The Cost of Corruption in Procurement and Public Purchase

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August 3, 2004

Abstract: The paper studies how to fight corruption in public purchase. It shows that for large markets public purchasers should implement competitive bidding, while for small ones they should purchase freely. For a market of medium range, they should retain discretion over the attribution rule. This creates room for corruption. The paper shows that extortion creates less distortion than capture. Then when susceptibility to corruption rises, it is optimal to shift from a capture to an extortion regime. Acknowledging that corruptibility is unobservable, this shift does not involve a loss of discretion, but a change in the nature of discretion.

JEL Classification Numbers: D73, D82, H57, K42.

Keywords: corruption, procurement, public purchase

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I thank Jean-Jacques Laffont, Jean Tirole, Colin Campbell, the participants of the 7th Jerusalem summer school in economic theory and of the EEA/ESEM 96 meetings for their very helpful critics and comments. This paper has also greatly benefited from two thorough referee reports. I am very grateful for the resulting improvements. Any remaining errors are mine.

1 Introduction

Government procurement of goods and services represents more than 18% of the world GDP.[1] For year 2002 this yields an estimate of USD 5.8 trillion. Despite the amounts at stake, tax-payers' ability and incentives to monitor the public purchases are weak. Corruption then is a major problem in public purchases. Until the entry into force of the OECD Convention on Combating Bribery of Foreign Officials in February 1999, the bribes paid to foreign public officials were tax deductible in OECD countries (at the noticeable exception of the US). Changing the law was not a political priority because corruption was perceived to be developing countries apanage. However, in the past decade, indictments or allegations of corruption against top ranking politicians and bureaucrats in OECD countries involving illegal payment for public contracts for infrastructure, defense, manufacturing, and service projects revealed a worldwide phenomenon.[2] The scandals also revealed how little was known about it. Non-governmental organizations, such as Transparency International, and governmental organizations, such as the World Bank, have since worked hard to construct indicators based on surveys of experts, enterprises, users of public services, and civil servants. Under the lead of Daniel Kaufmann, a World Bank team compiles this information using novel aggregation techniques to construct a worldwide governance databank. According to this ongoing research, the amounts of bribery for public procurement can be estimated in the vicinity of USD 200 billion per year.[3] That is, something like 3.5% of the world procurement spending.

Assuming this figure is accurate, it represents only one part of the overall cost of corruption as illustrated by the top-secret database of international bribery cases maintained by the US intelligence community. Using electronic eavesdropping it lists hundreds of contracts worth hundreds of billion of dollars that over the past 18 years went to the biggest briber rather than the highest bidder.[4] Since in practice nobody knows what would have been the final cost of the purchase if the more efficient supplier, rather than the bigger

[1] A study by the OECD Trade Committee (see OECD 2002) covering 130 countries estimates tant the size of all levels of government procurement markets (consumption and investment expenditure) expressed as a percentage of 1998 GDP data is 18.42%. For the OECD countries as a whole the ratio is 19.96% (or USD 4733 billion) and for the non-OECD countries it is estimated at 14.48% (or USD 816 billion).

[2] For instance, the French group of Serge Dassault has been accused of winning against the American Litton the 1 billion French francs "Carapace" defense contract while bribing several officials from the Belgium Socialist Party, including three ministers (Le Monde 1998). Similarly, the cabinet minister responsible for Japan's Self-Defense Agency, Fukushiro Nukaga, has been caught in a defense scandal involving 4.8 billion yen in government over-billing by the NEC group (The Economist 1998). In Italy, the inquiries beginning in February 1992 incited courts to open criminal investigations on corruption and related charges against 447 members of Parliament, over half of the total number. Investigators were after bribes worth an estimated 620 billion lire (The Economist 1996). In the United States scandals emerged in Chicago public housing administration. Apparently, millions were lost in over-billing by security firms patrolling the projects and in bloated procurement budgets. A federal investigation was also conducted to deal with bribery in the section of the Chicago Housing Authority handing out rent vouchers (The Economist 1995).

[3] The two business sectors the more prone to corruption are public/work construction and arms and defense. These are also the sectors where the biggest bribes are likely to be paid.

[4] For instance in 1998 they found that 60 "major international contracts" valued USD 30 billions went to the biggest briber. Similarly a 1995 CIA report indicated that in 1993 51 contracts with a value of USD 28 billions have been influenced by bribery (NBC 2000).

briber, had win the tender, it is not possible to uncover the real cost of corruption with survey techniques. This paper proposes a theoretical approach to uncover this "out of equilibrium" information. It develops a model based on classical procurement theory (i.e. without corruption) to study how incentives and rules for decision should be set to respond to the corruption threat. It next uses the data available on corruption, as well as new data on e-procurement, to calibrate the model. This technique enables us to produce an estimate of the total corruption cost which varies between 6.65 % up to 20.02% of the total procurement spending. In 2002 the loss can hence be estimated between USD 385.7 billion and USD 1.16 trillion.

The issue of collusion in organizations within the agency theoretical approach was first raised by Tirole (1986) in a principal-supervisor-agent model. In this paper he derived a 'collusion-proofness principle', showing that any feasible payoff to the principal can be achieved by a contract which does not induce collusion between the agent and the supervisor. This seminal framework has since been used to study the impact on collusion in different contexts.[5] The main results of this literature is that to fight collusion, it is optimal, first, to change the agent's contract in order to lower the benefit of collusion, and, second, to reduce the supervisor's discretion. A big objection to the collusion-proofness principle is that it contradicts reality. Kofman-Lawarrée (1993) were the first to address this problem and to explain collusion as an equilibrium phenomenon.[6] Kofman-Lawarrée (1996) and Strausz (1998) have shown that the collusion-proofness principle is not robust if we relax the assumption that the susceptibility to corruption of the supervisor is common knowledge. Under asymmetric information it is simply too costly for the principal to take into account for the more dishonest people in society so that residual collusion occurs at the equilibrium. Another concern with Tirole (1986) framework is that it focuses on mutually beneficial agreements between the supervisor and the agent. However, as illuminated by the literature on blackmail (Mogiljanski (1994), Konrad-Skaperdas (1997) and Leppamaki (2000)) extortion exists and cannot simply be overlooked.[7] The paper, which combines Tirole (1986) framework with the assumption that the integrity of the supervisor is not observable, considers both capture and extortion.

Capture occurs when a firm bribes a public official to obtain a trading advantage. This corresponds to 'active bribery' as termed in the OECD Convention.[8] On the other hand, extortion, which corresponds to 'passive bribery', occurs when a firm complies with

[5] See for instance Laffont-Tirole (1993), Carillo (1994), Hindriks & al (1996), Campbell (1996).

[6] Their analysis, based on an audit model, shows that when exerting effective control is possible but costly, expected maximum deterrence is not optimal. Following this line of research many papers focus on cases where collusion occurs at the equilibrium. See for instance Khalil-Lawarrée (1994), Kofman-Lawarrée (1996), Bac (1996), Strausz (1998).

