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Transnational Corruption and Innovation in Transition Economies

Alexis Habiyaremye* and Wladimir Raymond†

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Abstract

In this paper, we examine how transnational corruption affects host country firms' innovation behaviour and performance in transition economies of Eastern Europe and Central and Western Asia. Using firm-level data from the Business Environment and Enterprise Performance Survey, we show that the involvement of foreign firms in corruption practices reduces the propensity of firms in host countries to invest in research and development and harms their ability to improve their existing products and services. Using a simultaneous-equations recursive model and controlling for various innovation determinants, we also show that the reduction in innovation effort ultimately also hurts the host country's long-term ability to successfully bring new products on the market through indirect effects.

Keywords: Transnational corruption, Innovation, Transition Economies

JEL classification: H42, H57, L26, O31, P37

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1 Introduction

Innovation has increasingly been recognised as the main driver of long-term firm competitiveness. It is therefore undoubtedly 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 chivalry manners. Striving to gain and keep a competitive edge in innovation frequently takes place under 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 governance standards that are less stringent than those of their home markets where corruption is much less accepted. This form of corruption practices carried out across national boundaries has been a recurrent phenomenon 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 et al., 2002).[1] When powerful foreign firms use cross-border corruption to gain unfair advantages over their competitors, domestic firms operate with a severe handicap and can even be driven out of business altogether. The problem of corruption is a phenomenon that has afflicted human societies since time immemorial and its inhibiting effects on growth and economic development are by now widely recognised as being substantial. Although it has sometimes been argued that corruption can speed up business transactions and positively affect economic growth in the so-called "efficient wheel greasing" argument (Leff, 1964; Lui, 1986; Kaufmann and Wei, 1999),[2] the most commonly held view in the literature is that

[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. According to Kaufmann and Wei (1999), in an environment in which bureaucratic burden and delay are exogenous, an individual firm may find bribes helpful to reduce the effective

it undermines growth by lowering the investment rate in the economy (Shleifer and Vishny, 1993; Mauro, 1995; Wei, 2000). The adverse effects on the investment rate are however not sufficient to explain the long-run effects of corruption on growth. Since the emergence of endogenous growth theories, it is indeed 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 (Romer, 1990; Grossman and Helpman, 1991b; Aghion and Howitt, 1992). In order to analyse the long-term effects of corruption on economic growth, it is therefore crucial to understand how it affects the rate of innovation. On top of the well-known negative effects of domestic corruption, the phenomenon of transnational corruption can have even more devastating consequences on the entrepreneurial climate in host countries. This is especially valid in developing or transition economies, where it often involves powerful foreign corporations with considerable leverage over local public officials. The World Bank has calculated that in 2002 alone, bribes totalling a staggering 1 trillion US dollars were paid in transnational corrupt transactions, with a large share of that amount undoubtedly being paid to officials of weak governments by firms that extract and export natural resources for sale to developed countries (Carrington, 2010). The magnitude of this problem can also be epitomised by the case of Siemens AG, the German electronics giant, that had to pay more than 1.6 billion US dollars to the US and German governments in fines for acts of corruption in various nations around the world. Another prominent example is the case against the Halliburton Company, which disgorged a total of 559 million US dollars in 2009 as punishment for its corrupt practices in Nigeria.[3] This paper therefore aims to empirically analyse the effects of foreign firms' corrupt practices on innovation in their host countries. We investigate whether the relative presence of corrupt foreign firms and the intensity of

red tape it faces. The "efficient grease" hypothesis asserts therefore that corruption can improve economic efficiency and that fighting bribery would be counter-productive.

[3] A large number of prominent examples of corruption cases that have been brought to justice are known (see e.g. Carrington, 2010). Scandals that remain in impunity are also numerous. Examples of occult payments by foreign oil corporations for land use and blatant dumping of industrial waste as well as collusion with local security forces to suppress protests are abundant in the Niger Delta. Obviously, due to the secrecy of corruption, corrupt acts that never come to light are likely to be even more numerous.

their corruption activities in a given industry have negative effects on the likelihood of other firms in the same sector to engage in R&D activities (innovation efforts) and to generate innovation in the form of upgraded (incremental innovation) or new (major innovation) product lines or services in host countries. 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. Our analysis distinguishes between acts of petty corruption and cases of more active involvement of firms in corruption efforts to secure advantageous government contracts, which enables us to show how transnational corruption, especially the one linked to public procurement, is harmful to innovation effort in host countries. Our results indicate that transnational grand corruption has a stifling effect 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, domestic firms' participation in corrupt practices appears detrimental to innovation efforts and incremental innovation, but not to major innovation.

The remainder of the paper is organised as follows. Section 2 reviews the theoretical and empirical literature explaining corruption behaviour in transnational context and examines the nexus between corruption and innovation behaviour from which we derive our arguments. Section 3 describes the firm-level data, section 4 explains our methodological approach, section 5 discusses the findings and section 6 concludes the paper.

2 Corruption and innovation: theory and evidence

The literature on the effects of transnational corruption behaviour on 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, while the latter view, based on firm-level analysis, 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 et al. (2006), proactive steps to affect the public policy environment in a way favorable 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 sizable impact on the living standards of local officials, and therefore can be more persuasive. Evidence points rather to the fact that transnational and domestic corruption often feed upon each other, as in the familiar cases of autocratic rulers who make personal corrupt deals with multinational economic interests, and then export their wealth to numbered bank accounts in foreign countries.

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 but its empirical evidence is still largely lacking. The 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 and 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 et al. (2010) find that the odds of having to pay bribes increase significantly for innovative firms compared to non-innovators. Corruption undermines the foundations of institutional trust that are needed for the development of entrepreneurial and innovative activity. It reduces the incentives to invest in innovative ideas by negatively affecting the magnitude of the rewards that can be earned from entrepreneurship and innovation.

