The Welfare Implications of Cartel Network Design

María C. Avramovich
Universidad Nacional de Córdoba
Av. Valparaiso s/n, (5000) Córdoba, Argentina
Phone: 00 54 351 4437300
ceciliavramovich@eco.uncor.edu

Abstract

This paper investigates the welfare implications of introducing a network-design problem in a price-fixing collusion game. Within a model in which each cartel conspirator has a specific and irreplaceable market expertise, I demonstrate that a network design that serves to the needs of concealment can be detrimental to the objective of maximum profits, and vice versa. In this context, while a more severe antitrust policy contributes to deterrence, it can also distort the network design of surviving cartels, creating inefficiencies that are not considered in standard models of collusion. Leniency Programs can exacerbate this perverse effect from policy.

JEL classification: L4, L22, D21, D85, K21

Keywords: collusion, network design, antitrust policy, social welfare.

1 Introduction

The communication network of a cartel determines its systemic effectiveness and, consequently, its capacity to be born and survive over time. Therefore, the first challenge faced by conspirators is the design of a cartel network that serves to the needs of maximum profits and concealment at the same time.

Within a context in which communication leaves evidence, a network design that delegates inter-firm decisions to a handful of members becomes attractive, since it reduces the flows of information subject to be used as cartel evidence. However, this strategy is not free of adverse effects: in the interest of minimizing communication channels, cartel decisions may be affected by the problem of incomplete information, with side effects on the cartel's performance. Faced with this trade-off, What issues govern the network design of cartels? Do cartel's network strategy have welfare implications? If so, can the antitrust policy distort the network distribution of cartels in favor of welfare? The aim of this paper is to shed light on these questions.

In this paper I develop a model in which managers of two firms decide to form a cartel, and to this end they decide between two alternative network designs: the *complete* network and the *representative* network. In the *complete* network all conspiring managers attend cartel meetings and make decisions jointly. Instead, the *representative* network is characterized by delegation: only some representative managers attend cartel meetings and are thus in charge of all cartel decisions. Hence, delegation is conceived as a network strategy that allows cartel members to reduce the flows of information between them. Within a context in which communication leaves evidence subject to be used for cartel detection, the attractiveness of this strategy lies in the possibility to reduce the probability of cartel detection.

Two additional elements complete this framework. First, firms' managerial staffs are conformed by several managers, each one endowed with a unique and irreplaceable market *expertise*. I assume manager's *expertises* strategic complements, such that market decisions made jointly by all managers are preferred to those made individually. One way to interpret this it to consider firm's profits positively related to the number of managers (i.e., to the overall 'expertise') involved in market decisions. The second element refers to the 'sophistication' of the market. Identifying market sophistication to the difficulty of predicting demand or costs, or to the possibility of multiple interpretations of customer specifications for the product, among other related issues, I allow for markets with different degrees of sophistication. Managers' expertises and market sophistication are related in this way: the more sophisticated the market, the more valuable the expertise of each manager, and, therefore, the higher the loss of profits derived from delegating market decisions to some representative managers.

Considering all these pieces together, the introduction of a network decision problem to a standard collusion game creates a trade-off between cartel's targets of maximum profits and concealment, such that higher concealment can only be achieved at the expense of lower cartel profits, and vice-verse.

Three results stand out from this model. First, the possibility of deciding on the network design for the cartel contributes to sustain collusion in industries where it would'n be possible otherwise, and leads to games of imperfect collusion. Particularly, for highly sophisticated markets the benefits of the *complete* network design prevail over those of the *representative*, and perfect collusion is always achieved. However, as the market degree of sophistication goes down, some cartels may find it profitable to switch their network structure for the *representative* one, and imperfect collusion acquires relevance.[1] In this respect, it is important to highlight the extreme case of highly unsophisticated markets, where the attractiveness of a *representative* design goes beyond the possibility of increasing the expected benefits from collusion, but rather is that only this type of design allows for cartel sustainability. To my knowledge, this is a novel result in the literature of collusion.

The second result to stress refers to the deterrence effect of antitrust policy.

[1] Although the net income from sales is less than that from monopoly, the reduction in the expected costs from detection - due to delegation - more than compensates for such loss.

As is standard in the literature of collusion, I found that higher fines and/or more inspections make collusion harder to sustain, as both policies increase the expected costs from detection. However, in this paper the deterrence effect from higher fines is contingent on the cartel's network and on whether the policy is implemented through corporate or individual fines. Specifically, under the *representative* network design the deterrence effect of a fine increase does not depend on whether the policy is implemented through individual or corporate fines, but under the *complete* design it is higher when fines are set individually. This is so as in the latter case the number of subjects liable to individual fines exceeds that of subjects liable to corporate fines. The straightforward recommendation is to set individual fines as high as possible.

Finally, it should be mentioned that the welfare effect of the antitrust policy is not straightforward, as there are welfare implications that go beyond deterrence. Indeed, higher fines and/or more inspections also distort the network distribution of surviving cartels, biasing it towards a *complete* or a *representative* design. While the former bias creates a welfare gain, the latter, a welfare loss. In the paper, I show that this 'network-bias' is not monotonic on a single policy instrument[2], which makes highly difficult to predict, a priori, the policy implications on welfare. In this respect, the only assertion that can be safely stated is that a welfare gain follows a more severe antitrust policy when the Antitrust Authority (AA) increases inspections within a context of high corporate fines.

The paper continues as follows. After a brief description of the related literature in Section 2, I set up the model in Section 3. In Section 4, I solve it for the case in which the only possibility to organize a cartel is through the *complete* network design, and, in Section 5, I introduce the *representative* network as an alternative design. In Section 6, I analyze the welfare implications of antitrust policy. In Section 7, I extend the model for alternative antitrust policies, related to the distribution of inspections and the use of Leniency Programs. Finally, Section 8 concludes.

2 Related Literature

This paper is closely related to studies on the internal organization of conspiracies, in general, and of collusion, in particular. Focussed on collusion, the work of Baker and Faulkner (1993) is pioneer in analyzing the network design of cartels. Using archival data, the authors reconstruct the communication networks involved in the three mayor price-fixing conspiracies of the heavy equipment industry (switchgear, transformers and turbines), which had their mayor impetus in the 1950s.[3] In the analysis, they observe that in the network design of each of these cartels prevailed the need to maximize concealment over efficiency. Specifically, cartels that face low-information-processing needs tended

[2] It rather depends on the combination of instruments, individual and corporate fines and inspections.

[3] Although there is evidence of collusive arrangements in the electrical equipment industry since the early 1880s, most of the evidence is concentrated in the 1950s.

to establish a decentralized network, although centralization would have been the most efficient. The opposite occurred with cartels formed in markets with high-information processing needs.[4] Following Baker and Faulkner, I design a model in which cartel firms decide on their network configuration according to their needs of concealment and efficiency. This analytical model contributes to explain the rationality behind some of their result, and allows me to extend their work by analyzing the impact of the antitrust policy on the network configuration of cartels and its final implications on welfare.

In the analysis of the welfare implications of the cartel network, the studies of Belleflamme and Bloch (2004) and Roldan (2012) also precede my work, but within a context of market-sharing agreements. Defining a bilateral market-sharing alliance as an agreement by which firms commit not to enter each other's territory, Belleflamme and Bloch state that the number of alliances defines the collusive network of the cartel. Within this context, firm's incentives to form an additional agreement balance between two conflicting effects: the positive effect of having one less competitor on its home market, and the negative effect of losing access to one foreign market. Faced with this trade-off, the authors explain why alliances must reach a minimal size to be stable and why there coexist smaller groups of firms that do not form alliances with large alliances. Roldan (2012) extends Bellaflame and Bloch by analyzing the implications of antitrust policy on the optimal size of the network. Given the probability of detection increasing in the number of alliances already established and fines contingent on cartel profits, Roldan reinforces Bellaflame and Bloch general results. However, she also shows that in the presence of the AA the set of isolated firms enlarges and the minimum lower bound for alliances gets endogenous to each network configuration and on the probability of each firm being inspected.

My work differs from these in that I consider price-fixing agreements, rather than market-sharing ones. Operatively, this requires re-identifying the network of a cartel: In my set up, the network structure of a cartel is defined by the different roles that conspirators have in the network, which can be decision-making or operational. To my knowledge, this is a first attempt in modeling the network configuration of the cartel as a decision variable in a price-fixing collusion game. Despite these differences, I find my work closer to Roldan, in the common interest of how the antitrust policy distorts cartel's incentives to set one or another network structure and, ultimately, on its welfare implications.

Continuing with my interest on the welfare implications of antitrust policy, I find that my work is also close to the literature that observe perverse effects from antitrust policy. In this regard, let me classify it into two main strands: one that focus on the productive inefficiencies that policy creates, and another that address the possibility that it contributes to cartel sustainability rather than to deterrence. Among the former, stands out the work of Aubert, Kovacic and Rey (2006) and Aubert (2009), who analyze productive inefficiencies from whistleblowing and leniency programs. Avramovich (2013) extends this literature by considering a set up in which productive inefficiencies arise as a result

[4]The authors relate high-information processing needs to difficulties in predicting demand or negotiating product specifications with customers, among others. The opposite holds with products from industries characterized by low-information processing needs.

of a poorly designed antitrust policy even when implemented through standard policy instruments as fines and inspections. Among the literature on the perverse effects of antitrust policy on deterrence Spagnolo (2000) and Buccirossi and Spagnolo (2001 and 2006) stand out by their contributions on the perverse effects of leniency programs. Harrington (2004, 2005) and Avramovich (2013), on the other hand, analyze alternative set ups in which these perverse effects can be observed even following a fine increase. In this line of work, the novelty of the current paper is that it analyzes the perverse effects of antitrust policy by distorting the preferences of cartels over one or another network design. As for the type of perverse effect under consideration, I find closer to those related to the creation of inefficiencies in the economy.