[7] Mogiljanski (1994) focuses on regulatory blackmail in a static adverse selection model. Konrad-Skaperdas (1997) focuses on the problem of the credibility of threats in the extortion game between a gang and shopkeepers (i.e., will the gang carry out its threat if a shopkeeper refuses to pay). They show that with a small number of victims only a non-extortion equilibrium exists. However as the number of potential victims becomes large, the only subgame-perfect equilibria involve extortion. Leppamaki (2000) focuses on the blackmailer's commitment problem (i.e., not to come back again to ask for more money). He also outlines conditions under which successful extortion occurs.

[8] Collusion in Tirole (1986) corresponds to capture. It is a mutually beneficial agreement concludes by the supervisor and the agent against the principal.

a demand for a bribe to avoid being excluded from trade. The paper shows that these two forms of corruption are not equivalent in terms of the cost they impose on the tax-payers. That is, extortion occurs when, the acquisition strategy being limited tendering, the delegate threatens a legitimate supplier with exclusion. The firm prefers to pay a bribe rather than to lose the market. Extortion thus means a change in the distribution of the firm profit -a portion goes to the delegate's pocket– but not in the total amount paid by the tax-payers. This is different with capture which, as illustrated by the CIA database, obstructs allocative efficiency and increases the final purchase cost. It occurs when the delegate favors a producer in exchange of a bribe rather than to look for the most efficient supplier. Since capture is costly to taxpayers a benevolent government should fight against it by offering monetary incentives to the delegate. The bonuses are increasing with the market size so that sustaining a capture-free regime becomes rapidly costly. At the optimum the delegation framework is shifted towards the extortion regime in which no monetary incentives are needed. In other words, the results stipulate no loss of discretion in response to the threat of corruption, but instead a change in the *nature* of discretion.

Static comparative analysis shows that when society's susceptibility to corruption rises, the optimal response of an isolated principal is to shift from the capture regime to the extortion regime. We deduce that an exogenous increase of susceptibility to corruption in society is followed by an endogenous increase of corruption (i.e., extortion) in public markets (and presumably elsewhere). Paradoxically this is not the sign of the principal's wrongdoing but rather an optimal response. The overall impact is that corruption is self-reinforcing. Since corruption is endemic in many developing countries we deduce that extortion run high in these countries. This might help to explain why in most OECD countries the bribes (i.e., the "commission") paid to foreign public officials used to be tax deductible. The extorted firms wanted the "commissions" to be acknowledged as a cost.

The paper shows that depending on the size of the market (e.g., its amount in dollars) different rules should apply. For small markets, the public representatives should be free to conduct the purchase as they wish (e.g, direct purchase with limited tender), for large ones they should be required to rely on open tender. For a market of medium range, they should retain some discretion over the attribution rule. This creates room for corruption, but is still better for efficiency than bypassing the delegate expertise by a rigid set of rules.

The paper is organized as follows. Section 2 sets up the model. Section 3 derives the optimal contracts under the assumption that the delegate is incorruptible. Section 4 considers the possibility of corruption. Section 5 proposes a calibration of the model. Our main findings are summarized in Section 6.

2 The model

As in Tirole (1986) the paper considers a three-tier hierarchy: principal, delegate, firms. All the players are assumed to be risk neutral. The principal (i.e., the tax-payers), conventionally a 'he', wants to acquire a commodity or a service in the best of possible conditions. He entrusts the responsibility of the acquisition to a delegate (e.g, public servant or public representative), conventionally a 'she'. The principal's objective is to maximize the net surplus associated with the public acquisition. The size of the market is fixed $Q \geq 0$. It generates a gross surplus $S(Q) \geq 0$ increasing with Q ($S'(Q) > 0$). We assume that $S(Q)$ is large so that it is always worth procuring.

The firms: There are in the economy $N(\geq 1)$ firms that could take care of the production a priori. Depending on the commodity (the economic conjuncture, the time of year, and so on), N varies. We assume that it can either be high, equal to $\overline{N}$, in proportion α or low, equal to $\underline{N}$, in proportion $1-\alpha$. The distribution of N is common knowledge.[9]

A1 $\qquad N \in \{\underline{N}, \overline{N}\} \qquad$ with $\qquad \alpha = Prob\ (N = \underline{N})$.

To serve the market the firms are confronted with a variable cost function as in Baron-Myerson (1982):

$$C^i(\beta^i, q^i) = \beta^i q^i \qquad \beta^i \in [\underline{\beta}, \overline{\beta}] \quad i = 1, ..., N. \tag{1}$$

The term $q^i \geq 0$ represents the market share of firm i in total production ($\sum_{i=1}^{N} q^i = Q$), and β^i represents firm i's productivity (a high β^i corresponds to a high cost, i.e. an inefficient producer). The market share q^i is verifiable while β^i is privately known. We assume that at the pre-contracting stage a firm does not know the exact value of β^i. This assumption reflects the fact that there are idiosyncratic chocks affecting the production process. From an *ex-ante* point of view, the β^i are independently and identically distributed on $[\underline{\beta}, \overline{\beta}]$ according to the density function $f(.)$ associated with the distribution function $F(.)$. The support $[\underline{\beta}, \overline{\beta}]$, and the functions $F(.)$, $f(.)$ are common knowledge. To avoid bunching, we make the classical monotone hazard rate assumption:

A2 $\qquad F(\beta)/f(\beta)$ is non decreasing for all $\beta \in [\underline{\beta}, \overline{\beta}]$.

The delegate: The delegate's work is to implement the acquisition procedure. She can either negotiate the market with a single producer, this corresponds to limited tendering as termed in the General Procurement Agreement (GPA), or allocate it through competitive bidding, this corresponds to open tendering as termed in the GPA. The optimal decision depends on the relative cost to foster competition compared to the expected benefit. The cost of running open tendering which is common knowledge, is fixed K (≥ 0). It embodies the monetary and non monetary (delay) costs of the procedure. In practice this cost is very high.[10] For instance the State of California was able to save USD 9.7 millions annually by simply switching from manual to online processing of purchase orders (see www.pd.dgs.ca.gov/calbuy/aboutcalby.htm). The benefit on the other hand is uncertain. It depends on how successful the bidding procedure is, that is, on N the number of firms that ultimately submit an offer.

The delegate holds information, denoted σ, on N. Following Laffont-Tirole (1993) we assume that with probability ξ the delegate information is pertinent (she holds the

[9] We assume that it is binomial, but we could consider more general distribution.

[10] First the purchasing entity has to put its need very precisely in writing. Next it has to advertise tender information in official gazettes, newspapers, bulletin board or bidding information journals. If the firms that get the information are interested they have to work out detailed propositions. Finally the purchasing entity has to review and evaluate the offers.

true value of the number of potential bidders: $\sigma = N$), and with probability $1 - \xi$ it is uninformative (she holds nothing: $\sigma = \emptyset$).

