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Debt, Managers and Cartels

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Salvatore Piccolo* **and Giancarlo Spagnolo****

Abstract
We propose a theory of anticompetitive effects of debt finance based on the interaction between capital structure, managerial incentives, and firms ability to sustain collusive agreements. Shareholders' commitments not to expropriate debtholders through managers with valuable reputations or common incentive schemes greatly facilitate collusive behavior in product markets. Disclosure rules aimed at improving transparency in corporate governance or network-based credit markets can confer credibility to such arrangements even in environments where firms lack commitment power, thereby inducing collusion through leverage in otherwise competitive downstream industries. Managers are happy with the arrangement since they share in the collusive rent.

JEL Classification: D21, G32, L13, L41

Keywords: Bankruptcy, capital structure, collusion, corporate governance, credit markets, disclosure rules, financial regulation, managerial incentives, product market competition.

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1. Introduction

A growing evidence shows that cartels continue to exist, that they are actually ubiquitous and that collusive practices are becoming more complex and hence harder to detect, despite the quality and intensity of antitrust enforcement increased considerably over the last decades (see, e.g., Asker, 2010; Marshall and Marx, 2012; and Miller, 2009). Price-fixing conspiracies are the worst competitive problem for a market: up-to-date estimates of the economic costs of cartels show that the burden they impose on final consumers is far from being small.[1]

Recent theoretical advances, such as Harrington and Skrzypacz (2007, 2011), have considerably improved our knowledge of how cartels work. However, while a good understanding of the factors that confer stability to cartels is a key step towards the design of legal environments that effectively discourage them, there are still many aspects of cartels that are unknown. This paper offers a contribution to this debate by exploring the link between debt financing, corporate governance and cartel stability.

Although it seems natural to conjecture that leverage and managerial incentives may affect firms' collusive attitudes, and the importance of the relationship between corporate governance and product market competition has been stressed before (see, e.g., Allen and Gale, 2000, and Nini et al., 2013)[2], relatively little was known on the interaction between corporate governance and collusive behavior up to now. A starting point of our analysis is the empirical observation that, in some concentrated industries, high leverage is correlated with low output, high prices and more passive investment behavior: debt finance appears to have anti-competitive effects on at least some product markets.[3] Yet, these findings are somewhat surprising because established theories of the interaction between financial and product markets, like Brander and Lewis (1986) and Maksimovic (1988, 1995), predict that debt should lead high leveraged firms to compete more aggressively in the product market.

Our point is that a completely new perspective on the anticompetitive effects of leverage may emerge when combining appropriately managerial incentives, corporate debt design and product market competition, three aspects that have been traditionally studied in isolation in earlier models. Our model explains why debt and professional managers may be used as coordination devices by downstream firms to sustain non-competitive outcomes in otherwise competitive industries. In a nutshell, we find that when shareholders can credibly commit against strategic default by hiring a manager with an established reputation, debt need not hinder product market collusion, as originally found by Maksimovic, but may actually facilitate the establishment of market power via horizontal price fixing. Commitments to debtholder-

[1] See, e.g., Smuda (2013) and Boyer and Kotchoni (2011), who argue that the mean and median overcharge rates are about 20 percent and 18 percent of the selling price.

[2] While the survey by Allen and Gale (2000) discusses the theoretical forces that may induce competition to affect corporate governance, Nini et al. (2013) provide fresh evidence that creditors play a crucial role in the governance of corporations well outside of payment default states.

[3] See, e.g., Chevalier (1995), Chevalier and Sharfstein (1996), Kovenock and Phillips (1995, 1997), and particularly Phillips (1995).

friendly behavior through conservative managerial incentive schemes has an even stronger pro-collusive effect that reinforces those relating to managers' reputational concerns.

Our results are obtained in a dynamic leveraged oligopoly model à la Maksimovic's (1988, 1995). The novel feature of our analysis is that we allow firms to be led by managers that experience reputational costs from bankruptcy, as seems to be the case in many modern markets. Within this setting, we first show that for positive levels of managers' bankruptcy costs, debt facilitates firms' collusion: when leveraged firms are led by self-interested managers, the critical discount factor above which the monopoly outcome is sustainable is lower than in the case of self-managed firms. Intuitively, when managers experience reputational costs from financial distress, a high level of debt makes it more costly for them to deviate because this reduces the spot gain from deviation (relative to the case of self-managed firms). Two opposing effects shape the impact of an expansion of debt on the critical discount factor above which firms are able to sustain the monopoly outcome. On the one hand, higher indebtedness implies stronger incentives for the managers to break a collusive agreement: undercutting rivals secures the full monopoly profit in one period, which is (ceteris paribus) more attractive than repaying a large debt and sharing the monopoly profits with rivals. On the other hand, because defaulting managers experience a loss of reputation that might increase with the amount of unrepaid debt, expanding firms' indebtedness also makes the punishment phase more costly for them. On balance, this tension depends on the difference between the responsiveness of the managers' reputation loss to the amount of unrepaid debt and the managers' stake in the firm's profit. The punishment effect dominates when managers' reputation is strongly correlated with firm performance, and the opposite holds true otherwise.

Building on these two basic forces, we then endogenize debt by characterizing the mix between leverage and managerial incentives that maximizes the cartel's aggregate profit (subject to the relevant self-enforceability and participation constraints). This analysis provides several novel insights. First, we show that debt enhances firms' collusive ability only if they are led by self-interested managers: debt and managerial incentives are (weak) complements in our framework. Second, we argue that this complementarity bites only in the region of parameters where the (common) discount factor is neither too large nor too small, and managers' reputation loss from default is sufficiently responsive to the amount of unrepaid debt. The reason is as follows: if managers' personal cost of bankruptcy is sufficiently responsive to the amount of unrepaid debt, the effect of leverage on the punishment profits dominates its effect on the (net) gain from deviation.

Finally, our comparative statics suggests that firms operating in less concentrated industries and/or in industries with high market profitability are more likely to rely on debt to sustain collusive agreements. This is because, in these cases, firm managers are more tempted to undercut rivals in order to grab rents that are (ceteris paribus) higher than the utility they would obtain in the collusive phase. Similarly, higher debt financing is more likely to facilitate collusion in the product market when managers' bargaining power vis-à-vis shareholders is stronger. Indeed,

when managers enjoy better outside options, their stake in the firm's profit must increases, which leads (ceteris paribus) to higher profits from deviations and thus to relatively more reliance on debt to sustain non-competitive outcomes in the product market.

Note that our conclusions do not require coordination or communication across firms at any stage. Therefore, our analysis also sheds light on the effects of financial arrangements on tacit collusion. Our results are also robust to a number of natural extensions of the baseline model. First, we argue that, more generally, they are not sensitive to the type of product market competition. In particular, we find that debt is more likely to be used as a collusive device in industries that (everything else being kept constant) feature a higher elasticity of demand and/or a higher degree of product differentiation. Second, although in the baseline model we assume that firms are able to make binding commitments to debtholder-friendly behavior and to appropriate managerial incentive schemes, results remain qualitatively the same when the commitment hypothesis is relaxed. Specifically, we find that in an environment where financial choices and managerial contracts can be secretly renegotiated, debt financing might still facilitate collusion as long as firms manage to borrow from common lenders — i.e., the lending relationships between banks and product market rivals is non-exclusive. The effect is weaker, however, with secret renegotiation. This suggests that financial regulation, disclosure and liability rules designed to protect investors and limit financial market manipulation (like Form 8-k of the Securities Exchange Act) may have a direct impact on the commitment value of debt and managerial contracts, and through that channel on cartel formation and stability.[4] Moreover, recent evidence suggests that product market competition is sufficient to discipline firms, and that corporate governance only matters when product market competition is weak (Muller and Giraud, 2010 and 2011). In the light of these findings, our results imply that disclosure and liability rules designed to improve financial market transparency and corporate governance, by increasing cartel stability may also end up worsening precisely the problems they were supposed to address.

Summing up, our results make a step forward towards a better understanding of the relation between debt and cartel formation by complementing Maskimovic's pioneering analysis, the conclusions of which appeal more to industries where managerial incentives are less important — e.g., when firms have a large main shareholder that exerts strong control, or for entrepreneurial and family-run firms. The predictions of our model square with the evidence mentioned earlier and are consistent with classic empirical regularities, like debt issues being perceived as good news by the stock market (James, 1987; Harris and Raviv, 1991) and that the probability of a firm undertaking an LBO is positively related to competitors' leverage (Marsh, 1982; Chevalier, 1995).

Also, Zwiebel (1996) has convincingly argued that an important weakness of many models

[4] Our conclusion that the transparency/disclosure requirements typical of corporate governance regulations may facilitate collusion by allowing firms to easily monitor each other's financial and governance situation is close in spirit to Stigler's (1964) argument that public procurement transparency/disclosure rules may greatly facilitate bidding rings by allowing them to easily monitor other firms' choices.

of the disciplinary role of debt is that financial decisions must be made *ex ante* and must be out of managers' control, since debt leaves managers worse off.[5] One appealing feature of our model is that it provides a novel explanation for why, in some circumstances, managers are willing to choose high leverage, putting themselves under the threat of bankruptcy: a combination of debt and conservative incentives may be a commitment to profitable, collusive behavior and (for the commitment to be credible) managers must receive a stake of the collusive rent.

The paper is organized as follows. Section 2 relates our work to the existing literature. Section 3 sets up the baseline model, shows how managers' reputation and debtholder-friendly incentives affect the relation between debt finance and dynamic product-market competition, and characterizes the mix of debt and managerial incentives that maximizes collusive profits. Section 4 extends the analysis to the case of product differentiation and lack of commitment, and shows how common/allied lenders can monopolize competitive product markets by conferring credibility to commitments to "prudent management". Section 5 summarizes our policy predictions, while Section 6 concludes. All proofs are in the Appendix.

2. Related literature

Besides the literature already mentioned in the introduction, the paper is related to most previous research on the interaction between firms' financial structure and product market competition. It stands in contrast to the two most established theories on the subject, the "long purse" and the "limited liability" theories. According to McGee's (1958) and Telser's (1966) "long purse" or "deep pockets" theory, when some firms issue debt, their unleveraged competitors will find it convenient to engage in a market war in order to drive them to bankruptcy and eventually out of the market.[6] According to Brander and Lewis' (1986) "limited liability" theory, the "asset substitution" problem highlighted by Jensen and Meckling (1976) should lead shareholders of leveraged firms to disregard low product market states, from which they are protected by limited liability, and choose overly aggressive product market strategies.[7] The strictly related argument that owners' limited liability limits leveraged firms' ability to sustain tacit collusion was developed by Maksimovic (1988), and extended by Stenbacka (1994) and Hege (1998). Of course, these theories cannot explain the evidence mentioned in the introduction, as their natural implication is that debt finance should increase product market competition by leading either leveraged firms or their competitors to behave more aggressively.[8]

[5] In Zwiebel's words: "[...] this contrasts with common perception of leveraged choices being in the domain of standard managerial decisions. Managers commonly undertake capital decisions without any apparent extraordinary external threat." For example, in the leveraged buyout wave of the '80s it was managers who usually took the initiative, and increases in leverage were accompanied by simultaneous changes in managerial incentives.

