JANDHYALA, S. and OLIVEIRA, F.S. 2021. The role of international anti-corruption regulations in promoting socially responsible practices. *Journal of economic behavior and organization* [online], 190, pages 15-32. Available from: https://doi.org/10.1016/j.jebo.2021.07.017

The role of international anti-corruption regulations in promoting socially responsible practices.

JANDHYALA, S. and OLIVEIRA, F.S.

2021

The Role of International Anti-Corruption Regulations in Promoting Socially Responsible Practices

Srividya Jandhyala[a], Fernando S. Oliveira[b,*]

[a] Management Department, ESSEC Business School, 5 Nepal Park, Singapore 139408, Singapore

[b] Information Systems and Operations Management, The University of Auckland Business School, The Owen G Glenn Building, 12 Grafton Road, Auckland, 1010, New Zealand

ABSTRACT

We analyze how international anti-corruption rules impact the behavior of multinational firms in promoting sustainable practices. Competition from multinational firms is expected to lower bribe rents and hence corruption in host countries. However, we argue that the competition between domestic and multinational firms is unequal as (only) the latter face greater monitoring and sanction through international anti-corruption regulations. We develop a game theoretic model of bribing to examine the strategic response of firms under conditions of unequal competition. We show that under certain conditions the bribing probability of domestic firms *increases* when multinational firms facing greater penalties refrain from bribing. We use an agent-based simulation to analyze industries with heterogeneous firms, showing that the optimal strategies converge to the Nash equilibrium, and identify the major drivers of profitability and bribing.

Keywords: Agent-Based model; Corruption; Multinational Companies; Non-cooperative Games; Organizational Behavior.

1. Introduction

Firms regularly encounter pressure to engage in corrupt and fraudulent practices in the course of their operations, in supply chain management activities (e.g., Arnold, Neubauer, and Schoenherr, 2012; Mu and Carroll, 2016) and in procurement auctions (Padhi, Wagner and Mohapatra, 2016). In particular, corruption – the abuse of public power for private gain – is considered to be the norm rather than the exception around the world, but it is difficult to track (e.g., Bertrand, Simeon, Hanna and Mullainathan, 2007; Joseph, Gunawan, Sawani, Rahmat, Noyem, and Darus, 2016).

A number of big corruption scandals involving multinational companies such as Airbus, Ericsson, Odebrecht, Siemens, and Walmart have come to light in recent years, with companies paying hundreds of millions of dollars in bribes around the world. The most common reason to pay bribes was to gain an advantage in landing public procurement contracts with foreign governments (Ferdman, 2014). In one case involving Siemens, a German engineering company, bribery was widespread, purportedly to maintain the competitiveness of the firm, keeping the business alive, and not jeopardizing thousands of jobs (Schubert and Miller, 2008). Siemens had cash desks where employees could fill empty suitcases with cash and the firm openly claimed tax deductions for bribes, listing many of them in their accounts as "useful expenditure" (Economist, 2008). And they won public contracts to build railroads in Venezuela, cell phone systems in Bangladesh, a national ID project in Argentina, among others (Shapiro, 2008).

Germany, however, outlawed the bribery of foreign officials in 1999. And by listing their shared on the New York stock exchange in 2001, Siemens became subject to the stringent US anti-bribery law. Neither policy, however, seemed to stench the flow of bribes. In the six years after the firm's American listing, the firm paid more than $800 million in bribes to win contracts (Economist, 2008). When the law eventually caught up with them, the firm paid a record $1.6 billion fine to US and European regulators in 2008, and a further $3 billion on bribery-related fines and costs since then (Economist, 2015). These penalties appear to have initiated significant anti-corruption efforts within the firm (Watson, 2013). But what is less clear is how the enforcement of anti-bribery laws in Germany and the US has impacted the levels of corruption in Venezuela, Bangladesh, Argentina, or other foreign markets. Arguably, German and American regulators have little authority or ability to monitor the behavior of domestic firms or public officials in those countries.

Policymakers contend that international anti-corruption efforts that hold firms accountable in their home country for behavior in foreign markets are a "major breakthrough in the fight against corruption" (OECD, 2013:2), emphasizing the *de facto* enforcement of these regulations to lower corruption in host countries. This may well have the intended effect on multinational firms headquartered in developed countries with strong judicial system and significant resources for monitoring and sanction. However, this cost is not imposed on domestic competitors in the foreign country which may lead to perverse incentives. One survey across 15 emerging economies found that domestic firms have a much higher probability of bribing than multinational firms facing strong anti-bribery initiatives (Transparency International, 2000). Similarly, Jensen and Malesky (2018) show that bribery among domestic firms in Vietnam *increased* following the decline in bribery of multinational firms whose home countries adopted the OECD Anti-Bribery Convention. Following the passage of the UK's Anti-Bribery Act of 2010, UK firms in high-corruption countries experienced a drop in firm value as they could no longer win government contracts through bribery, but (domestic) competitors in these countries encountered an *increase* in firm value (Zeume, 2017).

We ask: How do the unequal costs of corruption influence the bribing behavior of domestic and multinational firms? Following research on the economics of corruption (e.g., Ades and Di Tella, 1999; Rose-Ackerman, 1999; Basu, Basu and Cordella, 2016), we use a game theoretic model to derive predictions based on clearly specified assumptions. Earlier models proposed by Rose-Ackerman (1975) describe the bribing incentives of firms engaged in a government contracting process, focusing on variations in demand characteristics (i.e., government preferences) and changes in the number of competitors. Schelling (1973, 1978) uses binary models of bribe taking behavior. Caulkins et al. (2014) extend Schelling's approach to consider a continuous probability of accepting bribes, while Perla et al. (2018) use Schelling's model to consider the network effects of corruption, analyzing how social tie formation enables the spread of corrupt behavior.

Also using game theory, Macrae (1982) proves that, under certain conditions, bribing is the dominant strategy and has a negative effect on economic development. Hindriks, Keen and Muthoo

(1999) analyze the importance of corruption in the design of a tax collection scheme, and Pasetta (1999) studies the divide asset game with bribing. In other examples, Celentani and Ganuza (2002) compare the prevalence of corruption when bribe takers compete or are organized in an illegal syndicate; Friehe (2008) models corruption in an inspection game; and Kingston (2007, 2008) analyzes the briber's dilemma in linked games, studying how the information structure and norms can be used against paying bribes, and the emergence of bribing cultures. Çule and Fulton (2009) study the inspection game, showing that it has multiple equilibria, and that corruption is persistent in many of these, meaning penalties can have perverse effects. Balafoutas (2011) studies how perceived public beliefs affect corrupt behavior in a repeated game, while Evrenk (2011) models a repeated game between a clean and a corrupt competition, showing that when corruption is high, in equilibrium, no politician adopts a political reform targeting corruption. Examining other aspects and settings, Zhu (2012) explains why higher penalties may fail to deter corruption; Accinelli and Carrera (2012) study how corruption is driven by imitation and Accinelli et al. (2017) analyze how politically active citizens can prevent the spread of corruption; Cerqueti and Coppier (2016) examine corruption in relation to pollution inspection issues; Litina and Palivos (2016) report the existence of multiple self-fulfilling equilibria in which different levels of corruption emerge; Strîmbu and González (2018) show that higher transparency increases the size of bribes paid. More recently, Buckenmaier, Dimant and Mittone (2020) analyze the bribing game within a tax evasion framework, showing that leniency towards whistle blowing decreases collusion and bribing acceptance rate, increasing the collected tax yield; Aragonès, Ribas and Tóth (2020) analyze competition between honest and corrupt politicians, showing that corruption cannot be eliminated when voters have heterogeneous preferences.

Our approach focuses specifically on the interaction between multinational and domestic firms. As indicated above, competition between them is unequal as multinational firms face greater monitoring and sanction through international anti-corruption regulations. Our game theoretical analysis indicates that under certain conditions this inequality creates perverse incentives for domestic firms, as follows: domestic firms *increase* their bribing propensity to capture the additional bribe rents as multinational firms lower their bribing in response to additional monitoring and sanction. This behavior is consistent with Galang's (2012) conceptualization where firms actively exploit opportunities presented by corruption, especially when it increases their own output and productivity compared with their less corrupt peers. We also find an important role of the internal costs associated with bribing, particularly costs arising from the diversion of resources from a firm's productive activity to bribing.

To complement our analytical approach and test the validity of the Nash equilibrium as a predictor of bribing behavior, we have also programed an agent-based simulation with heterogeneous firms. In our conceptualization, firms compete in a large number of projects and decide whether or not to bribe in each project. For this reason, an agent-based model is the closest representation of the problem. However, because the profit function depends on the prevalence of bribing in the firm and in the industry as a whole, an equilibrium analysis using game theory can predict how agents, deciding about binary variables, behave on average. An interesting outcome is the complementarity of the analysis using game theory and agent-based modeling.

2. Model Specification

We consider a model where N firms compete for government projects. Each firm competes for a portfolio of projects, either in parallel or over a period of time during which the environment does not change. Each project is a one-shot game where firms make simultaneous moves. For each project, a firm has to determine whether it will offer a bribe or not. In addition, while each firm has complete information about its own bribing decisions and the associated costs (including the likelihood of detection and severity of punishment), firms do not know the payoffs of the other firms competing in the market, nor do they observe the strategic choices of other firms (i.e., if the other firms bribe). What they can observe is the average level of bribing that emerges in the industry (as suggested by corruption indices or informed insiders). Therefore, this is a game of incomplete information, as decisions are made without taking into account the profit function and decisions of the other firms.

This model is representative of firms bidding for government procurement projects across many countries. Once a project has been identified, governments typically issue calls for tenders. Multiple firms may respond by submitting simultaneous bids. The bids are evaluated by a government authority which typically chooses a single winner based on some pre-defined criteria. In theory, an open and competitive bidding process ensures that the most qualified firms receive government funded contracts. In practice, firms can distort this process through bribery. A prominent example is the case of Odebrecht, a large Brazilian construction company. Between 2001-2016, Odebrecht paid $788 million in bribes for 100 projects in 12 countries (Mayka and Lovon, 2019). The bribes allowed them to win projects and buffer themselves from the consequences of poor performance. Bribery appears to be a strategic choice; firms worry that by not paying bribes they will lose business to rivals who do (Economist, 2020). The US government estimated that in a one-year period in the mid-1990s, foreign bribes undercut US firms' abilities to win contracts worth $45 billion (New York Times 1996).

Before starting to describe the actual model, we would like to note that it is parameter agnostic. We have written a very general framework that can be adapted to consider different industry conditions. Moreover, we also note that this is an abstraction of the real function, which is not observable and can probably only be locally approximated by our model. A major advantage of this approach, however, is transparency, as it is possible to derive analytical results that are general and supported by numerical simulations that are always instances of the general model.

The decision variable for each firm *i* is to bribe $(o_{ip} = 1)$ or not to bribe $(o_{ip} = 0)$ in each project *p*. There are *P* projects in the portfolio. The players in the game are modeled as risk neutral, rational players. They are seeking to maximize their expected payoffs, given their beliefs about the other players. We determine a firm's optimal bribing strategy over the entire portfolio, captured as its bribing probability. This is similar to Accinelli and Carrera (2012), Caulkins et al. (2014) and Perla et al. (2018), but we focus on the bribe paying side of the problem. Our model however differs from the approach in Cerqueti and Coppier (2016), as they use bribery as a way to report false information. It also differs from Zhu (2012), as she considers that there are two inspectors whose type (tough or soft) is not known to the corrupt official.

