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Corruption and Product Market Competition

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Corruption and Product Market Competition*

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Abstract

It is generally considered that more competition might help curb corruption, as rents, which motivate corrupt agreements, are decreasing in the degree of competition. This paper proposes a framework to analyze the relationship between corruption and competition. It studies the optimal incentive scheme for potentially corrupt officials in charge of inspecting firms that compete in the product market. Given that bribe-taking is sometimes tolerated in equilibrium, for specific values of the externality that motivated regulatory intervention, non-monotonic effects arise and more competition may lead to an increase in corruption. Moreover, it is shown that in this context competition is always welfare improving, even though it might lead to more corruption.

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“The role of competitive pressures in preventing corruption may be an important aspect of a strategy to deter bribery of low-level officials, but requires a broad based exploration of the impact of both organizational and market structure on the incentives for corruption facing both bureaucrats and their clients.” Susan Rose-Ackerman (1998).

1 Introduction

Following the emergence of corruption as a central topic of the international policy debate in the 90s, the economic understanding of the mechanisms of corruption has made important progress, both at the theoretical and empirical level¹. In the search for effective policy recommendations in the fight against corruption², it has been suggested that making markets more competitive may reduce corrupt behavior by reducing the available rents. A complete appraisal of the effects of such a policy, however, needs to take into account the complex incentive issues raised by the changes in both the organization of markets and their regulation, as pointed out in Susan Rose-Ackerman’s quote above³. While greater competition and thus smaller rents may make bribe-taking less interesting for bureaucrats, the incentives given to them to reduce the temptation of corruption may also change in the process. With less rents to grab, but more firms potentially subject to bribery and a different level of tolerance toward corrupt transactions, it is unclear whether the frequency and the aggregate amount of bribes will increase or decrease.

This paper’s main contribution is to provide a theoretical framework that accounts for the effect of competition on the contractual incentive scheme of bureaucrats in charge of an industry regulation. In doing so, it introduces endogenous corruption, based on informational foundations, in an industrial organization model where firms compete in the product market. The way politicians and higher levels of the bureaucracy define the rules that govern the interaction between private agents and lower levels bureaucrats then depends on the prevailing level of competition and the likelihood of corruption.

In a nutshell, we consider a situation in which there is regulatory inter-

¹See Bardhan (1997) and Aidt (2003) for surveys on corruption economics.

²See for example Klitgaard (1988), Rose-Ackerman (1999), World Bank (2002), and the references herein.

³A related point was also made in the rent-seeking literature (Krueger 1974, Bhagwati 1982).

vention to correct a negative externality linked to the production process. The need to rely on inspectors to discover the type of technology used by firms implies that better informed agents may enter in side agreements with these firms to hide the results of their inspection in exchange for a bribe. When there is heterogeneity of inspectors with respect to their honesty, the optimal choice is between no inspections at all, inspections and tolerance of some corruption, or inspections and no corruption.

There are widespread examples of such situations. To mention only a few, Rose-Ackerman (1999) reviews numerous references documenting bribery of inspectors in construction projects to reduce costs by violating safety rules and construction standards in Korea, Turkey, Russia and New York City. Other cases she mentions include systematic bribery to secure a favorable business climate by bending regulations, for example in the forestry industry and other natural resources, and payments to relax the implementation of environmental rules in Pakistan. Similar stories can be found in Klitgaard (1988).

The model generates a number of important conclusions. Looking at the range of values of the externality in which corruption is allowed to happen, two main points emerge. First, the avoidance of corruption may come at the cost of accepting market failure. In other words, over a range of parameters, corruption becomes less prevalent because the regulatory intervention that gave rise to it has become uneconomical and is dropped altogether. Second, and more importantly, for given values of the externality, non-monotonic effects arise, implying that in specific environments, more competition can either lead to an increase or a decrease in corruption. Finally, we also show that increased competition always enhances welfare when production externalities and potential corruption form part of the environment, even when this implies an increase in corruption. The main insights of the model hold both in the context of Cournot and Bertrand competition.

Our model first draws on the literature starting with Laffont and Tirole (1991) and Tirole (1992) that models corruption in the information-based setting of the principal-agent model, by introducing an intermediate supervisor in charge of reducing the uncertainty on behalf of the principal. A common tool of these models is to assume that bureaucrats vary in terms of their honesty or their fear to be caught, in order to obtain corruption in equilibrium. As mentioned above, we adapt this methodology to an industrial organization environment.

Specific theoretical contributions on the topic of corruption and compe-

tition include Bliss and Di Tella (1997) and Laffont and N'Guessan (1999). Bliss and Di Tella (1997) propose a model of extortion, in which the level of bribes, set unilaterally by graft-maximizing bureaucrats, forces some firms out of the market. They show in this setting that an increase in parameters of an exogenously given level of “deep competition” (lower overhead costs or more competition *for* the market) has an ambiguous effect on equilibrium corruption, measured by the size of individual bribes. The main difference with our model is that while they take bribing power as exogenously given (not based on informational foundations) and thereby make the number of firms a choice variable of bureaucrats, we endogenize the corruption game and vary the number of firms exogenously.

Emerson (2005), embeds Bliss and Di Tella’s framework in a model in which firms chose between being bribed or pertaining to an informal competing fringe. His model gives rise to multiple equilibria, with competition and corruption being negatively correlated, but does not endogenize corruption, relying instead on an exogenous detection function of corrupt officials.

Laffont and N'Guessan (1999) use a three-tiers hierarchy in an asymmetric regulation model where the stake for corruption is endogenous. There, uncertainty on the honesty of the bureaucrat in charge of reducing the information asymmetry between the firm and the regulator implies that some corruption may be tolerated in equilibrium. They study the effect of more competition at the supervision level, and more competition in the competitive sector producing goods that are complements or substitutes for the regulated sector goods. In both cases, they show that more competition may increase corruption, and that it also increases welfare. The limitation of this framework is that it studies the incentives for corruption in the context of the regulation of a unique, monopolistic firm, while competition only enters the picture indirectly by affecting the regulatory scheme between the principal and the monopoly.

Finally, our model also builds on Acemoglu and Verdier (1999), who analyze the trade-off between market failure and government intervention, and show that when bureaucrats are heterogeneous both intervention with no corruption and intervention with some corruption prevail only over certain ranges of parameters. However, their framework does not allow for market competition.

At the empirical level, Ades and Di Tella (1999) provide cross-country evidence that some aggregate measures of competition, like openness, industrial concentration or effectiveness of antitrust regulations, indeed correspond to

lower levels of perceived corruption, as captured by subjective indices published by The Economist Intelligence Unit or the World Competitiveness Report. Carrying out similar estimations in a sample of African countries, Laffont and N’Guessan (1999) show, however, the existence of non-monotonic effects, with the openness effect becoming negative in the case of the less corrupt countries. Ades and Di Tella (1997) find a positive relationship between more active industrial policy, considered to temporarily shelter chosen firms or sectors from competition, and corruption. Finally, Troesken (2003) documents the US historical experience in three different industrial sectors (public utilities, oil refining and whiskey distilling), and argues that corruption has been less prevalent in more competitive environments.

The rest of the paper is structured as follows. Section 2 introduces the assumptions on the production technology, the structure of the market and the nature of the regulatory intervention that eventually gives rise to corruption. Section 3 presents the results in the context of Cournot competition. Section 4 analyzes the evolution of welfare. Section 5 discusses Bertrand competition, and Section 6 concludes.

2 The Model

2.1 Market Structure

Consider the market for an homogenous good, in which aggregate demand is given by the inverse demand function $p(Q)$, which is common knowledge to all market participants as well as the government, and is assumed to be concave, continuous and have continuous first and second derivatives.

The good is supplied by n profit-maximizing firms, indexed by $i = 1, \dots, n$, so that $Q = \sum_{i=1}^n q_i$. Firms are assumed symmetric, i.e. they have access to the same technology.