[6] This argument has been formalized in models of "predation" — e.g., Benoit (1984), Fudenberg and Tirole (1986), and Bolton and Scharfstein (1990).

[7] This argument was also made by Maksimovic (1986).

[8] Noteworthy, a paper by Deamon (1997) analyzes an infinitely repeated version of the Brander and Lewis (1986) model trying to demonstrate a pro-collusive effect of debt. Unfortunately, the results of that paper are flawed. In the proof of Proposition 1 and in the remainder of the paper the author fails to acknowledge that the positive

The model is also related to the literature on banks as 'gatekeepers' of product markets pioneered by Bhattacharya and Chiesa (1995), analyzing the effects of a monopolist lender on downstream industries by focussing on entry, rather than collusive behavior. Bhattacharya and Chiesa show that a common lender internalizes market externalities between borrowing firms, facilitating information-sharing in R&D and ensuring that only one firm enters the product market. In this spirit, Cestone and White (2003) show that a monopolist/dominant bank would deny credit to a potential product market entrant when it is already financing an incumbent firm, and that banks are more prone to excluding entrants when they hold equity in the incumbent.[9] In addition to our dynamic approach, one fundamental difference between our model and these studies is that we do not need a monopolistic banking sector to obtain our results (they obtain with a perfectly competitive banking system). In these models, instead, the role of the monopolist (common) lender is key to blocking entry in the downstream market.

As for the common lender, Poitevin (1989) also emphasizes its coordinating role, but in a two-stage model à la Brander and Lewis (1986) with commitment. In this set-up, he shows that when firms borrow from a common lender their overly aggressive product market behavior may be reduced by a suitable choice of interest rates. Still, in his model the overall effect of debt finance remains *pro*-competitive. Moreover, in our model the need for a common lender arises only with lack of commitment. In this dimension, our model also has implications for bank specialization. Bank specialization automatically leads to situations where several competing firms are financed by the same bank(s). Here we show that there may be important additional benefits for banks from specializing on a certain type of borrowers, over and above informational ones.

Interestingly, the common lender mechanism echoes the findings of the literature dealing with the relation between partial cross ownership and tacit collusion — see, e.g., Gilo et al. (2006), among others. In these models partial ownership might help collusion insofar as it induces each firm to internalize the negative externality that a deviation from the collusive agreement imposes on its rivals through the stake it owns in their profits. In our model, these externalities are indirectly taken into account by the common lender mechanism, so that firms do not have to buy shares of competitors to cooperate. However, it is worth noting that although achieving the same goal of cross ownership, the common lender mechanism seems potentially more harmful because competition and antitrust authorities may be quite suspicious when observing cross

per-period probability of bankruptcy induced by debt increases the effective rate at which owners discount future profits. Moreover, the author neglects that, besides reducing firm shareholders' short-run gains from deviation and payoffs in the non-cooperative punishment phase, debt also directly reduces per-period payoffs during the collusive phase; and that this last effect alone dominates that on short-run gains from deviation. Taking these effects into account, in that model collusion would be more easily sustained by unleveraged firms who threaten to punish deviations by issuing debt during punishment phases. In other words, the repetition of Brander and Lewis' (1986) model leads to a theory of how the opportunity to issue debt facilitates collusion between unleveraged firms by lowering owners' payoffs during the punishment phase. However, such a theory would predict that firms are leveraged only during punishment phases, with empirical implications opposite to the evidence discussed in the introduction.

[9] Hellmann and DaRin (2002) reach analogous conclusions in an extension of their "big push" model.

ownerships agreements, while there are obvious specialization arguments that may justify the presence of a common lender. As a result, making a case against a cartel whose stability is guaranteed by a common lender may be more difficult than arguing against cross ownership.

Other theories have been proposed to rationalize the positive empirical relation between leverage and markups often found in product markets.[10] None of these papers deals with the relation between debt finance and firms' ability to sustain tacit collusion in dynamic competition. On this issue, the state of the art is the work of Maksimovic (1988, 1995), Stenbaka (1994) and Hege (1998), according to which debt always hinders firms' ability to sustain collusive agreements.

Finally, the paper is related to the recent and growing collection of work on collusion and vertical contracting — see, e.g., Nocke and White (2007, 2010), Jullien and Rey (2007), Piccolo and Miklós-Thal (2012) and Piccolo and Reisinger (2011), among others. All these papers analyze the impact of franchise contracts on cartel stability, but neglect the impact of debt financing as a collusive device, which is the key issue addressed in this paper.

3. The baseline model

Product market competition. N identical competing firms play an infinitely repeated game. Time is discrete ($\tau = 1, .., +\infty$), and the common discount factor is $\delta \in (0, 1)$. The firms maximize the expected discounted sum of their profits and, in each period, choose whether to collude or compete à la Bertrand. The gross profit of each firm i is: $\pi > 0$ if all firms collude (when they all charge the monopoly price); $N\pi$ if firm i deviates from a collusive agreement (by undercutting the monopoly price) while its $N - 1$ rivals stick to it; and 0 in the unique equilibrium of the stage game where all price at marginal cost. Price decisions in period τ become common knowledge at the beginning of period $\tau + 1$, so the game is one of perfect monitoring.

Credit market and capital structure. There is a competitive credit market. At $\tau = 0$, before the product market stage takes place, firms can issue long-term debt. A debt contract between firm i and its lender is a pair $(L_i, (b_i^\tau)_{\tau=1}^{+\infty})$, specifying a loan L_i (received by firm i in period $\tau = 0$), and a per-period (pledged) repayment b_i^τ, with

$$\sum_{\tau=1}^{+\infty} \delta^\tau b_i^\tau = L_i,$$

as implied by the banks' zero profit condition. For simplicity, assume that the initial loan L_i is consumed right away by firm i's shareholders. Hence, in the subsequent periods, debt is repaid

[10] For example, Glazer (1994), Showalter (1995) and Faure-Grimaud (2000) obtain anti-competitve effects of debt finance by modifying the assumptions of Brander and Lewis' (1986) model, and Aghion et al. (1999) develop a model where entrepreneurs can commit towards finance providers to increase effort at a cost, and find that an increase in external finance may either increase or decrease competition in oligopolistic product markets, depending on its initial level.

only through sales revenue. Whenever a firm is unable to repay its debt, bankruptcy occurs. Bankrupt firms are sold to new owners with short time horizons that maximize spot profits — i.e., if collusion breaks down, the market does not cartelize again.[11]

We assume, without loss of generality, that each firm borrows from one lender. The reason is that only the total size of each firm's pledged repayment matters to stabilizing collusion in the product market, as will be explained shortly.[12]

Organizational structure. Shareholders can delegate pricing decisions to self-interested managers. In contrast to Maksimovic's environment, in our model there is a conflict of interests between property and management. This misalignment of preferences is because managers dislike bankruptcy while shareholders don't — i.e., defaulted managers bear personal reputational costs. For professional managers, bankruptcy implies a substantial drop in their reputation, together with either the loss of their job or a drastic wage cut.[13] Moreover, lenders often explicitly ask shareholders to hire top managers with a particularly solid reputation for 'prudent behavior', who have much to lose from driving the firm into bankruptcy.[14]

Managers' costs of bankruptcy have already been taken into account by earlier models studying firms' financial policy (Ross, 1977; Hirshleifer and Thakor, 1992) or business cycles (Greenwald and Stiglitz, 1990 and 1993). Berk et al. (2010) showed that they are naturally caused by optimal contractual arrangements in perfectly competitive capital and labor markets.

Following this literature, we modify firms' long run objective function to incorporate such costs. Formally, we define by $C + \phi\left(b_i^\tau - \pi_i^\tau\right)$ the cost of bankruptcy for the manager that runs firm i, where $\pi_i^\tau < b_i$ is firm-i's actual profit when default occurs in period τ. Hence, each manager i's direct costs from financial distress are decomposed in a fixed component C, and a variable one $\phi\left(b_i - \pi_i^\tau\right)$ that is proportional to the severity of firm i's financial problems — see, e.g., Ross, (1977). Managers' reservation utility is $\underline{u}$, with $0 \leq \underline{u} < \pi$ — i.e., a higher $\underline{u}$ implies better outside options for the managers, as reflected by a more competitive labor market.

Managerial compensations. Following Fershtman and Judd (1987), we assume that in every period managers are paid a fixed wage (normalized to zero) plus a share $\alpha_i \in [0, 1]$ of the period's net profits — i.e., manager i's wage in every period τ is $w_i(\cdot) = \alpha_i(\pi_i^\tau - b_i)$, where π_i^τ is firm i's actual profit in period τ.[15] We denote this type of contracts as *Net Profit Sharing* (NPS).

[11] The alternative assumption, that after bankruptcy firms exit from the product market, readily transforms the model into a "predation" one. It can easily be shown that in this case debt makes collusion impossible: it greatly increases firms' incentives to deviate, drive competitors bankrupt, and monopolize the market, while no credible punishment is available to firms as a deterrent.

[12] This is because the credit market is perfectly competitive and there is no moral hazard.

[13] Gilson (1989) and Gilson and Vetsuypens (1993) found that about half of the managers of firms facing financial distress are replaced and are not re-hired by comparable (exchanged-listed) firms for the following three years; and that those who are retained experience very large reductions in salary and bonuses. See Eckbo and Thorburn (2003) and Eckbo et al. (2012) for more recent evidence on managers' costs from bankruptcy.

[14] Gilson (1989) also finds that a significant number of changes of management are initiated by creditors, e.g. during debt restructuring.

[15] Notice that gross profit sharing contracts would have an even stronger effect: with these schemes the managers' wage would not be affected by the firms' financial structure and the negative effect of debt on collusion found

To isolate the effects of debt and bankruptcy on managerial behavior and collusion we focus on managers under a long-term NPS which leads them to maximize an objective function equivalent in all aspects to that of shareholders except in the evaluation of bankruptcy.

Timing. The industry is funded at time $\tau = 0$. At this stage, firm owners (shareholders) simultaneously choose how much debt to take on and offer contracts to their managers. These choices become common knowledge before contracts are signed. From stage $\tau = 1$ onwards, managers play the repeated product market game described above on behalf of their shareholders if hired. Firm members — i.e., managers and shareholders — are protected by limited liability. Hence, in case of default, banks can seize at most the product market earnings.