We use a mixed strategies game (e.g., Fudenberg and Tirole 1991; Von Neumann and Morgenstern 1958) in which players decide the probability with which they will make a choice. Mixed strategies have been used previously to analyze the bribing and corruption problems, e.g, Pasetta (1999), Friehe (2008), Zhu (2012), Accinelli et al. (2017), Strîmbu and González (2018). For this reason, let the *bribing probability* y_i be the proportion of projects in which i bribes, as calculated in equation (1).

$$y_i = \frac{\sum_p o_{ip}}{P} \tag{1}$$

The *industry bribing probability* x is the average proportion of firms bribing in an industry (with N firms), representing Schelling's (1973, 1978) prevalence of corruption in society, calculated using equation (2). As x depends on the strategic choice (bribing) of the firms in the industry, it emerges from the model.

$$x = \frac{\sum_j y_j}{N} \tag{2}$$

The model structure is summarized in Figure 1. This scheme illustrates how the binary decisions by each firm are used to calculate the bribing probability for each firm and the industry bribing probability. The industry bribing probability in turn influences the behavior of each firm. Given that these firms learn by interacting with each other, the properties of the system as a whole (the bribing probability in a given industry) is an emergent property of the interactions between these firms.

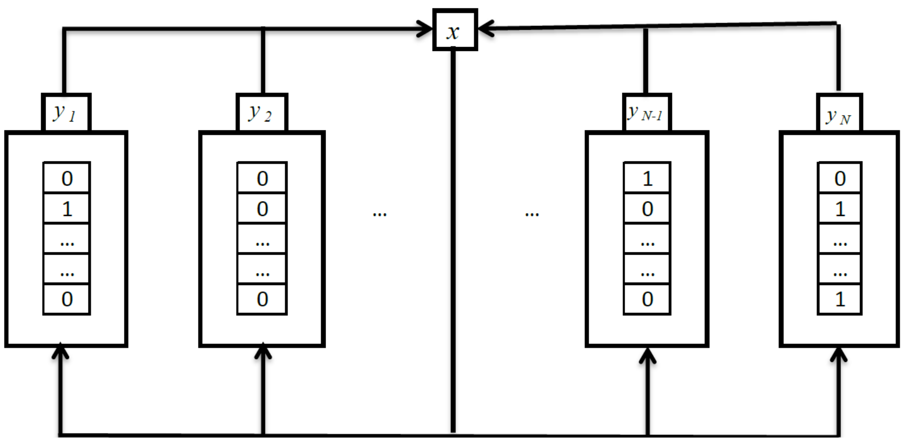


Figure 1: Model structure.

Let Ω_i^0 be the average profit of firm *i* when it does not bribe, conditioned on the behavior of the other firms in the industry. Each firm maximizes the expected profit, $E\left[\Omega_i\right]$, from bribing as described by equation (3).

$$\underset{y_i}{Max}\, E\left[\Omega_i\right] = (1-y_i)\Omega_i^0 + y_i\Omega_i^0\left(1+\alpha_i - b_i x - \lambda_i y_i - f_i\right), \qquad \text{for} \qquad i = 1,2,\ldots N \tag{3}$$

In equation (3), $\alpha_i > 0$ represents firm *i*'s average return from bribing, or the bribe effectiveness. The higher α_i the greater certainty and magnitude of returns for a firm that bribes. The average non-bribing profit, given that other firms do not bribe either, was standardized to 1. However, competition for bribe rents lowers the potential benefits (Hellman, Jones and Kaufmann 2002) at a rate of *b*. Thus, *b* refers to the sensitivity of rents to industry bribing.

The remaining parameters in equation (3) capture the average cost of bribing in relation to productivity losses and bribing costs. The first is caused by the diversion of resources from productive activities towards bribing. Research suggests that bribe payment is negatively correlated to firm growth (Fisman and Svensson 2007) and lowers firm productivity due to the diversion of managerial effort away from factor coordination (Bó and Rossi 2007). The *productivity losses* are represented by $\lambda_i y_i$, for each firm *i*, in which the productivity declines at the rate of λ_i.

The second cost is associated with the actual *bribe payment and punishment*. The bribe paid to secure an advantage can represent a sizeable value. In public procurement projects, bribes can range between 5%–25% of the contract value (OECD, 2007). Moreover, there is the risk of being caught and punished, what Macrae (1982) calls the probability that sanctions are imposed. The *bribe payment and punishment costs* are characterized in the model through the term f_i, a monetary cost and penalty associated with bribe payment.

When a firm refrains from bribing, it does not gain any profit advantage in the market compared to its competitors nor does it face any of the direct costs associated with bribing. From equation (3) we obtain a standardized measure of profit, $E\left[\Omega_i\right]$, by dividing the expected profit by the profit under no corruption scenario, Ω_i^0. The standardized profit presented in equation (4) has the same properties and the same optimal solution as equation (3) and it is easier to interpret.

$$\underset{y_i}{Max}\, E\left[\Pi_i\right] = (1-y_i) + y_i\left(1+\alpha_i - b_i x - \lambda_i y_i - f_i\right), \qquad \text{for } i = 1, 2 \ldots N \tag{4}$$

3. Properties of the Bribing Game

In the general model described in (4), we assume heterogeneity in firms' profit and penalty conditions. We now make several simplifying assumptions before analyzing the game.

First, we consider the special case where there are two types of firms within *N*: domestic firms (represented by index *d*) and multinational firms (represented by index *m*). We further assume that firms of a given type (*d* or *m*) have similar parameters, but the model parameters vary across the two types. Our focus is on the punishment costs, represented by f_d and f_m, for domestic and multinational firms, respectively. As international anti-corruption regulations monitor, regulate, and punish the behavior of firms from signatory countries in foreign markets, but do not directly influence domestic firms in the market, the punishment costs of the two groups are different; in particular $f_m > f_d$.

Second, let w_d and w_m represent, respectively, the proportion of domestic and multinational competitors in the industry, then *x* can be redefined by equation (5), in which y_d and y_m stand for the average bribing probability of domestic and multinational firms, respectively.

$$x = w_d y_d + w_m y_m \tag{5}$$

In Figure 2 we represent this aggregation of the firms into the two types (domestic and multinational). As in the base model, the properties of the system are an emergent property of the individual decisions, project by project, of each firm. However, in this case, we are able to aggregate the behavior of each firm into the behavior of the type to which it belongs to. This is an important step to facilitate the equilibrium analysis of the behavior of the different types of firm, on average.

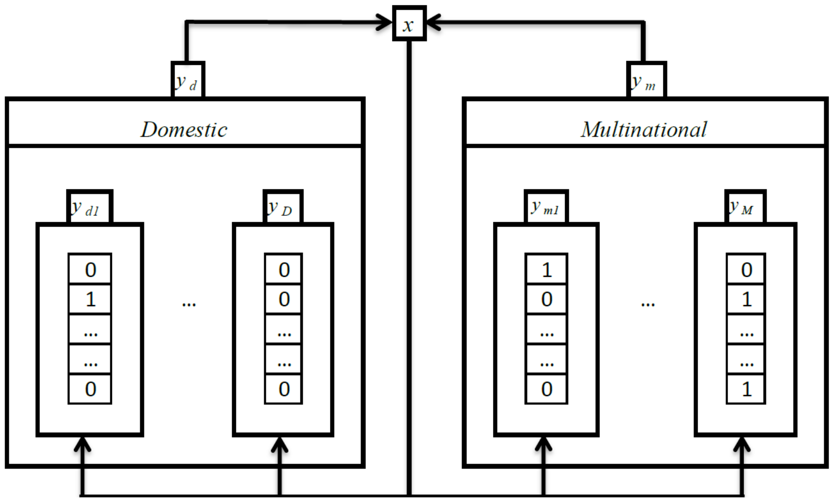


Figure 2: Aggregating firms by type: Domestic (*D* firms) vs. Multinational (*M* firms).

We proceed by computing the mixed strategies Nash equilibrium describing how the two types of firms interact. When domestic and multinational firms have at least one different parameter defining their respective profit functions, there is a mixed strategy Nash equilibrium such that both types of companies optimize their respective bribing probabilities, while the action of each type of firm is conditioned by the other type's strategy, as summarized in Proposition 1.

Proposition 1: *Let d and m stand for domestic and multinational firms, respectively, with at least one different parameter defining the respective profit functions. Then, the mixed strategy Nash equilibrium of the game defined by equations* (1) to (5) *is* $y_d^* = \dfrac{A_d - B_d A_m}{1 - B_d B_m}$, $y_m^* = \dfrac{A_m - B_m A_d}{1 - B_d B_m}$, *in which*

$$A_d = \frac{\alpha_d - f_d}{b_d w_d + 2\lambda_d},\ A_m = \frac{\alpha_m - f_m}{b_m w_m + 2\lambda_m}\quad B_d = \frac{b_d w_m}{b_d w_d + 2\lambda_d},\ B_m = \frac{b_m w_d}{b_m w_m + 2\lambda_m}.$$

[Proof is in the Appendix.]

Next, we consider the sufficient condition for the equilibrium to hold, as summarized in Proposition 2, which is always true as the marginal productivity loss due to bribing (λ_i) is always positive, independently of the type of firm.

Proposition 2: *Let d and m stand for domestic and multinational firms, respectively, with at least one different parameter defining the respective profit functions. A sufficient condition for* y_d^* *and* y_m^* *to be a Nash equilibrium of the game is for* $\lambda_d > 0$ *and* $\lambda_m > 0$. [Proof is in the Appendix.]

We now further simplify the model by assuming that all the parameters are equal for both types of firms, except the punishment costs, f_d and f_m. Lemma 1 represents the new equilibrium conditions.

Lemma 1: *Let* $0 < f_d < f_m$ *,* $\alpha_d = \alpha_m = \alpha$, $\lambda_d = \lambda_m = \lambda > 0$, *and* $b_d = b_m = b$, *then the mixed strategy Nash equilibrium of the bribing game is computed by the following equations*:

$y_d^* = \dfrac{2\lambda\alpha + bw_m f_m - (bw_m + 2\lambda) f_d}{2b\lambda + 4\lambda^2}$, $y_m^* = \dfrac{2\lambda\alpha + bw_d f_d - (bw_d + 2\lambda) f_m}{2b\lambda + 4\lambda^2}$. [Proof is in the Appendix.]

Furthermore, in Corollary 1 we find that the bribing probability of domestic firms is larger than that of multinational firms.

Corollary 1: *Let* $0 < f_d < f_m$, $\lambda_d = \lambda_m = \lambda > 0$, *and* $b_d = b_m = b$, *then, in the mixed strategy Nash equilibrium* $y_d^* - y_m^* > 0$. [Proof is in the Appendix.]

4. Bribing Patterns of Domestic and Multinational Firms

We now present a numerical analysis of the impact of competition on the bribing probability of domestic and multinational firms. We consider how the bribing probability changes when international anti-corruption regulations alter punishment costs for multinational (but not domestic) firms. We assign representative values to the various parameters in the model such that they meet the conditions for an equilibrium solution (Table 1).