Finally, I must refer to the literature related to a key element in my framework: cartel's ability to modify the probability of detection by deciding the amount of evidence to be created/destroyed.

In this respect, the first question to be examined is why cartels might be interested in keeping evidence of their activities. Aubert *et al.* (2006) suggest that firms may be interested in keeping evidence of the cartel if they fear that rivals will apply for leniency. Jellal and Souam (2004) and Avramovich (2013) point to firms' interest in keeping evidence taking into consideration that concealment is costly. Closer to the latters, this paper finds in costly concealment the reason for keeping more evidence than the minimal for cartel sustainability. However, among the three papers the opportunity cost of concealment differs. In Jellal and Souam destroying evidence requires costly effort that can be avoided under the under-performance of inspectors. In Avramovich (2013), to reduce the creation of cartel evidence, cartels have to remove effort from productive activities to assign it to concealment activities, which creates productive inefficiencies. Finally, in this paper, costly concealment is related to the inefficiencies that arise from delegating the organization of the cartel to some representatives.

The second issue to consider is the endogeneity of the probability of detection. Jellal *et al.* (2004) consider the probability of detection endogenous to the firms' and the inspector's efforts devoted to hide and discover collusion, respectively. Harrington (2004 and 2005) considers the probability of detection endogenous to current and previous periods' prices, since he assumes that anomalous price movement make customers and the AA suspicious that a cartel is operating. Harrington and Chen (2005) extends these works to leniency programs. Avramovich (2013) considers the probability of detection endogenous on firms effort devoted to concealment. Similar to the probability of detection, the probability of paying penalties is endogenous to the cartel firms' perception regarding the severity of the antitrust policy in Harrington and Chang (2009), and on the AA's resources devoted to prosecute and convict discovered cartels in Harrington (2011).

This paper is in line with those that consider the probability of detection (penalty) endogenous to the firm's behavior, not that of the AA. In this regards, its novelty lies in the market inefficiencies associated to higher concealment and, ultimately, to the antitrust policy.

3 The Model

Consider an economy with a continuum of industries. In each industry, there are two firms, A and B, producing perfect substitutes at a fixed marginal cost c. Denoting firms with the subindex i, firm i's cost of producing good q is represented by $C_i(q_i) = c$, for $i = A, B$. On the demand side, in each market there is an inelastic demand for two units of the good with reservation price v. I assume $v \sim U[\underline{v}, \overline{v}]$.

Markets differ in their degree of sophistication; which I associate with the capability to predict demand, the possibility of multiple interpretations of customer specifications for the product, or to the difficulty of predicting costs, among other related aspects. To model this, I define a market-sophistication parameter $\gamma \sim U[0, 1]$, such that the higher the γ, the more sophisticated the market. The economic implications from this element are discussed extensively throughout the paper.

Regarding firms, each firm has a functional-separation mode of organization. This means that firms have separate divisions for each activity (e.g., production, trade, sales, etc.), that defines who controls what information and who makes which decisions. Hence, at the head of each division there is a manager with an specific and irreplaceable *expertise*.[5] Given a one-to-one correspondence between managers and divisions, both are indistinctly denoted with the subindex j. For simplicity purposes, I limited j to two ($j = 1, 2$), i.e., each firm has two divisions run by a single manager each.

I assume managers' expertises strategic complements, such that market decisions made jointly by all managers of a firm lead to higher profits than decisions made without one of them. Following this, I set a model in which manager's expertise, firm's profits and market sophistication relate as follows: the more sophisticated the market, the more valuable the expertise of each manager, and, therefore, the higher the profit loss derived from delegating business decisions to a single manager.

In this context, firms maximize profits over an infinite time horizon with constant discount parameter δ and, to this end, they compete or collude on prices. The market demand goes to the lowest priced firm or, in case of a price tie, firms equally split demand.

Collusion requires communication between cartel members to set the collusive agreement. Over the paper I consider two types of communication: communication that originates at cartel meetings and any subsequent communication between two conspirators of the same firm. I assume that only the former one constitutes 'hard evidence' for cartel detection, since the latter can be dissembled as 'innocent communication' between two colleagues within a firm.[6] Hence,

[5]The model allows to consider *experience*, *knowledge* and *information* as alternative managerial characteristics. To simplify notation, and w.l.o.g., I consider *expertise* as a combination of the three.

[6]The ability of some cartel members to protect themselves by delegating direct contact with co-conspirators is also a key point of interest in Baker and Faulkner (1993). In their analysis of how the network design of a cartel effects verdict (guilt or innocence), sentence and fine, they

identifying managers as cartel members, in my set-up cartel meetings involve at least two members (one manager per firm) and at most four members.

Evidence lasts for one period and can be discovered by the AA during an inspection. Inspections are costly and are defined over firms' divisions: at each period the AA visits a firm in an industry with probability ρ and inspects a single division of that firm; so in a period it can be inspected firm A, firm B or both, but always inspections are carried out over a single division of the firm.[7] W.o.l.g. I assume equal probability of inspection across divisions within a firm, such that given an inspection to firm i the probability of inspecting division j is $\frac{1}{2}$. If during an inspection it is found hard evidence, the cartel is detected and condemn. Condemn implies the payment of corporate fines F for firms and individual fines f for each detected conspiring manager.

The cartel network design

Following Baker and Faulkner (1993), I identify the internal organization of cartels depending on how cartel decisions are taken. Specifically, I say that a cartel network is *complete* when all managers attend cartel meetings and made cartel decisions jointly. Otherwise, if only some representatives from each firm attend cartel meetings and, therefore, are those in charge of cartel decisions, I say that the cartel has a *representative* network.[8]

Two crucial issues arise from classifying cartels in this way. First, the probability of cartel detection is contingent on the network design of the cartel. Since firm inspections are carried out on one division at a time, the probability of cartel detection crucially depends on whether there is hard evidence of the cartel in the inspected division or not. Under the *complete* network there is hard evidence of collusion over all firms' divisions, as all division managers attend cartel meetings. Hence any inspection ends in cartel detection. Under the *representative* network, instead, there is cartel evidence only in the divisions whose manager attends cartel meetings. In this context, only those inspections carried out towards these divisions end up in cartel detection.

The straightforward result is that cartels can reduce the probability of detection by reducing managers' attendance to cartel meetings; i.e, by delegating cartel decisions to some representative manager.

---

show, among other things, that the more direct contacts a conspirator has, the greater the likelihood of a guilty verdict. Particularly, they observe that the odds of conviction increase by almost 50 percent for each additional direct tie to another conspirator. In the authors' words: '*[.] Degree centrality makes a person vulnerable. The more eyewitnesses to a conspirator's participation in price-fixing activities, the more likely the conspirator was to be found guilty. Degree means being 'in the thick of things' [.], and the results show that being in the thick of a conspiracy means one is likely to be found guilty'*.

[7] Assuming inspections carried out over a single division of each firm obeys to simplifying purposes, and in no way restricts the main results of the paper. However, in Section 7 I relax this assumption by allowing firm-wide inspections.

[8] This classification for cartel's network design differs slightly from that of Baker and Faulkner, whose *decentralized* category for network design covers more structures than the *complete* one that I use. Hence, to avoid misspecifications, I find it more appropriate to use the categories *complete* and *representative*, instead of *decentralized* and *centralized*, respectively, that Baker and Faulkner use.

Proposition 1 *The probability of cartel detection is* $h^C = \rho(2-\rho)$ *under the complete network design and* $h^R = \rho - \frac{1}{4}\rho^2$ *under the representative design.*

Corollary 1 *The probabilities of cartel detection* h^C *and* h^R *are monotonously increasing and concave in* ρ*, with the particularity that* $h^C(\rho = 1) = 1 > \frac{3}{4} = h^R = (\rho = 1)$ *and* $h'^C > h'^R$ *for* $\rho < \frac{2}{3}$ *and* $h'^C < h'^R$ *for* $\rho > \frac{2}{3}$*.*

Since the probability of cartel detection under the *complete* network design is higher than that under the *representative* one:

Lemma 1 *Delegating cartel decisions reduces the likelihood of detection.*

The second issue to consider refers to the distribution of cartel profits between conspirators. In a cartel with the *complete* network we should expect an equal distribution of profits. Since firms are symmetric and all members are subject to the same expected detection costs, any other distribution will be rejected by the member at a disadvantage. Under the *representative* network, instead, some members face higher expected costs from collusion than others, as only those attending cartel meetings are subject to individual fines. Therefore, to incentive the attendance to cartel meetings, I allow for monetary compensations between members.[9] Section 5 develops in detail the modeling formalities of this issue and its implications for the results of the game.