Firms compete *à la* Cournot⁴. Before looking at the equilibrium in this market, we characterize the technology available to the firms.

⁴We present the case of Cournot competition in the main part of the paper and discuss the case of Bertrand competition in Section 5.

2.2 Production Technology

Each firm can either use a “good” technology, with cost $\bar{c}(q)$, or a “bad” one, with a cost $\underline{c}(q)$. The functions $\underline{c}(\cdot)$ and $\bar{c}(\cdot)$ are convex and have continuous first and second derivatives. We assume that the bad technology has a lower cost over all the range of potential output, i.e. $\underline{c}(q) < \bar{c}(q)$, for all $q \leq q_M$, where q_M denotes the monopoly output in this market for the cost function $\underline{c}(\cdot)$. We define the function $\Delta c(q) \equiv \bar{c}(q) - \underline{c}(q)$.

When using the cheaper technology, the firm generates as a by-product a negative non-pecuniary externality to consumers, parametrized by the function $x(q)$, with $x' > 0$, $x'' \geq 0$. For now, we simply consider the case of a linear externality, $x(q) = xq$ and discuss later the case of $x(q)$ strictly convex.

We can think for example of the bad technology as one that generates air or water pollution, while the good technology is a cleaner, environment-friendly, production process that avoids contamination but is more expensive.

When presenting analytical results, the computations are done using generic demand and cost functions, for which the main results are shown to hold. However, graphic illustrations require the use of specific functional forms for costs. Unless specified otherwise, in these cases we consider the cost function with the bad technology given by $\underline{c}(q) = 0$, and the good technology entailing costs $\bar{c}(q) = \beta q$, $\beta > 0$, so that $\Delta c(q) = \beta q$.

2.3 Market Equilibrium

Assume first that only the good technology, characterized by the cost function $\bar{c}(q)$, is available. In this Cournot setting, all firms, being symmetrical in cost, choose the same production level in equilibrium, which we denote by q_n^G , where the subscript n indicates the number of firms active in the market. Aggregate production is $Q_n^G = nq_n^G$, and the price is given by $p_n^G = p(Q_n^G)$. Finally, the profit of any individual firm is given by $\Pi_n^G = p(Q_n^G) \cdot q_n^G - \bar{c}(q_n^G)$.

Similarly, if only the bad technology were available, individual output, aggregate output, price and individual profit, would be q_n^B , $Q_n^B = nq_n^B$, $p_n^B = p(Q_n^B)$ and $\Pi_n^B = p(Q_n^B) \cdot q_n^B - \underline{c}(q_n^B)$ respectively.

When both technologies are available, and in the absence of a regulatory constraint, it is a strictly dominant strategy for any individual firm to use the bad technology, so the relevant equilibrium is the one in which all firms use the bad technology and produce q_n^B .

2.4 Welfare

Denoting by $CS(Q_n)$ the consumer surplus when aggregate production is Q_n , social welfare, computed as the sum of consumer surplus and firms' profits, is:

$$W_n^i = CS(Q_n^i) + n\Pi_n^i - \mathbb{I}_{[c^i(\cdot) = \underline{c}(\cdot)]} x Q_n^i, \quad i = G, B, \quad (1)$$

where \mathbb{I} is the indicator function taking value 1 whenever the statement in brackets is true, i.e. the “bad” technology is in use, and 0 otherwise, so the third term on the right hand side is the effect of the externality. Comparing the two equilibria introduced above opens a rationale for regulatory intervention, as the welfare gain from preventing the externality might exceed the additional aggregate cost to the producers of the good. Consider a benevolent government, maximizing welfare. If $W_n^B > W_n^G$, social welfare is higher when the bad rather than the good technology is used, meaning that the increase in firms' profits exceeds the externality cost. Then, no intervention is necessary as producers select the bad technology willingly. However, if $W_n^G > W_n^B$, regulatory intervention inducing firms to switch to the good technology can be socially efficient⁵.

We now turn to discuss how regulatory intervention can enforce such a shift, and introduce the possibility of corruption.

2.5 Inspection Technology and the Scope for Corruption

It is realistic to assume that technology is not directly observable by the government, which needs to send inspectors to visit the firms and discover the production technique they are using⁶.

Instead, the government only observes the price, from which quantity can be inferred. In this context, when observing a price p different from p_n^G , the government knows for sure that (some of) the firms have been using the bad technology. Such an observation can then trigger a fine, which has to be high

⁵We assume that transaction costs make a contract between consumers and producers impossible, so allocation of property rights over the good affected by the externality is not a solution.

⁶Especially since in reality there might be many different production techniques with differing costs.

enough to prevent firms from using the bad technology.⁷

Such a mechanism, however, does not insure that firms will shift to the good technology. Given the threat to be fined, firms still have the possibility to keep on using the bad technology while aligning their production level to q_n^G . As all firms are identical, this becomes the new equilibrium. Firms produce q_n^G and use the bad technology, so the profit of any individual firm is given by:

$$\Pi_n^B(q_n^G) = p(Q_n^G) \cdot q_n^G - \underline{c}(q_n^G). \quad (2)$$

Social welfare becomes $W_n^B(Q_n^G)$ instead of W_n^B . Then, it could be that $W_n^B(Q_n^G) > W_n^G$, in which case no further step is taken. Alternatively, we might have $W_n^G > W_n^B(Q_n^G)$, and the government proceeds as in the main text below. In this last case, whether $W_n^B > W_n^B(Q_n^G)$ or $W_n^B < W_n^B(Q_n^G)$ is immaterial, as the mechanism is always used along with inspections⁸. Note that, in the absence of explicit collusion between the firms allowing for compensating output deviations, no individual firm has an incentive to deviate, as this would trigger a fine (on itself as well as possibly on other firms) that would make it worse off. Compared to the equilibrium with the good technology, each firm now makes an additional profit, which we denote by s . The parameter s is the stake of dishonest behavior, which further on will also represent the stake of corruption⁹. Note that $s = \Pi_n^B(q_n^G) - \Pi_n^G(q_n^G) = \Delta c(q_n^G)$.

To make sure that the good technology is used, a regime of inspection must therefore be put in place. Inspectors visit the firms and make a report on their technology. When an inspector reveals the use of the bad technology, a fine, considered to be equal to total profit $\Pi_n^G + s$, is imposed on the firm. For simplicity, we assume that each firm is visited by a different inspector.

⁷It must be at least equal to the gain from cheating. We assume for simplicity that the government imposes the largest possible fine, which amounts to ban the firms from participating in the market and confiscate all its assets subject to a limited liability constraint. Such a constraint rules out infinite fines that would solve the problem for a very small probability of being caught. More complex mechanisms can be devised, for example allowing for a subsidy linked to the use of the good technology. This would multiply opportunities for corruption without affecting the main intuitions.

⁸Doing away with the use of the mechanism altogether would not change substantially any of the results, at the cost of analytical complications.

⁹Alternatively, we could consider that the stake is the full profit $\Pi_n^B(q_n^G)$. This would not alter the main results but would require additional assumptions on the bargaining power of the firm and the corrupt inspectors below.

However, as inspectors generate information not directly verifiable by the highest level of their hierarchy, they may be tempted to improve their material condition by making a side deal with the firms they are visiting. If collusion indeed occurs, the inspector allows the firm to keep on using the bad technology, in exchange for a share¹⁰ α of the stake s .

It is a well known artifact of information-based corruption models that getting corruption in equilibrium entails having heterogeneous inspectors¹¹. We assume that inspectors are of two types. A proportion γ is less corrupt, or more afraid of being caught, while a proportion $1 - \gamma$ is more corrupt. Following the by-now standard assumption in the literature on regulatory capture that there is a deadweight loss of corruption, linked to the fact that side transfers may be inefficient or difficult, as well as to psychological aspects of the agents involved in corruption, like their relative honesty or fear to get discovered (See Laffont and Tirole, 1991, for a discussion on this aspect and the broader notion of enforceable side contracts), we consider that when the firm gives s , the inspector receives only ks . Less corrupt inspectors have strictly positive transaction costs ($k < 1$), while the more corrupt ones have lower transaction costs, which we normalize to 0 (thus $k = 1$). Figure 1 shows the probability and type of inspection.