A3 $\qquad \sigma \in \{N, \emptyset\} \quad \text{with} \quad \xi = Prob(\sigma = N).$

The information received by the delegate is hard evidence. When she is informed that $\sigma = \underline{N}$ or that $\sigma = \overline{N}$, she can prove it in court. However she can always hide her information and pretend that she learned nothing decisive. This claim is impossible –extremely costly– to verify.

To be willing to participate, the delegate needs to receive at least her reservation income normalized without loss of generality to zero. This minimum ensures her participation but provides no guarantee concerning her benevolence at work which depends on a personal discount rate for illegal revenue, $\delta_c \in [0, +\infty)$. Term δ_c reflects the individual integrity "price": when she receives illegally one unit of money it is worth $\frac{1}{1+\delta_c} \leq 1$ to her.

The timing:
$t = 1$ The principal sets the delegate's contract and the acquisition rules. He entrusts the enforcement of the acquisition rules to the delegate.
$t = 2$ Nature chooses N; The delegate obtains an information σ about N,
$t = 3$ The delegate meets with one firm; side contracting occurs based on expected value.[11]
$t = 4$ The delegate announces $\hat{\sigma}$; she chooses competitive bidding or sole sourcing according to the rule edited by the principal.
− If it is competitive bidding, the delegate sinks K and opens the market; Nature chooses $(\beta^1, ..., \beta^N)$; The N potential producers discover β^i; bidding takes place.
− If it is sole sourcing, the delegate selects a firm; Nature chooses β^i; the firm discovers β^i; negotiation takes place.
$t = 5$ Contracts are signed, production and transfer occur.

The next section provides the benchmark case of a benevolent (incorruptible) delegate. It is inspired from Auriol (1996).

3 Benevolent Delegate

In this section we assume that the delegate is not corruptible ($\delta_c = +\infty$).

3.1 Sole Sourcing: In the sole source case, the delegate maximizes with respect to $t(\beta)$ the principal net surplus $W(\beta) = S(Q) - t(\beta)$ under the participation constraint of the firm $\Pi(\beta) = t(\beta) - \beta Q \geq 0$.[12] Since she cannot observe the firm's marginal cost, she is not able to implement the first best solution, which consists of paying the commodity exactly what it costs to produce it (i.e., to set the firm transfer at $t^*(\beta) = \beta Q$). Protected by the asymmetry of information, the producer can always pretend to be inefficient, an impossible claim to verify. The firm informational rent is: $\Pi(\beta) = (\overline{\beta} - \beta)Q$. The total acquisition cost, which is the sum of the production cost, βQ, plus the informational rent,

[11] At this stage of the game, both the firm and the delegate ignore the realization of β.
[12] In the negotiated case a single firm produces, we drop for notation simplicity the index of the firm.

$(\overline{\beta} - \beta)Q$, is equal to $t(\beta) = \overline{\beta}Q$. The principal net expected surplus, then, is constant $EW = S(Q) - \overline{\beta}Q$. We deduce that, in the sole source case, the principal does not care which firm gets the market. It corresponds to a fixed price purchase.[13]

3.2 Competitive Bidding: Let $\beta^{-i} = (\beta^1, ..., \beta^{i-1}, \beta^{i+1}, ..., \beta^N)$. When she chooses a competitive procedure the delegate maximizes with respect to market shares q^i and transfer payments t^i, the principal net surplus $W^N(\beta^1, ..., \beta^N) = S(Q) - \sum_{i=1}^N t^i(\beta^i, \beta^{-i}) - K$, under the participation constraint of the firms $\Pi^i(\beta^i) = E_{\beta^{-i}}\left[t^i(\beta^i, \beta^{-i}) - \beta^i q^i(\beta^i, \beta^{-i})\right] \geq 0 \quad i = 1, ..., N$ and $Q = \sum_{i=1}^N q^i$. If she could observe the cost parameters $(\beta^1, ..., \beta^N)$, she would attribute the market to the most efficient producer and set his transfer at his cost level while the other firms produce or receive nothing. Indeed the firms' production cost being linear, there is no gain to split the production among them. The first best solution is: $t^{i*}(\beta^i, \beta^{-i}) = \beta^i Q$ if $\beta^i = min(\beta^1, ..., \beta^N)$ and $t^{i*}(\beta^i, \beta^{-i}) = 0$ otherwise.

In practice the delegate cannot observe $(\beta^1, ..., \beta^N)$. Since the cost parameters are independent and identically distributed, it is optimal under asymmetry of information to organize a second price type of auction (see Myerson (1981)). The firms make simultaneously and independently an offer (propose a price above which they accept to serve the market). The market is attributed to the firm with the lowest bid, but the price it gets in exchange for the production is the second lowest bid. This acquisition procedure has the advantage of being incentive compatible (in this game it is a dominant strategy for the bidders to announce their true cost β^i) and maximizing the expected surplus of the principal. The rent that a producer gets on expectation when he is one of N bidders of such an auction is:

$$E\Pi^i_N = Q \int_{\underline{\beta}}^{\overline{\beta}} [1 - F(\beta)]^{N-1} F(\beta) d\beta \qquad i = 1, ..., N. \tag{2}$$

Compared with the sole source case, the rent in (2) is reduced by $[1 - F(\beta)]^{N-1}$ which is the probability that a firm of type β is not minimizing the acquisition cost. That is, the firms' individual rent is decreasing with N and goes to zero for a competitive industry.

Let $f^N_{min}(\beta) = N[1 - F(\beta)]^{N-1} f(\beta)$ denote the density function of $min(\beta^1, ..., \beta^N)$ the minimum of N independent variable of type β^i, and $F^N_{min}(\beta) = 1 - [1 - F(\beta)]^N$ the distribution function. We deduce from (2) that $\sum_{i=1}^N E\Pi^i_N = Q \int_{\underline{\beta}}^{\overline{\beta}} \frac{F(\beta)}{f(\beta)} dF^N_{min}(\beta)$. Then the net expected surplus from competitive sourcing with N bidders is:

$$EW^N = S(Q) - Q \int_{\underline{\beta}}^{\overline{\beta}} \Big(\beta + \tfrac{F(\beta)}{f(\beta)}\Big) dF^N_{min}(\beta) - K. \tag{3}$$

A comparison of the welfare under sole sourcing with the welfare under competitive bidding at the exclusion of the fixed cost yields after an integration by part $EW^N + K - EW = Q \int_{\underline{\beta}}^{\overline{\beta}} [1 + \frac{d}{d\beta}\frac{F(\beta)}{f(\beta)}]\Big(F^N_{min}(\beta) - F(\beta)\Big) d\beta \geq 0$.[14] By introducing competition, the delegate reduces producers' expected rent. Since these rents are a cost to the principal,

[13] If the firms were ex ante asymmetric (e.g. if their cost were drawn from different supports) the result would be different. In this case, their average rent and cost being different, it would matter which firm would be selected (for more on this point see Auriol (1996)).