We first assume that contract announcements are binding — i.e., that there is full commitment both to managerial and loan contracts. Transparency requirements are mandatory in many countries where firms are obliged to disclose verifiable information about their financial structure as well as the contracts offered to their top managers (see Section 5.3 for a detailed discussion on the forms of regulation that facilitate the exchange of this type of information). By contrast, in countries where disclosure requirements are not mandatory or with weak enforcement of these standards, commitment seems a reasonable assumption as long as firms manage to exchange confidential information through trade associations, credit bureaus or common intermediaries. This is the case in many markets, which have been incidentally under close scrutiny from antitrust and competition authorities all over the world.[16] We will relax this hypothesis in Section 4.2 to see how the results change when firms' contract announcements are not binding.

Collusion. Since players are identical, throughout we will focus on symmetric and stationary collusive strategies that implement the monopoly outcome. A (stationary) debt contract between firm i and its lender is a pair (L_i, b_i), specifying a loan L_i (received by firm i in period $\tau = 0$), and a per-period (pledged) repayment b_i, with $b_i = (1 - \delta) L_i$ as implied by the banks' zero profit condition. Hence, besides prescribing managers to charge the monopoly price in the collusive phase, and the competitive price in the punishment phase, a collusive strategy must also recommend a financial structure (L, b) to be announced by all firms (hereafter simply denoted by b) and a NPS contract α to be offered by all shareholders to their managers.

Consistently with the commitment hypothesis, we assume that whenever there is a deviation at time $\tau = 0$ — i.e., either because one or more firms issue a contract different from α or because some of them borrow an amount different from L — firms play the zero profit equilibrium of the stage game in every subsequent period of the market game — i.e., out of the equilibrium path they all price at marginal cost. Note that this is behavior is rational since we have assumed that shareholders and managers are protected by limited liability.

by Maksimovic would disappear by assumption. Other commonly observed compensation contracts (like stock options and discrete bonuses) would obviously further strengthen the pro-collusive effect identified here — see, e.g., Spagnolo (2000, 2005).

[16] For example, in 2006 the European Commission concluded that a number of steel companies (Salzgitter AG, Thyssen Stahl AG, Krupp Hoesch Stahl AG, Empresa Nacional Siderúrgica SA and Corus UK Ltd) and their trade association (Eurofer), had colluded to fix prices, share markets and exchange confidential information.

3.1. Self-managed firms

Before analyzing the case where firms' strategic decisions are taken by self-interested managers, it is useful to describe the equilibrium outcome of the game when all firms are self-managed — i.e., there is no separation between property and management.

In this scenario, a symmetric and stationary collusive strategy requires a debt structure $b < \pi$ for every firm i to be issued at $\tau = 0$ and a price decision in every subsequent stage. As explained above, we consider, with no loss of generality, the class of strategies such that firms charge the monopoly price in equilibrium, while pricing at competitive level once a deviation occurs — i.e., firms use grim-trigger strategies to punish deviations. Hence, each firm i earns $\pi - b$ in collusion, $N\pi - b$ in deviation, and it goes bankrupt in the punishment phase.

For any debt $b \in [0, \pi)$, the condition for the collusive agreement to be respected by each firm i is

$$\frac{1}{1-\delta}(\pi - b) \geq N\pi - b + \frac{\delta}{1-\delta}\max\{0, -b\} \quad \Leftrightarrow \quad \delta \geq \delta^*(b) \equiv 1 - \frac{\pi - b}{N\pi - b}. \tag{3.1}$$

By inspection, collusion is more difficult to sustain when firms' debt increases (i.e., when b grows). This is Maksimovic's (1988, 1995) main result. Essentially, more indebted firms have less to gain by sticking to the collusive agreement. Hence, high debt destabilizes the formation of cartels in the product market. As a result, an optimal collusion strategy mandates no debt, so that the critical discount factor for the monopoly outcome to be sustainable is

$$\delta^* = \frac{N-1}{N},$$

which is the standard outcome of the repeated Bertrand game. In the next section we will argue that this conclusion may dramatically change when firms are run by self-interested managers.

3.2. Collusion via self-interested managers

Maksimovic's result is derived under the standard assumption of profit-maximizing firms. However, large companies are led by managers whose incentives may not be perfectly aligned with the objectives of their shareholders.[17] What is the role of managers when competition takes place repeatedly over time? Does a careful design of managerial incentives facilitate collusion? If so, how is this result affected by the firms' financial structure?

In this section we will address these issues in the simplest possible framework for our purposes. We will first analyze the impact of firms' leverage on the managers' incentive to collude, then we will characterize the levels of α and b that maximize the cartel's profits subject to the relevant participation and self-enforceability constraints. For brevity, we restrict the analysis to the most interesting region of parameters where $\delta < \delta^*$. Indeed, for δ larger than this threshold,

[17] Classical references include Williamson (1964), and Jensen and Meckling (1976).

the result is straightforward: shareholders do not even need to hire managers to sustain the monopoly outcome.

For any pair of contracts (α, b) prescribed by a symmetric collusive strategy, the self-enforceability condition for the monopoly outcome to be sustainable is

$$\frac{\alpha}{1-\delta}(\pi - b) \geq \alpha(N\pi - b) - \delta(C + \phi b). \tag{3.2}$$

The left-hand side of this condition is the managers' discounted stream of profits on the equilibrium path — i.e., when they all charge the monopoly price. The right-hand side is a manager's deviation profit, which is the sum of two opposing components: the spot gain from deviation $\alpha(N\pi - b)$, and the subsequent cost of bankruptcy $C + \phi b$. Since, by assumption, after bankruptcy the market will never cartelize again and punishment profits are zero, a deviating manager gets no rent in the continuation game following a price cut.

Hence, if pricing decisions are delegated to self-interested managers, the monopoly outcome can be sustained if and only if

$$\delta \geq \delta^{**}(b, \alpha),$$

with $\delta^{**}(b, \alpha) \in (0, 1)$ being the positive solution of condition (3.2) taken as equality.

To gain insights about firms' incentives to hire managers and to issue strategic debt, in the next lemma we study how α and b affect the critical discount factor $\delta^{**}(b, \alpha)$ and compare this threshold with that characterized in the case of self-managed firms.

Lemma 1. *Suppose that $\delta < \delta^*$, then for any $\alpha \in [0, 1]$ and $b \in [0, \pi]$:*

- *The monopoly outcome is harder to sustain when managers' compensation is more responsive to profits — i.e., $\delta^{**}(b, \alpha)$ is increasing in α.*
- *The impact of higher debt on the firms' collusive ability is ambiguous. Specifically, $\delta^{**}(b, \alpha)$ is decreasing in b if and only if α is not too large relative to ϕ; otherwise, the opposite holds true.*
- *Everything else being kept equal, collusion in the product market can be sustained more easily when all firms are led by self-interested managers than when they are self-managed — i.e., $\delta^{**}(\cdot) < \delta^*$ if $C + \phi b > 0$.*

The economic intuition of this result is as follows. First, when α grows large, managers are more tempted to deviate because, by doing so, they can grab a larger share of the monopoly profit. Hence, ceteris paribus, managerial compensations that are more responsive to firms' profits make collusion less easy to sustain — i.e., high-powered incentives hinder collusion.

By contrast, when firms are more indebted (i.e., if b increases), two opposing effects shape a manager's incentive to charge the monopoly price. On the one hand, a higher indebtedness implies stronger incentives to break the cartel: a manager that (unexpectedly) undercuts his

rivals can grab the full monopoly stake in one period, which is (ceteris paribus) more attractive than repaying a large debt and sharing the monopoly rent with rivals. On the other hand, because defaulting managers experience a loss of reputation proportional to the amount of unrepaid debt (as measured by the coefficient ϕ), increasing firms' indebtedness also makes the punishment phase more costly for the managers. On balance, this trade-off depends on the difference between the sensitivity of the managers' reputation loss to the unrepaid debt ϕ and the managers' stake into the firm α. The punishment effect dominates when managers' reputation is very sensitive to the firm's performance relative to their stake — i.e., when ϕ is large relative to α. Otherwise, the opposite holds true.

Finally, in contrast to Maksimovic (1988, 1995), for positive levels of bankruptcy costs, debt facilitates firms' collusion. Intuitively, when managers bear personal (reputational) costs from financial distress, a high level of debt makes it more costly for them to deviate because this reduces the spot gain from deviation. This effect unambiguously increases firms' ability to sustain a non-competitive outcome on the product market. Hence, Lemma 1 suggests that hiring self-interested managers may facilitate collusion, and, most importantly, that the managers' incentives to sustaining non-competitive outcomes on the product market might be amplified by high debt provided that managers' loss of reputation in case of default is strongly correlated with the amount of unrepaid debt. Building on these insights, in the next section we study the configuration of parameters under which this is actually an optimal strategy for the cartel.

3.3. Endogenizing debt

Lemma 1 raises a few natural questions that can be addressed in our simple environment: What is the combination of debt and NPS that maximizes the cartel's profit? Are these instruments substitutes or complements? Under what conditions does higher indebtedness facilitate price coordination in the product market? To address these issues, in the rest of the section we characterize the optimal symmetric collusion strategy that allows the monopoly outcome to be sustained in the product market — i.e., the combination of leverage b and NPS α that maximizes shareholders' aggregate profits subject to the managers' incentive compatibility (self-enforceability) and participation constraints.

Assume that shareholders need to hire managers in order to coordinate on a non-competitive outcome in the product market (we will verify ex post under what conditions this conjecture is actually satisfied). The cartel's maximization problem at $\tau = 0$ is

$$\max_{\alpha\in[0,1],b\in[0,\pi]} \frac{(1-\alpha)(\pi-b)}{1-\delta}$$

subject to

$$\alpha(\pi-b) \geq \underline{u}, \tag{3.3}$$

$$\frac{\alpha}{1-\delta}(\pi-b) \geq \alpha(N\pi-b) - \delta(C+\phi b). \tag{3.4}$$

Equation (3.3) is the managers' participation constraint: it simply requires that (on the equilibrium path) the managers' wage exceeds their reservation utility in every period. Equation (3.4) is the self-enforceability constraint already discussed above.

Since the shareholders' objective function is decreasing in α, while the critical discount factor $\delta^{**}(\cdot)$ is increasing in α, the participation constraint (3.3) will necessarily bind at an optimum of the cartel's maximization problem. Hence,

$$\alpha(b) = \min\left\{1, \frac{\underline{u}}{\pi - b}\right\}, \tag{3.5}$$

which is the minimal share of profits that shareholders need to give up to managers in order to guarantee their participation. Assuming without loss of generality that $\alpha(b) < 1$, substituting (3.5) into the cartel's objective function and into the self-enforceability constraint (3.4), the cartel's maximization problem rewrites as

$$\max_{b\in[0,\pi]} \frac{\pi - b - \underline{u}}{1-\delta},$$

subject to

$$\frac{1}{1-\delta}(\pi - b) \geq N\pi - b - \delta\frac{(C + \phi b)(\pi - b)}{\underline{u}}. \tag{3.6}$$

Notice that for $\underline{u} = 0$ managers are always willing to accept the zero rent contract $\alpha = 0$. This implies that the constraint (3.6) is satisfied for any debt level and for any discount factor δ. This argument echoes the findings of Spagnolo (2000, 2005) that appropriately designed managerial compensations may help firms to sustain collusive outcomes that could not be sustained by self-managed firms. Hence, when the market for managers is not very competitive and shareholders have strong bargaining power, hiring self-interested managers that are averse to bankruptcy and providing them with pro-collusive incentives, allows shareholders to implement the monopoly outcome for any discount factor. This case is, however, rather unrealistic, thus in the rest of the analysis we will focus on the scenario where managers' outside option binds (i.e., $\underline{u} > 0$), and it actually determines the lower bound on the fraction of collusive rents that shareholders need to forego in order to induce managers to participate in the collusive agreement.