¹⁰In what follows, we assume for simplicity that $\alpha = 1$. This does not change any of the following results.

¹¹This was anticipated in Tirole (1992) and illustrated for example by Acemoglu and Verdier (1999) and Laffont and N'Guessan (1999).

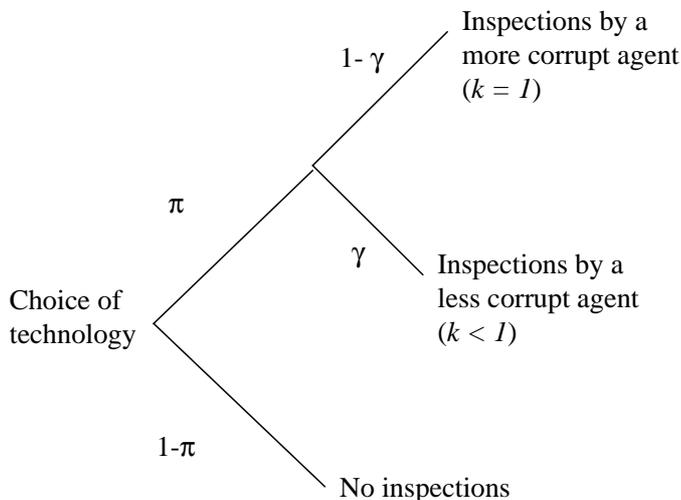


Figure 1

When inspectors are corruptible, the alternative is between giving them incentive payments to ensure their truthful reporting, or not using them at all. We model the reward r given to inspectors assuming that they have a non-zero probability ξ of getting caught if they enter a corrupt deal with the firm¹². Then, considering that inspectors are protected by limited liability and get an income of zero when caught, the reward must satisfy:

$$r \geq (1 - \xi) (\tilde{k}s + r) \Leftrightarrow r \geq \frac{1 - \xi \tilde{k}}{\xi} ks, \quad (3)$$

where $\tilde{k} \in \{k, 1\}$. To simplify notations, we call $\nu \equiv \frac{1 - \xi}{\xi}$, where ν can be interpreted as a risk parameter reducing the return from bribes¹³, and $\frac{d\nu}{d\xi} < 0$. As we will see when discussing the results, the government will have to decide whether it sets the reward at the level where all inspectors would behave honestly ($r = \nu s$), or alternatively at the level where only the more honest inspectors do so ($r = \nu ks$).

¹²This methodology is similar to Besley and McLaren (1993) and Mookherjee and Png (1995) among others.

¹³We keep ν distinct from k , as it captures different aspects of the corrupt environment. k relates to individual traits of agents, whereas ν denotes societal efforts to uncover corruption. This avoids the need for different probability of inspectors getting caught, focusing rather on heterogeneity along k .

Note that the total cost of monitoring depends on the stake of corruption (the sum of firms' extra profits). Although it increases in the number of firms, a countervailing effect arises because it is also linked to the amount of profit made by each firm, which is decreasing in n .

In a context with heterogeneous inspectors, inducing the use of the good technology requires that the probability of facing an inspection exceeds some threshold π^* . If $r = \nu s$, a cheating firm knows it will face tough inspections with probability π^* and get 0, while it secures an extra profit with probability $1 - \pi^*$. The minimum level of inspection necessary is then given by:

$$\begin{aligned} (1 - \pi^*) (\Pi_n^G + s) &= \Pi_n^G \\ \Leftrightarrow \pi^* &= \frac{s}{\Pi_n^G + s} \end{aligned} \quad (4)$$

When inspectors are honest and report truthfully their findings, it suffices to inspect $n\pi^*$ firms¹⁴ to make a firm's expected profit higher when it uses the good technology.

If the government chooses the lower reward $r = \nu ks$, when meeting a more corrupt inspector (probability $(1 - \gamma)\pi$) the firm makes a side deal, the extra profit realized s is taken away by the corrupt inspector, and corruption is uncovered with probability ξ . Thus, the firm gets away with Π_n^G with probability $(1 - \gamma)\pi^{**}(1 - \xi)$. The probability of inspections needed to enforce good behavior becomes:

$$\begin{aligned} (1 - \pi^{**}) (\Pi_n^G + s) + (1 - \gamma)\pi^{**}(1 - \xi)\Pi_n^G &= \Pi_n^G \\ \Leftrightarrow \pi^{**} &= \frac{s}{(\gamma + \xi(1 - \gamma))\Pi_n^G + s}. \end{aligned} \quad (5)$$

As the probability to meet a relatively honest inspector decreases, we obviously get that more inspections must be carried out ($\pi^{**} > \pi^*$).

Lastly, it is worth discussing how actual cheating and corruption occur in the model. As explained in the timing section below, corrupt inspectors send a signal previous to their visit to firms, so these know if they are going to face

¹⁴Or the natural number immediately above it, as $n\pi^*$ might not be a round value. In what follows, we treat n as continuous.

a corrupt demand when choosing their technology¹⁵. Although our model is static, this can be thought of as a shortcut for a model in which there is repeated interaction between firms and inspectors, who develop a reputation for being corrupt. Examples of such relationship abound. Schlosser (2002), in his fascinating account of the American fast food industry, relates that, in the 90s, slaughterhouses regularly infringing safety and hygiene regulations were often informed in advance about visits from USDA inspectors. Rose-Ackerman (1999, p18-19) characterizes corrupt relationships as repeated interactions and mentions the importance of connections between firms and government officials in cases of bribery oriented to avoid costly regulations in Indonesia and Pakistan (over the implementation of environmental rules), as well as in Mexico and Kenya (regarding the award of permits and licenses). Klitgaard (1988) reports examples from Philippines and Singapore, where inspectors are subject to frequent geographical and functional rotation to break possible corrupt relationships with the agents they supervise.

2.6 Timing

Finally, before turning to the analysis, let us recapitulate the timing of events.

1. The government announces the regulatory mechanism (price mechanism, fines) and the details of the inspection regime (intensity π , tasks and rewards r to inspectors).
2. If the reward is not set high enough to induce honest behavior by the more corrupt inspectors, these send a signal to the firm they are going to inspect, indicating their willingness to enter in a side agreement.
3. Firms decide on their production technique (the good technology or the bad one) and their production level.
4. The government observes the price. Inspections take place. Side-contracts, if any, are realized.
5. Inspectors entering corrupt deals, if any, are caught with probability ξ . Rewards are paid. Fines are imposed on firms if required.

¹⁵This modeling option is chosen for simplicity. Alternatively, one can think of firms randomizing between the good and the bad technologies, since they get the same payoff from each of them, as in Acemoglu and Verdier (1999). In this mixed strategy equilibrium, they would chose the bad technology with probability $(1 - \gamma) \pi^*$, which is also the probability to face an inspector asking for a bribe. It can be shown that such an equilibrium is immune to small deviations by the government (increasing the probability of inspection π^{**} by a tiny amount ε), as long as $\xi < \pi^{**}$.

We now consider the optimal decision from the point of view of a welfare maximizing government, in terms of having inspections or not and allowing or not corruption, and analyze how this pattern is affected by changes in the level of competition.

3 Analysis: Pattern of Government Intervention

Three possibilities arise. First, the government may choose to make high enough incentive payments, so all inspectors behave honestly. This entails paying them at least νs . Social welfare is then given by:

$$W^{NC} = CS(Q_n^G) + n\Pi_n^G - n\pi^* \lambda \nu s, \quad (6)$$

where the subscript NC stands for “No Corruption”, and the last term on the right hand side represents the incentive payment to the $n\pi^*$ inspectors, with λ parametrizing the cost of public funds. This expression assumes that although such payments are only transfers from one class of agents to another and do not reduce welfare *per se*, they are costly because they involve the need to raise distortionary taxes, i.e. paying an inspector r costs society λr in net terms.