Nonetheless, some scholars 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" (Asiedu and Freeman, 2009). 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, to acquire scarce foreign exchange or collude with tax collectors to reduce tax payments, which may boost their investment rate and increase their innovation capacity. Corruption may prevent blockage to firms' flow and planning of innovative activities. It can also act as a facilitator to boost the scope and scale of investments since it acts as a hedge against political risks. More generally, however, innovation and entrepreneurial activity require trustworthy institutions in order to flourish and corruption is seen as a factor undermining trust in institutions.

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 and impede innovation or foster it, depending on the dominant force between the "greasing" and the stifling effects. This form of transnational corruption 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 diminishes. Knowing that innovation is the most important determinant of their long-term competitive advantage, foreign firms can use their strong bargaining power with respect to local bureaucrats and politicians to outcompete domestic firms in government contracts and fence them out of innovative markets. In an environment where the institutions for governance and accountability are weak, foreign investors often worsen corruption by using bribes to substitute for the better local market insights and dense social networks of their domestic competitors (Tanzi and Davoodi, 1998; Søreide, 2006). The expected corrective effects of home country legal institutions, such as the US Foreign Corrupt Practice Act (FCPA), often do not materialise because foreign investors have found various ways to avoid these restrictions.[4]

In order to cast more light on how the corruption behaviour of foreign firms may stifle domestic innovative activity, we subdivide corruption activities into two major categories, namely the acts of grand corruption, in which firms willingly engage to gain market advantages,[5] and the more common practices of petty corruption by which firms are induced to make payment to bureaucrats "to get things done". We then cluster firms in various business activities according to their 2-digit ISIC code and analyse how the presence of corrupt (foreign and domestic) firms and their corruption intensity in each business sector affects their direct competitors' innovation (efforts and outcome) in the host countries. The measures of innovation used in this paper include R&D spending, the upgrading of existing product lines or services and the introduction of new products or services. The measures of corruption include the percentage of domestic and foreign firms in each industry that engage in *grand* and *petty* corruption, and the industry average informal payments as a percentage of a firm's contract value with the government, in the case of grand corruption and as a percentage of total annual sales, in the case of petty corruption.

[4]The FCPA and the OECD Convention on Bribery of Foreign Officials contain handy provisions allowing payments for "facilitation purposes". Moreover foreign nationals working for foreign subsidiaries of American firms were still not included in criminal liability for paying bribes to foreign officials under FCPA, leaving open a means of evasion of federal law that surely remains in use (Carrington, 2010).

[5]This form of corruption is found in "the shaking hand" model of corruption (see e.g. Hellman et al., 2002, 2003) where benefits accrue to the bribing firms as well as to the involved government officials.

3 Data

The data are derived from the fourth wave of the EBRD-World Bank Business Environment and Enterprise Performance Survey 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.[7] To collect the data, three different questionnaires are used, namely a core questionnaire that includes common questions asked to establishments from all sectors, a manufacturing questionnaire with additional manufacturing-specific questions that are asked only to establishments in that sector and a services questionnaire that comprises additional services-specific questions that are asked only to establishments from the service sector.

Table 1 gives, for each surveyed country, an overview of the targeted number of interviews 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 dropped because of these issues.[8] Unfortunately, we can

[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 respectively launched in 2002 and 2005 and utilised by Brown et al. (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] See http://www.enterprisesurveys.org/Methodology/ for more details.

[8] The EBRD and the World Bank were aware of the potential non-responses or refusals to respond

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

Country	Number of establishments					
	Target	Completed				Analysis
		All	Manuf.	Services	Core	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	12280	11998	5034	3842	3122	6509

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

only acknowledge these problems as the actual reasons for non-response or refusal to respond are unknown. Therefore, these issues should be borne in mind when

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.

Table 2: *Description of the cleaning process and the resulting sample of analysis*

Cleaning criteria	Number of establishments	
	dropped in cleaning	after cleaning
Sample before cleaning	11998	
Non-response or refusal		
Innovation	281	11717
Foreign status	116	11601
Business activities	30	11571
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	

interpreting the results.

3.1 Measures of innovation and corruption

The measures of innovation include R&D spending which captures firms' innovation effort or innovation input, the upgrading of existing product lines or services which is used as a proxy for incremental innovation output and the introduction of new products or services as a proxy for major innovation output. All three innovation measures are available only as binary variables (see Table 3).

Two types of corruption are considered, namely the bribery connected with public procurement, which is referred to in the literature on corruption as *grand* corruption, and the more traditional bribery to "get things done" referred to in the literature as *petty* corruption. The BEEPS provides information on the percentage of a firm's contract value paid as informal payment when the firm has secured or attempted to secure a contract with the government. Similarly, it provides information on the percentage of a firm's total annual sales paid as informal payment to public officials to "get things done" with regard to customs, taxes, licences and regulations among others. Four corruption variables are then considered, namely the percentage of firms in each 2-digit ISIC industry,[9] taken *separately* for each country, that engage in grand and petty corruption, and the industry average of the intensity of public procurement bribe (PPB) and that of bribe paid "to get things done". These 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 figures are calculated separately for domestic and foreign establishments.

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 labor 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 (CPI). The firm characteristics are included according to the theoretical and empirical literature on innovation, and sector and country dummies are included to control for sector and country effects.

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, i.e. $(657/6509) \times 100$, are foreign firms of which 19%, i.e. $(126/657) \times 100$, secured or attempted to secure a contract with the

[9] This paper does not focus on the effect of a firm's (domestic or foreign) corruption behaviour on its innovation activities where both innovation and corruption 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 potential competitors, especially foreign ones, hence the use of industry-level corruption variables.