Since the cartel's objective function is decreasing in b, the solution of the above maximization problem requires firms to issue the minimal level of debt that guarantees collusion, if it exists. In the next proposition we study how the trade-off discussed above shapes the optimal combination of debt and managerial incentives.

Proposition 1. *Assume that $\underline{u}$ is not too large. The optimal symmetric collusive strategy that allows firms to sustain the monopoly outcome has the following features:*

- *It combines debt and NPS only if*

$$\phi > \underline{\phi} \equiv \frac{2\underline{u}\,(N-1)\,C}{\pi\left[C - N\underline{u} - \sqrt{(C-N\underline{u})^2 + 4C\underline{u}}\right]}.$$

In this region of parameters, there exist two thresholds $\underline{\delta}$ *and* $\overline{\delta}$*, with*

$$0 < \underline{\delta} \equiv \frac{\underline{u}}{\pi\phi}\,(N-1) < \overline{\delta} \equiv \frac{1}{2} - \frac{N\underline{u} + \sqrt{(C-N\underline{u})^2 + 4C\underline{u}}}{2C} < \delta^*,$$

such that:

  - *For every* $\delta \in (\overline{\delta}, \delta^*]$ *firms do not issue debt to sustain the monopoly outcome:* $b^* = 0$*. However, shareholders must delegate pricing decisions to independent managers to sustain this outcome:* $\alpha^* = \frac{\underline{u}}{\pi} < 1$*.*
  - *For every* $\delta \in (\underline{\delta}, \overline{\delta}]$ *firms issue debt and hire independent and self-interested managers to sustain the monopoly outcome:* $\alpha^* = \frac{\underline{u}}{\pi - b^*} \in (0,1)$ *and* $b^* \in (0, \pi)$*, with* b^* *being the lowest (positive) solution of*

$$\frac{1}{1-\delta} + \delta\frac{C + \phi b}{\underline{u}} = \frac{N\pi - b}{\pi - b}. \tag{3.7}$$

  - *For every* $\delta < \underline{\delta}$ *the monopoly outcome is not sustainable — i.e., firms do not hire managers or issue debt — and the game features a unique SPNE that is the perfectly competitive one.*

- *If* $\phi \leq \underline{\phi}$*, firms never use debt to sustain the monopoly outcome. If* $\delta < \overline{\delta}$ *and the game features a unique SPNE that is the perfectly competitive one; if* $\delta \in \left[\overline{\delta}, \delta^*\right]$ *shareholders must delegate pricing decisions to independent (but not necessarily self-interested) managers to sustain the monopoly outcome:* $\alpha^* = \frac{\underline{u}}{\pi} < 1$*.*

Hence, debt expands firms' collusive ability only if they are led by self-interested managers. The complementarity between debt and delegation emerges only in the region of parameters where the discount factor is neither too large nor too small, and managers' reputational loss from default is sufficiently responsive to the amount of unrepaid debt. The reason is that when ϕ is large enough, the effect of debt on punishment dominates its effect on the (net) gain from deviation, thereby making high debt an anticompetitive device. This complementarity is the main novelty of our model. While the impact of managerial contracts on collusion has been extensively studied — see, e.g., Spagnolo (2000, 2005) — to the best of our knowledge the relationship between debt financing, CEO incentives and collusion has been systematically neglected in the earlier models.

Note that restricting the analysis to the case where $\underline{u}$ is not too large is without loss of insights: this restriction simply allows us to focus on the most realistic outcome of the game where shareholders get a positive share of the collusive rents (i.e., $\alpha^* < 1$). Indeed, when $\alpha^* = 1$ shareholders are indifferent between inducing collusion or letting their managers play the competitive outcome of the product market game. However, since they do not share collusive rents, the second option seems more reasonable.[18]

In the next proposition we study how the underlying parameters of the model affect the optimal debt structure when firms use debt for collusive purposes.

Proposition 2. *b^* and α^* are both increasing in N, π and $\underline{u}$, and decreasing in C, ϕ and δ.*

In less concentrated industries (i.e., where N is large) or in industries with high market profitability (i.e., where π is large), managers have more incentives to undercut rivals, whereby inducing more reliance on costly debt to offset this temptation. Moreover, when managers' bargaining power vis-à-vis shareholders increases (i.e., when the outside option $\underline{u}$ grows larger) they need to be rewarded more, which (ceteris paribus) induces shareholders to rely more on debt to squeeze the wedge between collusive and deviation profits. By contrast, the impact of both higher ϕ and C tend to make firms less willing to rely on debt in order to sustain the monopoly outcome; the reason is that when managers' personal costs from financial distress are larger, managers are (ceteris paribus) less eager to undercut rivals since the subsequent punishment would be more costly to them. Similarly, when players become more patient (i.e., δ increases) there is also less incentive to use debt for collusive purposes because managers assign a higher weight to the disutility they would suffer from being in a punishment phase.

Summing up, in contrast to Maksimovic (1988, 1995), our model predicts that debt can be used as a commitment device by competing firms to sustain non-competitive outcomes on the product market as long as firms' shareholders delegate pricing and production decisions to self-interested managers — i.e. debt should be a concern for antitrust authorities only in industries where firms are led by professional managers. This prediction is more likely to be confirmed in environments where defaulted managers are particularly concerned with their reputation.

As a final remark, note that in our simple Bertrand competition model, the solution of the repeated game with self-managed firms is *bang-bang*: either they can sustain the monopoly price, in which case the repeated game has a continuum of SPNE with the price ranging from monopoly to the marginal cost, or there is a unique SPNE where firms charge the price equal to the marginal cost. It can be easily shown that this property no longer holds when firms are led by self-interested managers: in this case, whenever the monopoly outcome cannot be sustained through an optimal combination of debt and NPS, firms' shareholders may be still able to sustain non-competitive outcomes that yield a profit lower than π but larger than zero — see, e.g., Piccolo and Miklos-Thal (2012) for an analysis in this spirit.

[18] In this case, even a small probability that an Antitrust case is opened against the cartel would dissuade the shareholders from inducing collusion in the product market.

4. Extensions

In this section we extend the baseline model in two natural directions. First, in Section 4.1 we study how the degree of product differentiation affects firms' propensity to rely on strategic debt financing to sustain non-competitive outcomes. Next, in Section 4.2 we show that the beneficial impact of debt on firms' collusion ability survives when managerial and loan contracts can be secretly renegotiated.

4.1. Product differentiation

So far, we have assumed that firms compete à la Bertrand in the product market. Hence, banks are not repaid in the punishment phase where bankruptcy occurs. The reason is that, off the equilibrium path, prices are set at marginal costs since firm members are protected by limited liability. What happens if products are differentiated? Do firms in less competitive environments rely more often on debt to sustain non-competitive outcomes?

Following Harrington and Chang (2012), here we consider a simple extension of the baseline model where, in the punishment phase, firms play the equilibrium of the static game and their profits are $\beta\pi$ (with $\beta < 1$), while a deviation from a collusive agreement secures a profit $\eta\pi$ to each firm (with $\eta > 1$).[19] We will interpret η as a measure of the demand elasticity, while β will proxy the degree of product differentiation.

As before, we focus (without loss of generality) on the most interesting region of parameters where the monopoly outcome cannot be sustained by self-managed firms — i.e.,

$$\delta < \delta_D^* \equiv \frac{\eta - 1}{\eta - \beta}.$$

To gain insights about the new forces that shape the relation between debt, managerial incentives and collusion in this setting, it is useful to start the analysis with the following lemma.

Lemma 2. *If the monopoly outcome is sustained through strategic debt, it must be* $b > \beta\pi$.

Essentially, since the punishment profit is larger with product differentiation than with pure Bertrand competition, firms producing differentiated goods need to set their indebtedness above the critical value $\beta\pi$ in order to induce default in the punishment phase. Indeed, a deviant manager incurs the costs of default $C + \phi(b - \pi\beta)$ only if the pledged repayment b exceeds the equilibrium payoff of the stage game $\beta\pi$.

Hence, assuming that $b > \beta\pi$, it can be easily shown that, with product differentiation, the self-enforceability constraint that allows firms to sustain the monopoly outcome is

$$\frac{\alpha}{1-\delta}(\pi - b) \geq \alpha(\eta\pi - b) - \delta(C + \phi(b - \beta\pi)). \tag{4.1}$$

[19] Note that this set-up is equivalent to the Bertrand model analyzed above for $(\eta, \beta) = (N, 0)$, while the outcome of a linear Cournot model where firms collude at the monopoly price obtains when $(\eta, \beta) = ((N+1)^2/4N, 4N/(N+1)^2)$.

As before, the level of debt in this set-up also has two opposing effects on the managers' incentives to sustain collusion. First, a higher level of debt makes deviations more appealing to managers because they are more tempted to undercut rivals and enjoy the full monopoly profit when firms' leverage is high; second, there is an effect on the punishment that makes managers less willing to deviate because their costs of default increase with the amount of unrepaid debt. Interestingly, this latter effect becomes weaker when firms' profits in the punishment phase increase, which means that relaxing product market competition tends to nullifying the beneficial impact of debt on the firms' ability to collude. This suggests that firms acting in more competitive industries should rely less on debt financing to relax competition.

In the next proposition, we provide a characterization of the optimal symmetric collusive strategy that supports the monopoly outcome.