However, this solution involves some waste of incentive payments, as a fraction γ of inspectors could be made honest with smaller payments, equal to νks . A second solution is thus to stick to this lower level of payments, and let a fraction $(1 - \gamma)$ of inspectors be bribed. Then, $(1 - \gamma) \pi^{**} n$ inspectors ask for a bribe and this is also the number of firms cheating and using the bad technology to produce q_n^G , while $\gamma n \pi^{**}$ inspectors remain honest.

This yields a level of social welfare equal to:

$$W^{PC} = CS(Q_n^G) + (1 - \gamma) \pi^{**} n (\Pi_n^G + s) + (1 - (1 - \gamma) \pi^{**}) n \Pi_n^G \quad (7) \\ - x (1 - \gamma) \pi^{**} Q_n^G - (\gamma + (1 - \gamma) (1 - \xi)) n \pi^{**} \lambda \nu ks,$$

where PC stands for “Partial Corruption”. Note that the second term on the right hand side, is equal to the profit made by firms getting away with the use of the bad technology (equal, for each of them, to $\Pi_n^G + s$), which part s is transferred to the corrupt inspectors with $k = 1$. As this is a simple transfer

between agents, it still enters social welfare¹⁶. As for the last term on the right hand side, corresponding to the incentive payment given to inspectors, it is multiplied by $\gamma + (1 - \gamma)(1 - \xi) \equiv \tau$, because it is paid both to the more honest inspectors and to the more corrupt ones that are not caught.

Finally, if no inspectors are used, social welfare is simply:

$$W^{NI} = CS(Q_n^G) + n(\Pi_n^G + s) - xQ_n^G, \quad (8)$$

Comparing W^{NC} , W^{PC} , and W^{NI} , it now can be shown that there are three thresholds defined by the following equations (all proofs are in the Appendix):

- $W^{PC} > W^{NI}$.

Comparing expressions (7) and (8), this is the case if:

$$x > \frac{\Delta c(q_n^G)}{q_n^G} \left(1 + \frac{\tau \pi^{**} \lambda \nu k}{1 - (1 - \gamma) \pi^{**}}\right) \equiv x^*. \quad (9)$$

- $W^{NC} > W^{NI}$.

Combining (6) and (8):

$$x > \frac{\Delta c(q_n^G)}{q_n^G} (1 + \pi^* \lambda \nu) \equiv x^{**}. \quad (10)$$

- $W^{NC} > W^{PC}$.

From (6) and (7), this is the case in the parameters region defined by:

$$x > \frac{\Delta c(q_n^G)}{q_n^G} \left(1 + \frac{\lambda \nu (\frac{\pi^*}{\pi^{**}} - \tau k)}{(1 - \gamma)}\right) \equiv x^{***}. \quad (11)$$

As proved in the Appendix, two situations may arise. In the first one, in which the probability ξ to catch an inspector incurring in corruption is low enough, the ordering is $x^{***} < x^{**} < x^*$. Then, only two regimes prevail and there are either no inspections at all, or inspections with full incentive

¹⁶It is possible to allow for a lower government's valuation of corrupt agents' welfare. We show below that the main analysis and conclusions are unaltered.

payments and no corruption. As the probability of detecting bribery is low, it is more costly to tolerate it and partial corruption never happens.

Alternatively, when the probability ξ to catch an inspector incurring in corruption becomes high enough, we get the ordering $x^* < x^{**} < x^{***}$, and there are three regions of parameters, where the following regimes prevail respectively: no inspection (*NI*), inspections and partial corruption (*PC*), and inspections and no corruption (*NC*). Partial corruption prevails in the range $[x^*, x^{***}]$, while there are no inspections for $x < x^*$ and there are inspections with no corruption for $x > x^{***}$. As society becomes more efficient at detecting corruption, it is less costly and can be tolerated more often. This first result is summarized in the following proposition 1.

Proposition 1 *There is a threshold $\xi^*(n) \equiv \frac{k-\gamma}{1-\gamma} \frac{\Pi_n^G+s}{(1+k)\Pi_n^G+ks}$ such that, for $\xi > \xi^*$, $x^* < x^{**} < x^{***}$, and there is no intervention (*NI*) for $x \leq x^*$, intervention with tolerance for partial corruption (*PC*) for $x^* < x < x^{***}$, and intervention with no tolerance for corruption (*NC*) for $x^{***} \leq x$. When $\xi \leq \xi^*$, $x^{***} < x^{**} < x^*$ and only two regimes exist: no intervention (*NI*) for $x \leq x^{**}$, and intervention with no tolerance for corruption (*NC*) for $x^{**} < x$. Moreover, $\frac{\partial \xi^*}{\partial n} > 0$, and $\xi^*(n)$ is bounded below by $\xi^*(1) = \frac{k-\gamma}{1-\gamma} \frac{\Pi_1^G+s}{(1+k)\Pi_1^G+ks}$ and above by $\xi^*(\infty) = \frac{k-\gamma}{k(1-\gamma)}$.*

For practical purposes, corollary 2 distinguishes three cases derived from proposition 1.

Corollary 2 *Case 1: If $\xi < \xi^*(1)$, $x^{***} < x^{**} < x^*$ whatever n and only the two regimes *NI* and *NC* prevail. Case 2: If $\xi^*(1) < \xi < \xi^*(\infty)$, partial corruption exists for low values of n , but there is a threshold above which it disappears. Case 3: Finally, if $\xi > \xi^*(\infty)$, $x^* < x^{**} < x^{***}$ whatever n , and partial corruption always exist.*

Since we are interested in the comparative statics on corruption, in the rest of this section we focus on the last of these cases, in which corruption actually occurs¹⁷. Similar results hold for the intermediate case in which partial corruption exists for n low enough, as discussed below. Intuitively,

¹⁷Graphical representations for cases 1 and 2 are given in the Appendix.

inspections are used when the burden of the externality becomes higher than the sum of the additional cost imposed on producers to eliminate it and the cost of incentive payments meant to ensure that inspectors behave honestly. Moreover, if a fraction of the inspectors is more corrupt and requires higher incentive payments to prevent bribery, there is a range over which the net gain resulting from the complete elimination of the externality is lower than the waste of incentive payments linked to the fact that the more honest inspectors could have been made to report truthfully with a lower reward. In this range, partial corruption dominates.

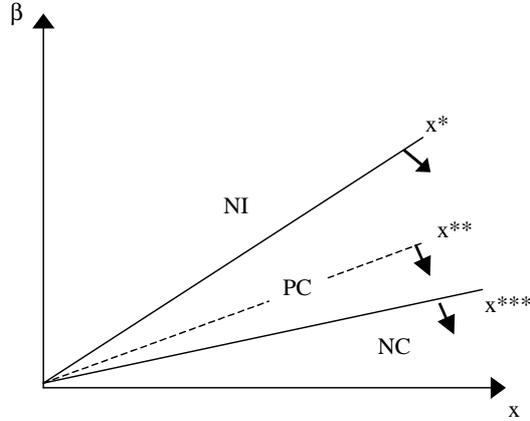
Looking at the range of parameters in which corruption is allowed to happen, we see that the comparative statics will depend crucially on the behavior of π^* and π^{**} .

Figure 2 shows the shape of the different regions and the main comparative statics, first in the space (x, β) for n fixed, then in the space (x, n) for β fixed, using the differential cost function $\Delta c(q) = \beta q$. It is easy to see (see Appendix) that all the thresholds x^* , x^{**} and x^{***} , as well as $\frac{\pi^*}{\pi^{**}}$, are increasing in n , the number of firms active in the market.

In panel (a), the region between the curves for x^* and x^{***} is characterized by partial corruption. The dotted curve in between corresponds to x^{**} .

The small arrows show that these curves rotate downwards when n increases. As this happens, the region in which corruption prevails is shrinking. For a given value of β , this is illustrated in panel (b).