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		
% firms with PPBs†	continuous	% firms in each 2-digit ISIC industry with public procurement bribery in 2007
PPB intensity†	continuous	industry average of PPBs as a percentage of government contract value in 2007
Petty corruption		
% firms with petty bribes†	continuous	% firms in 2-digit ISIC industry with petty bribery activities in 2007
Petty bribe intensity†	continuous	industry average of petty bribes as a percentage of total sales in 2007
Firm characteristics		
University degree	continuous	% labor 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	(Std. Dev.)	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						
% firms with PPBs						
foreign	126	29.365	0	(44.842)	0	100
domestic	1262	22.425	16.667	(26.396)	0	100
PPB intensity, in %						
foreign	126	2.690	0	(5.449)	0	30
domestic	1262	2.402	0.500	(3.683)	0	30
Petty corruption						
% firms with petty bribes						
foreign	657	20.244	0	(32.474)	0	100
domestic	5852	19.173	14.286	(18.292)	0	100
Petty bribe intensity, in %						
foreign	657	0.683	0	(2.458)	0	40
domestic	5852	0.917	0.400	(1.593)	0	27.5

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 and the mean across industries of the public procurement bribe (PPB) intensity of foreign firms is 2.7%. As for petty corruption, the average industry rate of corrupt foreign firms is 20% with an average industry petty bribe intensity of 0.683%. 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, 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), 60% and almost 80% of the firms deem respectively foreign competition and local competition at least fairly important. The majority of the firms belong to the manufacturing (45%) and

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

Variable	Mean	Median	(Std. Dev.)	Min.	Max.
Firm characteristics					
University degree	22.903	15	(25.033)	0	100
Employment, head counts	107.406	27	(419.402)	1	20843
Market share, in%	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		

the wholesale and retail trade (34%) sectors. Finally, most of the countries of the analysis are not very well ranked according to their 2007 CPI.

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 and by their bribe intensity. In other words, the correlations between industry percentage of R&D performers, and industry percentage of corrupt firms and bribe intensity are all negative and statistically significant. The presence of foreign firms with public procurement bribery is the most detrimental to R&D activities. When comparing foreign and domestic firms with respect to their corruption behaviour, grand corrup-

Table 6: Pairwise correlations between the percentage of R&D performers and innovators, and the percentage of corrupt firms and the mean bribe intensity defined at 2-digit ISIC

Corruption variables	Innovation variables		
	% R&D performers	% incremental innovators	% major innovators
Grand corruption, if gvt. contract			
% firms with PPBs			
foreign	-0.274**	-0.300**	-0.061
domestic	-0.129**	-0.009	-0.036
PPB intensity, in%			
foreign	-0.167†	-0.193*	0.112
domestic	-0.105**	-0.007	-0.001
Petty corruption			
% firms with petty bribes			
foreign	-0.125**	-0.074†	0.048
domestic	-0.206**	-0.073**	-0.025†
Petty bribe intensity, in %			
foreign	-0.089*	-0.103**	0.036
domestic	-0.154**	0.004	-0.034**

‡if positive. Significance levels : $\dagger$: 10% $*$: 5% $**$: 1%

tion of the former and petty corruption of the latter cause the most harm to R&D effort. Corruption, especially by foreign firms, is also detrimental to the upgrading of existing product lines or services (incremental innovation). However, the relation between corruption by domestic firms and incremental innovation, and the relation between corruption by foreign and domestic firms and the introduction of new products or services (major innovation) are 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.

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 (innovation effort), the upgrading of existing products or services (incremental innovation) and the introduction of new products or services (major innovation). The explanatory variables of primary interest are grand and petty corruption. Two measures of grand corruption are considered, namely the percentage of foreign and domestic firms in each 2-digit ISIC industry that are involved in public procurement bribery and the industry average of public procurement bribes as a percentage of government contract. Likewise, two measures of petty corruption are considered, namely the percentage of foreign and domestic firms in each 2-digit ISIC industry that are involved in petty bribe activities and the industry average of petty bribes as a percentage of total sales (see Table 3).[10] 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 groups defined respectively according to 2-digit ISIC and the 2007 CPI. The inclusion of the control variables is motivated as follows.

According to Schumpeter (1942), firm size is expected to affect positively 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

[10]Since many of the corruption practices examined in the BEEPS survey are illegal in most countries, respondents were expected to be reluctant to admit that they engaged in such activities. In order to increase the reliability of the collected data, every effort was made to assure respondents that their answers would be treated confidentially. Questions were phrased indirectly in the form of "firms in your line of business" and respondents were assured that responses would be aggregated and not attributable to themselves or their firms.

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 innovativeness. 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 (Grossman and Helpman, 1991a; Aghion and Howitt, 1992). Various studies have however indicated that the causality can be bidirectional, with innovative firms being 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. Both foreign and domestic competition create a pressure on local firms to use innovation either as a defensive or an offensive strategy to sustain their competitive advantage. Under foreign competition in their domestic market, firms may seek to explore innovation opportunities to bring new or improved products or services into the market to stay ahead of their competitors (Li and Vanhaverbeke, 2009). Competitive pressure can also be a strong incentive for firms to innovate if their strategy is to compete on quality and differentiation. Empirical evidence points to the existence of positive effects of competition on innovation (Porter, 1990; Geroski, 1990, 1994). Certain theoretical studies have however 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 (Romer, 1990; Grossman and Helpman, 1991a; Aghion and Howitt, 1998). Combining these apparently opposing views, Aghion et al. (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 decision 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 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 (Nemet, 2009).