[14] The expected surplus under sole sourcing is $EW = S(Q) - \overline{\beta}Q = S(Q) - Q \int_{\underline{\beta}}^{\overline{\beta}} \Big(\beta + \frac{F(\beta)}{f(\beta)}\Big) dF(\beta)$.

competitive bidding increases his surplus by that much. The benefit growths as competition intensifies (the difference between $F^N_{min}(.)$ and $F(.)$ increases with N). Indeed when the number of bidders is large they collectively bid more aggressively which reduce the final cost: the essence of competition. We define $k(N)$ as the marginal social benefit of introducing competition:

$$k(N) = \int_{\underline{\beta}}^{\overline{\beta}} \left[1 + \frac{d}{d\beta}\frac{F(\beta)}{f(\beta)}\right]\left[F^N_{min}(\beta) - F(\beta)\right] d\beta. \tag{4}$$

The choice between sole sourcing and competitive bidding reduces to the following trade-off. Competitive bidding yields a procedural cost K but gives a higher probability of a small acquisition cost, *the sampling effect* which is captured by $Qk(N)$.[15] We deduce that the optimal acquisition strategy is competitive bidding if $Qk(N) \geq K$, and sole sourcing is otherwise. As N is unknown ex ante, $k(N)$ is a random variable. The expected value of $k(N)$ depends on the information available on N. Let $\overline{k} = k(\overline{N})$, $\underline{k} = k(\underline{N})$, and $Ek = \alpha\underline{k} + (1-\alpha)\overline{k}$. We deduce from (4) that $\underline{k} \leq Ek \leq \overline{k}$. Conditionally on σ we get $E[k(N) \mid N] = k(N)$ and $E[k(N) \mid \emptyset] = Ek$.

Proposition 1 *The optimal acquisition policy consists of choosing open tendering whenever K is lower than $QE[k(N) \mid \sigma]$ and limited tendering is otherwise.*

From proposition 1 competitive acquisition is more valuable when the number of bidders N is large and when the level of procedural cost K is low. Moreover, the expected gain associated with competitive bidding increases with Q. The impact of a decrease in the marginal acquisition cost is proportional to the market size. Efficiency, which is not a big issue for small markets (flexibility and rapidity are more important factors) is crucial for the large ones. In most countries there are hence minimum thresholds for open tendering.

The optimal acquisition policy of proposition 1 relies on the assumption that the delegate is going to disclose honestly her information. We study next what happens when the delegate is corruptible. Depending on the value of Q, the stake for corruption varies.

4 Corruptible Delegate

When $Q \leq \frac{K}{\overline{k}}$, there is no stake for corruption because the market is too small to be open to tender. The optimal acquisition policy is limited tendering independently of the signal σ received by the delegate. Symmetrically, when $Q \geq \frac{K}{\underline{k}}$, the market is too big to be bilaterally negotiated. Whatever σ, the optimal policy is open tendering. In both cases, the information possessed by the delegate on N is socially useless. She cannot extract a rent from it.

On the other hand, when $\frac{K}{\overline{k}} \leq Q \leq \frac{K}{Ek}$, the optimal policy entails open tendering if $\sigma = \overline{N}$, and limited tendering is otherwise (i.e., when $\sigma = \emptyset$ or $\sigma = \underline{N}$). Since her information is pivotal, the delegate is free to choose the acquisition strategy whenever

[15] For more on the sampling effect see Auriol-Laffont (1993), Auriol (1996).

$\sigma = \overline{N}$. Instead of looking for the most efficient supplier, she might favor a producer in exchange for a bribe. Then if a firm captures the delegate, the principal ends up with the wrong decision, namely limited tender in favor of the briber, whenever $\sigma = \overline{N}$.

Finally, when $\frac{K}{Ek} \leq Q \leq \frac{K}{\underline{k}}$, the optimal policy involves limited tendering (i.e., direct purchase) if $\sigma = \underline{N}$, and open tendering is otherwise. In the case $\sigma = \underline{N}$, the interests of the firm (i.e., an incumbent) and of the principal coincide in the sense that they both prefer the truth to be disclosed and the fixed price purchase to be implemented. Nevertheless, the delegate can threaten the firm either by selecting a competitor, or worse for the taxpayers, by implementing open tendering (i.e., to announce $\hat{\sigma} = \emptyset$) if it refuses to pay a bribe. This particular kind of corruption is called extortion: the firm does not want to bribe the delegate but is obliged to.

To sum up, corruption is called *capture* if the delegate decides to use limited tendering while she privately knows open tendering is optimal. It is called *extortion* if she simply asks bribes from a firm while she privately knows limited tendering is optimal. The next figure represents the possibilities of corruption in function of the market size Q ("limited tender" and "open tender" are corruption-free zones).

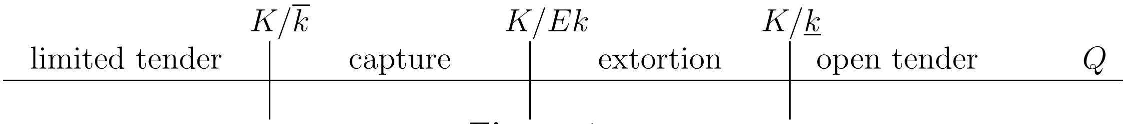

Figure 1

Extortion occurs when the optimal acquisition strategy is the fixed price purchase. To avoid being excluded from trade, a supplier abandons a share of its expected profit with the delegate. This alters the distribution of the rent between the delegate and the firm, but has no impact on the total acquisition cost. The taxpayers have to pay $\overline{\beta}Q$ anyway. Assuming fighting extortion is costly, it is not worthwhile for an isolated principal to waste resources preventing the delegate from getting a kickback if she is determined to get one. In this fight he faces costs and no benefit. We deduce the next result.

Proposition 2 *Optimal delegation policy does not try to prevent extortion.*

The result of proposition 2 relies on the assumption that susceptibility to corruption is exogenous and fixed.[16] However, in practice, tolerating extortion will lead to an increase of corruption (i.e., a decrease in δ_c). Then more extortion will also mean more capture.

This is bad because capture increases the final market cost. It has an efficient consequence on the top of the income-distribution consequence. In this sense it is more costly to the taxpayers than extortion. The principal wants to fight it. To encourage the delegate to resist capture he has to reward her when she reports $\sigma = \overline{N}$. More precisely, she will never collude with a firm if she receives behaving honestly what she could get in bribes discounted by $1 + \delta_c$. We assume that the delegate gets all the bargaining power in the secret negotiation because if the firm would refuse her take-it-or-leave-it offer she

[16]The result of proposition 2 is also conditional on the agents accepting passively to be extorted. However in practice people strongly resent being extorted. They will try to bypass public agencies and public officers to avoid extortion. This shunting behavior generates high efficiency costs.

would make the same offer to a competitor. Since, ex-ante, they are all symmetric, the particular one she chooses is not important. The bribe she can get is then the maximum that a producer is willing to pay to secure a monopoly position. By assumption, the firm's benefit from capture is: $\Delta\Pi = E\Pi - E\Pi^i_{\underline{N}}$. It is an expected term because at the side-contracting stage the firms do not know the exact value of β. Then the stake for collusion, $\Delta\Pi$, which increases with competitiveness $\overline{N}$ and market size Q, is fixed and known to everybody. This assumption greatly simplify the analysis of the corruption game: the delegate who gets all the bargaining power asks for $\Delta\Pi$. Let:

$$\Delta\pi = \int_{\underline{\beta}}^{\overline{\beta}} \left[1 - [1 - F(\beta)]^{\overline{N}-1}\right] F(\beta) d\beta, \tag{5}$$

The stake for capture is $\Delta\Pi = Q\Delta\pi$. In what follows, we consider the benchmark case where the delegate discount factor for illegal revenue is observable.