(a) Relationship between x and β for n fixed.



(b) Shape of intervention for varying x and n (β fixed).

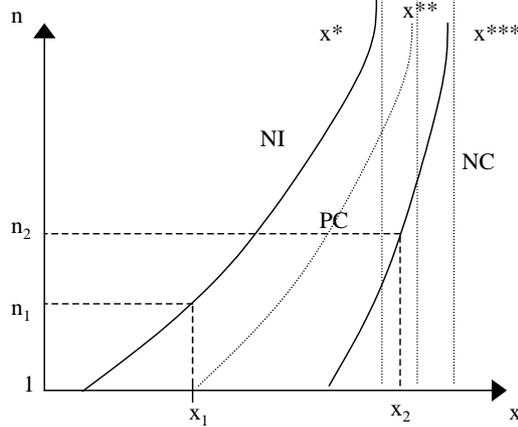


Figure 2

The important lessons from Figure 2 are the following¹⁸.

First, corruption does not always fade away in the limit, as shown by the fact that the asymptotes for x^* and x^{***} are different. For very high values of n , there is a range, in terms of x , in which corruption happens. Indeed, as firms coordinate on the good technology output q_n^G while using the bad technology, rents subside even with perfect competition.

¹⁸Applying a lower weight to corrupt agents' gains in the welfare function would simply shift the curves for x^* , x^{**} , and x^{***} to the left and shrink the PC region. The rest of the analysis would be unchanged.

Second, as n increases, regulatory intervention becomes undesirable for higher values of the externality x , leaving a wider region in which the market failure is tolerated. This is because, as there are more firms to inspect, there is an increase in the threshold, in terms of x , above which the sum of the additional cost imposed on producers to eliminate the externality and the cost of incentive payments meant to ensure that inspectors behave honestly exceeds the burden of the externality. In other words, the larger the number of firms, the higher the value of the unitary externality above which it is socially efficient to have inspections.

Finally and more importantly, note that although at first sight Figure 2 gives support to the intuition according to which, as competition increases and rents become smaller, corruption is eventually less prevalent, this in fact has little meaning. Indeed, it is only verified in a “statistical” sense, i.e. if one considers the region in which corruption is allowed to happen as the size of the externality x varies. In fact, the relevant x motivating a regulatory intervention is likely to be a constant given by the characteristics of the environment. Then, considering a specific value of the externality, non-monotonic results might prevail, as shown in the next section, and an increase in competition might well result in more corruption.

3.1 Does more Competition Imply more or less Corruption?

In Figure 3, we consider the specific unitary externality x_1 from Figure 2 and show the path for the value of the expected aggregate amount of bribes in the industry as n grows. As n exceeds n_1 , there is a discontinuity, since we drop out of the partial corruption regime.

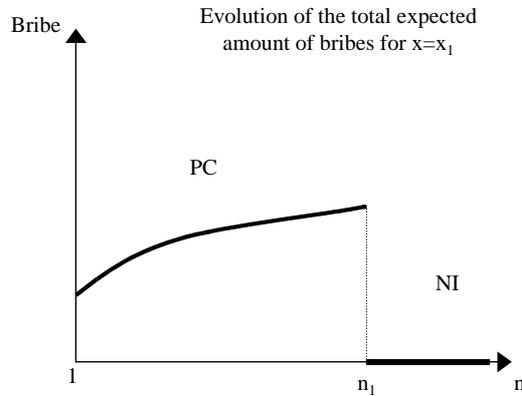


Figure 3: Comparative statics on bribes

In this case, the intuition is that, as n grows, intervention becomes too costly (remember that π^{**} grows) so inspections are dropped completely.

Although this fits the intuitive account in which a high enough degree of competition eventually kills corruption, the actual mechanism behind it is more complex than a simple reference to the size of the stakes available for side contracts. Indeed, the shift is from a regime in which regulatory control entails the tolerance of some corruption, to another one in which a socially costly externality is left unchecked.

Moreover, these conclusions might be completely reversed for different values of x as shown in Figure 4 below¹⁹.

¹⁹The shape of the portion of the curve above n_2 is linked to the comparative statics on the size of bribes (see Appendix) and is due to the specific cost function used. A different cost specification would still give rise to the jump at n_2 , but the total expected amount of bribes might be decreasing thereafter.

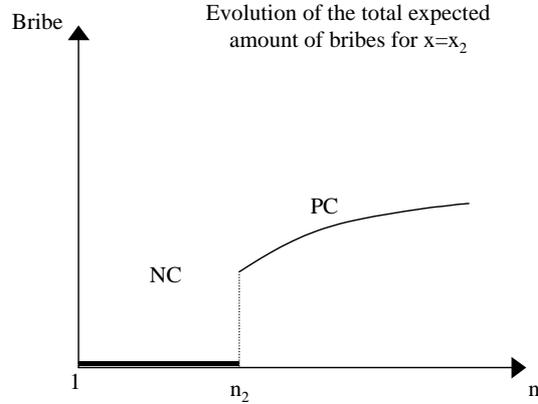


Figure 4: Comparative statics on bribes

Now, for an externality with a higher unitary cost, such as x_2 , there is no corruption initially, and the jump to a regime in which corruption actually happens when the number of firms increases.

As more inspections are needed (both n and $\frac{\pi^*}{\pi^{**}}$ increase), the additional cost of incentive payments meant to ensure that inspectors behave honestly increases. The sum of these payments and of the cost born by firms implementing the good technology now exceeds the burden of the externality, so that it becomes socially efficient to shift from inspections with high incentive payments, to a regime with lower incentive payments and partial corruption²⁰.

Proposition 3 summarizes the results so far.

Proposition 3 *With a benevolent government choosing the optimal regulatory regime, and depending on the level of the externality, different dynamics emerge with respect to corruption when n , the number of firms in the markets, grows.*

- For $x \leq x_{n=1}^*$, there is no intervention (NI) and thus no corruption, whatever n .

- For $x_{n=1}^* \leq x \leq x_{n=1}^{***}$, there is a threshold n' such that when n becomes bigger than n' , there is a shift from intervention with tolerance for partial

²⁰If x_2 is to the left of the asymptote for x^* , for some higher value of n it may even become better from a welfare point of view to scrap inspections altogether, and corruption again disappears, although we are now in a completely different regime since there are no inspections.

corruption (PC) to no intervention (NI).

- For $x_{n=1}^{***} \leq x \leq \beta(1 + \frac{\tau}{\gamma}\lambda\nu k)$, there are two thresholds n'' and n''' such that when n becomes bigger than n'' , there is a shift from intervention with no tolerance for corruption (NC) to intervention with tolerance for partial corruption (PC), and when n becomes bigger than n''' , there is a shift from intervention with tolerance for partial corruption (PC) to no intervention (NI).

- For $\beta(1 + \lambda\nu k) \leq x \leq \beta(1 + \frac{\lambda\nu(1-\tau k)}{1-\gamma})$, there is a threshold n'''' such that when n becomes bigger than n'''' , there is a shift from intervention with no tolerance for corruption (NC) to intervention with tolerance for partial corruption (PC).

- Finally, for $x \geq \beta(1 + \frac{\lambda\nu(1-\tau k)}{1-\gamma})$, there is intervention with no tolerance for corruption (NC) and thus no corruption, whatever n .

Note that in the intermediate case of corollary 2, in which the partial corruption region disappears when n crosses a certain threshold, the sequence described in proposition 3 is unchanged, except for the fourth bullet point that now features a transition from intervention with no corruption (NC) to no intervention (NI). The two cases illustrated in Figures 3 and 4 remain valid.

The conclusion of this section is that, depending on the type of market failure that government intervention intends to correct, very different patterns may emerge, from the case where corruption is reduced by increased competition, to the polar situation in which more competition can actually generate more corrupt transactions between agents.