Proposition 3. *Assume that $\underline{u}$ is not too large. The optimal symmetric collusive strategy that allows firms to sustain the monopoly outcome has the following features:*

- *It combines debt and NPS only if*

$$\phi > \underline{\phi}_D \equiv \frac{2\underline{u}\,(\eta-1)\,C}{\pi\left[C-\underline{u}\eta-\sqrt{(C-\underline{u}\eta)^2+4C\underline{u}}\right]}.$$

  In this region of parameters there exist two thresholds $\underline{\delta}_D$ and $\overline{\delta}_D$, with

$$0<\underline{\delta}_D\equiv\frac{\underline{u}\,(\eta-1)}{\phi\pi}<\overline{\delta}_D\equiv\frac{1}{2}-\frac{\underline{u}\eta+\sqrt{(C-\underline{u}\eta)^2+4C\underline{u}}}{2C}<\delta_D^*,$$

  such that:

  - *For every $\delta\in[\overline{\delta}_D,\delta_D^*)$ firms do not issue debt to sustain the monopoly outcome. However, shareholders must delegate the pricing decisions to independent managers to sustain this outcome: $\alpha_D^*=\frac{\underline{u}}{\pi}<1$.*
  - *For every $\delta\in[\underline{\delta}_D,\overline{\delta}_D)$ the monopoly outcome can be sustained only through a combination of NPS and debt: $\alpha_D^*=\frac{\underline{u}}{\pi-b_D^*}\in(0,1)$ and $b_D^*\in(\beta\pi,\pi)$ is the lowest (positive) solution of*

$$\frac{1}{1-\delta}+\delta\frac{C+\phi\,(b-\beta\pi)}{\underline{u}}=\frac{\eta\pi-b}{\pi-b}.$$

  - *For every $\delta<\underline{\delta}_D$ the monopoly outcome is not sustainable.*

- *If $\phi\leq\underline{\phi}_D$ firms never issue debt to sustain monopoly: this outcome can be sustained only for $\delta>\overline{\delta}_D$.*

Hence, product differentiation does not alter the main insight of Proposition 1: debt financing and NPS can be still used jointly to facilitate the achievement of a collusive outcome even if firms produce differentiated goods or if they compete by setting quantities.

Corollary 1. *b_D^* and α_C^* are both increasing in η and β.*

This simple comparative statics suggests that (ceteris paribus) debt is more likely to be used as a collusive device in industries that feature a higher elasticity of demand (a higher η). This is because the higher the profit that a firm can secure from deviation, the stronger the impact of debt on the wedge between collusive and deviation profits. By the same token, debt is more likely to be used as a collusive device in industries that feature higher equilibrium profits in the stage game (a higher β), which is typically the case when the degree of product differentiation grows larger. This is because the higher the profit in the punishment phase, the weaker the effect of higher debt on the managers' personal cost of default.

4.2. Secret contract renegotiation

Up to now, we have assumed that firms are able to commit to their financial structure as well as to the contracts that govern the agency relationship between property and management. However, as pointed out by Dewatripont (1988) and by Katz (1991), the commitment value of contracts with third parties can be greatly reduced by agents' ability to *secretly renegotiate* the (announced) contract. To take this point into consideration, in this section we relax the commitment power of the firm shareholders by considering two alternative scenarios. First, we study an 'imperfect commitment' regime where they can successfully commit to a given financial structure, but cannot announce credibly managerial contracts, which can be renegotiated afterwords. Second, we consider a regime with no commitment at all where, in addition to secretly changing the contracts offered to the managers, firm shareholders can also secretly renege on the announced debt. We will show that, in both scenarios, the design of firms' financial structure, bundled with low-powered managerial incentives, might still be used as an effective device to improve coordination in the product market.

Throughout the section we will impose the following assumption:

A1 Contracts announcements are not cheap talk: whatever contract is announced by a firm, it must be legally valid even if it can be secretly substituted by another (legally valid) contract afterwards.

This hypothesis is somewhat natural in the context at hand. It provides a minimal commitment requirement for debt and delegation to act jointly as collusive devices. Essentially, it implies that firms cannot lie to the market about their financial and hiring decisions, although the specific terms of these contracts can be modified through secret renegotiation.[20]

[20] For example, this assumption prevents shareholders from announcing that they have hired a manager and then firing him without being detected by competitors. If this were possible, Maksimovic's main result would still hold.

4.2.1. Imperfect commitment

In order to disentangle the effects of contract renegotiation on collusion, we first consider the case where firm shareholders can commit to a long-term debt structure, but they can actually (secretly) change the terms of the announced managerial contracts. The fact that debt announcements are not vulnerable to secret renegotiation seems particularly compelling in countries where banks share information on entrepreneurs' borrowing histories, and in particular on their total exposure — see, e.g., Degryse et al., (2011). In several countries, publicly managed credit registries consolidate information on borrowers' credit worthiness, which typically include their total indebtedness. But there are also many countries, including the US and Italy, where different private information sharing systems (credit bureaus) have been developed by financial intermediaries on a voluntary basis, as a response to information asymmetries. Credit bureaus and registries often pool data about past debts and report clients' total indebtedness, rather than just reporting past delinquencies and borrowers' characteristics.

In what follows we will argue that this type of information-sharing agreement may confer credibility to firms' announcements about their leverage, and thus help to sustain collusive outcomes in the product market even though managerial contracts can be secretly renegotiated.

The timing of the game is as follows:

- At time $\tau = 0$ each firm i announces a pair (b_i, α_i).
- Between $\tau = 0$ and $\tau = 1$ (say at $\tau = 1/2$) NPS contracts can be (secretly) modified (at no costs).
- From $\tau = 1$ onwards, the game unfolds as before.

Due to secret renegotiation, the solution concept is now PBE. As standard in the literature, we assume that out-of-equilibrium beliefs are *passive*: regardless of the contract offer received from his own shareholders, a manager always believes that the other players will stick to their equilibrium strategies. This assumption captures the idea that, since firm shareholders are independent and act simultaneously, they cannot signal to their manager information that they do not posses about the other shareholders' contracts. For simplicity, we assume again Bertrand competition in the product market as in the baseline model.[21]

The objective of the analysis is to show that firms can still use debt and NPS contracts jointly to sustain the monopoly outcome even if managerial contracts cannot be used as a credible commitment device. To address this issue, let us first define by

$$\Phi \equiv \left\{ (\alpha, b) : \frac{\alpha}{1-\delta} (\pi - b) \geq \alpha(N\pi - b) - \delta (C + \phi b), \, b \leq \pi \right\},$$

[21] Results would be even stronger with product differentiation where deviation entails a deadweight loss — i.e., $\eta < N$.

the set of debt and NPS contracts that induce collusion in the full commitment game. Next, consider an equilibrium candidate where firms are expected to announce the pair $(\alpha, b) \in \Phi$ and charge the monopoly price at every stage of the product market game. Moreover, denote by

$$\tilde{V}(\alpha, b) \equiv \max_{\tilde{\alpha} \in [0,1]} \left\{ (1 - \tilde{\alpha})(N\pi - b) : \tilde{\alpha}(N\pi - b) - \delta(C + \phi b) \geq \frac{\alpha}{1 - \delta}(\pi - b) \right\}, \tag{4.2}$$

the maximal utility that a firm's shareholders can earn by secretly switching to a different NPS contract, which induces their manager to undercut rivals and grab the deviation profit $N\pi$ net of the announced debt b. Recall that, for any $(b, \alpha) \in \Phi$, the shareholders' discounted stream of profits from sticking to the candidate equilibrium is

$$V(\alpha, b) \equiv \frac{1 - \alpha}{1 - \delta}(\pi - b).$$

Hence, the pair $(\alpha, b) \in \Phi$ is renegotiation proof if and only if

$$V(\alpha, b) \geq \tilde{V}(\alpha, b).$$

This condition simply states that a necessary and sufficient condition for a strategy that sustains the monopoly profit in the full commitment game to be renegotiation-proof is that a firm's shareholders must not profit from reneging on the managerial contract announced at $\tau = 0$ at their rivals' expense.

Lemma 3. *Any pair $(\alpha, b) \in \Phi$ is renegotiation proof if and only if*

$$\frac{1}{1 - \delta}(\pi - b) \geq N\pi - b - \delta(C + \phi b). \tag{4.3}$$

Whenever $b^* > 0$, the pair (α^*, b^*) characterized in Proposition 1 is not robust to the threat of renegotiation.

Under imperfect commitment, a credible collusion strategy must satisfy not only the incentive compatibility constraint of the managers, but also that of the whole firm seen as the coalition of ownership and control. Essentially, when managerial contracts are vulnerable to secret renegotiation, hiring self-interested managers does not affect collusion at the 'intensive margin' — i.e., α does not impact the self-enforceability constraint (4.3) — but only at the 'extensive margin' because managers' personal costs of default still affect the firm's (aggregate) profit in the punishment phase. To see why, consider an equilibrium candidate where firms are expected to collude and they all announce the pair $(\alpha, b) > 0$ that would sustain this outcome in the full commitment game. Suppose now that at stage $\tau = 1/2$ firm i's shareholders deviate by proposing a new and more profitable contract to their manager, and that this contract induces the latter to undercut rivals. If the new contract is signed, the manager must anticipate that a price deviation will cause default in the subsequent stages of the game, with the associated

loss of reputation. Hence, he must be compensated for this loss, which is feasible as long as (4.3) is not met. As a result, the pair (α^*, b^*), which clearly does not satisfy (4.3), is vulnerable to secret renegotiation because it takes only into account the managers' individual incentive compatibility constraint.

Proposition 4. *Assume **A1**. Then, even if managerial contracts can be secretly renegotiated, an optimal symmetric collusive strategy that is robust to renegotiation still combines debt and managerial contracts. This is true in the region of parameters where δ takes intermediate values, ϕ is large enough and $\underline{u}$ is not too large. In this case, firms are more leveraged than with full commitment.*

The economic intuition of this result is as follows. Although managerial contracts can be secretly renegotiated, when weighting the costs and benefits of collusion, the 'undercutting' ability of the coalition formed by shareholders and managers must still account for the managers' aversion to bankruptcy. Hence, debt might still enhance firms' ability to coordinate on a non-competitive outcome of the product market provided that managers' personal costs of default are sufficiently responsive to the amount of unrepaid debt. However, this requires firms to take excessive debt relative to the case of full commitment: shareholders can no longer play with managerial contracts to relax competition under the threat of renegotiation, in this case it is debt that confers credibility to pro-collusive managerial incentives, and not the other way around.

Building on this result, in the next section we will show that even when firms can secretly renegotiate their debt, they may still be able to enforce the monopoly outcome on the product market by precommitting to their financial structure.

4.2.2. No commitment at all

Consider now the extreme case of an entirely unregulated financial market, where announced loan contracts can also be secretly renegotiated at $\tau = 1/2$. The objective of this section is to study whether firms still manage to sustain a non-competitive outcome in the product market by using banks as a coordination device. We will argue that, as long as firms manage to borrow from common lenders, debt bundled with pro-collusive incentives might still facilitate the achievement of the monopoly outcome in the product market.

To begin with, it is useful to show that, when all contracts can be secretly renegotiated, debt cannot help collusion if firms borrow from exclusive lenders.

Proposition 5. *If each firm borrows from an exclusive lender, there is no scope for collusion when δ falls short of δ^*. In this case, debt has no strategic role whatsoever.*

The economic intuition for this proposition hinges on the simple idea that, with lack of commitment, loan contracts can be reneged at no costs when each firm borrows from an exclusive

lender. In this case, lenders do not internalize the impact of debt renegotiation in the product market. This result contrasts with the findings of Acemoglu (1998) who shows that leaving sufficient rents to managers could block secret renegotiation within one vertical structure by making it too expensive for owners.[22] In our model, under exclusive lending relationships, each vertical structure (i.e., the coalition composed by an exclusive lender and a firm) would strictly gain by secretly renegotiating both the internal contract and its debt, thereby inducing a unilateral defection from the product market agreement.