3.1 The timing of the game

The timing of the game is as follows. At stage 0, firms choose whether to collude or compete. If one firm chooses to compete, competition takes place and the game ends. If, instead, there is an agreement on collusion, firms decide on the network structure for the cartel, choosing between the *complete* and the *representative* designs. At stage 1 firms decide whether to follow the collusive agreement or to deviate. In the latter case, the deviant slightly reduces its price and gets all demand. At stage 2, production and price decisions are executed and the rival's price is observed. Also, inspections take place. At stage 3, firms get their payoffs from sales. Under cartel detection, firms and managers pay the corresponding fines and the game starts again from stage 0. If the cartel is not detected, but one firm has deviated, a punishment phase takes place. Finally, if none of the firms have deviated and the cartel is not detected, the game repeats itself from stage 1.

In this setup, firms make simultaneous pricing decisions in every period t. With an infinite horizon, firm i, $i = A, B$, chooses prices $p_{it} \in [0, v]$, in every t, $t = 1, 2, ..., \infty$.

Under collusion, price choices at date t depend on the history of previous sales, so that p_{it} depends on $H_{it} = (\ q_{i1}\ ;\ q_{i2}\ ;\ .\ .\ .\ ;\ q_{i,t-1}\ )$, $i = A, B$. The

[9] The reader can find other alternative ways to deal with this problem, such as managerial rotation to cartel meetings. However, as will be seen latter in the paper, the main results do not depend on this issue.

The timing

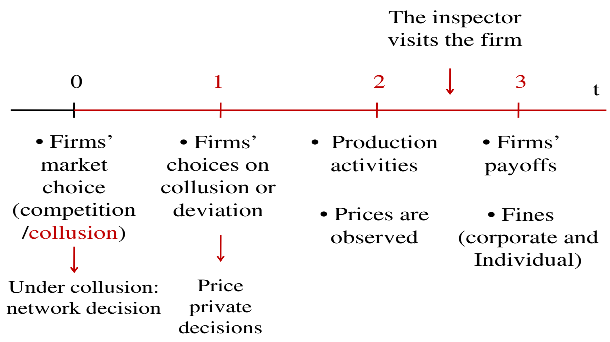

Figure 1: Time-structure of the game

rational behind this rule goes as follows: under collusion firms charge the same price and split the demand in halves, $q_i = 1$, $i = A, B$; thus, for a firm, no sales implies that the rival deviated in price. Therefore, the collusive strategy for firm i is to initially price at the collusive price p^c in period 1 and to continue pricing according to:

$$p_{it} = p^c \qquad if: \; q_h^\tau = 1 \quad \forall \tau \in \{1, ..., t-1\}, \; h = \{A, B\}$$

as long no firm has deviated from this path. If a firm has deviated, there is a reversion to the single-period Nash equilibrium strategy of pricing, since Nash reversion can assure zero profits for the deviant.

3.2 The one-shot game

In the one-shot game, firms choose price to maximize current profits:

$$\Pi_i = (p_i - c)\, q_i$$

Proposition 2 *There exists a one-shot game Nash equilibrium in which both firm obtains zero profits.*

Since at the static Nash equilibrium both firms obtains zero profits, Nash reversion constitutes an optimal penal code, as the deviant obtains zero profits.

4 Collusion under the *complete* network design

Under the *complete* design for the cartel network all managers attend cartel meetings and, consequently, are liable to individual fines. In this context firm

i's problem is to chose price to maximize expected profits from collusion:[10]

$$\Pi_i = (p_i - c)\, q_i - \rho\,(2-\rho)\ \ (2f + F) \tag{1}$$

The first term is firm i's payoff from production and the second one is the expected cost from detection. Regarding the latter, note that under detection the firm is responsible for the corporate fine F, as well as each manager is for the individual fine f. This gives an overall liable fine of $2f + F$ per firm.

Under collusion firms charge the same price and split the demand in halves: $p_i = p^c$ and $q_i^c = 1$, $i = A, B$. Thus, in each period, firm i's expected profits from collusion are: $\Pi_i^c = \Pi(p_i = p^c \mid q_i = 1)$.

If a firm decides to deviate, it slightly reduces its price and gets all demand. Thus, under deviation the firm behaves as an efficient monopolist that produces the two units of the good that the market demands and obtains monopoly profits $\Pi_i^d = \Pi(p_i = p^c \mid q_i = 2)$ in the current period, and zero thereafter.[11]

Regarding manager's payoffs, within a firm managers split profits equally, as any other distribution will be rejected by the one at a disadvantage. Hence, manager j's payoff from collusion and deviation are $\Pi_{ij}^c = \Pi_i^c/2$ and $\Pi_{ij}^d = \Pi_i^d/2$, respectively.

4.1 Cartel Sustainability

Collusion is sustainable as long as firms have no incentives to deviate, i.e., when the current gains from deviation (G) are no greater than the present value of net future profits from collusion. Hence, the Incentive Compatibility Condition (ICC) for collusion sustainability is:

$$(ICC) \qquad G \ = \ \Pi_i^d - \Pi_i^c \ \leq \ \frac{\delta}{1-\delta}\ \Pi_i^c \tag{2}$$

Given a *complete* network for the cartel, the ICC yields:

$$p^c - c \ \leq \ \frac{\delta}{1-\delta}\ [\ p^c - c - \rho\,(2-\rho)\ \ (2f + F)\ ] \tag{3}$$

For $\delta > \frac{1}{2}$, a price increase relaxes the ICC, hence firms always charge the reservation price under collusion, $p^c = v$. Prices lower than v, make collusion harder to sustain and prices higher than v would imply no sales. So, collusion is sustainable if and only if perfect collusion is sustainable. Along the paper I assume $\delta > \frac{1}{2}$.[12]

Making $p^c = v$ in (3) and solving for v:

$$v \ \geq \ v_1 = c + \ \frac{\delta\ \rho\ \ (2-\rho)\,(2f+F)}{(2\delta - 1)} \tag{4}$$

[10] The problem of the firm can be identified as a cooperative problem for the two managers of the firm.

[11] Since the optimal penal code yields zero profits for the deviant forever after deviation, the current value of total profits from deviation equates current profits from deviation.

[12] Otherwise, if $\delta \leq \frac{1}{2}$, collusion is not profitable. $\delta > \frac{1}{2}$ is the standard level of patient assumed in models of collusion.

Proposition 3 *For the complete cartel network design: there exists* $v_1 \in [\underline{v}, \overline{v}]$ *such that perfect collusion is sustainable in all industries with high enough reservation price,* $v \geq v_1$*. Otherwise, competition takes place.*

The threshold price v_1 *is increasing in* F*,* f *and* ρ*.*

From the AA's point of view, v_1 states the effectiveness of the antitrust policy to deter cartels: an increase in fines (corporate or individually considered) and/or in the likelihood of an inspection raises the threshold parameter v_1, making collusion harder to sustain. Regarding fines, it is important to remark that an increase in individual fines has a greater impact on deterrence than the equal policy but with corporate fines. This is so since the number of subjects liable to individual fines (managers) exceeds that of subjects liable to corporate fines (firms); hence higher individual fines increase the expected costs from detection more than higher corporate fines. (Figure 2)

Collusion under the *complete* network design

The deterrence effect of more severe antitrust policies

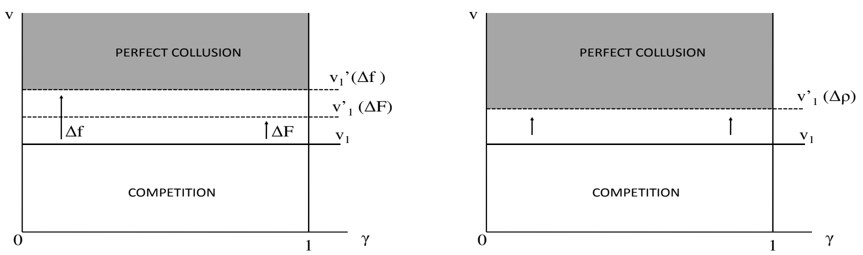

Figure 2: Left: Threshold parameter v_1 before (solid line) and after (dashed lines) a fine increase. An increase in individual fines increases the threshold parameter v_1 more than one in corporate fines. Right: Threshold parameter v_1 before (solid line) and after (dashed lines) an increase in inspections.

5 The *representative* network design

Through a *representative* network cartels reduce detection costs, as this network design allows to reduce cartel evidence and the number of conspirators subject to individual fines. However, this network strategy also has negative implications for cartels: within a context where manager's expertises are strategic complements, the absence of some managers at the time of making cartel decisions lead to inaccurate decisions, with negative side effects on cartel's profits.[13]

In this context firm i's problem is to chose price to maximize expected

[13]The model allows for different interpretations for *inaccurate*: *imperfect*, *erroneous*, etc. W.l.o.g. over the paper I use the term *inaccurate* to simplify the reference.

profits from collusion:

$$R_i = (p_i - c)\, q_i\, (1-\gamma) - \rho \left(1 - \frac{1}{4}\rho\right)\ (f + F) \tag{5}$$

I use the notation R_i for firm i's profits under the *representative* network, to differentiate it from those obtained under the *complete* network (Π_i).

The first term in (5) is firm i's payoff from production. This term is less than that under the *complete* network in a proportion $\gamma \in (0, 1)$, capturing the initial assumption that: the more sophisticated the market, the more valuable the expertise of each manager, and, therefore, the higher the profits loss from delegating business decisions to a handful of managers. The second term is firm i's overall expected cost from detection. Note that the firm's overall liability in terms of fines includes the individual fine of the manager that attends cartel meetings and the corporate fine.

As in the case of the *complete* network, under collusion firms charge the same price and split the demand in halves: $p_i = p^c$ and $q_i^c = 1$, $i = A, B$. Thus, in each period, firms obtain expected profits: $R_i^c = R_i(p_i = p^c \mid q_i = 1)$.