4 Isowelfare curves

To complete the previous analysis, we now look at the evolution of welfare in the different regimes as parameters values for the number of firms and the impact of the externality vary. Figure 5 presents the map of isowelfare curves in the space (x, n) .

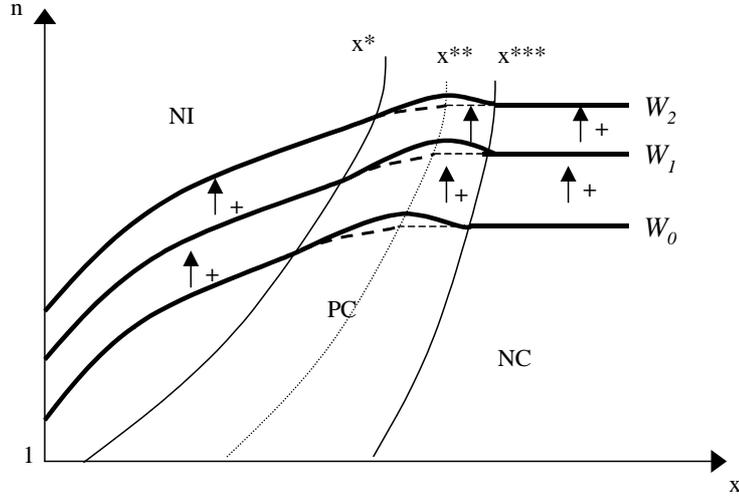


Figure 5: Isowelfare curves

The derivation of the shape of the isowelfare curves in each region and the way they connect can be summarized in the following intuitive way. First, considering that in region NI , welfare is given by $W^{NI} = CS(Q_n^G) + n(\Pi_n^G + s) - xQ_n^G$, it is easy to see that along the vertical axis (for $x = 0$), welfare is increasing in n . For strictly positive values of x , and n constant, since the consumer surplus and profit terms are independent of x , it is also obvious that $W^{NI}(n, x) > W^{NI}(n, x + \varepsilon)$, where $W^{NI}(n, x)$ is the welfare function evaluated at the values n and x . Therefore at any interior point in regime NI , moving horizontally and to the right must lead to a lower isowelfare curve. This justifies the increasing shape of the curves in this region²¹, as well as the fact that a move upwards implies a shift to a curve denoting a higher level of welfare, as indicated by the small arrows in the graph.

Looking now at the NC region on the right part of the graph, welfare is given by $W^{NC} = CS(Q_n^G) + n\Pi_n^G - n\pi^* \lambda \nu s$. As this expression is independent of x , it follows that for given n welfare is constant and the isowelfare curves are horizontal as depicted in Figure 5.

Moreover, by definition, along the frontier locus for x^{**} , we have $W^{NI} = W^{NC}$, so the curves must connect at the frontier and we also deduce that, by continuity, welfare is increasing as we move upwards in the NC region.

²¹The concavity can be readily derived by looking at the second derivative of the welfare function.

Finally, a similar argument shows that isowelfare curves in the intermediate *PC* region must connect along the x^* locus with those of the *NI* region, and along the x^{***} locus with those of the *NC* region. Again, a continuity argument leads to welfare being increasing as one moves upwards.

This welfare ordering thus shows that for a given level of externality, and whatever the regime we are in, increasing competition is always welfare improving. This holds true even considering that such an increase in competition may lead to more corruption, as shown for example in Figure 4.

Finally, note that the same welfare comparisons hold in the case where the intermediate *PC* regime disappears.

This discussion is summarized in the following proposition 4.

Proposition 4 *An increase in the number of firms active in the market is always welfare improving, even if it leads to a jump to a regime with increased tolerance for corruption.*

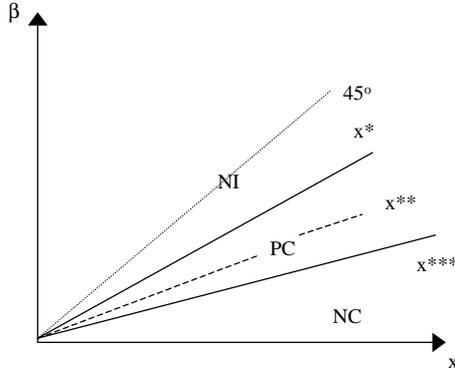
5 Bertrand Competition

Assume now that firms compete *à la* Bertrand and that total output is shared equally between the firms in the market. Then, $\Pi_n^G = 0$, and $\pi^* = \pi^{**} = 1$. The main difference with the Cournot competition model is that now firms must be inspected with probability 1 to induce them to shift to the good technology. This comes from the fact that when using the good technology, profits are driven down to zero, so the only credible threat in expected terms is to capture any positive profit for sure. Expressions for x^* , x^{**} and x^{***} can be readily derived from equations (9) to (11), with $\pi^* = \pi^{**} = 1$, as $x^* = \frac{\Delta c(q_n^G)}{q_n^G} \left(1 + \frac{\tau}{\gamma} \lambda \nu k\right)$, $x^{**} = \frac{\Delta c(q_n^G)}{q_n^G} (1 + \nu \lambda)$, and $x^{***} = \frac{\Delta c(q_n^G)}{q_n^G} \left(1 + \frac{\lambda \nu (1 - \tau k)}{(1 - \gamma)}\right)$.

Obviously, the pattern of government intervention will depend on the shape of the cost function. To represent this graphically, we first use the same cost function as before ($\Delta c(q) = \beta q$). Note that in this case, the threshold values are independent of n , which is due to the fact that $\frac{\Delta c(q_n^G)}{q_n^G} = \beta$. The different regimes²² are shown in figure 5, where the values for x^* , x^{**} and x^{***} correspond to the asymptotic values in Figure 2.

²²Again, the intermediate regime *PC* disappears for ξ lower than the threshold $\xi^* = \frac{k - \gamma}{k(1 - \gamma)}$, which is now independent of n . We present the case in which $\xi > \xi^*$.

(a) Relationship between x and β for n fixed.



(b) Shape of intervention for varying x and n (β fixed).

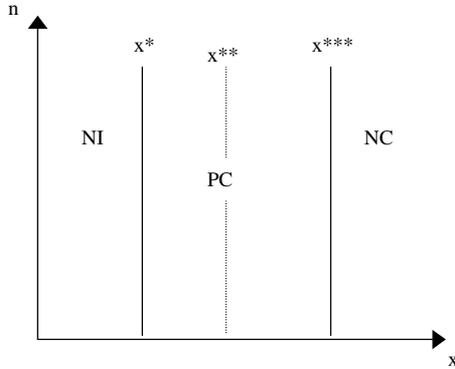


Figure 5: Bertrand competition

In this case, it is straightforward to see that a change in the number of participating firms does not have any effect on the range of parameters for which corruption is allowed to happen. This result clearly derives from the particularity of Bertrand competition, in which profits are zero whatever the number of firms, and from the fact that both the unitary cost differential between the two technology and the unitary externality are constant.

Consider now a strictly convex cost function²³, $\bar{c}(q) = \beta q^2$. Thresholds x^* and x^{***} become:

$$x^* = \beta q_n \left(1 + \frac{\tau}{\gamma} \lambda \nu k \right) \quad (12)$$

²³Considering a convex externality of the form $x(Q) = xQ^z$, with $z > 1$ would lead to similar results.

and

$$x^{***} = \beta q_n \left(1 + \frac{\lambda \nu (1 - \tau k)}{(1 - \gamma)} \right). \quad (13)$$

If q_n is decreasing²⁴ in n , these two thresholds are decreasing in the number of firms, yielding the pattern described in Figure 6.