4.2 Simultaneous-equations trivariate probit

Given the binary nature of the measures of innovation, we consider a simultaneous-equations *trivariate* probit with *observed* binary endogenous regressors, i.e.,

$$rd_i = \mathbb{1}[\boldsymbol{\beta}_1' \overline{\mathbf{corrupt}}_i + \boldsymbol{\delta}_1' \mathbf{x}_{1i} + \epsilon_{1i} > 0], \tag{4.1}$$

$$upgrade_i = \mathbb{1}[\gamma rd_i + \boldsymbol{\beta}_2' \overline{\mathbf{corrupt}}_i + \boldsymbol{\delta}_2' \mathbf{x}_{2i} + \epsilon_{2i} > 0], \tag{4.2}$$

$$newpdt_i = \mathbb{1}[\vartheta upgrade_i + \lambda rd_i + \boldsymbol{\beta}_3' \overline{\mathbf{corrupt}}_i + \boldsymbol{\delta}_3' \mathbf{x}_{3i} + \epsilon_{3i} > 0], \tag{4.3}$$

where $\mathbb{1}$ denotes the indicator function which takes the value one 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, $\overline{\mathbf{corrupt}}_i$, firm, industry and country characteristics, $\mathbf{x}_{1i}$, and other unobserved variables summarized in the error term ϵ_{1i}. If the firm's R&D incentive is positive,[11] the firm is observed to be an R&D performer. Thus rd_i is a binary variable taking the value one if firm i has had positive R&D spending during 2005-2007, and zero otherwise. The coefficients to be estimated are $\boldsymbol{\beta}_1$ that captures the effect of corruption activities by foreign and domestic firms on R&D and $\boldsymbol{\delta}_1$ 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 $\boldsymbol{\beta}_2$ and $\boldsymbol{\delta}_2$ 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 one 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, $\boldsymbol{\beta}_3$ and $\boldsymbol{\delta}_3$ that capture respectively the direct effect of R&D, corruption and control variables on major innovation.

[11] 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.

Before turning to the estimation strategy, a few remarks 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 (see Section 3). 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. We believe that a simultaneous-equations specification with feedback effects in equations (4.1) and (4.2) would complicate the model substantially without necessarily bringing additional value to the study, the main focus being the effect of corruption (especially by foreign firms) on innovation activities in host countries. Nonetheless, the model is of the simultaneous-equations type where the endogeneity of rd_i in equation (4.2) and that of rd_i and $upgrade_i$ in equations (4.3) are accounted for through the correlations of the error terms. Finally, since the model has nonlinear conditional means, the coefficients of equations (4.1)-(4.3) only pick up the sign and significance of the effects of the explanatory variables. In order to quantify these effects, we need to calculate marginal effects or average partial effects.[12] Because of the simultaneous-equations characteristic of the model, three types of average partial effects (APEs), namely direct, indirect and total APEs are to be computed. For instance, corruption has a direct effect on incremental innovation, captured by $\boldsymbol{\beta}_2$, 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 $\boldsymbol{\beta}_1$. The total effect of corruption on incremental innovation is the sum of the direct and the indirect effect.

[12]In large samples, both types of effects should be similar. We opt for the second one for reasons of computation convenience.

4.3 Estimation

Full information maximum likelihood

We estimate the model using full information maximum likelihood (FIML) estimation techniques. In other words, equations (4.1)-(4.3) are *jointly* estimated by maximum likelihood, which requires distributional assumptions regarding the error terms $\boldsymbol{\epsilon}$. Given the regressors, the error terms are assumed to be normally distributed with mean $\mathbf{0}$ and covariance matrix $\boldsymbol{\Sigma} = \begin{pmatrix} 1 & & \\ \rho_{12} & 1 & \\ \rho_{13} & \rho_{23} & 1 \end{pmatrix}$, where ρ_{12}, ρ_{13} and ρ_{23} are also to be estimated. A test of the exogeneity of rd_i and $upgrade_i$ is obtained by *jointly* testing the null hypothesis H_0: $\rho_{12} = \rho_{13} = \rho_{23} = 0$ using Wald or likelihood ratio tests. The log-likelihood consists of $2^3 = 8$ components calculated over various subsamples defined by equations (4.1)-(4.3), i.e.

$$\ln L = \sum\nolimits_{000} \ln L_{000} + ... + \sum\nolimits_{111} \ln L_{111}, \tag{4.4}$$

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

$$L_{jk0} = \int_a^b \int_c^d \int_{-\infty}^{-A_{3i}} \phi_3(\epsilon_{1i}, \epsilon_{2i}, \epsilon_{3i}) d\epsilon_{1i} d\epsilon_{2i} d\epsilon_{3i}, \tag{4.5}$$

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

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

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

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

$$A_{1i} \equiv \boldsymbol{\beta}_1' \overline{\mathbf{corrupt}}_i + \boldsymbol{\delta}_1' \mathbf{x}_{1i}, \tag{4.6a}$$

$$A_{2i} \equiv \gamma rd_i + \boldsymbol{\beta}_2' \overline{\mathbf{corrupt}}_i + \boldsymbol{\delta}_2' \mathbf{x}_{2i}, \tag{4.6b}$$

$$A_{3i} \equiv \vartheta upgrade_i + \lambda rd_i + \boldsymbol{\beta}_3' \overline{\mathbf{corrupt}}_i + \boldsymbol{\delta}_3' \mathbf{x}_{3i}. \tag{4.6c}$$

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

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

The multiple integrals of equations (4.5) and (4.7) involve multivariate cumulative distribution functions which are evaluated using the GHK simulator so that the resulting log-likelihood to be maximised is a simulated log-likelihood.[13]

Average partial effects

Various types of APEs, namely joint, conditional and marginal, can be computed upon estimation of multivariate discrete choice models (see e.g. Greene, 2012). We are interested in the marginal APEs which, unlike in the trivariate probit with exogenous regressors, are different from the standard univariate probit APEs for equations in which the binary dependent variables appear as regressors. Let us write the exogenous linear indexes as

$$\boldsymbol{\pi}_m' \mathbf{z}_{mi} \equiv \boldsymbol{\beta}_m' \overline{\mathbf{corrupt}}_i + \boldsymbol{\delta}_m' \mathbf{x}_{mi}, \qquad m \in \{1, 2, 3\}.$$[14]

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

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

[13]The GHK simulator is named after the econometricians Geweke, Hajivassiliou and Keane. The model has been implemented using the user-written *cmp* command by David Roodman in Stata 12.1 (see e.g. Roodman, 2011).