Under deviation, instead, the deviant reduces its price slightly to get all demand and behaves as an efficient monopolist producing the two units of the good that the market demands. At this point, it is important to note that there is no loss of efficiency in this case, as the best deviation strategy implies a market strategy designed jointly by all managers of the deviant firm. Hence, firm's payoff from deviation is $R_i^d = R_i(p_i = p^c \mid q_i = 2\ , \gamma = 0)$ in the current period, and zero thereafter.

Manager's payoff distribution

The delegation process that characterizes the *representative* network design assigns specific functions to each cartel member: the members attending cartel meeting are endowed with a strong decision-making role, which differs from the purely operational one assigned to those who are kept out of meetings. This differentiated function, distorts managers' expected costs from collusion. Particularly, managers attending cartel meetings face the highest expected cost, as they are the only ones liable to individual fines under detection. In this context, managers of the same firm must agree on how to split profits from collusion between them.

To deal with this issue, I allow for monetary compensations between managers of the same firm, such that both obtain the same payoff from collusion in expected terms. Defining $\alpha \in [0; 1]$ a profit distribution parameter, the optimal distribution rule implies:

Corollary 2 *Under the representative network design the manager that attends cartel meetings is compensated by his co-conspirator of the same firm for the risk he faces by attending cartel meetings with a proportion $\alpha > \frac{1}{2}$ of firm's profits* *from collusion:*

$$\alpha = \frac{1}{2} + \frac{\rho\left(1-\frac{1}{4}\rho\right)\ f}{2\,(p^c - c)\,(1-\gamma)} \tag{6}$$

After the compensation, both managers get equal expected profits from collusion.

The first term in (6) states the equal distribution of profits, and the second one the overpayment that the '*meeting*' manager demands for attending cartel meetings. The higher the individual fine f and/or the probability of inspection ρ, the higher this compensation.

5.1 Cartel Sustainability

Given firm's expected payoffs from collusion and deviation R_i^c and R_i^d, the ICC condition under the *representative* network design is:

$$(p^c - c)\,(1+\gamma)\ \leq\ \frac{\delta}{1-\delta}\ \left[\ (p^c - c)\,(1-\gamma) - \rho\left(1 - \frac{1}{4}\ \rho\right)\ (f+F)\ \right] \tag{7}$$

In the LHS of (7) the gains from deviation are higher than those observed for the *complete*-network case in a proportion γ. That is because a deviant not only gets higher profits due to more sales $(p^c - c)$, but also due to more efficient market decisions $(\gamma(p^c - c))$. The higher the market sophistication, the greater the benefits from the latter effect, and so the higher the incentives to deviate.

The RHS of (7) also differs from that of the *complete*-network case; now due to two opposite effects. On the one hand, delegation introduces inefficiencies that reduce the net payoff from sales in the proportion γ (first term in brackets). But on the other hand, it also entails lower expected costs from detection (second term in brackets). While the first effect makes collusion harder to sustain, the second one encourages it. The overall effect is, a priori, undetermined.

Despite these differences, it remains true the previous result that firms charge the reservation price under collusion, $p^c = v$.[14] So, collusion is sustainable if and only if it is sustainable at price v. However, it is not true anymore that firms can achieve perfect collusion, as monopoly profits are reduced in a proportion γ.

Making $p^c = v$ in the ICC and solving for v

$$v\ \geq\ v_2 = c + \frac{\delta\ \rho\left(1 - \frac{1}{4}\ \rho\right)(f+F)}{(2\delta - 1 - \gamma)} \tag{8}$$

Proposition 4 *For the representative cartel network design: there exists $v_2 \in [\underline{v}, \overline{v}]$ and $\hat{\gamma} = 2\delta - 1$, such that imperfect collusion is sustainable in all industries with $\gamma < \hat{\gamma}$ and high enough reservation price $v \geq v_2$.*

The threshold price v_2 is increasing in F, f and ρ.

[14] As in the *complete*-network case, given $\delta > \frac{1}{2}$, prices lower than v make collusion harder to sustain, and prices higher than v would imply no sales.

The novel element in Proposition (4) is that collusion can not be sustained in highly sophisticated markets with the *representative* network design, that is for $\gamma > \hat{\gamma}$. In these cases, the efficiency losses from delegating cartel decisions to some representatives are extremely high to allow for cartel sustainability. In the opposite case, for $\gamma < \hat{\gamma}$, the standard result holds, and collusion is achieved with a high enough reservation price v. (Figure 3)

Collusion under the *representative* network design

The deterrence effect of more severe antitrust policies

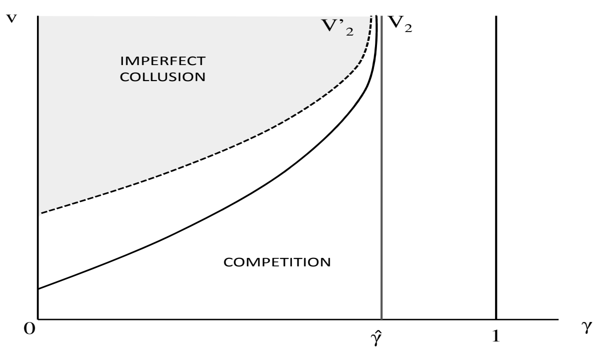

Figure 3: Threshold price v_2 in terms of the market sophistication parameter γ: the more sophisticated the market, the harder to sustain collusion with the *representative* network design. Antitrust policy: threshold price v_2 before (solid line) and after (dashed lines) a fine increase and/or an increase in inspections.

Finally, for the purposes of antitrust policy, the standard result holds: higher fines and/or more inspections increase the threshold price v_2, making collusion harder to sustain. However, notice that the effect of higher fines no longer depends on the type of fine considered (individual or corporate), as the numbers of subjects liable to both types of fines coincide.

5.2 On cartel's network decision

In some industries, collusion is sustainable under both network designs, so cartel firms have to decide which one to adopt. To this end, they compare their expected profits from collusion in each case and choose the one with the highest return. Corollary 3 summarizes the result of such a comparison:

Corollary 3 *For $v > \max\{v_1, v_2\}$ collusion is sustainable under both network designs, and there exists a threshold price:*

$$v_n = \frac{\rho(2-\rho)(2f+F) - \rho(1-1/4\rho)(f+F)}{\gamma} \; + \; c \tag{9}$$

such that:

- *for $v > v_n$ the complete network design is preferred over the representative, as the former gives higher expected profits from collusion;*
- *otherwise, the opposite holds, and the representative design is chosen.*

The threshold parameter v_n states the opportunity cost of setting the *representative* network design instead of the *complete* one. In the first term, the numerator shows the profit gains from delegation due to the lower probability of detection and less people liable to fines. The denominator, on the other hand, recalls that delegation introduces inefficiencies in cartel decisions that reduce cartel's net profits from sales in a proportion γ. The higher this ratio, the more attractive the *representative* design. Regarding the second term in (9), it states that the attractiveness of the *representative* design increases with the unitary production cost c. To see this, remember that the profit loss from delegation $\gamma(p^c - c)$ decreases with c, hence the higher this parameter, the more attractive the delegation.

Lemma 2 summarizes the market equilibrium and Figure 4 illustrates it:

Lemma 2 *Given threshold parameters v_1, v_2 and v_n:*

- *Firms play collusion if $v \geq \min\{v_2, v_1\}$. Within this context, if $v \in (v_2, v_n)$ firms set the representative network design; otherwise they set the complete one.*
- *If, instead, $v < \min\{v_2, v_1\}$ competition takes place.*

Market equilibrium and optimum network design

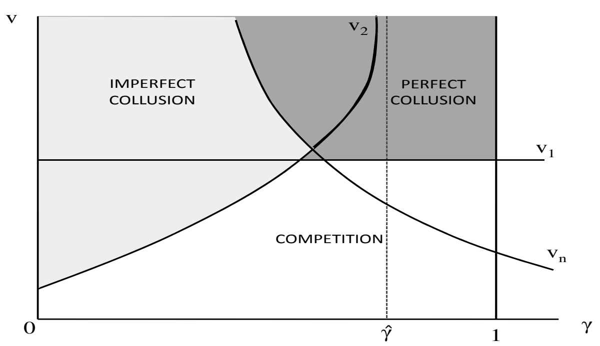

Figure 4: Threshold prices v_1 and v_2 for cartel sustainability, and threshold parameter v_n for network decision.

For the AA's purposes, v_n constitutes a target parameter to distort the network distribution of cartels. Indeed, following a more severe antitrust policy, some cartels will disappear but some others will still find it profitable to continue in conspiracy and, to this end, they will take into account how the policy distorted v_n.[15] In what follows, I discuss this process in detail.

Assume first that the AA increases fines. For surviving cartels, this implies higher expected detection costs and, consequently, lower expected profits from collusion. This payoff loss is totally unavoidable for cartels with the *representative* network design; however it is not so for those with the *complete* one, who may find in delegation the way to cushion part of the impact. Indeed, since higher fines increase the gains from delegation without modifying its costs[16], switching the *complete* network design for the *representative* one becomes attractive. Figure 5 illustrates this result.