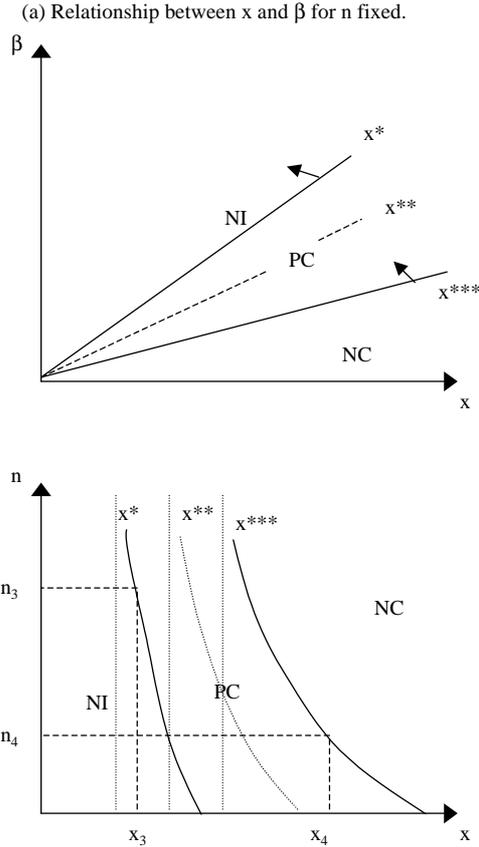


Figure 6: Bertrand competition

Again, the region in which corruption happens shrinks as n grows, although it does not completely disappear in the limit. This time, however,

²⁴This is true if the Hahn-Novshek condition is met (a firm's marginal revenue falls as the output of all other firms rise), the inverse demand curve is downward-sloping and marginal cost is non-decreasing (see Martin, 2002). This holds for example for a specification of linear demand and constant marginal cost. Alternatively, if q_n is increasing in n , we get a pattern similar to the one in Figure 2.

due to the convexity of the cost function, there is some cost saving related to the fact that, as the number of firms grows, each one produces a smaller individual output and faces a smaller unit cost of shifting to the good technology. Thus, there are “aggregate” decreasing returns to scale of the good technology. The reduction in cost outweighs the additional incentive cost of inspectors, so as n grows, it becomes valuable to send in inspectors for lower level of the externality and the NI region becomes smaller.

Here also, the pattern of intervention for a given level of externality x can show different dynamics with respect to the occurrence of corruption. Considering an externality characterized by a unitary cost x_4 , we obtain the same comparative statics as in Figure 3, with corruption disappearing for $n > n_4$. However, for an externality with a lower unitary cost, such as x_3 , these are completely reversed, with no corruption initially, and the jump to a regime in which corruption actually happens when the number of firms increases, as in Figure 4.

The intuition is now slightly different. As the number of firms grows, the sum of the cost of shifting to the good technology (remember that each one produces a smaller individual output and thus faces a smaller unit cost) and the incentive payments decreases in n and eventually becomes smaller than the externality cost, making it socially efficient to shift from no inspections to a regime with some inspections. However, the potential gain is not high enough to justify the waste of incentive payments that inspections without any corruption entail, so partial corruption is tolerated.

6 Conclusion

We have developed a model in which firms compete in the market for an homogenous good. Regulatory intervention to correct a negative externality linked to the production process, and the reliance on heterogeneous inspectors to determine the type of technology used by firms may generate some corruption in equilibrium. For specific values of the externality that motivate the regulatory intervention, we provide evidence of non-monotonic effects, implying that in specific environments more competition can either lead to an increase or a decrease in corruption. Moreover, we show that more competition is welfare enhancing regardless of its effects on corruption. The main insights of the model hold both in the context of Cournot and Bertrand competition.

One of the main aspect that we have left for future research is the introduction in this setting of a link between potential or realized corruption and competition, thus endogenizing the degree of competition as well. As suggested by Bliss and Di Tella (1997), corrupt agents may adjust their behavior taking into account the fact that their bribe demands affect firms' decision to enter or exit the market, thus making the degree of competition, and the associated rents, endogenous. Combining this feature with our endogenous corruption setting is certainly promising. This would open the possibility to analyze the dynamic effects of policy interventions, for example those affecting barriers to entry in certain industries or specific crack-down on corruption, and clarify the conditions in which such policies may be successful.

Finally, additional theoretical aspects to be considered include the fact that the organizational structure in which corrupt agents evolve and the interactions between them also influence the level of corruption that prevails (Rose-Ackerman, 1999, Shleifer and Vishny, 1993). Competition between bureaucrats is an issue that certainly deserves further research.

At the empirical level, it would be interesting to obtain microeconomic data and disentangle the incentive effects discussed earlier. While existing studies argue, on the basis of cross-country or inter-industry comparisons, for a link between more competition and less corruption, it is unclear whether policy interventions inducing limited shifts in the degree of competition within specific industries or sectors would have the same unambiguous results.

7 Appendix

7.1 Derivation of the Thresholds in Section 3.

Recall the expressions for social welfare with no intervention (*NI*), intervention and partial corruption (*PC*) and intervention and no corruption (*NC*) respectively:

$$\begin{aligned}
W^{NI} &= CS(Q_n^G) + n\Pi_n^B(q_n^G) - xQ_n^G, \\
W^{PC} &= CS(Q_n^G) + (1 - \gamma)\pi^{**}n\Pi_n^B(Q_n^G) + (1 - (1 - \gamma)\pi^{**})n\Pi_n^G \\
&\quad - x(1 - \gamma)\pi^{**}Q_n^G - (\gamma + (1 - \gamma)\xi)n\pi^{**}\lambda\nu ks, \\
W^{NC} &= CS(Q_n^G) + n\Pi_n^G - n\pi^*\nu\lambda s.
\end{aligned}$$

For the ease of comparisons, we can rewrite these expressions as:

$$\begin{aligned}
W^{NI} &= CS(Q_n^G) + n(p(Q_n^G) \cdot q_n^G - \underline{c}_i(q_n^G)) - xQ_n^G, \\
W^{PC} &= CS(Q_n^G) + n(p(Q_n^G) \cdot q_n^G - \underline{c}_i(q_n^G)) - (1 - (1 - \gamma)\pi^{**})n\Delta c(q_n^G) \\
&\quad - x(1 - \gamma)\pi^{**}Q_n^G - \tau n\pi^{**}\lambda\nu ks, \\
W^{NC} &= CS(Q_n^G) + n(p(Q_n^G) \cdot q_n^G - \bar{c}_i(q_n^G)) - n\pi^*\nu\lambda s.
\end{aligned}$$

where $\tau \equiv (\gamma + (1 - \gamma)\xi)$. It is then easy to check that $W^{PC} > W^{NI}$ is equivalent to:

$$\begin{aligned}
&xQ_n^G > (1 - (1 - \gamma)\pi^{**})n\Delta c(q_n^G) + x(1 - \gamma)\pi^{**}Q_n^G + \gamma n\pi^{**}\lambda\nu ks \\
\Leftrightarrow &x(1 - (1 - \gamma)\pi^{**})Q_n^G > (1 - (1 - \gamma)\pi^{**})n\Delta c(q_n^G) + \gamma n\pi^{**}\lambda\nu ks \\
\Leftrightarrow &x > \frac{\Delta c(q_n^G)}{q_n^G} \left(1 + \frac{\tau\pi^{**}\lambda\nu k}{1 - (1 - \gamma)\pi^{**}}\right) \equiv x^*,
\end{aligned}$$

where we make use of the fact that $s = \Delta c(q_n^G)$. $W^{NC} > W^{NI}$ entails:

$$\begin{aligned}
&xQ_n^G > n\Delta c(q_n^G) + n\pi^*\lambda\nu s \Leftrightarrow xQ_n^G > n\Delta c(q_n^G)(1 + \pi^*\lambda\nu) \\
\Leftrightarrow &x > \frac{\Delta c(q_n^G)}{q_n^G}(1 + \pi^*\lambda\nu) \equiv x^{**}
\end{aligned}$$

Similarly, the condition for $W^{NC} > W^{PC}$ is given by:

$$\begin{aligned}
&n(p(Q_n^G) \cdot q_n^G - \bar{c}_i(q_n^G)) - n\pi^*\nu\lambda s > n(p(Q_n^G) \cdot q_n^G - \underline{c}_i(q_n^G)) \\
&\quad - (1 - (1 - \gamma)\pi^{**})n\Delta c(q_n^G) - x(1 - \gamma)\pi^{**}Q_n^G - \gamma n\pi^{**}\lambda\nu ks.
\end{aligned}$$