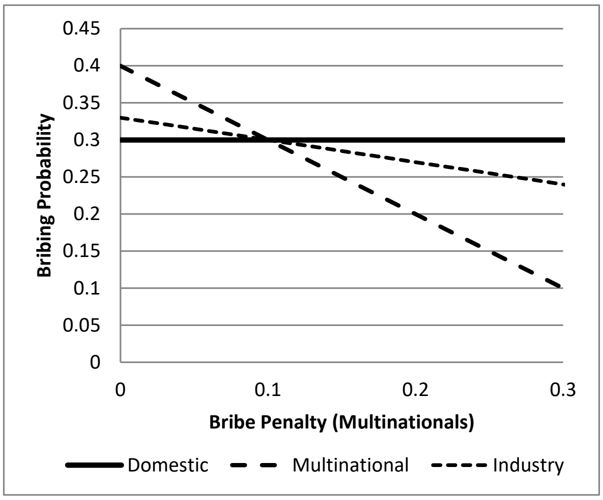
Table 1: Sample parameter values in a stylized setting.

Parameter	Description	Base case	Parameter	Description	Base case
α	Relative gain of bribing firm over non-bribing firm	0.4	w_m	Proportion of multinational firms	0.3
b	Sensitivity of rents to industry bribing (Extent to which the difference in returns of bribing and non-bribing firms are affected by other firms' bribing actions)	-0.5 0 0.5	λ	Rate of productivity decline due to bribing	0.5
f_d	Bribe cost and penalty for domestic firms	0.1	f_m	Bribe cost and penalty for multinational firms	0.2

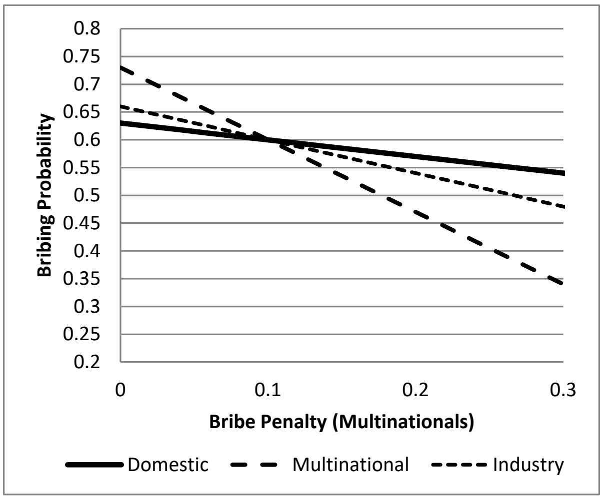
We compare three conditions related to the different effects of industry bribing on a firm's profits. The parameter *b* (sensitivity of rents to industry bribing) is an important factor, affected by government discretion and industry structure. (i) $b = 0$ when the relative profits from bribing (versus not bribing) are not affected by the proportion of bribing in the industry. We would expect $b = 0$ when the industry is highly competitive and additional bribe rents offered by governments are not dependent on firms' bribing behavior. (ii) $b < 0$ when the profits of bribing are impacted to a lesser degree by the proportion of bribing in the industry. Bribing is an acceptable practice and firms provide a quality of service that is similar whether they bribe or not. Governments have significant discretion with little to no oversight such that they can significantly alter the scope of projects, and hence associated rents, based on the proportion of firms bribing. (iii) $b > 0$ when the profits from bribing are impacted to a greater degree by the proportion of bribing in the industry. This may be the case when governments have low discretion in altering the scope of the project. This may indeed be the case when institutional checks and balances are present, and oversight of government activities is significant. Alternately, this may be true when there is a drive to reduce bribing acts not only through punishment but also by selecting suppliers that give assurances of not engaging in such practices. More likely, $b > 0$ in industries where bribing is associated with poor product and (or) service quality; in this case, non-bribing is also a public signal of higher product quality, acting as a form of product differentiation and protecting the firm's revenues from bribing competition.

4.1. Altering punishment costs

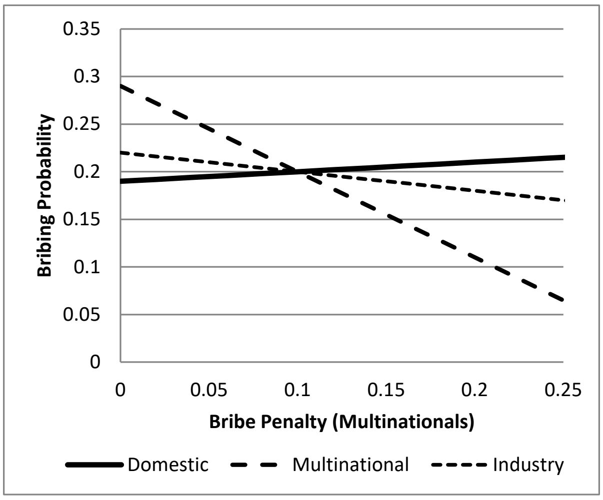
We start by examining how the expected punishment costs for multinational firms affect bribing. Figure 3 describes bribing behaviors as a function of punishment costs for multinational firms (all other parameters fixed).



(i) $b = 0$.



(ii) $b = -0.5$.



(iii) $b = 0.5$.

Figure 3: Bribing probability as a function of punishment costs on multinational firms. Domestic refers to the bribing probability of domestic firms, Multinational is the multinational firms' bribing probability, and Industry to the average industry bribing probability.

First, across all three cases, the bribing probability of multinational firms decreases as their punishment costs increase. Second, although the bribing probability of multinational firms can sometimes be higher than the corresponding probability of domestic firms (extreme left region in Figure 3), we expect such situations to be unlikely. Since multinational firms are subject to the laws and jurisdictions of the foreign country, f_m cannot be lower than f_d. Third, as multinational firms are subject to greater monitoring and sanction, the overall industry bribing probability also decreases (Industry in Figure 3). Given this is the intent of international anti-corruption regulations we conclude they are effective to a certain degree.

The behavior of domestic firms, however, shows different trends across the three conditions. When $b < 0$ we observe the expected pattern of decline in both multilateral and domestic firms' bribing probability. However, the other two conditions demonstrate interesting patterns. When $b = 0$ there is no change in domestic firms' bribing probability even when the penalty on multinational firms increases. Unlike multinational firms, the bribing probability of domestic firms does not decrease with punishment costs for multinationals. Even more striking, when $b > 0$ the bribing probability of domestic firms *increases* with better enforcement of international anti-corruption regulations. This effect is observed because the potential rents from bribing remain unchanged.

In other words, when $b > 0$, although multinational firms refrain from bribing due to higher punishment costs, the potential gains from bribing are unaffected – therefore, domestic firms respond by replacing the bribes that might have otherwise been paid by the multinational firms and increase their own bribing activity. For this reason, domestic firms capture a greater share of the rents from bribing when multinational firms are penalized for the same.

Proposition 3 supports and generalizes the results depicted in Figure 3.

Proposition 3: Let $\lambda_d = \lambda_m = \lambda > 0$, $b_d = b_m = b$, *and* $f_m > f_d > 0$, *then, in the mixed strategy Nash equilibrium*: (a) The impact of an increase of penalties on multinationals, *m*, on the bribing probability of domestic firms, *d*: *i*) $\frac{\partial y_d^*}{\partial f_m} = 0$ if and only if $b = 0$; *ii*) $\frac{\partial y_d^*}{\partial f_m} < 0$ if and only if $b < 0$ and $\lambda > -\frac{b}{4}$.; *iii*)

$\frac{\partial y_d^*}{\partial f_m} > 0$ if and only if $b > 0$, or $b < 0$ and $\lambda < -\frac{b}{4}$. (b) The impact of an increase of penalties on multinationals on their bribing probability: *i*) $\frac{\partial y_m^*}{\partial f_m} = 0$ if and only if $\lambda = -\frac{bw_j}{2}$, $\lambda \neq -\frac{b}{2}$ and $b < 0$; *ii*) $\frac{\partial y_m^*}{\partial f_m} < 0$ if $b \geq 0$; when $b < 0$ it follows that $\frac{\partial y_m^*}{\partial f_m} < 0$ if $\lambda < -\frac{bw_j}{2}$, or if $\lambda > -\frac{b}{2}$. *iii*) $\frac{\partial y_m^*}{\partial f_m} > 0$ when $b < 0$ and $-\frac{bw_j}{2} < \lambda < -\frac{b}{2}$. [Proof is in the Appendix.]

We now look at an example of the workings of the stylized model, based on the parameters summarized for the base case in Table 1.

Example. In Figure 3, as in Proposition 3, when $b = 0$ we have $\frac{\partial y_d^*}{\partial f_m} = 0$. When $b = -0.5$, given the parameters in Table 1, the condition $\lambda > -\frac{b}{4}$ is equivalent to $0.5 > 0.125$, implying that $\frac{\partial y_d^*}{\partial f_m} < 0$ (as observed in Figure 3.ii). When $b = 0.5$ and $\frac{\partial y_d^*}{\partial f_m} > 0$ (the bribing probability increases for domestic firms as the punishment costs for multinational firms increases, as can also be verified in Figure 3.iii). In Figures 3.i) and 3.iii),, when $b \geq 0$, the $\frac{\partial y_m^*}{\partial f_m} < 0$: this same result arises from Proposition 3, as when $b = -0.5$, as condition $\lambda > -\frac{b}{2}$ holds true, $0.5 > 0.25$, then $\frac{\partial y_m^*}{\partial f_m} < 0$.

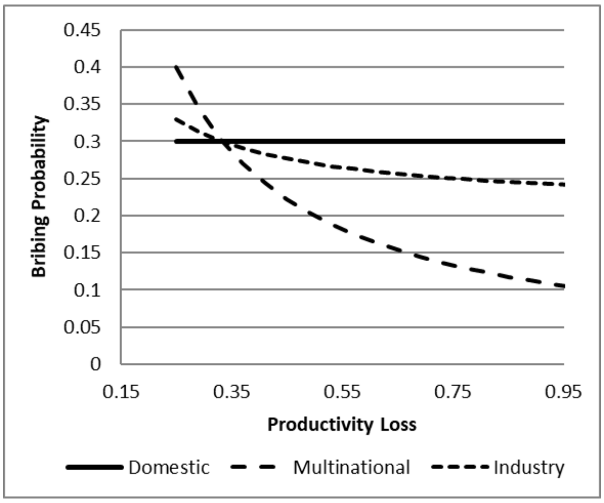
4.2. Examining the impact of productivity loss on bribing

We now analyze the impact of productivity loss on bribing. We examine the loss of productivity effect ranging from a very high λ for an "inexperienced" multinational firm (on the far right of Figure 4) to a very low λ for an "experienced" multinational. In the case of an inexperienced multinational, its unfamiliarity with, and lack of roots in a local environment, as well as its lower perceived legitimacy, can be significant liabilities. In the context of bribing, this translates to significant search costs.

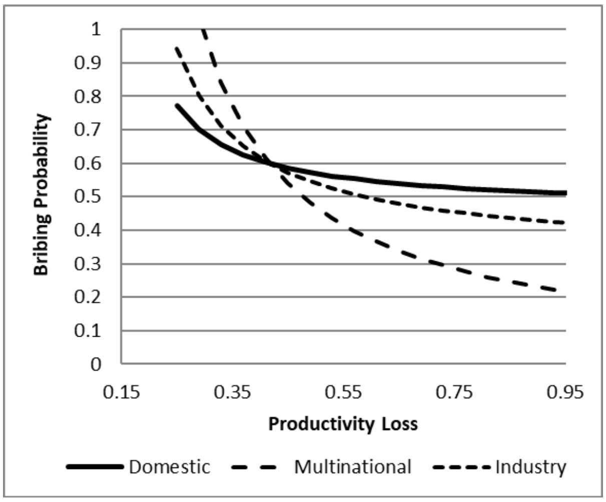
For example, the inexperienced multinational may not have ties to local politicians and regulators or is unaware of local norms. With low legitimacy, such firms also face potentially greater indirect costs, such as reputation costs. Thus, the inexperienced multinational faces significant productivity losses from bribery. In contrast, the experienced multinational – which we refer to as one with a large advantage in expertise and significant in-country experience – has greater legitimacy and lower liability of foreignness. Given their in-depth knowledge of the host country's institutional and environmental conditions, as well as bribing norms, their search costs are low. Further, their greater perceived legitimacy can buffer them from reputational costs. Consequently, their productivity losses are lower. Figure 4 describes the bribing pattern of domestic and multinational firms as the productivity losses of multinational firms increase.