Deterrence and network-distortion effects of a fine increase

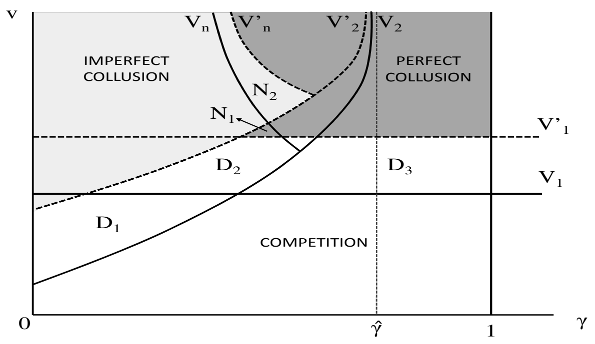

Figure 5: Higher fines increase thresholds v_1 and v_2, making collusion harder to sustain. Area $D_1+D_2+D_3$ identifies industries in which collusion is no longer sustainable. Also, higher fines raise v_n, inducing some surviving cartels to switch (*i*) their *representative* network for the *complete* one, in order to sustain collusion (area N_1), or (*ii*) their *complete* network for the *representative* one to maximize profits (area N_2).

If, instead, the AA increases inspections, the 'network-distortion' effect from changes in v_n no longer occurs in one direction. Now, it is possible to observe cartels switching their *complete* network for the *representative* design, or the other way around. To see this, let's decompose the marginal effect of ρ in v_n as follows:

$$\frac{\partial v_n}{\partial \rho} = \frac{\left(\frac{\partial h^C}{\partial \rho} - \frac{\partial h^R}{\partial \rho}\right)(f+F) \; + \; \frac{\partial h^C}{\partial \rho} f}{\gamma} \tag{10}$$

Since the sophistication parameter γ is non-negative, the sign of equation (10) depends entirely on its numerator. Hence, focusing on it, I define its first

[15]While it is theoretically possible to achieve full deterrence through infinite fines, in practice imposed sentences show that fines are well below those values. For this reason, the collusion literature highly recommends to analyze in detail the implications of antitrust policy in the case of finite fines. The same comment applies for the case of full inspections, with the aggravating that this policy demands costly resources for society.

[16]The opportunity cost of delegation $\gamma(v-c)$ does not depend on any policy instrument.

and second terms as the *probability effect* and the *manager effect*, respectively. The *probability effect* compares the impact of more inspections on the expected costs of detection under each network design given the lowest possible fine.[17] From Corollary 1, we known that this term can be positive or negative (the sign of $h'^C - h'^R$ depends on the initial value of ρ)[18], hence the final effect of the *probability effect* on v_n is, a priori, undetermined. The *manager effect*, instead, is always positive. It concerns only to cartels that have the *complete* network design, as it shows the marginal cost of one more inspection due to the additional manager that attends cartel meetings under this network configuration.

Considering these two effects, Corollary 4 summarizes the final impact of more inspections on the network-decision process of surviving cartels:

Corollary 4 *There exist $\hat{\rho}$ and $\hat{F}$ such that: for $\rho > \hat{\rho}$ and $F > \hat{F}$, more inspections induce some surviving cartels to switch their representative network design for the complete one $\left(\frac{\partial v_n}{\partial \rho} < 0\right)$. Otherwise, the opposite holds and $\left(\frac{\partial v_n}{\partial \rho} > 0\right)$.*

For the economic intuition behind Corollary 4 consider first the case of $\rho > \hat{\rho}$ and $F > \hat{F}$. When inspections are highly frequent, the marginal effect of an additional 'visit' is negligible for cartels with the *complete* network, as for them the likelihood of detection was already huge.[19] However, for cartels with the *representative* design, such an additional visit is a headache, as its impact on the probability of detection is still relevant. Analytically, that is $h'^C - h'^R < 0$. If, in addition, the corporate fine is high, then the entire *probability effect* becomes highly negative, and dominates in the sign of (10). As a result, some cartels find it profitable to switch their *representative* network design for the *complete* one.[20] (Figure 6, Right)

Following an analogous reasoning, if ρ and F are not simultaneously high, the entire sign of (10) is positive.[21] This states that more inspections induce some surviving cartels to switch their *complete* network design for the *representative* one. (Figure 6, Left)

Lemmas 3 and 4 summarize the implications of antitrust policy on deterrence and on the network design of surviving cartels.

Lemma 3 ***: The deterrence effect from policy***
A more severe antitrust policy improves deterrence, with the peculiarity that the

[17] That is, the total fine to be payed when a single manager per-firm attends cartel meetings.

[18] In short: when inspections are rarely ($\rho < 2/3$), the marginal effect of an additional inspection on the probability of detection is higher under the *complete* network, $h'^C - h'^R > 0$. But, for frequent inspections ($\rho > 2/3$), the opposite holds, $h'^C - h'^R < 0$.

[19] In Spanish there is a refrain that says: *'Qué le hace una mancha más al tigre?'*, which has its English equivalent in the expression *'a drop in the ocean'*, i.e., one more drop in the ocean does not make any difference, just like an additional spot on the skin of the tiger. In our context, this would be to say that when the likelihood of being inspected is high, one more inspection does not make any difference.

[20] Indeed, faced with ρ and F high, for some cartels the strategy of maximizing profits and paying a high fine in almost all periods becomes more attractive than that of obtaining low profits in all periods and paying the same fine with a (still) high probability.

[21] Notice that this result holds even when inspections are highly frequent, as $h'^C - h'^R < 0$ is a necessary condition for $\frac{\partial v_n}{\partial \rho} < 0$, but the entire rule also demands for F high.

Deterrence and network-distortion effects of more inspections

Figure 6. Left   Figure 6. Right

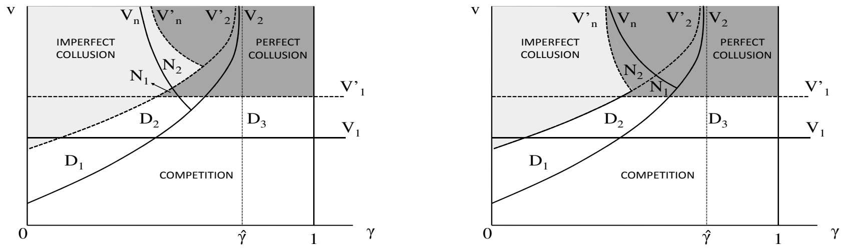

Figure 6: Thresholds v_1 v_2 and v_n before (solid lines) and after (dashed lines) an increase on inspections. Area $D_1 + D_2 + D_3$ represents the deterrence effect of the policy. Area B_1 represents cartels that switch their *representative* network design for the *complete* one for cartel sustainability purposes. Area B_2, instead, represents surviving cartels that switch network to maximize profits; from the *complete* to the *representative* design (Left), or vice-verse (Right).

impact of individual fines is higher than that of corporate fines for cartels that set the complete network design.

Corollary 5 *For cartel deterrence, the optimal policy is to set individual fines as high as possible.*

Lemma 4 ***: The network-distortion effect from policy***
Given $\gamma < \hat{\gamma}$, a more severe antitrust policy:

- *Induces some cartels to switch network for sustainability purposes, from the representative design to the complete one; and*
- *There exists $\hat{\rho}$ and $\hat{F}$, such that: for $\rho > \hat{\rho}$ and $F > \hat{F}$ more inspections induce some other cartels to switch network for profitability purposes, also from the representative design to the complete one. Otherwise, the opposite holds.*

6 Welfare implications

In this economy demand is perfectly inelastic, thus collusion creates a welfare loss if and only if it introduces some inefficiency that is not in competition; e.g., inefficiencies in the production or sale processes, or management inefficiencies, among others.

Defining the social welfare in an industry W as the addition of the consumer surplus and the producer surplus. Under competition, social welfare is exclusively given by the consumer surplus, as price competition leads to zero profits to both firms. Under collusion, instead, firms extract all consumer surplus from the consumption of the good, hence social welfare is given by the producer surplus and the expected revenues from fines. In this regard, note that under the *representative* network design the producer surplus is download sloping in the market sophistication parameter γ, as the managerial efficiency loss from delegation is increasing with the sophistication of the market.[22]

Denoting with W^* welfare under competition, and with W^C and W^R welfare under collusion with the *complete* network design and with a *representative* one, respectively, the following inequality is straightforward:

$$W^* = W^C = 2(v-c) > 2(v-c)(1-\gamma) = W^R \tag{11}$$

Collusion creates a welfare loss if and only if it is implemented through a *representative* network design; otherwise it only redistributes welfare between consumers and producers. Such a welfare loss is increasing in the market sophistication parameter γ stating that the more sophisticated the market, the higher the social loss from cartels' preference for the *representative* network design.

In this setup, a more severe antitrust policy can have two welfare effects. On the one side, it can increase welfare by discouraging collusion in industries whose cartels were organized under the *representative* network design. But, on the other side, it can reduce welfare by biasing the network distribution of surviving cartels towards the *representative* (inefficient) design.

From results described in Sections 4 and 5 and the above discussion, Lemma 5 follows immediately:

Lemma 5 *There exists $\hat{\gamma}$, $\hat{\rho}$ and $\hat{F}$ such that:*

- *For $\gamma > \hat{\gamma}$: the antitrust policy has no effect on welfare.*
- *For $\gamma < \hat{\gamma}$: more inspections increase welfare within a context of already frequent inspections and high corporate fines ($\rho > \hat{\rho}$ and $F > \hat{F}$). Otherwise, the welfare implications from policy are, a priori, undetermined.*

In highly sophisticated markets ($\gamma > \hat{\gamma}$), collusion is sustainable only under the *complete* network design. In this context, a more severe antitrust policy prevents some cartel formation, but without any welfare gain, as cartels under this network design are efficient.