[14]In our jargon, the exogenous linear indexes are linear functions of the sole exogenous regressors.

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), i.e.

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

Since rd_i is a binary variable,

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

which, using the standard normal CDF, is written as

$$\mathbb{E}(upgrade_i \big| \mathbf{z}_{1i}, \mathbf{z}_{2i}) = \ \Phi_1\left(\boldsymbol{\pi}_1' \mathbf{z}_{1i}\right) \Phi_1\left(\gamma + \boldsymbol{\pi}_2' \mathbf{z}_{2i}\right) + \Phi_1\left(-\boldsymbol{\pi}_1' \mathbf{z}_{1i}\right) \Phi_1\left(\boldsymbol{\pi}_2' \mathbf{z}_{2i}\right). \tag{4.9}$$

The conditional mean associated with equation (4.3) also requires using the LIE, i.e.,

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

which using similar derivations yields

$$\begin{aligned}\mathbb{E}(newpdt_i \big| \mathbf{z}_{1i}, \mathbf{z}_{2i}, \mathbf{z}_{3i}) = & \ \Phi_1\left(\boldsymbol{\pi}_1' \mathbf{z}_{1i}\right) \Big[\Phi_1\left(\gamma + \boldsymbol{\pi}_2' \mathbf{z}_{2i}\right) \Phi_1\left(\vartheta + \lambda + \boldsymbol{\pi}_3' \mathbf{z}_{3i}\right) \\ & + \Phi_1\left(-\gamma - \boldsymbol{\pi}_2' \mathbf{z}_{2i}\right) \Phi_1\left(\lambda + \boldsymbol{\pi}_3' \mathbf{z}_{3i}\right)\Big] \\ & + \Phi_1\left(-\boldsymbol{\pi}_1' \mathbf{z}_{1i}\right) \Big[\Phi_1\left(\boldsymbol{\pi}_2' \mathbf{z}_{2i}\right) \Phi_1\left(\vartheta + \boldsymbol{\pi}_3' \mathbf{z}_{3i}\right) \\ & + \Phi_1\left(-\boldsymbol{\pi}_2' \mathbf{z}_{2i}\right) \Phi_1\left(\boldsymbol{\pi}_3' \mathbf{z}_{3i}\right)\Big].\end{aligned} \tag{4.10}$$

We obtain the marginal APEs of, say 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

Before discussing the results, it is worth mentioning that two variants of the model have been estimated. In variant 1, we consider as corruption regressors the percentage of firms in each 2-digit ISIC industry that engage in grand and petty corruption. In variant 2, the industry average of the intensity of public procurement bribe and that of the bribe paid "to get things done" are used. We then select our preferred model on the basis of Akaike and Bayesian information criteria. Both criteria indicate that variant 1 is the better specification. Hence, we shall report and discuss extensively the results of variant 1 in this section while, for the sake of exhaustiveness, those of variant 2 are reported in Appendix B.

Table 7: Akaike and Bayesian Information Criteria[‡]

Model	N	k	lnL	AIC	BIC
Variant 1	6509	73	-10248.535	20643.07	21138.08
Variant 2	6509	73	-10261.229	20668.46	21163.47

[‡]Notes: N = # observations, k = # parameters, lnL = log-likelihood. The Akaike and Bayesian information criteria are computed as AIC = -2lnL + 2N and BIC = -2lnL + $k$ln$N$.

Table 8 shows FIML estimates of the determinants of R&D, incremental and major innovation with the industry percentage of corrupt firms as the corruption regressors. Total average partial effects are reported for all explanatory variables with the exception of sector categories and country groups.[15] The APEs are fur-

[15]The estimates for sector categories and country groups are not reported in order to save space. They can be obtained upon request.

Table 8: FIML estimates of the determinants of R&D, and incremental and major innovation with the percentage of corrupt firms in industry as a measure of corruption‡

Variable	R&D		Upgraded products		New products	
	APE	Std. Err.	APE	Std. Err.	APE	Std. Err.
Upgraded products	-	-	-	-	0.4089**	0.0130
R&D	-	-	0.1920**	0.0106	0.1955**	0.0136
Grand corruption						
% foreign firms	-0.0015†	0.0008	-0.0028**	0.0008	-0.0026**	0.0009
% local firms	0.0002	0.0004	0.0003	0.0005	0.0002	0.0005
Petty corruption						
% foreign firms	-0.0006	0.0005	0.0002	0.0005	0.0019**	0.0006
% 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	0.1141**	0.0160	0.0178	0.0169	0.0121	0.0186
Local						
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			

‡Notes: 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%

ther decomposed into direct and indirect effects for the corruption regressors, and reported in Table A.1.

Effects of corruption on innovation

The results 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. More specifically, a one percentage point increase of foreign firms with public procurement bribery activities in the firm industry decreases the likelihood of performing R&D, improving existing lines of products and services and introducing new products or services respectively by 0.15%, 0.28% and 0.26%. As for petty corruption, these activities 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 on major innovation operates mainly indirectly through reducing innovation efforts and incremental innovation (see Table A.1). We find no stifling effect of foreign petty corruption on R&D and incremental innovation. The effect of petty corruption on major innovation 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 positive and significant total effect. This "wheel greasing" effect is rather surprising but decreases as the percentage of corrupt firms increases (see Figure 1). Furthermore, grand corruption by foreign firms, which is our main focus, does have a consistent stifling effect on all three measures of innovation.