Towards the left of the graph (*depicting the experienced multinational firm*), we find that multinational firms have similar (*iii*) or higher (*i* and *ii*) bribery probability, due to their expertise advantage and knowledge of the country, despite international anti-corruption regulations. In contrast, on the right (*with inexperienced multinational firms*) the bribing probability, as expected, is lower. Proposition 4 proves this same result analytically.

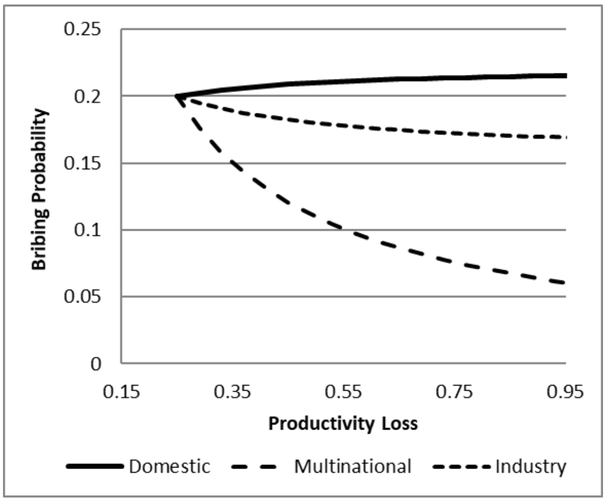
Proposition 4: *Let* $b_d = b_m = b$, $0 < f_d < f_m$, $\lambda_d > 0$, *and* $\lambda_m > 0$. *then*: (A) *When* $b = 0$ *then* $\frac{\partial y_d^*}{\partial \lambda_m} = 0$*; if* $b < 0$ *then* $\frac{\partial y_d^*}{\partial \lambda_m} < 0$*; if* $b > 0$ *then* $\frac{\partial y_d^*}{\partial \lambda_m} > 0$ *if and only if* $b < 2\frac{\lambda_d}{w_d}.\frac{\alpha - f_m}{f_m - f_d}$. (B) $\frac{\partial y_m^*}{\partial \lambda_m} < 0$ *if and only if* $0 \le b < 2\frac{\lambda_d}{w_d}.\frac{\alpha - f_m}{f_m - f_d}$ *or if and only if* $0 > b > -2\frac{\lambda_d}{w_d}$. [Proof is in the Appendix]



(i) $b = 0$.



(ii) $b = -0.5$.



(iii) $b = 0.5$.

Figure 4: Bribing probability as a function of productivity losses of multinational firms. Domestic refers to the bribing probability of domestic firms, Multinational is the multinational firms' bribing probability, and Industry to the average industry bribing probability.

Next, we provide an example to illustrate the results depicted in Figure 4 and generalized in Proposition 4, based on the parameters summarized in Table 1.

Example. As illustrated in Figure 4.i), when $b = 0$ the $\frac{\partial y_d^*}{\partial \lambda_m} = 0$, which is also the general result proved in Proposition 4. In Figure 4.ii)hen $b = -0.5$ the $\frac{\partial y_d^*}{\partial \lambda_m} < 0$, which is also the conclusion from Proposition 4. In Figure 4.iii), when $b = 0.5$, the $\frac{\partial y_d^*}{\partial \lambda_m} > 0$, this result is also supported by Proposition 4, as $b < 2\frac{\lambda_d}{w_d}.\frac{\alpha - f_m}{f_m - f_d}$, given that $0.5 < 2\frac{0.5}{0.7}.\frac{0.4-0.2}{0.2-0.1}$ is equivalent to $0.5 < 2.85$. In all three Figures 4 we observe that $\frac{\partial y_m^*}{\partial \lambda_m} < 0$, this result also follows from Propositon 4, as either $b \geq 0$ and $0 \leq b < 2\frac{\lambda_d}{w_d}.\frac{\alpha - f_m}{f_m - f_d}$, which is equivalent to $0 \leq b < 2.85$ (Figures 4.i and 4.iii); or when $b = -0.5$ (Figure 4.ii), it follows from Proposition 4 that $0 > b > -2\frac{\lambda_d}{w_d}$ and equivalently $0 > -0.5 > -1.42$.

Crucially, the impact of the change in the multinational productivity loss on the bribing of domestic firms depends on *b*, which measures the impact of the spread of bribery on profit. When *b* = 0 domestic firms are not affected by the experience of multinationals. If *b* < 0, the profits of bribing firms are affected to a lesser degree by the spread of bribing. The overall level of bribing is higher but, interestingly, the increase in the productivity loss of multinationals leads to a large decrease in the bribing probability of all the firms in the industry. When *b* > 0, the profits of bribing firms are strongly affected by the industry bribing propensity. For this reason, overall levels of bribing are lower. However, with the increase in the multinationals' productivity loss (and the decrease in bribing proportion), domestic firms start bribing more. Because of their lower productivity loss of bribing, domestic firms take over bribing opportunities which, otherwise, would have been taken up by multinationals.

5. Examining Heterogeneity in Firms' Profiles

We now analyze how firm heterogeneity influences behavior. We use agent-based simulation as it is able to accommodate firms with different objective functions. Agent-based simulation is a different way of doing science, differing from both deductive and inductive methods (Axelrod, 1997). Its main advantage is that it allows the modeling of out-of-equilibrium behavior (e.g., Arthur, 2006), including a formal analysis of non-linear organizational behavior (Davis et al., 2007). This methodology is useful to understand macro-level effects from micro-level observations (Smith and Rand, 2018), and to capture organizational behavior (e.g., Albin and Foley, 1992; Caldart and Oliveira, 2010; Clement and Puranam, 2017) and the exploration and exploitation trade-off in learning (e.g., March, 1991).

5.1 The Agent-Based Pseudocode

The pseudocode for the agent-based simulation, based on neighborhood search (e.g., Westhoff, Yarbrough, and Yarbrough, 1996; Levinthal, 1997; Caldart and Oliveira, 2010; Billinger et al., 2014), is described in Table 2.

First, we set up the parameters. The simulation runs R times. At the start of each run, in Step 1 we initialize the N firms by randomly assigning a given bribing strategy, not bribe (0) or bribe (1) to each one of the P projects each firm holds. We also randomly initialize each of the required parameters in Table 1 from a uniform distribution with a range equal to the value of the parameter in Table 1, plus and minus u% of the parameter value. Then we compute the average level of bribing in the P projects for each firm (y_i), the bribing proportion in the industry (x), and using equation (4) we calculate each firm's initial profit.

In Step 2 the firms learn by interacting with each other. For each one of the T iterations, each firm i implements a neighborhood search with probability z. This means that when applying the neighborhood search, the firm evaluates each one of the possible moves (bribing changes to not bribing, and vice-versa) exhaustively. If no search is possible, it continues using the same bribing strategies for each one of the P projects. If the search is possible, for each one of the projects it chooses the opposite strategy (bribing changes to not bribing, and vice versa). If for a given project p

the search finds a profitable change, it stops and returns the updated decision vector with the new decision for project *p*.

Table 2: Pseudocode of the local search algorithm

Set-up:

Number of batch runs: *R*
Number of firms: *N*
Number of Iterations: *T*
Learning Probability: z
Number of projects: *P*

Parametric Uncertainty: *u*
Parameters describing each type of firm (Table 1)

For *r* =1 to R:

Step 1. Initialization

Initialize the bribing probability of each firm:

Generate the *P* elements (0 or 1) randomly for each firm *i*, with equal probability.

Generate the parameters in Table 1 randomly for each firm *i*, from a uniform distribution between the expected value of the parameter in Table 1 +/- *u*%.

Calculate y_i : average level of bribing in the *P* projects of firm *i* .

Compute the average bribing probability *x*.
Compute each firm's initial profit.

Step 2. Policy improvement

For *t* =1 to *T*:

For each firm *i*:

a) Generate a random number ω between 0 and 1
b) If $\omega < z$
   Neighborhood search:
   For *p* = 1 to *P*:
   i. Change decision from 1 to 0, or 0 to 1 (from the current to the opposite decision) and recalculate y_i.
   ii. Compute the firm's profit, equation (4), with the new decision.

      If the profit increased, stop search and return the updated vector with *N* decisions, and the corresponding y_i.

5.2 Simulation Results

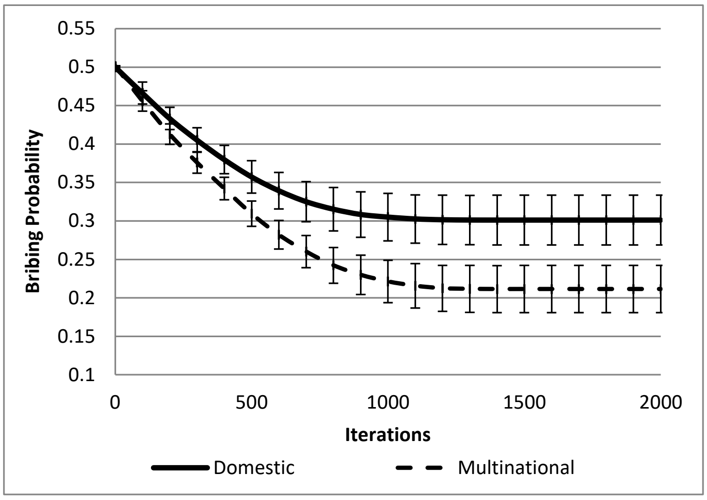
Let *T* be the number of iterations (2000, a large enough number to allow convergence) and *R* be the number of runs (100), and *z* be the probability a firm engages in a local search to improve its current profit. This probability should be set to a "low" value (for example 5%) to facilitate learning. *P* (100) is the number of projects a firm competes in. For any given project the firm decides between bribing, 1, or not bribing, 0. (The higher the number of projects the longer the algorithm takes to converge, but the more accurate the computation.) The number of firms N is equal to 10. The parameters used in each run, for each agent, are generated from a uniform distribution with range equal to the expected value reported in Table 1, plus and minus u as a proportion of the mean. The simulation parameters are summarized in Table 3.

We have tested the algorithm under different parameter settings, varying the number of players and projects assigned to each player. In the results depicted in Figures 6 and 7 the bars represent the 95% confidence intervals.