In less sophisticated markets ($\gamma < \hat{\gamma}$), instead, two welfare effects follow a more severe antitrust policy. First, there is a deterrence effect that increases welfare by preventing some cartel formation under the *representative* network design (area $D_1 + D_2$ in Figures $5-6$). Second, there is a switching-network effect - which can be for sustainability or profitability purposes (areas N_1 and N_2 in Figures $5-6$, respectively)- that increases welfare if the network-switch

[22]Indeed, firm i's efficiency loss from delegation is given by: $-(v-c)\gamma$.

goes from the *representative* design to the *complete* one. Particularly, this holds for a policy that combines high inspections with high corporate fines. Hence, only in this latter case a more severe antitrust policy assures a welfare again. In any other case the two welfare effects go in opposite directions, and the final effect is, a priori, undetermined.

7 Extensions and Variations

Preceding Sections analyzed how the possibility to decide between two designs for the cartel internal organization affects cartel sustainability and social welfare. The analysis assumed inspections defined on the divisions of firms, and a standard antitrust policy implemented through fines and inspections. This Section relaxes each of these two assumptions in turn. First, by extending inspections to the entire firm, and second by introducing leniency programs as a new policy instrument to fight cartels.

□ **Firm-wide inspections.** I first extend the analysis by allowing inspections throughout the firm, rather than inspections carried out to a single division of the firm at a time. In this context, all cartel evidence is found during an inspection to a firm. Hence, the probability of cartel detection is given by $\rho(2-\rho)$ regardless of the network design chosen. However, firms may still find the *representative* design attractive, as through delegation they can still reduce the liable fine under detection. This is because managers who do not attend cartel meetings are not liable to individual fines.

Therefore, with respect to the basic set-up, considering firm-wide inspections only implies higher expected costs from detection - both under collusion and deviation - under the *representative* design. In terms of the ICC that is:

$$(p^c - c)\,(1+\gamma) \;\le\; \frac{\delta}{1-\delta}\;[\;(p^c - c)\,(1-\gamma) - \rho\,(2-\rho)\;\;(f+F)\;] \tag{12}$$

Again, the optimal pricing strategy under collusion is to charge the reservation price v. Making $p^c = v$ in the ICC and solving for v:

$$v \;\ge\; v_2' = c + \;\frac{\delta\;\rho\,(2-\rho)\,(f+F)}{(2\delta - 1 - \gamma)} \tag{13}$$

In its essence, the threshold price v_2' does not differ from that observed when divisions were defined on firms' divisions (v_2), in the sense that more severe antitrust policies make collusion harder to sustain. Neither it is distorted the result that collusion is only sustainable in industries with unsophisticated markets, that is for $\gamma < \hat{\gamma}$. However, $v_2' > v_2$ since under firm-wide inspections the probability of cartel detection is higher, which states that collusion is harder to sustain under the *representative* network design in this case.

Proposition 5 summarizes these results:

Proposition 5 *Under the complete network design, firm-wide inspections do not distort the incentives to collude with respect to the case of inspections carried out through one firm division per visit. Under the representative network design, instead, firm-wide inspections discourage collusion.*

Regarding the optimal network strategy for cartels that can set both designs:

Corollary 6 *For* $v > \max\{v_1, v_2'\}$ *collusion is sustainable under both network designs, the complete and the representative, and there exists a threshold price* $v_n' \in [\ \max\{v_1, v_2'\}\ ,\ \overline{v}\ ]$ *:*

$$v_n' = \frac{\rho(2-\rho)f}{\gamma}\ +\ c$$

such that: for $v > v_n'$*, the complete design is preferred over the representative one - as the former gives higher expected profits from collusion -; otherwise, the opposite holds and the representative design is chosen.*

Note that Corollary 6 is analogous to Corollary 3 for the basic set up, but for the fact that now cartels can not reduce the probability of detection through delegation. Within this context, delegation loses some attractiveness and, therefore, the threshold parameter v_n' is lower than that previously observed, $v_n' < v_n$.

Lemma 6 *Firm-wide inspections make the delegation of cartel decisions less attractive. Therefore, this policy of inspections increases social welfare with respect to the case in which inspections are carried out through a single division at a time.*

Regarding the economic implications of antitrust policy, firm-wide inspections do not distort the *deterrence* effect described in Lemma 3 for the basic model: a more severe antitrust policy always improves deterrence. However, this new definition for inspections does affect the *network-distortion* effect from policy observed in Lemma 4 and, therefore also the final welfare results described in Lemma 5.

Lemmas 7 and 8 substitutes Lemmas $3-5$ for the basic set up

Lemma 7 *Under firm-wide inspections, a more severe antitrust policy:*

(i) Improves deterrence, and

(ii) For $\gamma < \hat{\gamma}$*:*

- *Can induce some cartels to switch network for sustainability purposes, from the representative design to the complete one; and*
- *when the policy is implemented through individual fines or inspections: induces some other cartels to switch network for profitability purposes. Now, from the complete design to the representative one. Otherwise, surviving cartels keep their previously chosen networks.*

Lemma 8 *There exists $\hat{\gamma}$ such that:*

- *For $\gamma > \hat{\gamma}$: the antitrust policy has no effect on welfare.*
- *For $\gamma < \hat{\gamma}$: higher corporate fines contributes to welfare. Otherwise, the welfare implications from policy are, a priori, undetermined.*

The intuition behind Lemmas 7 and 8 is the same that for the basic set-up: a more severe antitrust policy increases welfare if it prevents collusion under the *representative* network design, either because these cartels stop colluding (*deterrence effect*) or because they switch their current network for the *complete* one (*network-distortion* effect). Since collusion with the 'target' network design can only be sustained in low-sophisticated markets ($\gamma < \hat{\gamma}$) any welfare analysis restricts to these cases. Within this context, higher corporate fines improve deterrence without side effects on the network election of the surviving ones. Hence, the policy undoubtedly increases welfare. If, instead, the policy is implemented through more inspections and/or higher individual fines, the final effect on welfare is, a priori, undetermined. That is because two opposing welfare effects follow to these policies. On the one hand, there is the *network-distortion* effect that induces some surviving cartels to switch network towards the *representative* design. This is detrimental for welfare. But on the other hand, there is the standard *deterrence* effect that reduces the population of cartels that set the *representative* design, which contributes to welfare.

□ **Leniency programs (LPs).** For the next variation assume that the AA introduces a Leniency Program that offers a fine amnesty to the first cartel firm to come forward with hard evidence of the cartel. Denoting the amnesty parameter by $\theta \in [0,1]$, the fine amnesty is $(1-\theta)\,F$.

Following the standard implementation of LPs, I consider public applications, such that leniency reports are observed by rivals. This implies that the cartel breaks after a leniency application and that, therefore, leniency applications only take place under deviation.[23]

For a deviant, the introduction of a LP implies two strategies to choose from: (a) deviation with report, and (b) deviation without report. In this decision, a deviant applies for leniency if and only if the fine payed after reporting is lower than the expected fine to be paid without it. In other words, there is a leniency application if and only if the amnesty parameter θ is lower than the probability of cartel detection. For a cartel with the *complete* network design this condition is: $\theta < \hat{\theta} = \rho\,(2-\rho)$; while for a cartel that sets the *representative* design is: $\theta < \hat{\theta}^R = \rho\left(1 - \frac{1}{4}\rho\right)$. Since the latter condition is the strongest of the two, Proposition 8 follows immediately:

Proposition 6 *There exist $\hat{\theta}^R$, $\hat{\theta}^n$, $\hat{\theta} \in (0,1)$, with $\hat{\theta}^R < \hat{\theta}^n < \hat{\theta}$, such that:*

[23] A leniency application is a betrayal to the collusive agreement. Hence, public reports lead to cartel breakdown regardless of whether it finally ends in a sentence for collusion or not. Consequently, there are no leniency applications under collusion.

- *For* $\theta < \hat{\theta}^R$*, a LP improves deterrence and welfare,*
- *For* $\theta \in \left(\hat{\theta}^R, \hat{\theta}^n\right)$*, a LP improves deterrence with no effect on welfare,*
- *For* $\theta \in \left(\hat{\theta}^n, \hat{\theta}\right)$*, a LP improves deterrence, but reduces welfare,*
- *For* $\theta > \hat{\theta}$ *a LP has no deterrence effect, neither welfare implications.*

Proposition 7 states two main results. First, that deterrence is increasing in the amnesty offered by the program - i.e., decreasing in the parameter θ. Thus, the analysis strongly favors full amnesties, as deterrence is maximized at $\theta = 0$.

Second, that the welfare effect from leniency is not monotonous in θ. To see this, keep in mind that the welfare effect of a LP depends entirely on its capability to prevent cartels from using the *representative* network design to collude. Having said this, when amnesties are high ($\theta < \hat{\theta}^R$), the welfare gain from the program is clear: high amnesties deter collusion in all industries, including those in which collusion was implemented with the *representative* network design. However, as amnesties go down, the welfare implications of the program vary a lot. For $\theta \in \left(\hat{\theta}^R, \hat{\theta}\right)$, the amnesty is not attractive enough to deter collusion for cartels that use the *representative* network design, but it is so for those that use the *complete* one. In this context, some cartels will break, but others will find collusion still profitable by switching its *complete* network for the *representative* design. Particularly, the latter holds when the gains from deviation with a leniency application do not exceeds the net value of future profits from collusion under the *representative* network design. In terms of the amnesty parameter θ: for $\theta \in \left(\hat{\theta}^n, \hat{\theta}\right)$. In this very last case the introduction of a LP reduces welfare by increasing the population of cartels that conspire under the *representative* network design. Finally, for really low amnesties ($\theta > \hat{\theta}$), the program has no effect on deterrence, neither on welfare.

