphi_1(\boldsymbol{\pi}_2'\mathbf{z}_{2i})\Phi(-\boldsymbol{\pi}_1'\mathbf{z}_{1i})]\{directeffect\}\}\\ &+ \pi_{1z}\varphi_1(\boldsymbol{\pi}_1'\mathbf{z}_{1i})[\Phi(\gamma+\boldsymbol{\pi}_2'\mathbf{z}_{2i}) - \Phi\,(\boldsymbol{\pi}_2'\mathbf{z}_{2i})]\{indirecteffect\}\end{aligned} \tag{A.2}$$

where we use the symmetry of the normal distribution, that is $\varphi_1(\boldsymbol{\pi}_1'\mathbf{z}_{1i}) = \varphi_1(-\boldsymbol{\pi}_1'\mathbf{z}_{1i}$

Finally, the APEs in the major innovation equation (Equation (4.3)) are given by

$$\partial[\mathbb{E}\left(newpdt_i|\mathbf{z}_{1i},\mathbf{z}_{2i},\mathbf{z}_{3i}\right)]/\partial z = \pi_{3z}'F(z_i)\_\{direct\ effect\} + \pi_{2z}'G(z_i) + \pi_{1z}'H(z_i)\_\{indirect\ effect\} \tag{A.3}$$

where $z_i = (z_{1i}, z_{2i}, z_{3i})$, and F, G and H are respectively given by:

$$\begin{aligned}F(z_i) = {}&\Phi(-\boldsymbol{\pi}_1'\mathbf{z}_{1i}[\varphi_1(\vartheta+\boldsymbol{\pi}_3'\mathbf{z}_{3i})\Phi(\boldsymbol{\pi}_2'\mathbf{z}_{2i}) + \varphi_1(\boldsymbol{\pi}_3'\mathbf{z}_{3i})\Phi(-\boldsymbol{\pi}_2'\mathbf{z}_{2i})]\\ &+ \Phi(\boldsymbol{\pi}_1'\mathbf{z}_{1i})[\varphi_1(\vartheta+\lambda+\boldsymbol{\pi}_3'\mathbf{z}_{3i})\Phi(\gamma+\boldsymbol{\pi}_2'\mathbf{z}_{2i}) + \varphi_1(\lambda+\boldsymbol{\pi}_3'\mathbf{z}_{3i})\Phi(-\gamma-\boldsymbol{\pi}_2'\mathbf{z}_{2i})];\end{aligned}$$

$$\begin{aligned}G(z_i) = {}&\varphi_1(\gamma+\boldsymbol{\pi}_2'\mathbf{z}_{2i})\Phi(\boldsymbol{\pi}_1'\mathbf{z}_{1i})[\Phi(\vartheta+\lambda+\boldsymbol{\pi}_3'\mathbf{z}_{3i}) - \Phi(\lambda+\boldsymbol{\pi}_3'\mathbf{z}_{3i})]\\ &+\varphi_1(\boldsymbol{\pi}_2'\mathbf{z}_{2i})\Phi(-\boldsymbol{\pi}_1'\mathbf{z}_{1i})[\Phi(\vartheta+\boldsymbol{\pi}_3'\mathbf{z}_{3i}) - \Phi(\boldsymbol{\pi}_3'\mathbf{z}_{3i})];\end{aligned}$$

and

$$\begin{aligned}H(z_i) = {}&\varphi_1(\boldsymbol{\pi}_1'\mathbf{z}_{1i})[\Phi(\gamma+\boldsymbol{\pi}_2'\mathbf{z}_{2i})\Phi(\vartheta+\lambda+\boldsymbol{\pi}_3'\mathbf{z}_{3i}) - \Phi(\boldsymbol{\pi}_2'\mathbf{z}_{2i})\Phi(\vartheta+\boldsymbol{\pi}_3'\mathbf{z}_{3i})\\ &+\Phi(-\gamma-\boldsymbol{\pi}_2'\mathbf{z}_{2i})\Phi(\lambda+\boldsymbol{\pi}_3'\mathbf{z}_{3i}) - \Phi(-\boldsymbol{\pi}_2'\mathbf{z}_{2i})\Phi(\boldsymbol{\pi}_3'\mathbf{z}_{3i})]\end{aligned}$$

Table A1. Direct, indirect and total average partial effects of corruption on innovation.

	R&D spending	Upgraded products		
Variable	Direct	Direct	Indirect	Total
Grand corruption				
Percent foreign firms	−0.00146†	−0.00251**	−0.00027†	−0.00278**
Percent local firms	0.00025	0.00028	0.00005	0.000323
Petty corruption				
Percent foreign firms	−0.00063	0.00035	−0.00012	0.00023
Percent local firms	−0.00129**	−0.00105**	−0.00024**	−0.00129**
			New products	
Grand corruption				
Percent foreign firms		−0.00119	−0.00142**	−0.00261**
Percent local firms		−0.000008	0.00018	0.00017
Petty corruption				
Percent foreign firms		0.00195**	−0.00003	0.00192**
Percent local firms		0.00091*	−0.00078**	0.00013

Significance levels: † : 10% * : 5% ** : 1%