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 with grand corruption activities up to a certain percentage of corrupt firms. Beyond a certain threshold, i.e. 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

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

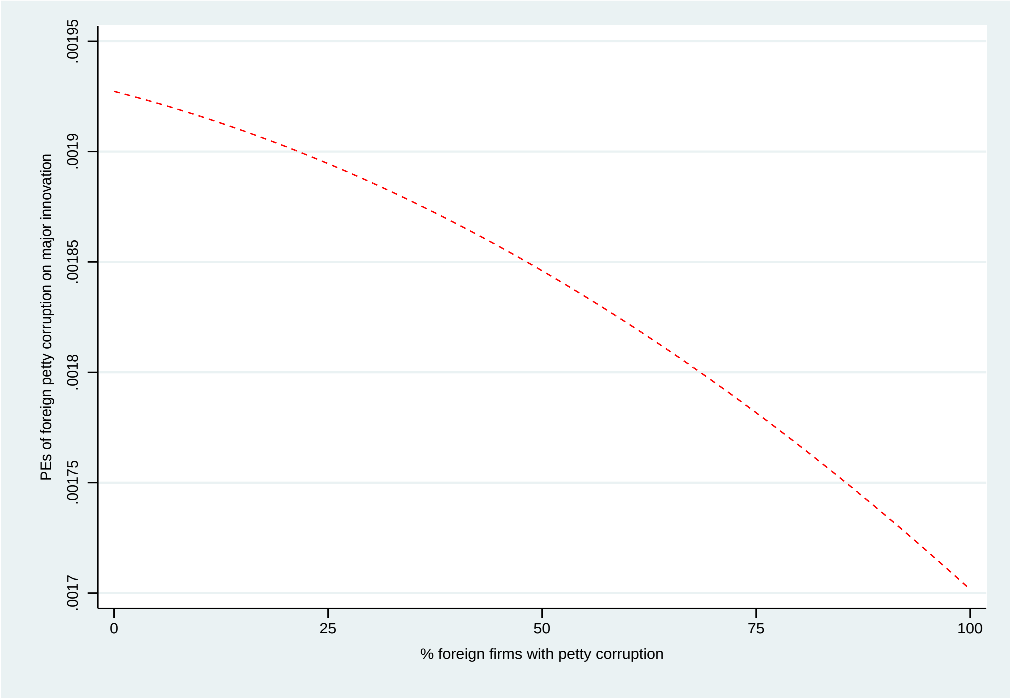
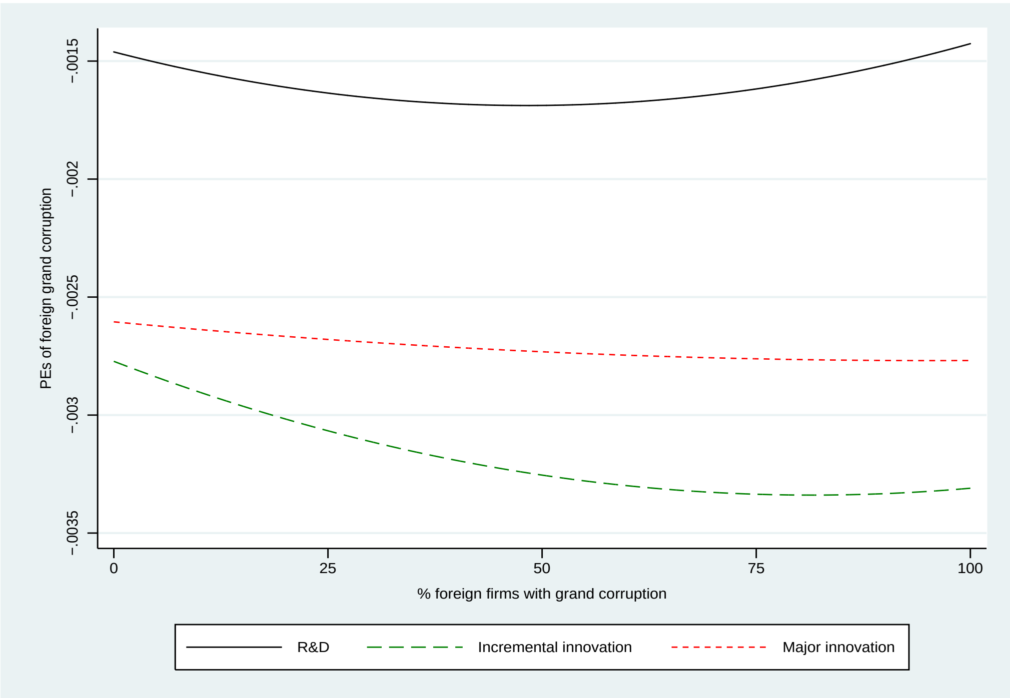
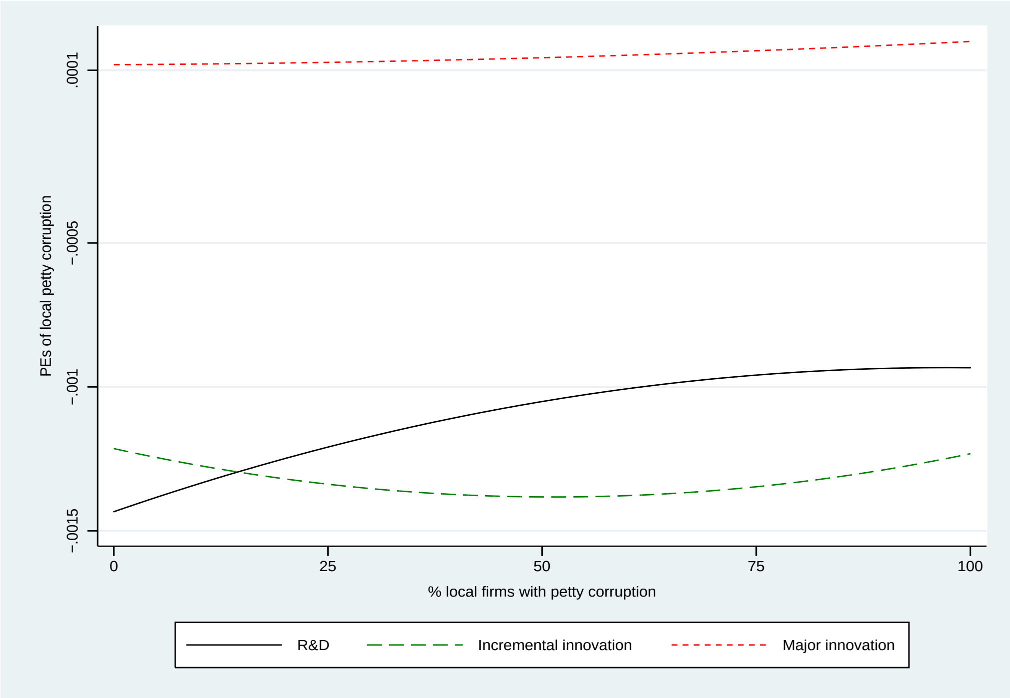