4.1 The Symmetric Information Case

Under the assumption that $\delta_c \in [0, +\infty)$ is observable, any possible outcome can be obtained through a capture-proofness contract (see Tirole 1986). There is, thus, no loss of generality to restrict the analysis to situations where there is no bribe for capture in equilibrium. In equilibrium there is coexistence of full revelation of delegate information and corruption (i.e. extortion). Let $x_c^\sigma \in [0, 1]$ denote the probability that the principal chooses competitive bidding when the information disclosed by the delegate is σ and 1-x_c^σ the probability that he chooses sole sourcing ($\sigma \in \{\underline{N}, \overline{N}, \emptyset\}$). A capture-proofness contract for the delegate is:

$$R(\sigma) = \begin{cases} x_c^{\overline{N}}(1 - x_c^{\emptyset})\frac{Q\Delta\pi}{1+\delta_c} & \text{if } \sigma = \overline{N}, \\ 0 & \text{otherwise} \end{cases}$$

Taking into account the capture-proofness rent that he must abandon to the delegate – basically $\frac{Q\Delta\pi}{1+\delta_c}$ when $\sigma = \overline{N}$ is pivotal information– and the informational rent that he must abandon to the firms,[17] the utilitarian principal maximizes with respect to $x_c^\sigma \in [0, 1]$:

$$EV = (1-\xi)\left\{(1-x_c^{\emptyset})EW + x_c^{\emptyset}\left(\alpha EW^{\overline{N}} + (1-\alpha)EW^{\underline{N}}\right)\right\} + \xi(1-\alpha)\left\{(1-x_c^{\underline{N}})EW + x_c^{\underline{N}}EW^{\underline{N}}\right\}$$
$$+ \xi\alpha\left\{(1-x_c^{\overline{N}})EW + x_c^{\overline{N}}EW^{\overline{N}} - x_c^{\overline{N}}(1-x_c^{\emptyset})\frac{\Delta\Pi}{1+\delta_c}\right\}.$$

Let $\kappa = \frac{\alpha\xi\overline{k} + (1-\xi)Ek}{\alpha\xi + 1 - \xi}$ be a convex combination of $\overline{k}$ and Ek, and let

$$\lambda(\delta_c) = 1 - \frac{1}{1+\delta_c}\frac{\Delta\pi}{\overline{k}}. \tag{6}$$

The following result is proven in the appendix.

[17] The firm's informational rent has the same shape as in section 3 because the information structure between the delegate and the firms regarding β^i is unchanged.

Proposition 3 *When the corruptibility of the delegate δ_c is known, the optimal delegation framework distinguishes four regimes:*

+ $Q\lambda(\delta_c) \leq \frac{K}{\underline{k}} \quad \forall Q \leq \frac{K}{\kappa}$: the acquisition procedure is **limited tender**.

+ $Q\lambda(\delta_c) \geq Max\{\frac{K}{\overline{k}}, \frac{Q[\alpha\xi\overline{k}+(1-\xi)Ek]-(1-\xi)K}{\alpha\xi\overline{k}}\} \quad \forall Q \in [\frac{K}{\overline{k}}, \frac{K}{Ek}]$: the acquisition procedure depends on delegate information sustained by **capture-proofness** *contracts.*

+ $Q\lambda(\delta_c) \leq \frac{Q[\alpha\xi\overline{k}+(1-\xi)Ek]-(1-\xi)K}{\alpha\xi\overline{k}} \quad \forall Q \in [\frac{K}{\kappa}, \frac{K}{\underline{k}}]$: the acquisition procedure depends naively on delegate announcement such that **extortion** *occurs.*

+ $Q \geq \frac{K}{\underline{k}}$: the acquisition procedure is **open tender**.

Figure 2 illustrates proposition 3. The line $Q\lambda(\delta_c)$ describes the regimes to be implemented in function of Q.

[Figure 2]

When the delegate is not corruptible proposition 1 and 3 coincide (i.e., $\lambda(+\infty) = 1$). Now when δ_c is finite, the principal has to deter capture by rewarding the delegate when $\sigma = \overline{N}$ is a pivotal information. He uses this information only when the expected benefit of implementing his preferred acquisition decision outweighs the capture-proofness rent (i.e., if $Q\lambda(\delta_c) \geq \frac{K}{\overline{k}}$). From (6), $\lambda(\delta_c)$ which is lower than 1, is decreasing in δ_c. The interval in term of market size, where the principal implements capture-proofness contracts, shrinks when δ_c decreases.[18] Then for very corrupted agents it happens that the capture regime is suppressed (i.e., for the low value of δ_c it occurs that $Q\lambda(\delta_c) \leq \frac{K}{\overline{k}}, \forall Q \in [\frac{K}{\overline{k}}, \frac{K}{Ek}]$). The delegate receives a flat wage –her reservation wage– and the principal is confronted with the following choice. He can either neglect the delegate information –limited tendering regime– or partly uses it –extortion regime. It is easy to check that extortion dominates limited tendering when $Q \in [\frac{K}{\kappa}, \frac{K}{Ek}]$, and that the reverse is true when $Q \in [\frac{K}{\overline{k}}, \frac{K}{\kappa}]$. In this case the delegate retains choice only for $Q \in [\frac{K}{\kappa}, \frac{K}{\underline{k}}]$, as compared to $Q \in [\frac{K}{\overline{k}}, \frac{K}{\underline{k}}]$ in the first best. That is, *in response to the capture threat, the principal reduces delegate discretion* . This is the "lack of discretion" result stressed by the collusion-proofness literature.

4.2 The Asymmetric Information Case

As first pointed out by Kofman-Lawarrée (1996) and by Strausz (1998), it is not realistic assuming that the principal knows the corruptibility of his delegates. If he was able to identify corruptibility, he would hire honest delegates only. The principal does not know δ_c, but has an *a priori* on this parameter given by the distribution function $G(\delta_c)$ and the density function $g(\delta_c)$ over $[0, +\infty)$ satisfying the monotone hazard rate property.

A4 $$\frac{1 - G(\delta_c)}{g(\delta_c)} \text{ is decreasing } \forall \delta_c \in [0, +\infty).$$

[18] To be more specific Proposition 3 establishes that for a given $Q \in [\frac{K}{\overline{k}}, \frac{K}{Ek}]$, the capture-proofness regime is implemented only when $Q\lambda(\delta_c) \geq Max\{\frac{K}{\overline{k}}, \frac{Q[\alpha\xi\overline{k}+(1-\xi)Ek]-(1-\xi)K}{\alpha\xi\overline{k}}\}$. Since $Max\{\frac{K}{\overline{k}}, \frac{Q[\alpha\xi\overline{k}+(1-\xi)Ek]-(1-\xi)K}{\alpha\xi\overline{k}}\}$ is independent of δ_c, and since from (6) $\lambda(\delta_c)$ decreases with δ_c, we deduce the result.