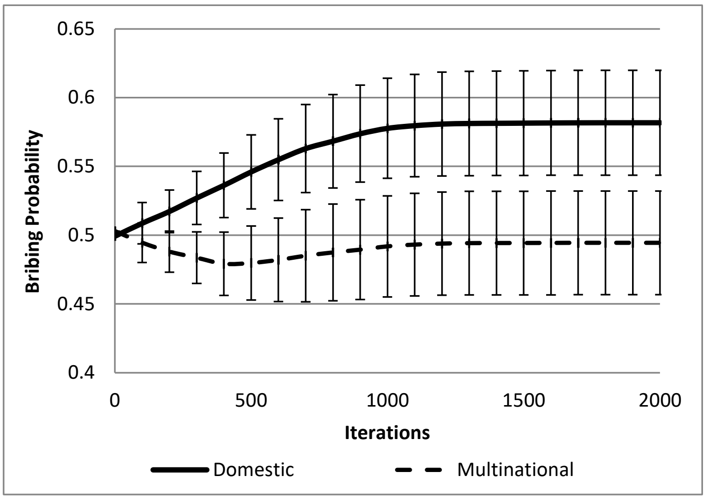
Table 3: Parameters for the Agent-Based Model

Number of Iterations: $T = 2000$
Number of batch runs: R = 100
Learning probability: z = 0.05
Number of projects: $P = 100$
Number of firms: $N = 10$
Parametric Uncertainty: $u = 0.2$ (Figure 6), $u = 0, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3$ (Figure 7)
Parameters describing each type of firm (Table 1)

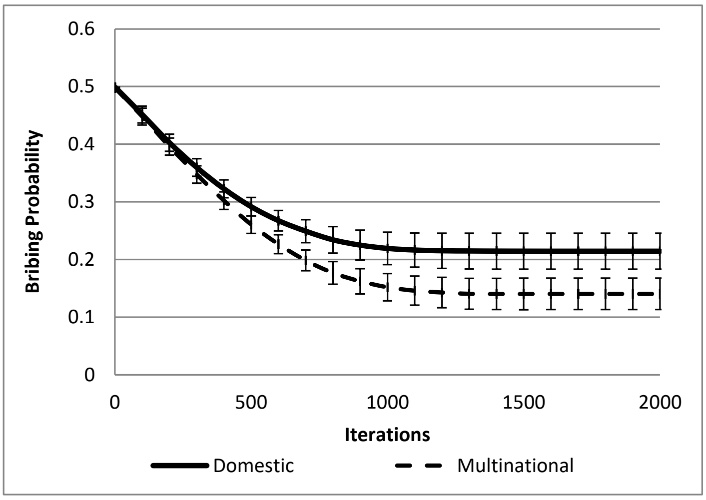
In Figure 6 we analyze three cases as a function of the impact of bribing proportion on profit (b), considering a parametric uncertainty u of 20%: $b = 0$, the profit of bribing and non-bribing firms are affected similarly by x; $b = -0.5$, the profit of bribing firms is affected *less* by x; and $b = 0.5$, the profit of bribing firms is affected *more* by x. In all three cases, the simulations converge to the neighborhood of the Nash equilibrium, as it is included in the confidence intervals (the range of which increases as the results converge on equilibrium). The increase in the range of the confidence intervals is caused by the agents learning to bribe using different strategies, depending on the specific parameters defining their behavior.



(i) $b = 0$



(ii) $b = -0.5$



(iii) $b = 0.5$

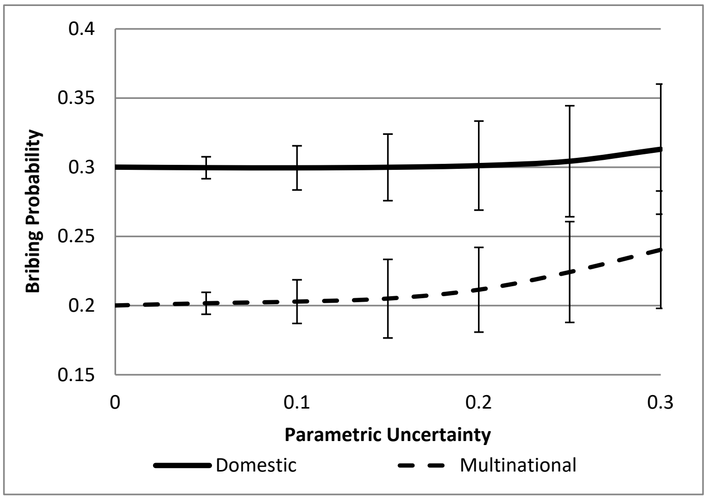
Figure 6: Heterogeneous Firms Learn the Optimal Bribing Probability. Parametric uncertainty of 20%.

For $b = 0$ the domestic firms learn to bribe in about 30.1% of the projects, whereas multinationals bribe in about 21.1% of the projects (Figure 6.*i*). The respective confidence intervals are [26.9%, 33.3%] and [18.1%, 24.2%], which include the Nash equilibrium pair {30%, 20%}, reported in the corresponding Figure 3.*i*). Similarly, for $b = -0.5$, the domestic firms learn to bribe in about 58.2% of the projects, whereas multinationals bribe in about 49.4% of the projects (Figure 6.*ii*). The respective confidence intervals are [54.4%, 62.0%] and [45.7%, 53.2%], which include the Nash equilibrium {57%, 47%} described in Figure 3.*ii*). Finally, for $b = 0.5$, the domestic firms learn to bribe in about 22.7% of the projects, whereas multinationals bribe in 12.8% of the projects (Figure 6.*iii*). The respective confidence intervals are [19.3%, 26.3%] and [10.0%, 15.6%], which include the Nash equilibrium {21%, 11%} reported in Figure 3.*iii*).

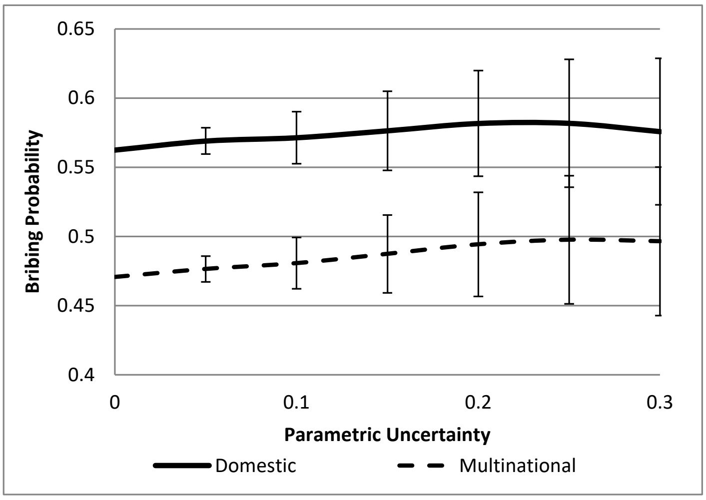
The speed of convergence of the agent-based simulation to the Nash equilibrium can be faster or slower depending on the prior knowledge held by the agents regarding the optimal strategy. In Figure 6 all the players are randomly assigned bribing decisions with an average probability of 50%. For this reason, the convergence process takes longer when the Nash equilibrium deviates from this prior knowledge. The closer the prior strategies are to the actual optimum behavior, the faster the convergence process will be.

In order to better understand the impact of uncertainty on the players' optimal bribing strategies, in Figure 7 we depict the expected bribing probability (with the respective confidence intervals) as a function of parametric uncertainty (ranging from 0% to 30%). In all the three cases the range of the confidence intervals increases monotonically with parametric uncertainty.

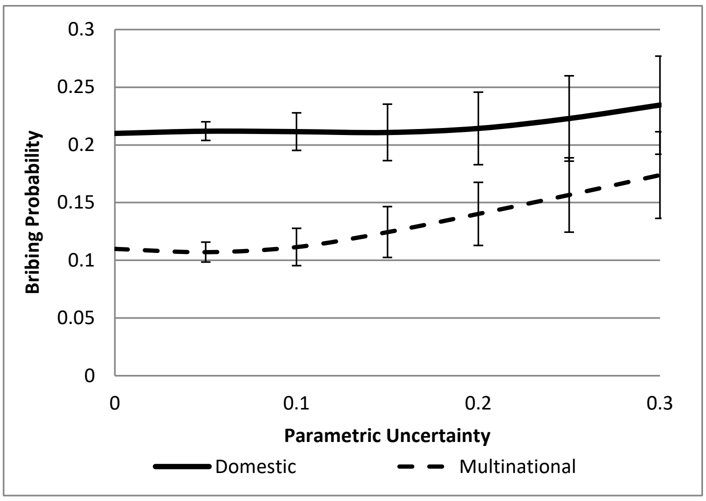
In all three settings, the confidence intervals include the Nash equilibrium, except for multinational companies under the specific condition: when b equals 0.5 and there are high levels of uncertainty. In this exceptional case, the bribing probability of multinational firms is above that predicted by game theory; thus, statistical evidence allows us to reject the hypothesis that the Nash equilibrium is a good predictor of the actual behavior of firms in this case, as uncertainty impacts behavior in a way captured by the agent-based model, but not by the Nash equilibrium.



(i) $b = 0$



(ii) $b = -0.5$



(iii) $b = 0.5$

Figure 7: Impact of Parametric Uncertainty on the Optimal Bribing Probability.

Overall, the results reassure us that when uncertainty is low, the Nash equilibrium is a robust predictor of the actual behavior of firms in the conditions described in the game. It is also very interesting to observe that even though in the agent-based simulation the decision space is composed of binary decisions and based on behavior learned by reinforcement (a very different setting from the optimizing players in the game theory setting), the optimal strategy, nonetheless, remains the same.

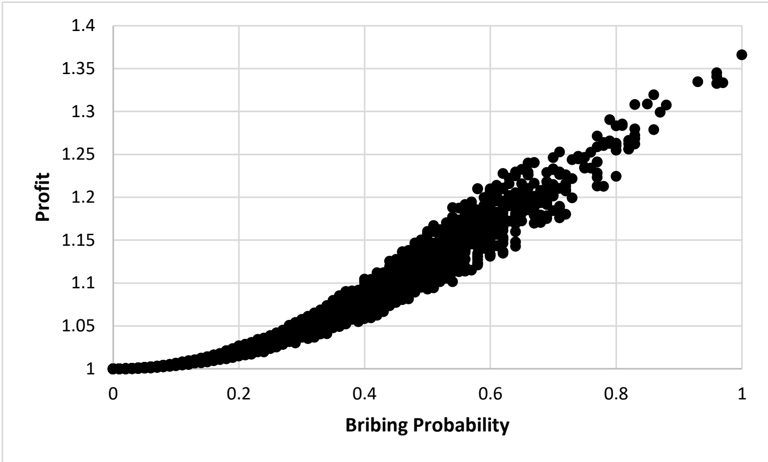
In Figure 8 we plot the relationship between bribing probability and profitability (for the three different choices of b). The results show that: the higher the bribing probability the higher the expected profit; bribing is most profitable and the bribing probability highest when b is negative (compared to the other two conditions; $b = 0$ and $b > 0$); the relationship between bribing probability and profit is non-linear, and the higher the bribing probability the more uncertain its impact on profit is.

To further analyze the relationship between the different parameters and the bribing behavior, we present results from a linear regression model, in three different specifications (with $b < 0$, $b = 0$, and $b > 0$) and a sample size of 7000 in each model. The conditional relationship between the different parameters and bribing probability and expected profit are presented in Tables 4 and 5, respectively.