Figure 2: Partial effects of grand corruption by foreign firms on R&D, and incremental and major innovation for different levels of corruption



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

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



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.

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 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, market share, having export activities, receiving government subsidies and securing contracts with the government are all important factors 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.

6 Conclusion

Despite its localised short-term gains, corruption is *in fine* an undesirable phenomenon as it both undermines the reliability of governance institutions and jeopardises long-run economic growth by lowering investment rate. When foreign firms engage in it in their host countries, they bring about transnational corruption that feeds upon local corruption and adds to its harmful effects. By the fundamental role innovation plays as a determinant of long-term growth and competitiveness of firms, it is also one of the most important channels through which corruption undermines growth.

To highlight the growth effects of corruption through this channel, we have empirically analysed the effect of transnational corruption on innovation efforts and innovation success in transition economies of Eastern Europe and Central and Western Asia. Making a distinction between acts of grand corruption in government contracts and the more routine practices of petty corruption, we have estimated the firms' likelihood of engaging in innovative activities in the presence of foreign and domestic corrupt corporations operating in their business sector. Our results show that an increase in the proportion of foreign firms engaging in grand corruption discourages investment in research and development, reduces the likelihood of upgrading existing lines of products and services, and stifles the achievement of new products or services. Likewise, an increase in the proportion of domestic firms with petty corruption activities decreases the likelihood of R&D activities and incremental innovation success. No significantly negative direct effect of corruption, be it foreign or domestic, on major innovation was observed. The significantly negative effect of foreign grand corruption on major innovation operates mainly through reducing innovation efforts and incremental innovation (indirect effect). There seems to be a “wheel greasing” effect of foreign petty corruption on the achievement of new products, but this effect tends to decrease as the level of corruption increases.

In the light of these results, we can argue 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. 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. 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.

Our results indicate that transnational corruption exacerbates the negative effects of local corruption by further deteriorating the innovation potential of firms in host countries. Its short-term positive payoffs for bribing firms must be weighed against the long-term loss in the ability of competing firms to generate future innovations. 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. The ongoing efforts engaged by the European Union to fight corruption in transition economies are still relevant today and must continue to be targeted at both local bureaucracy and foreign corporations especially those involved in public procurement in these economies.

Appendix A Direct, indirect and total average partial effects

Here we derive direct, indirect and total average partial effects for each equation of the recursive simultaneous-equations trivariate probit.

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

$$\partial\mathbb{E}(rd_i|\mathbf{z}_{1i})/\partial z = \pi_{1z}\phi_1(\boldsymbol{\pi}_1'\mathbf{z}_{1i}), \tag{A.1}$$

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 (eq. (4.2)) are obtained as

$$\begin{aligned}\partial\mathbb{E}(upgrade_i|\mathbf{z}_{1i},\mathbf{z}_{2i})/\partial z =& \underbrace{\pi_{2z}\Big[\phi_1\big(\gamma+\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\,\Phi_1\big(\boldsymbol{\pi}_1'\mathbf{z}_{1i}\big)+\phi_1\big(\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\,\Phi_1\big(-\boldsymbol{\pi}_1'\mathbf{z}_{1i}\big)\Big]}_{\text{direct effect}}\\ &+\underbrace{\pi_{1z}\phi_1\big(\boldsymbol{\pi}_1'\mathbf{z}_{1i}\big)\Big[\Phi_1\big(\gamma+\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)-\Phi_1\big(\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\Big]}_{\text{indirect effect}},\end{aligned} \tag{A.2}$$

where we use the symmetry of the normal distribution, i.e. $\phi_1(\boldsymbol{\pi}_1'\mathbf{z}_{1i}) = \phi_1(-\boldsymbol{\pi}_1'\mathbf{z}_{1i})$.