To capture the idea that corruption varies across place and time, a population identified by its distribution function $G_\theta(.)$ over $[0,+\infty)$ is said to be more corrupted than a population identified by the distribution function $G_{\theta'}(.)$ if the following condition holds.

A5 $\frac{1-G_\theta(\delta_c)}{g_\theta(\delta_c)} \leq \frac{1-G_{\theta'}(\delta_c)}{g_{\theta'}(\delta_c)} \qquad \forall \delta_c \in [0,+\infty).$

In other words, the hazard rate of an honest population dominates the hazard rate of a more corrupted one. Moreover, assumption 5 implies that a population which is corrupted is associated to lower bribes' discount rate than a more honest one.[19]

If the principal cannot observe δ_c, he is not able to tailor the contracts in function of delegates' type. They are all alike, but for δ_c. To be sure that the most corrupted delegate (i.e. $\delta_c = 0$) will cooperate honestly, he has to abandon to all other types the highest possible rents. The only capture-proofness contract consists into offering $Q\Delta\pi$ to all of them. The principal prefers to offer less, accepting in exchange the risk of having some capture in equilibrium.

The principal chooses a critical value δ_c^l to optimize on the bonus $\frac{Q\Delta\pi}{1+\delta_c^l}$ that he offers to the delegate in exchange for the (pivotal) information $\sigma = \overline{N}$. If the delegate he faces is relatively honest (is of type $\delta_c \geq \delta_c^l$), she accepts the rent and reports truthfully, which yields a net surplus $EW^{\overline{N}} - \frac{Q\Delta\pi}{1+\delta_c^l}$. If she is corrupted (is of type $\delta_c \leq \delta_c^l$), she prefers to hide her information and to collude with a producer, which yields the net surplus EW. The principal chooses δ_c^l to solve $\text{Max}_{\delta_c}\ [1-G(\delta_c)]\Big(EW^{\overline{N}} - \frac{Q\Delta\pi}{1+\delta_c}\Big) + G(\delta_c)EW$. We deduce that δ_c^l satisfies the following equation:[20]

$$\frac{1-G(\delta_c^l)}{g(\delta_c^l)}\frac{1}{(1+\delta_c^l)^2} + \frac{1}{1+\delta_c^l} = \frac{Q\overline{k} - K}{Q\Delta\pi}. \tag{7}$$

The marginal benefit associated with the decrease of the rent distributed to the honest fraction of the population, $[1-G(\delta_c^l)]\frac{Q\Delta\pi}{(1+\delta_c^l)^2}$, is equalized to the marginal cost of the increase of the number of captured delegates implementing distorted acquisition decisions, $g(\delta_c^l)[Q\overline{k} - \frac{Q\Delta\pi}{1+\delta_c^l} - K]$. From equation (7), one can check that δ_c^l decreases with Q. Indeed, for the large value of Q, an anti-competitive bias in the attribution process generates substantial over cost. To limit such bias, the principal strengthens the delegate incentives by increasing her unitary reward. Since δ_c^l decreases, the probability that the delegate is captured, $G(\delta_c^l)$, thus decreases with market size Q. Moreover, one can check that the optimal delegate reward decreases when the level of corruption decreases among the population (δ_c^l increases when delegate distribution shifts in A5 sense). If honesty rises among the population, more people are going to take the principal's bonus rather than bribes. It becomes very costly to offer $\frac{Q\Delta\pi}{1+\delta_c^l}$ to all of them, the principal lowers the bonus. We consider next how the optimal delegation policy is distorted by the asymmetric information on δ_c. The proposition is demonstrated in the appendix.

Proposition 4 *When δ_c is not observable, the optimal delegation framework distinguishes four regimes to be implemented by the delegate in function of market size Q:*

[19] $\frac{1-G_\theta(\delta_c)}{g_\theta(\delta_c)} \leq \frac{1-G_{\theta'}(\delta_c)}{g_{\theta'}(\delta_c)} \quad \forall \delta_c \in [0,+\infty) \Rightarrow G_\theta(\delta_c) \geq G_{\theta'}(\delta_c) \quad \forall \delta_c \in [0,+\infty).$

[20] To avoid a corner solution we assume that $Q\overline{k} - Q\Delta\pi - K < 0$ and that $G(.)$ is non degenerated.

+ $Q \leq \frac{K}{\bar{k}}$*: the acquisition procedure is* **limited tender**.

+ $Q\lambda(\delta_c^l) - \frac{K}{\bar{k}} \geq \frac{\alpha\xi+1-\xi}{\alpha\xi}\frac{\kappa Q-K}{\bar{k}} \quad \forall Q \in [\frac{K}{\bar{k}}, \frac{K}{Ek}]$*: the acquisition procedure depends on delegate announce sustained by the incentive payment* $\frac{Q\Delta\pi}{1+\delta_c^l}$ *such that* **capture** *occurs with probability* $G(\delta_c^l)$*).*

+ $Q\lambda(\delta_c^l) - \frac{K}{\bar{k}} \leq \frac{\alpha\xi+1-\xi}{\alpha\xi}\frac{\kappa Q-K}{\bar{k}} \quad \forall Q \in [\frac{K}{\kappa}, \frac{K}{\underline{k}}]$*: the acquisition procedure depends naively on delegate information such that* **extortion** *occurs.*

+ $Q \geq \frac{K}{\underline{k}}$*: the acquisition procedure is* **open tender**.

The first result from proposition 4 is that whatever the principal's belief in the corruptibility of the society, the rules concerning limited tendering and open tendering are *first best*. These rules are independent of delegate's information. Limited tendering is implemented when Q is small, open tendering when Q is large. This is illustrated in figure 3 by the fact that the regime to be implemented is determined by a line pivoting around $\frac{K}{\bar{k}}$ (instead around 0 in the symmetric information case, see figure 2). Figure 3 is drawn for the distribution function $G_\theta(\delta_c) = 1 - [\frac{1}{1+\delta_c}]^\theta \quad \delta_c \in [0, +\infty], \quad \theta > 0$.[21] For a given Q, the line $Q\lambda(\delta_c^l) - \frac{K}{\bar{k}} = \frac{1}{1+\theta}(Q - \frac{K}{\bar{k}})$ provides the regime to be implemented.