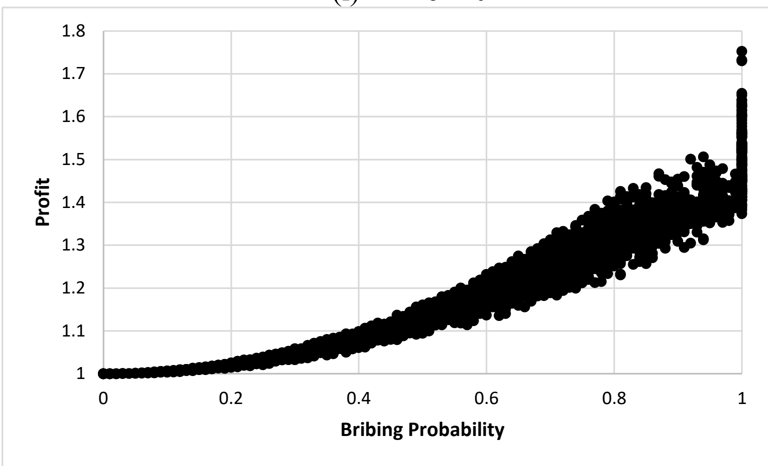
In Table 4 we attempt to explain the major determinants of the optimal bribing probability. All three models have an excellent fit, with the R^2-adjusted ranging from 91% to 97% and the results are largely consistent with the analytical specification. The coefficient of relative gain of bribing (α_i) is positive and significant; as the relative gain of bribing increases, the bribing probability also increases, with the highest effect when $b < 0$.

The coefficient of sensitivity of rents to industry bribing (b_i) itself has a negative impact on the bribing probability across the two conditions $b > 0$ and $b < 0$. On average, as the sensitivity of rents to industry bribing increases, there is a lower likelihood of firm bribing. However, this effect is stronger when $b < 0$ as in this condition the relative gains from bribing are lowered to a greater degree.

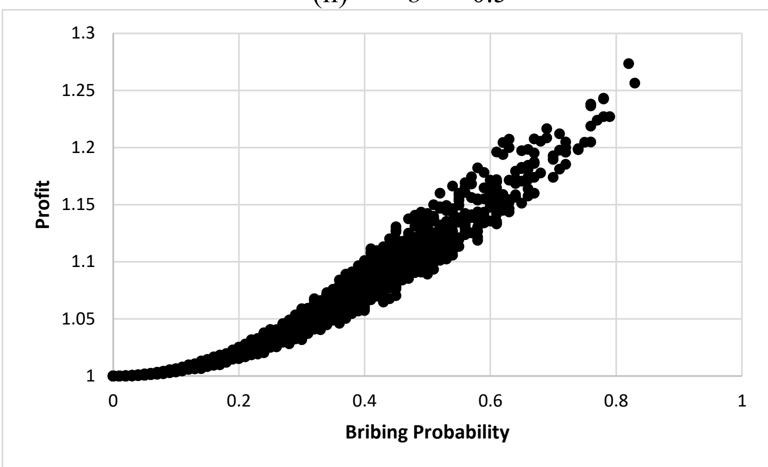
The impact of productivity losses (λ_i) on bribing probability is negative and significant in the three models such that the higher the λ_i the less profitable it is to bribe. However, this negative effect is strongest when $b < 0$, as it is in this setting that bribing is most profitable.



(i) $b = 0$



(ii) $b = -0.5$



(iii) $b = 0.5$

Figure 8: Profit as a Function of Bribing Probability for Heterogeneous Firms.

As expected, the impact of bribing cost and penalty (f_i) also has a negative and significant impact on the bribing probability, with the effect being strongest when $b < 0$ (when bribing is more profitable) and weakest when $b > 0$ (when bribing is a negative function of the prevailing behavior in the industry).

Table 4: Linear regression model of bribing probability (y_i) on model parameters (α_i, b_i, λ_i, f_i).

	Model 1 $b_i < 0$	Model 2 $b_i = 0$	Model 3 $b_i > 0$
Constant	0.53	0.297	0.262
	(0.009)	(0.003)	(0.007)
Relative gain of bribing (α_i)	1.03	0.967	0.867
	(0.004)	(0.002)	(0.003)
Sensitivity of rents to industry bribing (b_i)	-0.51	--	-0.185
	(0.012)		(0.009)
Productivity loss (λ_i)	-1.05	-0.567	-0.425
	(0.013)	(0.006)	(0.009)
Bribe cost and penalty (f_i)	-0.957	-0.955	-0.88
	(0.013)	(0.007)	(0.01)
$R^2 - Adj.$	0.91	0.97	0.918
F - test	17979	75705	19550
S. E.	0.053	0.026	0.041
N	7000	7000	7000

Note: all *p*-values are below 0.01. S.E. in parentheses.

In Table 5, we replicate our linear regression analysis with expected profits as a function of the parameters. As in Table 4, all three models have a very good fit, with the R^2-adjusted ranging from 74% to 84%. The intercept of the regression equation is approximately equal to 1, the standardized profit for a non-bribing firm. The coefficient of the relative gain of bribing (α_i**)** is positive and significant, with the highest value when $b < 0$, as expected.

The coefficient of sensitivity of rents to industry bribing (b_i) itself has a negative impact on profitability across the two conditions, $b > 0$ and $b < 0$, as the coefficient is negative. On average, as the sensitivity of rents to industry bribing increases, firms have lower profitability. However, this effect is stronger when $b < 0$ as in this condition the relative gains from bribing are lowered to a greater degree.

The coefficients of productivity loss (λ_i) and bribing cost and penalty (f_i) are both negative. As productivity loss or bribe cost and penalty increase, the profits are lower. Further, consistent with the finding on relative gains to bribing (α_i), the impact is stronger when $b < 0$.

Table 5: Linear regression model of profit (Π_i) on model parameters (α_i , b_i , λ_i , f_i).

	Model 1 $b_i < 0$	Model 2 $b_i = 0$	Model 3 $b_i > 0$
Constant	1.03	1.02	1.04
	(0.007)	(0.002)	(0.003)
Relative gain of bribing (α_i)	0.583	0.297	0.19
	(0.003)	(0.001)	(0.001)
Sensitivity of rents to industry bribing (b_i)	-0.3	--	-0.048
	(0.009)		(0.004)
Productivity loss (λ_i)	-0.38	-0.118	-0.084
	(0.009)	(0.004)	(0.004)
Bribe cost and penalty (f_i)	-0.518	-0.26	-0.174
	(0.01)	(0.004)	(0.004)
$R^2 - Adj.$	0.85	0.835	0.743
F - test	9845	11860	5058
S. E.	0.039	0.019	0.0175
N	7000	7000	7000

Note: all *p*-values are below 0.01. S.E. in parentheses.

6. Conclusions

In this paper, we have analyzed the bribing behavior of domestic and multinational firms using a game-theoretical model to understand how unequal competition among firms can have unexpected consequences. In particular, in some cases the strategic response of domestic firms may well be to *increase* their own bribing behavior when competing with multinational firms whose actions are exposed to greater monitoring and sanction through international rules and regulations, even if the overall industry bribing probability declines. In our model, the increase in domestic firms' bribing probability is associated with the sensitivity of rents to industry bribing (specifically $b < 0$). Thus, increasing bribe penalties for multinational firms can have an adverse impact on domestic firms' bribing behavior if they face consistently lower penalties.

Using agent-based simulation we established the robustness of the Nash equilibrium as predictors of bribing behavior when uncertainty is low. Moreover, we conclude that heterogeneous firms learn to behave in accordance with the optimal strategy of the respective firm type. Our model also suggests that parametric uncertainty impacts not only the range of the confidence intervals, but also its expected optimal bribing level. In one exceptional case with high parameter uncertainty, the game theoretical equilibrium is a biased predictor of bribing behavior, and agent-based modeling needs to be used instead. We have analyzed the sensitivity of bribing and profitability to the different parameters, and used regression analysis to identify the conditions under which penalties are the most effective in dissuading bribing behavior.

While our agent-based model only considered learning on bribing decisions, it is possible that firms learn along other dimensions as well. As the focus of our analysis is on bribing decisions, we examined this choice. However, analyzing changes in bribing decisions when firms learn on multiple parameters remains subject to future work.

Our theory and models suggest several policy implications. First, we shed light on why better monitoring and increased penalties on multinational firms through international anti-corruption initiatives may be insufficient for constraining bribing behavior. We uncover interdependencies between domestic and multinational firms, rents available, government policy, and punishment costs. In particular, focusing international efforts on the supply side of bribes rather than the demand side ignores the potential rents in competitive markets. Any institution designed to tackle host country corruption must include a wider set of actors and create a more level playing field among multinational and domestic firms. Second, our models demonstrate that when returns from bribing are more certain, the incentives for domestic firms to bribe are magnified. One implication is to generate interdependencies among bureaucrats or divisions for a particular policy issue. For example, if a firm has to depend on several agencies to receive a permit, bribing a single official may not generate the desired outcome. In addition, while the firm could bribe officials in all the agencies involved, this increases the bribe cost, which may make the rewards from bribing less appealing.

Notwithstanding the increasing emphasis in the literature on the impact of ethically and socially responsible behavior on firm performance, we find in some instances – such as the benefits from corruption rents in our model – the relationship may not be straightforward. Thus, future work should critically examine the setting in which market and institutional mechanisms can be better coordinated to generate positive social outcomes.

References

Accinelli, E., Carrera, E.J.S., 2012. Corruption Driven by Imitative Behavior. *Economics Letters* 117, 84-87.

Accinelli, E., Martins, F., Oviedo, J., Pinto, A., Quintas, L., 2017. Who Controls the Controller? A Dynamical Model of Corruption. *The Journal of Mathematical Sociology* 41 (4), 220-247.

Ades, A., Di Tella, R., 1999. Rents, Competition, and Corruption. *American Economic Review* 89(4), 982-993.

Albin, P., Foley, D., 1992. Decentralized, Dispersed Exchange without an Auctioneer: A Simulation Study. *Journal of Economic Behavior and Organization* 18, 27-51.

Aragonès, E., Rivas, J., Tóth, Á., 2020. Voter Heterogeneity and Political Corruption. *Journal of Economic Behavior & Organization* 170, 206-221.

Arnold, U., Neubauer, J., Schoenherr, T., 2012. Explicating Factors for Companies' Inclination Towards Corruption in Operations and Supply Chain Management: An Exploratory Study in Germany. *International Journal of production Economics* 138, 136-147.

Arthur, B., 2006. Out-of-equilibrium economics and agent-based modeling. In Handbook of Computational Economics, (eds) K. Judd and L. Tesfatsion. Elsevier, North Holland.

Axelrod, R., 1997. The Complexity of Cooperation: Agent-Based Models of Competition and Collaboration. Princeton University Press, Princeton, New Jersey.

Balafoutas L., 2011. Public Beliefs and Corruption in a Repeated Psychological Game. *Journal of Economic Behavior & Organization* 78, 51-59.

Basu, K., Basu, K., Cordella, T., 2016. Asymmetric Punishment as an Instrument of Corruption Control. *Journal of Public Economic Theory* 18(6), 831-56.

Bertrand, M., Simeon, D., Hanna. R., Mullainathan, S., 2007. Obtaining a Driver's License in India: An Experimental Approach to Studying Corruption. *The Quarterly Journal of Economics* 122(4), 1639-1676.

Billinger, S., Stieglitz, N., Schumacher, T.R., 2014. Search on Rugged Landscapes: An Experimental Study. *Organization Science* 25(1), 93-108.

Bó, E.D., Rossi, M.A., 2007. Corruption and inefficiency: Theory and evidence from electric utilities. *Journal of Public Economics* 91(5–6), 939-962.

Buckenmaier, J., Dimant, E., Mittone, L. 2020. Effects of institutional history and leniency on collusive corruption and tax evasion. *Journal of Economic Behavior & Organization* 175(*C*), 296-313.