8 Conclusion

In this paper I develop a model in which cartel firms have to decide on the network organization of the cartel. Specifically, they decide between two alternative network configurations: the *complete* design and the *representative* design. The main difference between the two lies in the number of conspirators directly involved in cartel decisions: while in the former design decisions are jointly made by all conspirators, in the latter they are delegated to some representative members. Through delegation, cartels can reduce the amount of hard evidence that they create, as there are fewer conspirators involved in cartel meetings, however it also introduces some inefficiencies to cartel's decisions whenever each manager has an specific and irreplaceable market knowledge.

Within this context, I show that for highly sophisticated markets (i.e., markets in which each manager's expertise is highly valuable), delegation never occurs, as the cartel costs associated to this strategy are too high. Hence, all cartels collude with the *complete* network configuration. However, by relaxing the degree of sophistication of the market, the number of cartels that find it profitable to switch their *complete* network for the *representative* design gets higher. And so does the number of industries that find in this network configuration the 'key' to sustain collusion.

Hence, the first result that stands out is that delegation constitutes a network strategy that allows collusion sustainability in industries in which it wouldn't be possible otherwise. Hence, by not considering alternative network configurations we would be underestimating the true population of cartels; especially faced to highly predictable markets.

For the AA's purposes, the network choice of cartels also has important implications. Regarding deterrence: the deterrence effect of higher individual fines is higher than that of corporate fines when cartels set the *complete* network design. This is so as under this network configuration the number of subjects liable to individual fines exceeds that of subjects liable to corporate fines. As this gap vanishes under the *representative* network design, to fight these other cartels both fines are equally effective. Based on these results - and since fines are costless to the AA -, the straightforward deterrence recommendation is to set individual fines as high as possible.

Regarding welfare, I show how the possibility to switch the cartel network configuration from one design to the other breaks the standard result that welfare is monotonously increasing in the severity of the antitrust policy. Indeed, In Section 6 I explain in detail how more inspections within a context of low corporate fines can induce some surviving cartels to switch their *complete* network for the *representative* design and, consequently, reduce welfare.

I achieve to a similar result by allowing for Leniency Programs (LP). Although leniency has the standard welfare implications for extreme amnesty values (very high/low amnesties), it does not have them for intermediate amnesty values. Indeed, high amnesties increase the gains from deviation and make collusion harder to sustain. Very low amnesties, on the other hand, result unattractive and do not distort the incentives to collude. However, for intermediate amnesty levels: at the same time that the program induces some cartels to break, it can also induce some others to switch their *complete* network design for the *representative* one, as this allows keeping the conspiracy safe from a leniency report. In this context, while the program is good for deterrence it is detrimental to welfare purposes.

On the basis of these results, the analysis favors setting very high fines (and or amnesties if LP are allowed) such that no cartel survives. However, in practice this is not always credible or possible to implement. In this context, the main message from the paper is that the antitrust policy has to be carefully designed, such that combining all its instruments conveniently: since welfare is non-monotonic in the level of most of the policy instruments individually considered, pushing crime detection too much with a single instrument can lead to undesirable outcomes.

These results lead to a number of interesting observations, some of which may be lines for future work. For instance, What if agency problems follow to delegation? This new element in the model increases the cost of delegation and, therefore, reduces the attractiveness of the *representative* network design. In terms of welfare, at least two opposite results arise: one the one hand, there is a welfare gain from a biased network distribution towards the *complete* (efficient) design, but on the other hand there is a welfare loss due to more inefficient '*representative*' cartels. In this context, I find it crucial to analyze the implications of antitrust policy on firms' productive efficiency, deterrence and welfare. Other interesting line for future work goes in line with the modeling assumptions on the network designs. In this paper I find clear results considering two network configurations (the *complete* and the *representative*); however there is no guarantee that these extend to alternative designs. This concern, without no doubt, opens a door for promising work, to my knowledge still incipient in the literature. These types of questions lead one to think about the importance of establishing the optimal detection policy under different frameworks; a clear challenge for future work on the subject.

References

[1] Aubert, C. Managerial effort incentives and market collusion. TSE Working Papers 09-127, Toulouse School of Economics (TSE), Dec. 2009.

[2] Aubert, C., Rey, P., and Kovacic, W. E. The impact of leniency and whistle-blowing programs on cartels. *International Journal of Industrial Organization 24*, 6 (2006), 1241–1266.

[3] Avramovich, M. C. What if cartel fines are not high enough? implications on deterrence and productive efficiency. *Revista de Economía y Estadística LI* (2013), 53–84.

[4] Baker, W. E., and Faulkner, R. R. The social organization of conspiracy: Illegal networks in the heavy electrical equipment industry. *American Sociological Review 58* (1993), 837–860.

[5] Belleflamme, P., and Bloch, F. Market sharing agreements and collusive networks*. *International Economic Review 45*, 2 (2004), 387–411.

[6] Buccirossi, P., and Spagnolo, G. Leniency programs and illegal exchange: how (not) to fight corruption. Tech. rep., Working Papers in Economics and Finance, 451, Stockholm School of Economics, 2001.

[7] Buccirossi, P., and Spagnolo, G. Leniency policies and illegal transactions. *Journal of Public Economics*, 90 (2006).

[8] Buccirossi, P., and Spagnolo, G. Corporate governance and collusive behaviour. CEPR Discussion Papers 6349, C.E.P.R. Discussion Papers, June 2007.

[9] Calvó-Armengoi, A., and Zenou, Y. Social networks and crime decisions: The role of social structure in facilitatingdelinquent behavior. *International Economic Review Vol. 45, No. 3* (2004), 939–958.

[10] Chang, M.-H., and Harrington, J. E. J. Modeling the birth and death of cartels with and application to evaluating competition policy. *Journal of the European Economic Association 7(6)* (Dec. 2009), 1400–1435.

[11] Chen, J., and Harrington, J. E. J. The impact of the corporate leniency program on cartel formation and the cartel price path. CIRJE F-Series CIRJE-F-358, CIRJE, Faculty of Economics, University of Tokyo, Aug. 2005.

[12] Griffin, J. M. An inside look at a cartel at work: Common characteristics of international cartels. American Bar Association.

[13] Harrington, J. E. J. Cartel pricing dynamics in the presence of an antitrust authority. *RAND Journal of Economics 35*, 4 (Winter 2004), 651–673.

[14] Harrington, J. E. J. Optimal cartel pricing in the presence of an antitrust authority. *International Economic Review* (February 2005).

[15] Harrington, J. E. J. How do cartels operate? *Foundations and Trends in Microeconomics* (Agoust 2006).

[16] Harrington, J. E. J. When is an antitrust authority not aggressive enough in fighting cartels? *International Journal of Economic Theory 7*, 1 (03 2011), 39–50.

[17] Holmstrom, B., and Milgrom, P. Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design. *Journal of Law, Economics and Organization 7*, 0 (Special I 1991), 24–52.

[18] Jellal, M., and Souam, S. Delegation, incentives and antitrust enforcement. Working Papers 2004-41, Centre de Recherche en Economie et Statistique, 2004.

[19] Levenstein, M. C., and Suslow, V. Y. What determines cartel success? *Journal of Economic Literature 44*, 1 (March 2006), 43–95.

[20] Roldán, F. Collusive networks in market-sharing agreements in the presence of an antitrust authority. *Journal of Economics and Management strategy 21, N4* (2012), 965Ű987.

[21] Spagnolo, G. Self-defeating antitrust laws: How leniency programs solve bertrand's paradox and enforce collusion in auctions. Tech. rep., FEEM Working Paper No. 52.2000. Available at SSRN: http://ssrn.com/abstract=236400 or doi:10.2139/ssrn.236400, 2000.

[22] Spagnolo, G. *Handbook of Antitrust Economics*, vol. 1 of *MIT Press Books*. The MIT Press, June 2008, ch. 7, pp. 259–303.

Appendix

♦ **Proposition 1: Cartel probability of detection**

Under the *centralized* network design, the probability of finding cartel evidence during an inspection to a firm is 1 - regardless of the division inspected. Hence, the probability of cartel detection is:

$$h^c = \rho_A(1-\rho_B) \ + \ \rho_B(1-\rho_A) \ + \ \rho_B \ \rho_A \ = \ \rho(2-\rho)$$

since the probability of inspection to firms A and B are equal, $\rho_A = \rho_B = \rho$.

Under the *decentralized* design, instead, the result of an inspection depends on the division inspected. If it is inspected the one whose manager attends cartel meetings, the cartel is detected. Otherwise, it is not detected. Identifying with ρ_{ij} the probability of inspecting division j of firm i and assuming that the manager that attends cartel meetings is $j = 1$, the probability of cartel detection is:

$$h^d = \rho_{A1}(1-\rho_B) \ + \ \rho_{A1}\rho_{B2} \ + \ \rho_{B1}(1-\rho_A) \ + \ \rho_{B1}\rho_{A2} \ + \ \rho_{A1}\rho_{B1}$$

Since: (i) $\rho_A = \rho_B = \rho$, and (ii) divisions of a firm are inspected with equal probability, $\rho_{i1} = \rho_{i2} = \frac{1}{2}\rho_i$, the above equation yields: $h^d = \rho - \frac{1}{4}\rho^2$

♦ **Lemma 1:** Since: (i) $h^c(0) = h^d(0) = 0$, (ii) $\frac{\partial h^c}{\partial \rho}, \frac{\partial h^d}{\partial \rho} > 0$, and (iii) $h^c(1) = 1 > \frac{3}{4} = h^d(1)$, hence: h^c is higher than h^d for any value of $\rho \in [0, 1]$.