By contrast, when a bank deals simultaneously with multiple firms, renegotiation is costly because the common lender anticipates that a deviation by one of them induces the others to default. Hence, when offered a renegotiation proposal by one client, the lender requests a premium that must compensate him for the (anticipated) loss on its remaining clients. Clearly, if this premium is large enough, renegotiation may be unviable. As a result, the establishment of financial networks may help firms to internalize the negative externalities stemming from secret renegotiation. The simplest financial network one can imagine entails a single common lender: all firms coordinate to borrow (at least in part) from a common bank. When the common lender plays the role of a coordination device, a collusive strategy that is renegotiation-proof requires all firms to borrow from the same bank, and announce a debt contract $(b, L) > 0$ and a profit sharing rule $\alpha > 0$ such that:

(i) The self-enforceability constraint (4.3) is met.

(ii) The coalition formed by a deviant firm and the common lender cannot gain from reneging on the announced debt contract.

(iii) As long as one firm does not apply for credit to the common lender, this lender denies credit to all its clients.

(iv) Each firm charges the monopoly price in the product market as long as its credit application has been accepted and all its competitors have announced the pair (b, α). Otherwise, it charges a price equal to the marginal cost.

Assume, without loss of generality, that whenever renegotiation occurs, the deviating firm (say firm i) and the common lender agree to sign a new debt contract $(L_i, b_i) = (0, 0)$ and firm i pays an up-front lump sum transfer T_i to the bank. The common lender is indifferent between accepting and refusing this new debt contract if and only if

$$T_i = \underbrace{\frac{b(N-1)}{1-\delta}}_{\text{Renegotiation Premium}},$$

[22] This solution, however, requires that in equilibrium part of the manager's rents are paid by the lender — i.e., that the manager is simultaneously on the payroll of both bank and firm, a seldom observed arrangement.

where the *renegotiation premium* measures the discounted value of the loss that the common lender incurs by accepting the renegotiation proposed by firm i, which (due to Bertrand competition) would lead its other $N-1$ clients to default because of firm i's price cut. Hence, firm i prefers not to renege on its announced debt if and only if

$$N\pi - \frac{(N-1)\,b}{1-\delta} \leq \frac{\pi - b}{1-\delta} \quad \Leftrightarrow \quad b \geq \underline{b}\,(\delta) \equiv \pi \frac{N\,(1-\delta)-1}{N-2},$$

where the left-hand side of the first expression is firm i's net gain from renegotiation (and deviation), while the right-hand side is the discounted value of profits from sticking to the cartel's collusive strategy.

Since firms' equilibrium payoff are decreasing in b, an optimal collusive strategy relying on debt (if it exists) must require all firms to announce $\underline{b}\,(\delta) \in (0, \pi)$. Hence, the relevant constraint for this to be self-enforceable is

$$\frac{\pi - \underline{b}\,(\delta)}{1-\delta} \geq N\pi - \underline{b}\,(\delta) - \delta\,(C + \phi \underline{b}\,(\delta))\,. \tag{4.4}$$

If this inequality holds for some $\delta < \delta^*$, then an optimal collusive strategy that is renegotiation-proof exists. The next proposition shows that there exists a non-empty region of parameters where the monopoly outcome is sustained by the strategy described above.

Proposition 6. *Assume **A1**. If ϕ and π are sufficiently high and $\underline{u}$ is not too large, there exists a non-empty subset of discount factors where the monopoly outcome can be sustained only by means of a symmetric, renegotiation-proof strategy profile that combines debt and NPS and relies on a common lender. In this case all firms announce $\underline{b}\,(\delta) < \pi$ and*

$$\underline{\alpha}\,(\delta) = \frac{\underline{u}}{\pi - \underline{b}\,(\delta)}.$$

This result shows that even in the complete absence of commitment (i.e., in the absence of disclosure rules and information sharing devices that facilitate binding communication between competing firms), shareholders may still gain from using strategic debt to improve their ability to sustain collusion in the product market via the common lender mechanism. The role of this bank is to internalize, through loan contracts, the negative externalities between its clients (firms) when they may be tempted to use secret renegotiation to break a collusive agreement in the product market.

In the rest of the section, we show that the logic of the common lender applies more generally to cases of indirect leakages, where only subsets of firms have a common lender. Specifically, we argue that collusion can also be sustained through the formation of financial networks: the cartel members are divided into subgroups (networks) each borrowing from the same lender. Consider a strategy that prescribes each $m < N$ firms to borrow from the same lender, so that there are

N/m lenders active in equilibrium.[23] Under this hypothesis, a collusive strategy requires each firm to announce a debt structure (L, b), with $L(1-\delta) = b$, and some positive α such that:

(i) The pair (b, α) satisfies the self-enforceability constraint (4.3).

(ii) The coalition formed by a deviant firm and its lender cannot gain from reneging on the announced debt contract.

(iii) As long as a firm does not apply for credit to the expected lender, this bank denies credit to all its other clients.

(iv) Each firm charges the monopoly price in the product market as long as its credit application has been accepted, and all its competitors have announced the pair (b, α). Otherwise, it charges a price equal to the marginal cost.

Hence, off the equilibrium path, an active lender is indifferent between accepting and refusing firm i's debt renegotiation proposal if and only if

$$T_i = \underbrace{\frac{(m-1)\,b}{1-\delta}}_{\text{Renegotiation Premium}},$$

where, as before, the renegotiation premium is the discounted value of the loss that an active bank would incur by accepting the renegotiation proposed by one of its m clients, which (due to Bertrand competition) would lead its remaining $m-1$ clients to default because of firm i's subsequent price cut. Following the same logic as above, firm i prefers not to renege on its announced debt if and only if

$$N\pi - \frac{(m-1)\,b}{1-\delta} \leq \frac{\pi - b}{1-\delta} \quad \Leftrightarrow \quad b \geq \underline{b}_m(\delta) \equiv \pi \frac{N(1-\delta) - 1}{m-2},$$

where it can be easily verified that $\underline{b}_m(\delta) = \underline{b}(\delta)$ for $m = N$. Note that the repayment $\underline{b}_m(\delta)$ is decreasing in m. This means that firms belonging to larger financial networks (i.e., for which m is large) need to pledge lower repayment rates to sustain collusion, so as to share larger monopoly rents. As a result, larger financial networks should be associated with more collusive behavior in the product market.

Since firms' equilibrium payoff are decreasing in b, an optimal collusive strategy involving debt (if it exists) must require all firms to announce $\underline{b}_m(\delta)$. Hence, the relevant constraint for this to be self-enforceable is

$$\frac{\pi - \underline{b}_m(\delta)}{1-\delta} \geq N\pi - \underline{b}_m(\delta) - \delta\left(C + \phi \underline{b}_m(\delta)\right).$$

[23] We assume with no loss of generality that N/m is an integer greater than 1.

In the next proposition we show that there exists a non-empty region of parameters where the monopoly outcome is sustained by the strategy described above.

Proposition 7. *Assume **A1**. If ϕ and π are sufficiently high and $\underline{u}$ is not too large, there exists a non-empty subset of discount factors where the monopoly outcome can be sustained by means of a symmetric, renegotiation-proof strategy that combines debt and NPS and requires only $N/m > 1$ active banks, each lending to a network of m firms. In this case, all firms announce $\underline{b}_m(\delta) < \pi$ and*

$$\alpha_m(\delta) = \frac{\underline{u}}{\pi - \underline{b}_m(\delta)}.$$

If $N = 2$, collusion is sustainable only via a common lender — i.e., $m = 2$.

This result shows that the common lender mechanism discussed above can be decentralized in terms of a number of independent firm-bank networks, like Japanese keiretsus or German "house bank" systems. An analogous result could be derived (at the cost of substantial additional complications of model and notation) for the case of firms with multiple banking relationships (Detragiache et al., 2000; Carletti, 2004; Carletti et al., 2007). Then there can be "partly common lending" for more downstream firms keeping the amount of leverage constant, and "indirect common lending" among any two downstream firms (in the spirit of Kranton and Minehart, 2001, each firm has at least a common lender with another firm that has at least a common lender with another firm....in the industry), both of which will reinforce the result derived in this section.

As already mentioned in Section 2, it is worth noting that, although achieving the same goal of cross ownership (e.g., Gilo et al., 2006), the common lender mechanism emphasized here seems more harmful because competition and antitrust authorities may be quite suspicious when observing cross ownerships agreements, while there are obvious specialization arguments that may justify the presence of a common lender. Therefore, making a case against a cartel whose stability is guaranteed by a common lender may be more difficult than arguing against cross ownership.

5. Policy implications

In this section we discuss the main policy implications of our model.

5.1. Competition policy

In the light of knowledge available before this paper, high debt was considered a factor hindering cartel stability, and could have been included in antitrust authorities' screens or check lists as a factor reducing the likelihood of the presence of a cartel. Our results have shown that this would not be warranted. While cartels that are sufficiently stable without debt may have no reason to incur the cost of raising debt, given that high collusive profits should themselves increase the

liquidity available to firms, we have shown that there are plausible circumstances where cartels that may not be stable without debt may actually become stable with high debt. This implies that the empirical relationship between debt and cartels is likely to be very complex, and that the presence of high debt in an industry cannot be taken as reassuring information regarding the presence of a cartel.

5.2. Information sharing and privacy rules

Our model has important implications for the role of information-sharing systems in credit markets. Following Sharpe (1990) and Pagano and Jappelli (1993), many papers have highlighted the bright side of information-sharing agreements between banks. In these models, pooling data on defaults and customers' characteristics enables banks to lend more safely, overcoming adverse selection or promoting borrowers' efforts to repay loans (Padilla and Pagano, 1997 and 2000). However, this literature typically neglects the impact of these information-sharing agreements on the outcome of the product markets, and thus on the welfare of final consumers. In our model, information-sharing systems may have a dark side previously undetected: firms' access to information on competitors' financial structure may facilitate price fixing in the product market at the expense of final consumers. This is only the case for "positive" information sharing — i.e., on new or outstanding debt rather than on poor repayment behavior — and if non-financial firms have access to this information, either directly from the credit bureau, or indirectly through their banks. Both of these aspects are subject to regulation, and our results suggest that the effects on product markets should be taken into account when designing the regulatory framework.[24]

5.3. Corporate governance regulation

As already mentioned in the introduction, our results imply that several disclosure and liability rules designed to protect investors and limit financial market manipulation may have a direct impact on the commitment value of debt and managerial effects, and through that on cartel formation and stability.