[Figure 3]

The second result from proposition 4 is that whatever the distribution of corruptibility in the population, when $Q \in [\frac{K}{\bar{k}}, \frac{K}{\underline{k}}]$ the optimal policy is either to implement the capture or the extortion regime. The principal relies as often as in the first best case on the delegate expertise to settle the acquisition decision. Contrary to the symmetric information case, *there is no loss of discretion in response to the corruption threat*. That is, the lack of discretion result does not hold anymore. The choice between the capture and the extortion regime depends, for a given distribution $G(.)$ on Q. Since the transfer $\frac{Q\Delta\pi}{1+\delta_c^l}$ increases more than proportionally when market size increases (because δ_c^l decreases when Q increases), it becomes very costly to implement this regime for the large value of Q. The principal rather chooses a competitive procedure whenever the delegate claims that $\sigma = \emptyset$. It implies that extortion occurs.

When the susceptibility to corruption in the population rises (in A5 sense), the delegate's decisions that might lead to capture are reduced.[22] However, contrary to the symmetric information case, it is never totally suppressed. When corruption runs very high the capture regime is limited to the interval $Q \in [\frac{K}{\bar{k}}, \frac{K}{\kappa}]$. Indeed, for this range of the parameters suppressing the discretion of the delegate would mean ignoring her information by always choosing limited tendering, which is the decision that a corrupted delegate ($\delta_c \leq \delta_c^l$) is going to implement anyway (a corrupted delegate announces $\hat{\sigma} = \emptyset$ when $\sigma = \overline{N}$). On the other hand, a relatively honest delegate ($\delta_c \geq \delta_c^l$) is going to

[21] It is parameterized by θ such that the greater θ is, the more the population is corrupted. The fraction of the population which is honest is $\left[\frac{1}{1+\delta_c^l}\right]^\theta$. When $\theta \to 0$ the whole population is honest, and when $\theta \to +\infty$ it is totally corrupted.

[22] The critical value δ_c^l decreases with corruption (in A5 sense), so that $Q\lambda(\delta_c^l) - \frac{K}{\bar{k}}$ also decreases with corruption. Since $\frac{\alpha\xi+1-\xi}{\alpha\xi}\frac{\kappa Q-K}{\bar{k}}$ is constant we deduce from proposition 4 that the capture regime is less implemented when corruption increases.

implement the principal's preferred decision in exchange for the premium of honesty. For $Q \in [\frac{K}{\overline{k}}, \frac{K}{\kappa}]$, bypassing delegate information means the loss of this occasional increase in surplus without providing any corresponding benefit.[23]

The legal framework that emerges from the theoretical analysis involves open tendering for large purchases, and no monitoring for small ones. For a market of medium range, the purchasers retain some discretion over the attribution decision. The legislation that rules public purchases in OECD countries is in line with these findings. For instance European legislation requires from EU members to publish procurement contracts in the Official Journal of the European Communities once they reach the values mentioned in the GPA. Companies from countries that signed the GPA , including the USA, Canada, Israel and Japan, can participate on equal terms as companies from member-states of the EU. The thresholds vary with the commodities. For instance up to 31 december 2005, it is in euros 5.923.624 for works, 154.014 for supplies of products and services for national authorities and 236.945 for other authorities. According to the preceding analysis this difference is explained by different procedural costs K. They are indeed much higher in works, because the proposal phase involves large design costs, than in supplies of products. Consistent with our results, the public purchasers are incited to use limited-tendering only when one firm possesses a 'unique capability' that cannot easily be duplicated (i.e., when N is anticipated to be low).

5 An assessment of the corruption cost

In this section we aim to compute the social cost of active corruption (i.e., capture). We know from the preceding analysis that when capture occurs the cost of the purchase is $T = \overline{\beta}Q = (\underline{\beta} + \Delta\beta)Q$. Let N denotes the number of firms that would have shown up at a competitive bidding. In order to calibrate the model we consider uniform distribution for the cost parameter (i.e., β is uniformly distributed over $[\underline{\beta}, \underline{\beta} + \Delta\beta]$). Under the uniform assumption we deduce from equation (4) that the social loss associated with capture is:

$$L = \Delta\beta Q \frac{N-1}{N+1}. \tag{8}$$

On the other hand, the firm capture rent is by virtue of equation (5):

$$\Delta\Pi = \Delta\beta Q \Big\{ \frac{1}{2} - \frac{1}{N(N+1)} \Big\} \tag{9}$$

It is easy to check that the loss is higher than the firm rent if and only if $N^2 - 3N + 2 \geq 0$. This is true for any $N \geq 1$. Then for $N = 1$ we get $L = \Delta\Pi = 0$, for $N = 2$ we get $L = \Delta\Pi$, and for $N = +\infty$ $L = 2\Delta\Pi$.

The firm and the delegate share the rent so that the bribes received by public officials are a fraction of $\Delta\Pi$. To economize on notation we denote by $\frac{1}{1+\delta}$ the delegate cut of

[23]Formally, we see from equation (7) that $Q\lambda(\delta_c^l) - \frac{K}{\overline{k}} = \frac{1}{\overline{k}} \frac{1-G(\delta_c^l)}{g(\delta_c^l)(1+\delta_c^l)} \geq 0 \; \forall Q \in [\frac{K}{\overline{k}}, \frac{K}{Ek}]$. Moreover $\frac{\alpha\xi+1-\xi}{\alpha\xi} \frac{\kappa Q - K}{\overline{k}} \leq 0 \; \forall Q \in [\frac{K}{\overline{k}}, \frac{K}{\kappa}]$. Proposition 4 implies that the capture regime is always implemented.

$\Delta\Pi$. Then a larger δ means a smaller share of the rent for the delegate. The bribes are denoted $B = \frac{\Delta\Pi}{1+\delta}$. Depending on $N \in [2, +\infty]$ we deduce that the social loss of capture is

$$L \in [(1+\delta)B, 2(1+\delta)B]. \tag{10}$$

In practice bribes are recorded as percentages of the total purchase cost. Let α denotes the percentage. We have $B = \alpha T$. Combining $B = \alpha(\underline{\beta} + \Delta\beta)Q$ with equation (9) we obtain

$$1+\delta = \frac{1}{\alpha}\frac{\Delta\beta}{\underline{\beta}+\Delta\beta}\Big[\frac{1}{2} - \frac{1}{N(N+1)}\Big]$$

In order to evaluate the social loss L we now turn to $(1+\delta)$ calibration. As explained in the introduction the World Bank estimates that bribes paid to win public market represent some 3.5% of total procurement cost. In what follows we set $\alpha = 3.5\%$.

The second term is more tricky to calibrate because the information on firms' cost support $[\underline{\beta}, \underline{\beta} + \Delta\beta]$ is not available. However, we are able to assess a lower bound for $\frac{\Delta\beta}{\underline{\beta}+\Delta\beta}$ by using information on e-procurement and competitive bidding procedures. That is, $\frac{\Delta\beta}{\underline{\beta}+\Delta\beta}$ represents in percentage the reduction of purchasing price that would be realized if one could move from monopoly (i.e., from price $(\underline{\beta}+\Delta\beta)Q$ when $N = 1$) to competitive sourcing (i.e., to price $\underline{\beta}Q$ when $N = +\infty$).