This is equivalent to:

$$\begin{aligned}
&x(1 - \gamma)\pi^{**}Q_n^G > \\
&\quad (\pi^* - \gamma k\pi^{**})n\lambda\nu s + n\Delta c(q_n^G) - (1 - (1 - \gamma)\pi^{**})n\Delta c(q_n^G),
\end{aligned}$$

which after some transformation, and using again $s = \Delta c(q_n^G)$, gives:

$$x > \frac{\Delta c(q_n^G)}{q_n^G} \left(1 + \frac{\lambda\nu(\pi^* - \tau k \pi^{**})}{(1-\gamma)\pi^{**}} \right) \equiv x^{***}.$$

It can be checked that in order for $x^{**} > x^*$ and $x^{***} > x^{**}$ to hold, both inequality require that:

$$\frac{\pi^*}{\pi^{**}} - \tau k > \pi^*(1-\gamma)$$

Using expressions (4) and (5) in the text, this inequality becomes $\frac{(\gamma+\xi(1-\gamma))\Pi_n^G+s}{\Pi_n^G+s} - \tau k > (1-\gamma)\frac{s}{\Pi_n^G+s}$.

After some transformation, this gives $(\gamma(1-k) - (1-\gamma)(1-\xi)k)(\Pi_n^G + s) + \xi(1-\gamma)\Pi_n^G > 0$. This is equivalent to say that there is a threshold $\xi^* = \frac{k-\gamma}{1-\gamma} \frac{\Pi_n^G+s}{(1+k)\Pi_n^G+ks}$ such that for $\xi > \xi^*$, we have the ordering $x^* < x^{**} < x^{***}$. Alternatively, for $\xi \leq \xi^*$, we get $x^{***} < x^{**} < x^*$.

7.2 Graphical Representation of cases 1 and 2, Corollary 2.

Figures 7 and 8 show the shape of the different regions and the main comparative statics in the space (x, n) for β fixed, using the differential cost function $\Delta c(q) = \beta q$.

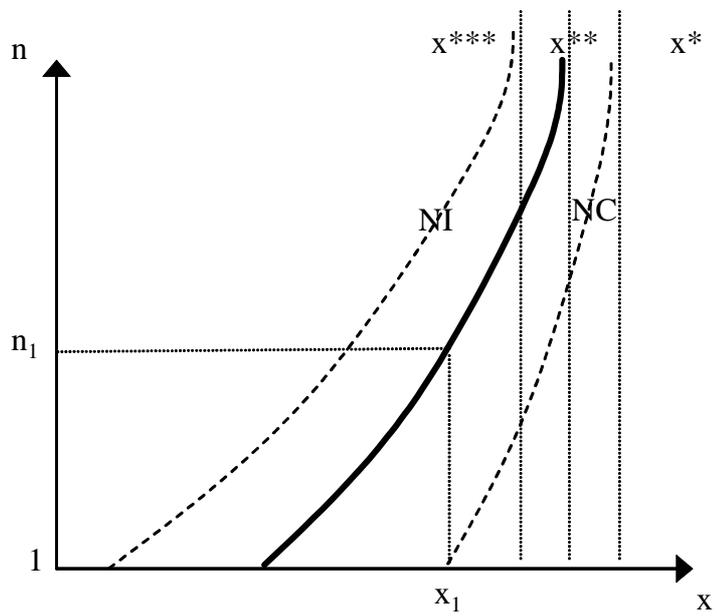


Figure 7: Case 1

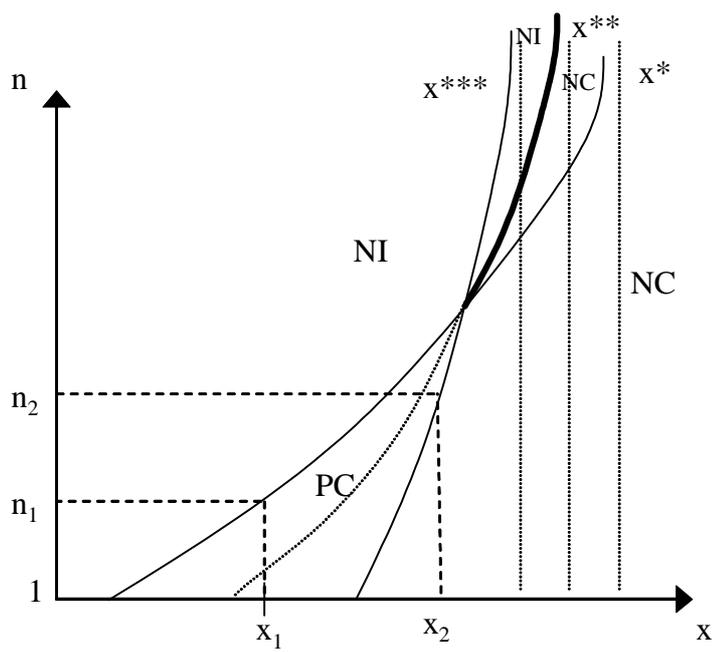


Figure 8: Case 2

7.3 Comparative Statics for π^* and π^{**} in Figure 2.

Using the functional form in the text ($\Delta c(q) = \beta q$), we can rewrite π^* and π^{**} as;

$$\pi^* = \frac{s}{\Pi_n^G + s} = \frac{\beta q_n^G}{p_n^G q_n^G - \beta q_n^G + \beta q_n^G} = \frac{\beta}{p_n^G},$$

and

$$\begin{aligned} \pi^{**} &= \frac{s}{(\gamma + \xi(1 - \gamma)) \Pi_n^G + s} \\ &= \frac{\beta q_n^G}{(\gamma + \xi(1 - \gamma)) p_n^G q_n^G - (\gamma + \xi(1 - \gamma)) \beta q_n^G + \beta q_n^G} \\ &= \frac{\beta}{(\gamma + \xi(1 - \gamma)) p_n^G + (1 - (\gamma + \xi(1 - \gamma))) \beta}. \end{aligned}$$

As p_n^G is decreasing in n , it comes that both π^* and π^{**} are increasing in n .

Moreover, note that $\frac{\pi^*}{\pi^{**}}$ can be rewritten as:

$$\begin{aligned} \frac{\pi^*}{\pi^{**}} &= \frac{(\gamma + \xi(1 - \gamma)) p_n^G + (1 - (\gamma + \xi(1 - \gamma))) \beta}{p_n^G} \\ &= (\gamma + \xi(1 - \gamma)) + \frac{(1 - (\gamma + \xi(1 - \gamma))) \beta}{p_n^G}, \end{aligned}$$

which is again increasing in n .

7.4 Comparative Statics on Bribes

Consider the region of parameters $[x^*, x^{***}]$ in which corruption actually happens. Then as n , the number of firms operating in the market, increases, the size of aggregate bribes is given by:

$$S = (1 - \gamma) \pi^{**} n s = (1 - \gamma) \pi^{**} n \Delta c(q_n^G),$$

which can be written as:

$$S = (1 - \gamma) \frac{\beta}{(\gamma + \xi(1 - \gamma)) p_n^G + (1 - (\gamma + \xi(1 - \gamma))) \beta} n \beta q_n^G.$$

Using the values $p_n^G = \beta + \frac{1-\beta}{n+1}$ and $q_n^G = \frac{1-\beta}{n+1}$, we get after some computations:

$$S = \frac{(1 - \gamma)(1 - \beta)\beta^2}{\beta \frac{n+1}{n} + (\gamma + \xi(1 - \gamma)) \frac{1-\beta}{n}},$$

so that $\frac{\partial S}{\partial n} > 0$.

Finally, it is easily shown that S is constant in the case of Bertrand competition.

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