Caldart, A., Oliveira, F., 2010. Analysing industry profitability: A "complexity as cause" perspective. *European Management Journal* 35, 155-164.

Caulkins, J.P., Feichtinger, G., Grass, D., Hartl, R.F., Kort, P.M., Novak, A.J., Seidl, A., Wirl, F., 2014. A Dynamic Analysis of Schelling's Binary Corruption Model: A Competitive Equilibrium Approach. *Journal of Optimzation Theory Applications* 161, 608-625.

Celentani, M., Ganuza, J.-J., 2002. Organized versus competitive corruption. *Annals of Operations Research* 109, 293–315.

Cerqueti, R., Coppier, R., 2016. Corruption, Evasion and Environmental Policy. *IMA Journal of Management Mathematics* 27, 235-253.

Clement, J., Puranam, P., 2017. Searching for structure: Formal organization design as a guide to network evolution. *Management Science 64*(8), 3879-3895.

Çule, M., Fulton, M., 2009. Business Culture and Tax Evasion: Why Corruption and the Unofficial Economy Can Persist. *Journal of Economic Behavior & Organization* 72, 811-822.

Davis, J., Eisenhardt, K., Bingham, C., 2007. Developing theory through simulation methods. *Academy of Management Review* 32, 480–499.

Economist, 2008. Bavarian Baksheesh. 17 December 2008. https://www.economist.com/business/2008/12/17/bavarian-baksheesh

Economist, 2015. The anti-bribery business. 9 May 2015. https://www.economist.com/business/2015/05/09/the-anti-bribery-business

Economist, 2020. Bribery pays – if you don't get caught. 29 August 2020. https://www.economist.com/business/2020/08/27/bribery-pays-if-you-dont-get-caught

Evrenk, H., 2011. Why a Clean Politician Supports Dirty Politics: A Game-Theoretical Explanation for the Persistence of Political Corruption. *Journal of Economic Behavior & Organization* 80, 498-510.

Ferdman, R.A., 2014. How the World's Biggest Companies Bribe Foreign Governments – in 11 Charts. Washington Post, 3 December 2014. https://www.washingtonpost.com/news/wonk/wp/2014/12/03/how-the-worlds-biggest-companies-bribe-foreign-governments-in-11-charts/

Fisman, R., Svensson, J., 2007. Are corruption and taxation really harmful to growth? Firm level evidence. *Journal of Development Economics* 83(1), 63-75.

Friehe, T., 2008. Correlated Payoffs in the Inspection Game: Some Theory and An Application to Corruption. *Public Choice* 137, 127-143.

Fudenberg, D., Tirole, J., 1991. Game Theory. Cambridge: MIT Press.

Galang, R.M.N., 2012. Victim or victimizer: Firm responses to government corruption. *Journal of Management Studies 49*(2), 429-462.

Hellman, J., Jones, G., Kaufmann, D., 2002. Far from home: Do foreign investors import higher standards of governance in transition economies? Available at SSRN 386900.

Hindriks, J., Keen, M., Muthoo, A., 1999. Corruption, extortion and evasion. *Journal of Public Economics* 74, 394–430.

Jensen, N. M., Malesky, E.J., 2018. Nonstate Actors and Compliance with International Agreements: An Empirical Analysis of the OECD Anti-Bribery Convention. *International Organization* 72(1), 33-69.

Joseph, C., Gunawan, J., Sawani, Y., Rahmat, M., Noyem. J.A., Darus, F., 2016. A Comparative Study of Anti-Corruption Practice Disclosure Among Malaysian and Indonesian Corporate Social Responsibility (CRS) Best Practice Companies. *Journal of Cleaner Production* 112, 2896-2906.

Kingston, C., 2007. Parochial Corruption. *Journal of Economic Behavior & Organization* 63, 63-87.

Kingston, C., 2008. Social Structure and Cultures of Corruption. *Journal of Economic Behavior & Organization* 67, 90-102.

Litina, A., Palivos, T., 2016. Corruption, Tax Evasion and Social Values. *Journal of Economic Behavior & Organization* 124, 164-177.

Levinthal, D., 1997. Adaptation on rugged Landscapes. *Management Science* 43, 934-950.

Macrae, J., 1982. Underdevelopment and the economics of corruption: A game theory approach. *World Development* 10(8), 677-687

Mayka, L., Lovon, A., 2019. How one company's deep web of corruption took down governments across Latin America. Washington Post, 23 May 2019. https://www.washingtonpost.com/politics/2019/05/23/how-one-companys-deep-web-corruption-took-down-governments-across-latin-america/

March, J., 1991. Exploration and exploitation in organizational learning. *Organization Science* 2, 71–87.

Mu, E., Carroll, J., 2016. Development of a fraud risk decision model for prioritizing fraud risk cases in manufacturing firms. *International Journal of Production Economics* 173, 30-42.

New York Times, 1996. U.S. Enlists Rich Nations in Move to End Business Bribes. 12 April 1996. http://www.nytimes.com/1996/04/12/world/us-enlists-rich-nations-in-move-to-end-business-bribes.html?pagewanted=all&src=pm, accessed 17 November 2020.

OECD, 2007. Methods, actors, and counter-measures: Bribery in Public Procurement. In Bribery in Public Procurement. OCED Publishing: Paris.

OECD, 2013. OECD Working Group on Bribery: Annual Report on Activities Undertaken in 2012. OECD Publishing. [29 September 2014].

Padhi, S.S., Wagner, S.M., Mohapatra, P.K.J., 2016. Design of Auction Parameters to Reduce the Effect of Collusion. *Decision Sciences* 47 (6), 1016 - 1047.

Pasetta, V., 1999. Dynamics in divide the money game with bribing. *Annals of Operations Research* 88, 361-377.

Perla, A., Nikolaev, A., Pasiliao, E., 2018. Workforce Management under Social Link Based Corruption. *Omega* 78, 222-236.

Rose-Ackerman, S., 1999. Corruption and government: Causes, consequences, and reform. Cambridge University Press.

Rose-Ackerman, S., 1975. The economics of corruption. *Journal of Public Economics* 4, 187–203.

Schelling, T.C., 1973. Hockey helmets, concealed weapons, and daylight saving: a study of binary choices with externalities. *Journal of Conflict Resolution* 17(3), 381–428.

Schelling, T.C., Micromotives and Macrobehavior. Norton, New York, 1978.

Schubert, S. Miller, T.C., 2008. At Siemens, bribery was just a line item. New York Times, 20 December 2008. https://www.nytimes.com/2008/12/21/business/worldbusiness/21siemens.html

Shapiro, A., 2008. Siemens hit with $1.6 billion fine in bribery case. NPR, 16 December 2008. https://www.npr.org/templates/story/story.php?storyId=98317332

Smith, E.B., Rand, W., 2018. Simulating macro-level effects from micro-level observations. *Management Science 64*(11), 5405-5421

Strîmbu, O., González, P., 2018. Does Transparency Reduce Political Corruption? *Journal of Public Economic Theory* 20, 123-135.

Transparency International, 2000. Transparency International releases new bribe payers index. http://www.transparency.org/news/pressrelease/transparency_international_releases_new_bribe_payers_index_bpi_2002, accessed 17 November 2020.

Von Neumann, J., Morgenstern O., 1958. Theory of Games and Economic Behavior. Princeton University Press, 3rd edition.

Zhu, J., 2012. Do Severe Penalties Deter Corruption? A Game-Theoretic Analysis of the Chinese Case. *The China Review* 12 (2), 1-32.

Watson, B., 2013. Siemens and the battle against bribery and corruption. The Guardian. 18 September 2013. https://www.theguardian.com/sustainable-business/siemens-solmssen-bribery-corruption

Westhoff, F.H., Yarbrough, B.V., Yarbrough, R. M., 1996. Complexity, Organization, and Stuart Kauffman's The Origins of Order. *Journal of Economic Behavior & Organization* 29, 1-25.

Zeume, S., 2017. Bribes and firm value. *The Review of Financial Studies* 30(5), 1457-1489.

APPENDIX

Proposition 1 – Proof: By simultaneously maximizing the expected profit of all the firms in the industry, as represented by (3.b), and by the necessary condition for maximization, it follows that we obtain the mixed strategies Nash equilibrium of the game by solving the system of equations (A.1). The derivatives of system (A.1) are represented by equations (A.2).

$$\begin{aligned}\frac{dE[\Pi_d]}{dy_d} &= 0\\ \frac{dE[\Pi_m]}{dy_m} &= 0\end{aligned} \tag{A.1}$$

$$\begin{aligned}\alpha_d - b_d x - 2\lambda_d y_d - f_d &= 0\\ \alpha_m - b_m x - 2\lambda_m y_m - f_m &= 0\end{aligned} \tag{A.2}$$

By plugging in equation (4) into equations (A.2), and after some simple algebraic manipulations, we obtain the reaction functions of the domestic (A.3) and multinational (A.4) firms. These reaction functions describe how domestic firms react to the level of bribing in the multinational firms and vice-versa. By solving the system of equations (A.3) and (A.4), and by defining $A_d = \frac{\alpha_d - f_d}{b_d w_d + 2\lambda_d}$, $A_m = \frac{\alpha_m - f_m}{b_m w_m + 2\lambda_m}$, $B_d = \frac{b_d w_m}{b_d w_d + 2\lambda_d}$, $B_m = \frac{b_m w_d}{b_m w_m + 2\lambda_m}$ we derive the Nash equilibrium bribing strategies for the domestic, $y_d^* = \frac{A_d - B_d A_m}{1 - B_d B_m}$, and multinational firms, $y_m^* = \frac{A_m - B_m A_d}{1 - B_d B_m}$.

$$y_d = \frac{\alpha_d - f_d}{b_d w_d + 2\lambda_d} - \frac{b_d w_m}{b_d w_d + 2\lambda_d} y_m \tag{A.3}$$

$$y_m = \frac{\alpha_m - f_m}{b_m w_m + 2\lambda_m} - \frac{b_m w_d}{b_m w_m + 2\lambda_m} y_d \tag{A.4}$$ ■

Proposition 2 - Proof: The second order sufficient conditions for the Nash equilibrium in Proposition 1 to hold are $\frac{d^2E[\Pi_d]}{dy_d^2}<0$ and $\frac{d^2E[\Pi_m]}{dy_m^2}<0$. Taking the second derivative from the profit function (3) we obtain $\frac{d^2E[\Pi_d]}{dy_d^2}<0 \Leftrightarrow -2\lambda_d<0 \Leftrightarrow \lambda_d>0$ and $\frac{d^2E[\Pi_m]}{dy_m^2}<0 \Leftrightarrow -2\lambda_m<0 \Leftrightarrow \lambda_m>0$. ■

Lemma 1 - Proof: As, from Proposition 1, $y_d^*=\frac{A_d-B_dA_m}{1-B_dB_m}$, and as $\alpha_d=\alpha_m=\alpha$, $\lambda_d=\lambda_m=\lambda>0$, *and* $b_d=b_m=b$, it follows that $y_d^*=\frac{\left(\frac{\alpha-f_d}{bw_d+2\lambda}\right)-\left(\frac{bw_m}{bw_d+2\lambda}\right)\left(\frac{\alpha-f_m}{bw_m+2\lambda}\right)}{1-\left(\frac{bw_m}{bw_d+2\lambda}\right)\left(\frac{bw_d}{bw_m+2\lambda}\right)}$,which simplifies to, after some simple algebraic operations, $y_d^*=\frac{2\lambda\alpha+bw_mf_m-(bw_m+2\lambda)f_d}{2b\lambda+4\lambda^2}$. Similarly, from Proposition 1, $y_m^*=\frac{A_m-B_mA_d}{1-B_dB_m}$ which is equivalent to $y_m^*=\frac{2\lambda\alpha+bw_df_d-(bw_d+2\lambda)f_m}{2b\lambda+4\lambda^2}$. ■