♦ **Proposition 2: Equilibrium in pure strategies**

This is the standard result of Nash Equilibrium (NE) in a duopoly competition *à la Bertrand* with firms with equal and constant marginal costs. A brief proof of it requires at least three steps:

Let's first prove that there is no NE with $p_i \neq p_j$. Assume $p_i < p_j$. Since i has the lowest price, it serves all demand. The corresponding payoffs are $\Pi_i(p_i, p_j) = 2(p_i - c) > 0$ (I have assumed $p_i > c$, as $p_i < 0$ yields negative profits), and $\Pi_j(p_i, p_j) = 0$. Given these payoffs, choosing p_i is a profitable deviation for firm j, which shows that $p_i < p_j$ is not a NE. With the same logic, $p_j < p_i$ is not a NE either. Hence, if there is a NE, it must be at $p_i = p_j$.

Let's prove now that there is no NE with $p_i = p_j = p^* \neq c$. Assume first that $p_i = p_j = p^* < c$. In this context firms split demand in halves ($q_i = q_j = 1$), but get negative profits. A price $p^* < c$ would never be chosen. Assume, instead, that $p_i = p_j = p^* > c$. Again, firms split demand in halves, but notice that firm i can increase profits with a slight reduction in its price. In this way, firm i gets all demand and increase profits: $\Pi_i(p^*, p^*) = (p^* - c) < \Pi_i(p^* - \epsilon, p^*) = (p_i^* - \epsilon - c)2$, which is close to $(p^* - c)2$ when ϵ is close to zero. With the same logic, firm j also finds in a price reduction a profitable deviation. Hence $p_i = p_j = p^* > c$ is not a NE either.

Finally, let's show that $p_i = p_j = p^* = c$ is a NE. For $p_i = p_j = p^* = c$, firms split demand and obtain zero profits each, $\Pi_i(p^*, p^*) = 0$. In this context, if a firm reduces its price, it obtains negative profits. If, instead, it increases its price, the rival charges p^* and serves all demand. As there is no profitable deviation from the candidate outcome, this is a NE.

⧫ **Proposition 3:** In main text.

⧫ **Corollary 2:** Defining $\alpha \in [0;1]$ a distribution parameter, the payoff distribution rule that equates managers' expected profits from collusion implies:

$$R^c_{i1} = R^c_{12} \qquad , \qquad for\ i = A, B$$

were: $R^c_{i1} = (p^c - c)(1-\gamma)\alpha - \rho\left(1 - \frac{1}{4}\rho\right)\left(f + \frac{F}{2}\right)$ and $R^c_{i2} = (p^c - c)(1-\gamma)(1-\alpha) - \rho\left(1 - \frac{1}{4}\rho\right)\frac{F}{2}$. W.l.o.g. I have identified manager $i = 1$ as the manager that attends cartel meetings. Solving for α: $\alpha = \frac{1}{2} + \frac{\rho\left(1-\frac{1}{4}\rho\right) f}{2(p^c-c)(1-\gamma)} > \frac{1}{2}$.

⧫ **Proposition 4:** In main text.

⧫ **Lemma 2:** Holds from Propositions 3-4, and Corollary 3.

⧫ **Lemma 3: The *deterrence effect* from policy**

A more severe antitrust policy improves deterrence if thresholds parameters v_1 and v_2 are increasing in antitrust instruments F, f and ρ.

By definition, under the *complete* network design: $v_1 = c + \frac{\delta\ \rho\ (2-\rho)(2f+F)}{(2\delta-1)}$.

Taking partial derivative of v_1 with respect to fines F and f, one at the time: $\frac{\partial v_1}{\partial F} > 0$ and $\frac{\partial v_1}{\partial f} = 2\ \frac{\partial v_1}{\partial F}$, for $\delta > \frac{1}{2}$. An increase in fines always improves deterrence, but the highest impact is given when the policy is implemented through f. Working alike with respect to the antitrust parameter ρ, it holds that $\frac{\partial v_1}{\partial \rho} > 0$.

Under the *representative* network design, instead: $v_2 = c + \frac{\delta\ \rho\left(1-\frac{1}{4}\ \rho\right)(f+F)}{(2\delta-1-\gamma)}$.

The partial derivatives of v_2 with respect to the policy instruments f, F and ρ are all positive for the relevant case in which this type of network designs holds ($\gamma < 1/2$): $\frac{\partial v_2}{\partial f} = \frac{\partial v_2}{F} > 0$ and $\frac{\partial v_2}{\partial \rho} > 0$, for $\delta > 1/2$.

⧫ **Lemma 4: The *network-distortion* effect from policy**

Given the threshold parameter: $v_n = \frac{\rho(2-\rho)(2f+F) - \rho(1-1/4\rho)(f+F)}{\gamma} + c$, proving Lemma 4 implies proving three statements:

St.1: *'More severe antitrust policies induce some cartels to switch network for sustainability purposes, from the representative to the complete design.'*. Defining γ_{n1} the value of γ at which v_n and v_1 cross each other, and γ_{n2} the analogous value but for the case of v_n and v_2 crossing each other, Statement 1 holds for $\gamma_{n2} < \gamma_{n1}$.

St.2: *'Higher fines lead some surviving cartels to switch their complete network design for the representative one'*. That is to say: $\frac{\partial v_n}{\partial F}, \frac{\partial v_n}{\partial f} > 0$.

Since: $\frac{\partial v_n}{\partial f} = \frac{2\rho(2-\rho) - \rho(1-1/4\rho)}{\gamma} > 0$ and $\frac{\partial v_n}{\partial F} = \frac{\rho(2-\rho) - \rho(1-1/4\rho)}{\gamma} > 0$, statement 1 holds.

St.3: *More inspections have an ambiguous effect on the cartel's network decision. There exists $\hat{\rho}$ and $\hat{F}$, such that: for $\rho > \hat{\rho}$ and $F > \hat{F}$, more inspections lead some surviving cartels to switch their representative network design for the complete one. Otherwise, the opposite holds.*

That is to say: $\frac{\partial v_n}{\partial \rho} < 0$ for $\rho > \hat{\rho}$ and $F > \hat{F}$; while $\frac{\partial v_n}{\partial \rho} > 0$ in any other case. Given the partial derivative of v_n with respect to ρ:

$$\frac{\partial v_n}{\partial \rho} = \left(h'^C - h'^R\right)(f + F) + h'^C f$$

the first term in brackets on the RHS is positive for $\rho < 2/3$, and negative the other way around, since $h'^C = 2 - 2\rho > 0$ and $h'^R = 1 - 1/2\rho > 0$. Hence, defining $\hat{\rho} = 2/3$, if $\rho < \hat{\rho}$, $\frac{\partial v_n}{\partial \rho} > 0$. Otherwise, there exists $\hat{F} = \frac{f(6-7\rho)}{3\rho-2}$ such that $\frac{\partial v_n}{\partial \rho} > 0$ for $F < \hat{F}$ and $\frac{\partial v_n}{\partial \rho} < 0$ for $F > \hat{F}$.

♦ **Lemma 5:** Holds from Propositions 3-4, Corollary 3, and Lemma 2.

♦ **Propositions 5:** In main text.

♦ **Lemma 6:** Follows from:

- Firm-wide inspections do not affect the sustainability of cartels that set the *complete* network design with respect to the case in which inspections are driven towards a single division per firm (Proposition 5). However, they reduce it when cartels set the *representative* design , $v_2' > v_2$ (See Propositions 4 and 5), and
- Given collusion sustainability with the two network designs, cartels are less prone to delegate when inspections are firm-wide than when they are driven towards a single division per firm, $v_n' > v_n$ (See Corollaries 3 and 6).

♦ **Lemma 7-8:** Holds from Proposition 5 and Corollary 6.

♦ **Proposition 6:** For the analysis of the threshold parameters $\hat{\theta}$ and $\hat{\theta}^R$ see main text. The threshold parameter $\hat{\theta}^n$ arises from the ICC that faces a cartel that in the absence of the LP used to collude with the *complete* network design, but that after its introduction finds that: (i) such a network strategy is not sustainable anymore, and (ii) keeping conspiring with the *representative* design is more profitable than deviating with a leniency report. That is:

$$(v - c) - \theta(2f + F) \leq \frac{\delta}{1-\delta} \; [v - c - \rho(1 - 1/4\rho)(f + F)]$$

Solving for θ, the threshold parameter $\hat{\theta}^n$ is $\hat{\theta}^n = \frac{(v-c) - \frac{\delta}{(1-\delta)} \; [v-c-\rho(1-1/4\rho)(f+F)]}{2f+F}$. With a little bit of algebra, the reader can prove that: $\hat{\theta}^n \in \left(\hat{\theta}^R, \hat{\theta}\right)$.

As in the basic set-up, the welfare implications of the policy depend directly on its ability to prevent collusion under the *representative* network design.