For example, since 2004 companies are required to report to the Security and Exchange Commission, in the Form 8k (introduced already by the Securities and Exchange Act but extended in 2004), any material change in their financial situation, including changes in debt, within four business days of their occurrence. The public, including competitors, can access these forms through the SEC's EDGAR website. While the increased transparency these measures generate may have important benefits in terms of corporate governance, our results suggest that they may also facilitate anti-competitive effects of governance structure. This is in line with Stigler's

[24] In a recent paper, Bennardo et al. (2014) also highlight a potential dark side of information sharing in credit markets. However, their mechanism is of a completely different nature. In their model borrowers do not compete on the product market, and sharing information about past credit histories may lead the credit market to collapse insofar as it exacerbates moral hazard problems between banks competing for the same borrower.

(1964) classic point that transparency rules aimed at improving accountability (he was focusing on disclosure rules in public procurement) may greatly facilitate the formation and stability of bidding rings. Since recent evidence suggests that product market competition is a crucial determinant of firms' performance, and that corporate governance only matters when product market competition is weak, transparency requirements aimed at improving corporate governance may actually end up being counterproductive if they facilitate the collusive suppression of product market competition.

6. Concluding remarks

In this paper we have questioned the established view that debt finance hinders firms' ability to sustain collusive behavior in product markets. Endogenizing firms' choice of both leverage and managerial incentives, we have shown that debt can have strong stabilizing effects on product market collusion, be it tacit or explicit. While current corporate governance rules that force the disclosure of truthful information to the market (and to competitors) ensure the credibility of these commitments, we have shown that the pro-collusive effect of debt is present even in very unregulated environments where rules that limit CEOs' ability to lie about their firm's financial situation are lacking or poorly enforced. These results have novel, direct implications for competition policy, corporate governance regulation and the design of credit bureaus.

Our results do not imply that a positive relationship between leverage and cartels should be observed, because where cartels are stable without debt the supracompetitive profits may well induce managers to reduce outstanding debt and the market discipline (or rent sharing) it may imply on how supracompetitive profits are used. However, our result that debt can have pro-collusive effects may help to reduce the conflict between theory, which previously suggested strong negative effects of debt on cartel stability/formation, and the large body of evidence (discussed in the Introduction) suggesting that when all firms are highly leveraged in a concentrated industry, debt tends to benefit all firms.

One more implication of our theory is that it is important to consider the interaction between the different components of firms governance structures to fully grasp their potential consequence on firms' behavior. An empirical implication of our results is indeed that managerial rents and pro-collusive managerial incentive schemes should be more common where industry leverage is positively related to firms' markups.

7. Appendix

Proof of Lemma 1. For any pair (b, α) let $\delta^{**}(b, \alpha)$ denote the solution in δ of the self-enforceability constraint (3.2) take as equality. Hence, $\delta^{**}(b, \alpha)$ solves

$$\Gamma(\delta|b, \alpha) \equiv \frac{\pi - b}{1 - \delta} - (N\pi - b) + \frac{\delta}{\alpha}(C + \phi b) = 0.$$

First, notice that at $\Gamma(\delta|b, \alpha) \to +\infty$ as $\delta \to 1$ and that $\Gamma(0|b, \alpha) < 0$. Hence, $\Gamma(\delta|b, \alpha)$ admits a solution in $(0, 1)$. Next, observe that

$$\frac{\partial \Gamma(\delta|b, \alpha)}{\partial \delta} = \frac{\pi - b}{(1 - \delta)^2} + \frac{1}{\alpha}(C + \phi b) > 0,$$

$$\frac{\partial^2 \Gamma(\delta|b, \alpha)}{\partial \delta^2} = -\frac{\pi - b}{1 - \delta} < 0 \quad \forall b < \pi.$$

Hence, there is a unique $\delta^{**}(b, \alpha) \in (0, 1)$ that solves $\Gamma(\delta|b, \alpha) = 0$.

It then follows that, by the Implicit Function Theorem

$$\frac{\partial \delta^*(\alpha, b)}{\partial \alpha} = \frac{\frac{\delta^{**}(\cdot)}{\alpha^2}(C + \phi b)}{\frac{\pi - b}{(1 - \delta^{**}(\cdot))^2} + \frac{1}{\alpha}(C + \phi b)} > 0.$$

Moreover,

$$\frac{\partial \delta^*(\alpha, b)}{\partial b} = \frac{\frac{1}{1 - \delta^{**}(\cdot)} - 1 - \frac{\delta}{\alpha}\phi}{\frac{\pi - b}{(1 - \delta^{**}(\cdot))^2} + \frac{1}{\alpha}(C + \phi b)} = \frac{\delta^{**}(\cdot)\left[\frac{1}{1 - \delta^{**}(\cdot)} - \frac{\phi}{\alpha}\right]}{\frac{\pi - b}{(1 - \delta^{**}(\cdot))^2} + \frac{1}{\alpha}(C + \phi b)} < 0 \quad \Leftrightarrow \quad \frac{\alpha}{\phi} < 1 - \delta^{**}(\cdot).$$

Next, recall that $\delta^{**}(\cdot)$ is increasing in α and that $\delta^{**}(\cdot) \to 0$ as $\alpha \to 0$. Hence, $\frac{\partial \delta^*(\alpha, b)}{\partial b} < 0$ if and only if $\frac{\alpha}{\phi}$ is small enough.

Finally, observe that

$$\Gamma(b, \delta, \alpha)|_{\delta = \delta^*(b)} = \frac{\delta^*(b)}{\alpha}(C + \phi b) > 0.$$

Hence, $\delta^{**}(b, \alpha) < \delta^*(b)$. ■

Proof of Proposition 1. To begin with, note that the self-enforceability constraint (3.4) can be rewritten as

$$\frac{\delta}{\alpha}(C + \phi b) \geq N\pi - b - \frac{1}{1 - \delta}(\pi - b).$$

This condition becomes harder to meet when α grows larger. Next, note that the shareholders' objective function is decreasing in α. Hence, whenever sustainable, an optimal collusive agreement must be such that the managers' participation constraint binds — i.e.,

$$\alpha(b) = \min\left\{1, \frac{\underline{u}}{\pi - b}\right\}.$$

Let us consider the case where $\alpha(b) < 1$, later on we will show that this is actually the case for $\underline{u}$ small enough. Substituting $\alpha(b)$ into the shareholders' objective function, the cartel's maximization problem can be rewritten as

$$\max_{b\in[0,\pi]} \frac{\pi - b - \underline{u}}{1-\delta},$$

subject to

$$\frac{1}{1-\delta} + \delta\frac{C+\phi b}{\underline{u}} \geq \frac{N\pi - b}{\pi - b}. \tag{A1}$$

Notice that the above objective function is decreasing in b. At $b = 0$ (which maximizes the shareholders' unconstrained maximization problem) the above constraint holds if and only if

$$G(\delta) \equiv 1 + \delta(1-\delta)\frac{C}{\underline{u}} - (1-\delta)N \geq 0,$$

where $G(\cdot)$ is strictly concave in δ. Moreover, $G(0) = 1 - N < 0$ and

$$G(\delta^*) = \frac{C(N-1)}{\underline{u}N^2} > 0.$$

Hence, the lowest positive solution of $G(\delta) = 0$, say $\overline{\delta}$, must lie within the interval $\left(0, \frac{N-1}{N}\right)$. This implies, in turn, that $G(\delta) \geq 0$ if and only if

$$\delta \geq \overline{\delta} \equiv \frac{1}{2} - \frac{N\underline{u} + \sqrt{(C - N\underline{u})^2 + 4C\underline{u}}}{2C} \in \left(0, \frac{N-1}{N}\right).$$

Next, let

$$F(b) \equiv \frac{1}{1-\delta} + \delta\frac{C+\phi b}{\underline{u}} - \frac{N\pi - b}{\pi - b},$$

we can conclude that, for some $\delta < \overline{\delta}$, the optimal symmetric collusive strategy requires $b^* > 0$, with b^* being the lowest (positive) solution of $F(b) = 0$. However, note that this equation admits a solution only if its right-hand side does not lie above the left-hand side for every $b \in (0, \pi)$. First, recall for

$$\lim_{b\to\pi^-} F(b) = -\infty,$$

and

$$F(0) = \frac{1}{1-\delta} + \delta\frac{C}{\underline{u}} - N < 0 \quad \forall\delta < \overline{\delta}.$$

Next observe that for any $b < \pi$

$$\frac{\partial}{\partial b}\left[\frac{N\pi - b}{\pi - b}\right] = \pi\frac{N-1}{(\pi-b)^2} > 0 \qquad \frac{\partial^2}{\partial b^2}\left[\frac{N\pi - b}{\pi - b}\right] = \frac{2(N-1)\pi}{(\pi-b)^3} > 0.$$

Hence, a necessary and sufficient condition for b^* to exist is

$$\frac{\partial}{\partial b}\left[\frac{N\pi - b}{\pi - b}\right]\Bigg|_{b=0} = \frac{N-1}{\pi} < \frac{\partial}{\partial b}\left[\delta\frac{C+\phi b}{\underline{u}}\right] = \delta\frac{\phi}{\underline{u}} \quad \Leftrightarrow$$

$$\delta > \underline{\delta} \equiv \frac{\underline{u}\,(N-1)}{\phi\pi}$$

Moreover, it can be easily shown that

$$\overline{\delta} > \underline{\delta} \quad \Leftrightarrow \quad \phi > \underline{\phi} \equiv \frac{2\underline{u}C\,(N-1)}{\pi\left[C - N\underline{u} - \sqrt{(C-N\underline{u})^2 + 4C\underline{u}}\right]}.$$

Hence, in the region of parameters where $\phi > \underline{\phi}$ the interval $(\underline{\delta}, \overline{\delta})$ is non-empty, so that the monopoly outcome is sustained by a collusive strategy that requires banks to issue a debt with a per-period repayment b^* and to hire managers that are rewarded with a share $\alpha^* = \frac{\underline{u}}{\pi - b^*}$ of the firms' net profit. Note that since the function $F(b)$ shifts downward when $\underline{u}$ increases, b^* is increasing in $\underline{u}$, which means that

$$\alpha^* = \min\left\{1, \frac{\underline{u}}{\pi - b^*}\right\},$$

is (weakly) increasing in $\underline{u}$. Hence, $\alpha^* < 1$ if and only if $\underline{u}$ is not too large relative to π.

In the region of parameters where $\delta \leq \underline{\delta}$, the monopoly outcome cannot be sustained, and shareholders' optimal strategy is not to hire managers nor to issue debt. Finally, note that when $\phi \leq \underline{\phi}$, the monopoly outcome can be sustained only if $\delta \geq \overline{\delta}$ and for $\delta \in [\overline{\delta}, \delta^*)$ this outcome is sustained only by means of managers and not through debt. For $\delta \geq \delta^*$ even self-managed firms can sustain the monopoly outcome. ■

Proof of Proposition 2. The proof of this result hinges on a straightforward application of the Implicit Function Theorem to condition (3.7), and has already been sketched in the proof of Proposition 1 above, so it will be omitted.