We use data on e-procurement to assess the value of $\frac{\Delta\beta}{\underline{\beta}+\Delta\beta}$. E-procurement reduces substantially the procedural cost of procurement (i.e., K). The firms registered into the system receive automatically the tender offers. If they wish to submit an offer they do it electronically from office. Since more firms are informed of the tender, and since it is less costly for them to submit an offer, the number of bidders increases. For instance, the number of bidders has been multiplied by 3 since the Korean administration moved from classical procurement to e-procurement.[24] Surveys and cases studies, both in public and private sectors, hence reveal reduction of purchasing price. In private e-procurement savings on the order of 13% have been found. For public e-procurement savings on the order of 20% are common. This figure is consistent with the 20% saving found by Domberger-Hall-Lee (1995) in their survey of the empirical literature on the impact of competitive tendering. These estimates represent a lower bound for $\frac{\Delta\beta}{\underline{\beta}+\Delta\beta}$. We take a conservative approach to be sure that we do not over-estimate the social cost of corruption by setting in what follows $\frac{\Delta\beta}{\underline{\beta}+\Delta\beta} = 0.2$.

The Last term, $\frac{1}{2} - \frac{1}{N(N+1)}$ varies between $\frac{1}{3}$ and $\frac{1}{2}$ as N increases from 1 to $+\infty$. In what follows we consider $\frac{1}{2} - \frac{1}{N(N+1)} \in [\frac{1}{3}, \frac{1}{2}]$.

We deduce that

$$1+\delta \in [1.9, 2.86].$$

This figure puts the delegate cut of the firm expected rent between 0.35 and 0.52. More importantly we are able to compute an estimate of the social loss of capture. Depending on $N \in [2, +\infty]$ we get:

[24] Korea is one of the few countries in the world which has already achieved the implementation of its e-procurement public system.

$$L = [1.9, 5.72]B. \quad (11)$$

This yields an estimate which varies between 6.65 % and 20.02% of the total procurement spending. In 2002 the loss can hence be estimated between USD 385.7 billion up to USD 1.16 trillion.

6 Conclusion

The paper also shows that extortion should not necessarily be fought against, while capture should. This involves offering the public representatives incentives payment increasing with the market size. In practice the purchasers are not monitored and they receive the same reward no matter what size of the market they are dealing with. In other words, their discretion is high and their incentives are flat. One may wonder why the public delegation system lacks the basic incentive that is found in any private system. A plausible explanation is that the delegation framework in public purchases has not been designed while bearing cost minimization in mind. As evoked in the introduction there are much documented evidences that political parties finance their campaigns with the money of capture from public contracts. The recent scandal of the financing of the Rassemblement Pour la Rpublique (RPR) party involving the President of France, Jacques Chirac, illustrates this point (see Le Monde 2000). If we admit that the political system is fueled with the money of capture, we deduce that the interest of the political class is to facilitate the collection of bribes, not to block them. Then corruption in procurement and public purchase should be understood as more a political economy issue than a contract theory one.

APPENDIX 1: Proof of Proposition 3 and 4

Proposition 3: For $Q \in [0, \frac{K}{\overline{k}}] \cup [\frac{K}{Ek}, +\infty)$ the optimal delegation framework is as described proposition 1; it is changed for $Q \in [\frac{K}{\overline{k}}, \frac{K}{Ek}]$. Since the principal problem EV is linear in x_c^σ, at the optimum these probabilities are either 0 or 1. Moreover since $Q\underline{k} - K \leq 0$ for $Q \in [\frac{K}{\overline{k}}, \frac{K}{Ek}]$, we have $x_c^{\underline{N}} = 0$. The principal problem is rewritten:
$EV = \; EW + (1-\xi)\, x_c^{\emptyset}\Big[QEk - K\Big] + \alpha\xi x_c^{\overline{N}}\, \Big[(1-x_c^{\emptyset})\Big(Q\lambda(\delta_c)\overline{k} - K\Big) + x_c^{\emptyset}\Big(Q\overline{k} - K\Big)\Big].$
Then $Q\lambda(\delta_c)\overline{k} - K \leq 0$ implies $\alpha\xi x_c^{\overline{N}}(1-x_c^{\emptyset}) = 0$, and $\alpha\xi(Q\overline{k} - K) + (1-\xi)(QEk - K) \leq 0$ implies $x_c^{\emptyset} = 0$. That is for $Q\kappa \leq K$ and $Q\lambda(\delta_c) \leq \frac{K}{\overline{k}}$ the optimal policy is sole sourcing. Similarly when $Q\lambda(\delta_c) \geq \frac{K}{\overline{k}}$ and $Q\kappa \leq K$, it is optimal to set $x_c^{\overline{N}} = 1$ and $x_c^{\emptyset} = 0$. The optimal policy is to use delegate information sustained by capture-proofness contracts. On the other hand, when $Q\lambda(\delta_c) \geq \frac{K}{\overline{k}}$ and $Q\kappa \geq K$ we get $x_c^{\overline{N}} = 1$ and $x_c^{\emptyset} = 1$. The optimal policy is to implement competitive bidding whenever the delegate claims that $\sigma = \emptyset$ (extortion regime). Finally when $Q\lambda(\delta_c) \leq \frac{K}{\overline{k}}$ and $Q\kappa \leq K$, two cases are possible. If $\alpha\xi\Big(Q\lambda(\delta_c)\overline{k} - K\Big) \geq (\alpha\xi + 1 - \xi)\Big(Q\kappa - K\Big)$, which is equivalent to $\frac{(\alpha\xi+1-\xi)Q\kappa-(1-\xi)K}{\alpha\xi\overline{k}} \leq Q\lambda(\delta_c)$, then $x_c^{\overline{N}} = 1$ and $x_c^{\emptyset} = 0$ (capture-proofness regime). If the inequality is reverse then $x_c^{\overline{N}} = 1$ and $x_c^{\emptyset} = 1$ (extortion regime). By aggregating these results we obtain proposition 3.

Proposition 4: The principal maximizes with respect to $x_c^{\hat{\sigma}} \in [0, 1]$:

$$EV^{AI} = (1-\xi)\left\{(1-x_c^{\emptyset})EW + x_c^{\emptyset}\Big(\alpha EW^{\overline{N}} + (1-\alpha)EW^{\underline{N}}\Big)\right\} + \xi(1-\alpha)\left\{(1-x_c^{\underline{N}})EW + x_c^{\underline{N}} EW^{\underline{N}}\right\}$$
$$+\xi\alpha\left\{(1-x_c^{\overline{N}})EW + x_c^{\overline{N}} x_c^{\emptyset} EW^{\overline{N}} + x_c^{\overline{N}}(1-x_c^{\emptyset})\left((1-G(\delta_c^l))\Big(EW^{\overline{N}} - \frac{Q\Delta\pi}{1+\delta_c^l}\Big) + G(\delta_c^l)EW\right)\right\}$$

where $EW = S(Q) - \overline{\beta}$, EW^N is defined equation (3), $Q\Delta\pi$ is defined equation (5), and δ_c^l equation (7). Then proposition 4 is demonstrated in the same fashion as proposition 3.

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