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

$$\partial\mathbb{E}(newpdt_i|\mathbf{z}_{1i},\mathbf{z}_{2i},\mathbf{z}_{3i})/\partial z = \underbrace{\pi_{3z}F(\mathbf{z}_i)}_{\text{direct effect}} + \underbrace{\pi_{2z}G(\mathbf{z}_i)+\pi_{1z}H(\mathbf{z}_i)}_{\text{indirect effect}}, \tag{A.3}$$

where $\mathbf{z}_i = (\mathbf{z}_{1i},\mathbf{z}_{2i},\mathbf{z}_{3i})$, and F, G and H are respectively given by

$$\begin{aligned}F(\mathbf{z}_i) =& \Phi_1\big(-\boldsymbol{\pi}_1'\mathbf{z}_{1i}\big)\Big[\phi_1\big(\vartheta+\boldsymbol{\pi}_3'\mathbf{z}_{3i}\big)\,\Phi_1\big(\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)+\phi_1\big(\boldsymbol{\pi}_3'\mathbf{z}_{3i}\big)\,\Phi_1\big(-\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\Big]\\ &+\Phi_1\big(\boldsymbol{\pi}_1'\mathbf{z}_{1i}\big)\Big[\phi_1\big(\vartheta+\lambda+\boldsymbol{\pi}_3'\mathbf{z}_{3i}\big)\,\Phi_1\big(\gamma+\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\\ &+\phi_1\big(\lambda+\boldsymbol{\pi}_3'\mathbf{z}_{3i}\big)\,\Phi_1\big(-\gamma-\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\Big],\end{aligned}$$

$$G(\mathbf{z}_i) = \phi_1\big(\gamma + \boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\,\Phi_1\big(\boldsymbol{\pi}_1'\mathbf{z}_{1i}\big)\left[\Phi_1\big(\vartheta + \lambda + \boldsymbol{\pi}_3'\mathbf{z}_{3i}\big) - \Phi_1\big(\lambda + \boldsymbol{\pi}_3'\mathbf{z}_{3i}\big)\right]$$
$$+ \phi_1\big(\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\,\Phi_1\big(-\boldsymbol{\pi}_1'\mathbf{z}_{1i}\big)\left[\Phi_1\big(\vartheta + \boldsymbol{\pi}_3'\mathbf{z}_{3i}\big) - \Phi_1\big(\boldsymbol{\pi}_3'\mathbf{z}_{3i}\big)\right]$$

and

$$H(\mathbf{z}_i) = \phi_1\left(\boldsymbol{\pi}_1'\mathbf{z}_{1i}\right)\Big[\Phi_1\big(\gamma + \boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\Phi_1\big(\vartheta + \lambda + \boldsymbol{\pi}_3'\mathbf{z}_{3i}\big) - \Phi_1\big(\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\Phi_1\big(\vartheta + \boldsymbol{\pi}_3'\mathbf{z}_{3i}\big)$$
$$+ \Phi_1\big(-\gamma - \boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\Phi_1\big(\lambda + \boldsymbol{\pi}_3'\mathbf{z}_{3i}\big) - \Phi_1\big(-\boldsymbol{\pi}_2'\mathbf{z}_{2i}\big)\,\Phi_1\big(\boldsymbol{\pi}_3'\mathbf{z}_{3i}\big)\Big].$$

Standard errors are obtained by the delta method.

Table A.1: Direct, indirect and total average partial effects of corruption on innovation

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

Significance levels : $\dagger$: 10% $\quad *$: 5% $\quad **$: 1%

Appendix B Estimation results with industry bribery intensity

Table B.2: FIML estimates of the determinants of R&D, and incremental and major innovation with the average bribe intensity in industry as a measure of corruption‡

Variable	R&D		Upgraded products		New products	
	APE	Std. Err.	APE	Std. Err.	APE	Std. Err.
Upgraded products	-	-	-	-	0.4096**	0.0130
R&D	-	-	0.1934**	0.0106	0.1947**	0.0136
Grand corruption						
Foreign PPB	-0.0122†	0.0073	-0.0208**	0.0070	-0.0043	0.0085
Local PPB	0.0013	0.0029	0.0007	0.0036	0.0044	0.0039
Petty corruption						
Foreign bribe	-0.0422	0.0074	-0.0001	0.0069	0.0159	0.0098
Local bribe	-0.0101**	0.0038	0.0007	0.0038	0.0007	0.0043
Univ. degree	0.0010**	0.0002	0.0002**	0.0000	0.0003**	0.0001
Employment	0.0347**	0.0043	0.0108*	0.0046	0.0064	0.0052
Market share	0.0076**	0.0026	0.0090**	0.0027	0.0107**	0.0031
Export	0.0934**	0.0141	0.0620**	0.0137	0.0907**	0.0161
Subsidies	0.0906**	0.0188	0.0750**	0.0176	0.0908**	(0.0211)
Gvt. contract	0.0929**	0.0153	0.0952**	0.0143	0.1435**	0.0172
Competition						
Foreign						
Fairly important	0.0252†	0.0146	0.0301*	0.0147	0.0242	0.0167
Important	0.0697**	0.0148	0.0334*	0.0149	0.0220	0.0169
Very important	0.1145**	0.0160	0.0184	0.0170	0.0120	0.0186
Local						
Fairly important	0.0131	0.0190	0.0555**	0.0175	0.0630**	0.0190
Important	0.0028	0.0168	0.0747**	0.0161	0.0980**	0.0176
Very important	0.0312†	0.0171	0.0707**	0.0169	0.1074**	0.0184
# observations			6059			
Log-likelihood			-10261.229			

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

Table B.3: Direct, indirect and total average partial effects of corruption on innovation

Variable	R&D spending	Upgraded products		
	Direct	Direct	Indirect	Total
Grand corruption				
Foreign PPB intensity	-0.01222†	-0.01853**	-0.00227	-0.02080**
Local PPB intensity	0.00125	0.00043	0.00023	0.00066
Petty corruption				
Foreign bribe intensity	-0.00422	0.00066	-0.00079	-0.00013
Local bribe intensity	-0.01008**	0.00257	-0.00188*	0.000695
		New products		
Grand corruption				
Foreign PPB intensity		0.00654	-0.01087**	-0.00433
Local PPB intensity		0.00387	0.00052	0.00439
Petty corruption				
Foreign bribe intensity		0.01681†	-0.00089	0.01592
Local bribe intensity		0.00238	-0.00171	0.00067

Significance levels : $\dagger$: 10% $*$: 5% $**$: 1%

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