Corollary 1 - Proof: From Lemma 1, and as $w_d=1-w_m$, it follows that

$y_d^*-y_m^*=\frac{2\lambda\alpha+bw_mf_m-(bw_m+2\lambda)f_d}{2b\lambda+4\lambda^2}-\frac{2\lambda\alpha+bw_df_d-(bw_d+2\lambda)f_m}{2b\lambda+4\lambda^2}=\frac{(b+2\lambda)(f_m-f_d)}{2\lambda(b+2\lambda)}=\frac{f_m-f_d}{2\lambda}$. Then as $0<f_d<f_m$, and as from Proposition 2, $\lambda>0$, it follows that $y_d^*-y_m^*>0$.■

Proposition 3 - Proof: Let $f_m>f_d>0$. From Lemma 1 we have $y_d^*=\frac{2\lambda\alpha+bw_mf_m-(bw_m+2\lambda)f_d}{2b\lambda+4\lambda^2}$ and $y_m^*=\frac{2\lambda\alpha+bw_df_d-(bw_d+2\lambda)f_m}{2b\lambda+4\lambda^2}$. (a) By taking the partial derivatives of the equilibrium bribing probabilities to the punishment cost on multinationals, i.e., for all $i\neq j$ we get: $\frac{\partial y_i^*}{\partial f_j}=\frac{bw_j}{2b\lambda+4\lambda^2}$.

Especifically for the impact of the change in the penalty on multinationals on the bribing behavior of domestic firms we get $\frac{\partial y_d^*}{\partial f_m}=\frac{bw_m}{2b\lambda+4\lambda^2}$.

i) Then, $\frac{\partial y_d^*}{\partial f_m} = 0$ if and only if $b = 0$. *ii*) $\frac{\partial y_d^*}{\partial f_m} < 0$ if and only if $\frac{bw_m}{2b\lambda + 4\lambda^2} < 0$, which, as $w_m > 0$, is equivalent to $b < 0$ and $2\lambda(b + 4\lambda) > 0$; or $b > 0$ and $2\lambda(b + 4\lambda) < 0$. From which it follows, as $\lambda > 0$: $b < 0$ and $\lambda > -\frac{b}{4}$; or $b > 0$ and $\lambda < -\frac{b}{4}$ (as this second condition is false), we obtain: $b < 0$ and $\lambda > -\frac{b}{4}$. *iii*) $\frac{\partial y_d^*}{\partial f_m} > 0$ if and only if $\frac{bw_m}{2b\lambda + 4\lambda^2} > 0$, which, as $w_m > 0$, is equivalent to $b < 0$ and $2\lambda(b + 4\lambda) < 0$; or $b > 0$ and $2\lambda(b + 4\lambda) > 0$. From which it follows, as $\lambda > 0$: $b < 0$ and $\lambda < -\frac{b}{4}$; or $b > 0$ and $\lambda > -\frac{b}{4}$ (which is a tautology), and we obtain: $b > 0$ or $b < 0$ and $\lambda < -\frac{b}{4}$.

(b) By taking the partial derivatives of the equilibrium bribing probabilities of multinational firms as a function of the punishment costs at which they are subjected we obtain $\frac{\partial y_m^*}{\partial f_m} = -\frac{bw_d + 2\lambda}{2b\lambda + 4\lambda^2}$. *i*) $\frac{\partial y_m^*}{\partial f_m} = 0$ if and only if $bw_d + 2\lambda = 0$ and $2\lambda(b + 2\lambda) \neq 0$, which, as $w_d > 0$ and $\lambda > 0$ it is equivalent to $\lambda = -\frac{bw_d}{2}$, $\lambda \neq -\frac{b}{2}$ and $b < 0$.

ii) $\frac{\partial y_m^*}{\partial f_m} < 0$, i.e., $-\frac{bw_d + 2\lambda}{2b\lambda + 4\lambda^2} < 0$ if and only if $\frac{bw_d + 2\lambda}{2b\lambda + 4\lambda^2} > 0$, which is equivalent to $bw_d + 2\lambda > 0$ and $2\lambda(b + 2\lambda) > 0$ or $bw_d + 2\lambda < 0$ and $2\lambda(b + 2\lambda) < 0$, and to: $\lambda > -\frac{bw_d}{2}$ and $\lambda > -\frac{b}{2}$, or $\lambda < -\frac{bw_d}{2}$ and $\lambda < -\frac{b}{2}$. From which it follows that, if $b \geq 0$ then $\frac{\partial y_m^*}{\partial f_m} < 0$; if $b < 0$ then $\frac{\partial y_m^*}{\partial f_m} < 0$ only if $\lambda < -\frac{bw_d}{2}$ or $\lambda > -\frac{b}{2}$. *iii*) $\frac{\partial y_m^*}{\partial f_m} > 0$, i.e., $-\frac{bw_d + 2\lambda}{2b\lambda + 4\lambda^2} > 0$ if and only if $\frac{bw_d + 2\lambda}{2b\lambda + 4\lambda^2} < 0$, which is equivalent to $bw_d + 2\lambda > 0$ and $2\lambda(b + 2\lambda) < 0$ or $bw_j + 2\lambda < 0$ and $2\lambda(b + 2\lambda) > 0$, and to:

$\lambda > -\frac{bw_d}{2}$ and $\lambda < -\frac{b}{2}$, or $\lambda < -\frac{bw_d}{2}$ and $\lambda > -\frac{b}{2}$. Hence, $\frac{\partial y_m^*}{\partial f_m} > 0$ when $b < 0$ and $-\frac{bw_d}{2} < \lambda < -\frac{b}{2}$.■

Proposition 4 - Proof: As defined in Proposition 1, $y_d^* = \frac{A_d - B_d A_m}{1 - B_d B_m}$ and $y_m^* = \frac{A_m - B_m A_d}{1 - B_d B_m}$.

$y_d^* = \frac{A_d - B_d A_m}{1 - B_d B_m}$, then $y_d^* = \frac{\left(\frac{\alpha - f_d}{bw_d + 2\lambda_d}\right) - \left(\frac{bw_m}{bw_d + 2\lambda_d}\right)\left(\frac{\alpha - f_m}{bw_m + 2\lambda_m}\right)}{1 - \left(\frac{bw_m}{bw_d + 2\lambda_d}\right)\left(\frac{bw_d}{bw_m + 2\lambda_m}\right)}$, after a few algebraic manipulations we obtain $y_d^* = \frac{bw_m\left[f_m - f_d\right] + 2\lambda_m\left(\alpha - f_d\right)}{2bw_d\lambda_m + 2bw_m\lambda_d + 4\lambda_d\lambda_m}$. Similarly, from Proposition 1,

$y_m^* = \frac{A_m - B_m A_d}{1 - B_d B_m}$ which is equivalent to $y_m^* = \frac{\left(\frac{\alpha - f_m}{bw_m + 2\lambda_m}\right) - \left(\frac{bw_d}{bw_m + 2\lambda_m}\right)\left(\frac{\alpha - f_d}{bw_d + 2\lambda_d}\right)}{1 - \left(\frac{bw_m}{bw_d + 2\lambda_d}\right)\left(\frac{bw_d}{bw_m + 2\lambda_m}\right)}$, from which we obtain $y_m^* = \frac{bw_d\left[f_d - f_m\right] + 2\lambda_d\left(\alpha - f_m\right)}{2bw_d\lambda_m + 2bw_m\lambda_d + 4\lambda_d\lambda_m}$. Then, as

$$\frac{\partial y_d^*}{\partial \lambda_m} = \frac{2\left(\alpha - f_d\right)\left[2bw_d\lambda_m + 2bw_m\lambda_d + 4\lambda_d\lambda_m\right] - \left[bw_m\left[f_m - f_d\right] + 2\lambda_m\left(\alpha - f_d\right)\right]\left(2bw_d + 4\lambda_d\right)}{\left[2bw_d\lambda_m + 2bw_m\lambda_d + 4\lambda_d\lambda_m\right]^2}.$$

(A) Then, if $b = 0$ then $\frac{\partial y_d^*}{\partial \lambda_m} = \frac{2\left(\alpha - f_d\right)4\lambda_d\lambda_m - 2\left(\alpha - f_d\right)4\lambda_d\lambda_m}{\left[4\lambda_d\lambda_m\right]^2} = 0$. Moreover,

$\frac{\partial y_d^*}{\partial \lambda_m} > 0$ if and only if

$2\left(\alpha - f_d\right)\left[2bw_d\lambda_m + 2bw_m\lambda_d + 4\lambda_d\lambda_m\right] - \left[bw_m\left[f_m - f_d\right] + 2\lambda_m\left(\alpha - f_d\right)\right]\left(2bw_d + 4\lambda_d\right) > 0$, which, after some algebraic manipulations is equivalent to $4b\lambda_d\left(\alpha - f_m\right) > 2b^2 w_d\left(f_m - f_d\right)$. Then, if $b > 0$ this is equivalent to $2\lambda_d\left(\alpha - f_m\right) > bw_d\left(f_m - f_d\right)$ and to, $b < 2\frac{\lambda_d}{w_d}.\frac{\alpha - f_m}{f_m - f_d}$; on the other hand, if $b < 0$ then this is equivalent to $2\lambda_d(\alpha - f_m) < bw_d(f_m - f_d)$ and to, $b > 2\frac{\lambda_d}{w_d}.\frac{\alpha - f_m}{f_m - f_d}$, which is false. Therefore,

when $b < 0$, we obtain $\frac{\partial y_d^*}{\partial \lambda_m} < 0$.

(B) Additionally, as $\frac{\partial y_m^*}{\partial \lambda_m} = \frac{-\left[bw_d\left[f_d - f_m\right] + 2\lambda_d(\alpha - f_m)\right](2bw_d + 4\lambda_d)}{\left[2bw_d\lambda_m + 2bw_m\lambda_d + 4\lambda_d\lambda_m\right]^2}$, if $b = 0$ then

$\frac{\partial y_m^*}{\partial \lambda_m} = -\frac{8(\alpha - f_m)}{4^2\lambda_m{}^2} < 0$. Moreover, $\frac{\partial y_m^*}{\partial \lambda_m} < 0$ if and only if

$\left[bw_d\left[f_d - f_m\right] + 2\lambda_d(\alpha - f_m)\right](2bw_d + 4\lambda_d) > 0$, i.e., $2\lambda_d(\alpha - f_m) > bw_d(f_m - f_d)$ and

$2bw_d + 4\lambda_d > 0$, from which we obtain $b < 2\frac{\lambda_d}{w_d}.\frac{\alpha - f_m}{f_m - f_d}$ and $b > -2\frac{\lambda_d}{w_d}$. Then $\frac{\partial y_m^*}{\partial \lambda_m} < 0$ if and only if

$0 < b < 2\frac{\lambda_d}{w_d}.\frac{\alpha - f_m}{f_m - f_d}$ or if and only if $0 > b > -2\frac{\lambda_d}{w_d}$.