Proof of Proposition 3. Substituting $\alpha = \frac{\underline{u}}{\pi - b}$ into the self-enforceability condition (4.1) and rearranging

$$\frac{1}{1-\delta} + \delta\frac{C + \phi\,(b - \beta\pi)}{\underline{u}} \geq \frac{\eta\pi - b}{\pi - b}. \tag{A2}$$

Since he cartel's objective function is decreasing in b, an optimal collusive strategy features $b > 0$ only if (A2) is not met at $b = \beta\pi$ — i.e.,

$$\frac{1}{1-\delta} + \delta\frac{C}{\underline{u}} < \eta.$$

Let $\overline{\delta}_C$ be the solution of

$$\frac{1}{1-\delta}+\delta\frac{C}{\underline{u}}=\eta \quad \rightarrow \quad \overline{\delta}_C=\frac{1}{2}+\frac{\underline{u}\eta-\sqrt{(C-\underline{u}\eta)^2+4C\underline{u}}}{2C}.$$

In the region of parameters where $\delta<\overline{\delta}_C$, if collusion is sustainable, a symmetric strategy solving the cartel's program must require firms to issue debt $b_C^*>0$ with b_C^* being the lowest solution of

$$\frac{1}{1-\delta}+\delta\frac{(C+\phi(b-\beta\pi))}{\underline{u}}=\frac{\eta\pi-b}{\pi-b}.$$

Following the same approach as in the proof of Proposition 1, it can be shown that this condition admits at least one solution if and only if

$$\delta>\underline{\delta}_C\equiv\frac{\underline{u}(\eta-1)}{\phi\pi}.$$

Finally, note that the interval $\left(\overline{\delta}_C,\underline{\delta}_C\right)$ is non-empty if and only if

$$\phi>\underline{\phi}_C\equiv\frac{\underline{u}(\eta-1)}{\pi\left[\frac{1}{2}+\frac{\underline{u}\eta-\sqrt{(C-\underline{u}\eta)^2+4C\underline{u}}}{2C}\right]}.$$

The rest of the proof follows the same type of arguments used to prove Proposition 1. ■

Proof of Corollary 1. Let

$$H(b)\equiv 1+\delta\frac{C+\phi(b-\beta\pi)}{\underline{u}}-(1-\delta)\frac{\eta\pi-b}{\pi-b}.$$

Note that $H''(b)<0$ and $H(\beta\pi)<0$ in the region of parameters where $\delta\in\left(\underline{\delta}_C,\overline{\delta}_C\right)$ and $\phi>\underline{\phi}$. Next, recall that b_C^* solves $H(b)=0$, so that $H'(b_C^*)>0$. Then a direct application of the Implicit Function Theorem implies

$$\frac{\partial b_C^*}{\partial\beta}=\frac{\phi\pi}{\underline{u}H'\left(b_C^*\right)}>0,$$

$$\frac{\partial b_C^*}{\partial\eta}=\frac{(1-\delta)\pi}{\left(\pi-b_C^*\right)H'\left(b_C^*\right)}>0. \blacksquare$$

Proof of Lemma 3. We need to show that for any pair (α,b) such that

$$\frac{1}{1-\delta}(\pi-b)<N\pi-b-\delta(C+\phi b), \tag{A3}$$

then $V(\alpha,b)>\tilde{V}(\alpha,b)$. Using definition of $V(\cdot)$ and $\tilde{V}(\cdot)$, it is easy to show that

$$V(\alpha,b)-\tilde{V}(\alpha,b)=N\pi-b-\delta(C+\phi b)-\frac{1}{1-\delta}(\pi-b),$$

which is strictly positive when (A3) is met.

Finally, note that at $(\alpha, b) = (\alpha^*, b^*)$ the above condition rewrites as

$$V(\alpha^*, b^*) - \frac{1-\alpha^*}{1-\delta}(\pi - b^*) = \frac{\delta(C + \phi b^*)(1-\alpha^*)}{\alpha^*} > 0,$$

which concludes the proof. ■

Proof of Proposition 4. Lemma 3 implies that, under imperfect commitment, the relevant self-enforceability constraint is

$$\frac{1}{1-\delta}(\pi - b) \geq N\pi - b - \delta(C + \phi b) \quad \Rightarrow \quad \frac{1}{1-\delta} + \delta\frac{C + \phi b}{\pi - b} \geq \frac{N\pi - b}{\pi - b}.$$

Note that (on the equilibrium path) the shareholders' objective function is decreasing in b. Hence, an optimal collusive strategy requires $b > 0$ only if

$$\frac{\pi}{1-\delta} - [N\pi - \delta C] < 0 \quad \Leftrightarrow \quad \delta < \overline{\delta}_{IC} \equiv \frac{1}{2} - \frac{\sqrt{(\pi N - C)^2 + 4\pi C} - \pi N}{2C}. \tag{A4}$$

In this region of parameters, if it exists, the optimal debt level (say b^*_{PC}) must be the lowest solution of

$$\underbrace{\frac{1}{1-\delta} + \delta\frac{C + \phi b}{\pi - b}}_{\equiv \Gamma(b)} = \underbrace{\frac{N\pi - b}{\pi - b}}_{\equiv \vartheta(b)}. \tag{A5}$$

Note that

$$\frac{\partial \Gamma(b)}{\partial b} = \delta\frac{C + \pi\phi}{(\pi - b)^2} > 0, \qquad \frac{\partial^2 \Gamma(b)}{\partial b^2} = 2\delta\frac{C + \pi\phi}{(\pi - b)^3} > 0,$$

and that

$$\frac{\partial \vartheta(b)}{\partial b} = \frac{\pi(N-1)}{(\pi - b)^2} > 0, \qquad \frac{\partial^2 \vartheta(b)}{\partial b^2} = \frac{2\pi(N-1)}{(\pi - b)^3} > 0.$$

Moreover, it can be shown that

$$\lim_{b \to \pi^-} [\Gamma(b) - \vartheta(b)] = \begin{cases} +\infty & \Leftrightarrow \delta(C + \phi\pi) > (N-1)\pi \\ -\infty & \Leftrightarrow \delta(C + \phi\pi) < (N-1)\pi \end{cases}$$

and that $\Gamma(0) < \vartheta(0)$ in the region of parameters under consideration. Hence, (A5) admits a solution $b^*_{PC} \in (0, \pi)$ if and only if $\delta(C + \phi\pi) > (N-1)\pi$, which implies in turn

$$\delta > \underline{\delta}_{IC} \equiv \frac{(N-1)\pi}{C + \phi\pi}. \tag{A6}$$

Comparing (A4) with (A6), it is easy to show that they are compatible if and only if

$$\phi > \max\left\{0, \frac{2C(N-1)}{2C - \sqrt{(\pi N - C)^2 + 4\pi C} + \pi N} - \frac{C}{\pi}\right\}.$$

Finally, following the logic of the proof of Proposition 1, it can be shown that also in this case $\alpha_{IC}^{*} < 1$ as long as $\underline{u}$ is not too large relative to π. ■

Proof of Proposition 5. The proof of this result is immediate. Consider an equilibrium candidate where each firm-bank relationship is exclusive. Suppose that, in equilibrium, all firms are expected to announce the pair $(b, \alpha) > 0$ and to charge the monopoly price in every stage of the product market game. Then a firm's shareholders can profitably deviate by giving back the loan L and offering to the exclusive lender a new debt contract $(b', L') = (0, 0)$. The bank will accept this zero profit contract, and thus the shareholders of the deviating firm will have an incentive to renege also on the announced NPS contract so as to increase α up to the point that makes the manager willing to deviate. This is, of course, profitable since we are focusing in the region of parameter where $\delta < \frac{N-1}{N}$ and shows that debt cannot help collusion if firms borrow from exclusive lenders. ■

Proof of Proposition 6. First, recall that in the regime where firms cannot commit to NPS contracts a necessary condition for debt to be help collusion is

$$\frac{\pi}{1-\delta} - [N\pi - \delta C] < 0 \quad \Leftrightarrow \quad \delta < \overline{\delta}_{IC} = \frac{1}{2} - \frac{\sqrt{(\pi N - C)^2 + 4\pi C} - \pi N}{2C},$$

Recall that, in order for debt to be profitable on the equilibrium path, it must be

$$\pi - \underline{b}(\delta) = \pi \frac{N\delta - 1}{N - 2} \geq 0 \quad \Leftrightarrow \quad \delta \geq \frac{1}{N}.$$

Hence, a necessary condition for debt to be used as a collusive device is

$$\overline{\delta}_{IC} > \frac{1}{N} \quad \Leftrightarrow \quad \frac{N^2}{N-1} < N^2 - \frac{C}{\pi},$$

which is true if $\pi \geq \pi^{*}$, where

$$\underline{\pi} = \frac{(N-1)C}{(N-2)N^2}.$$

Next, let

$$T(\delta) \equiv \frac{\pi}{1-\delta} - [N\pi - \delta C] - \underline{b}(\delta)\delta \left[\frac{1}{1-\delta} - \phi\right].$$

Using the definition of $\underline{b}(\delta)$, it is easy to verify that

$$T\left(\overline{\delta}_{IC}\right) = \underbrace{\underline{b}\left(\overline{\delta}_{IC}\right)}_{>0}\overline{\delta}_{IC}\left[\phi - \frac{1}{1-\overline{\delta}_{IC}}\right] > 0 \quad \Leftrightarrow \quad \phi > \phi^{*} \equiv \frac{1}{1-\overline{\delta}_{IC}}.$$

Hence, continuity of $T(\cdot)$, implies that for ϕ large enough $T(\cdot) > 0$ for δ close enough to $\overline{\delta}_{IC}$. In this range of parameters an optimal collusive strategy that supports the monopoly outcome and is robust to renegotiation requires $\underline{b}(\delta) < \pi$ and $\underline{\alpha}(\delta) < 1$ for $\underline{u}$ not too large. ■

Proof of Proposition 7. First, recall that in the regime where firms cannot commit to NPS contracts a necessary condition for debt to be help collusion is

$$\delta < \overline{\delta}_{IC} = \frac{1}{2} - \frac{\sqrt{(\pi N - C)^2 + 4\pi C} - \pi N}{2C}.$$

Next, note that

$$\underline{b}_m(\delta) \leq \pi \quad \Leftrightarrow \quad \delta \geq \frac{N - m + 1}{N}.$$

Hence, a necessary condition for debt to be used as a collusive device is

$$\overline{\delta}_{IC} - \frac{N - m + 1}{N} > 0 \quad \Leftrightarrow \quad \pi > \underline{\pi}_m \equiv \frac{(N - (m-1))(m-1)C}{(m-2)N^2},$$

where, of course, $\underline{\pi}_m = \underline{\pi}$ for $m = N$. Next, let

$$A(\delta) \equiv \frac{\pi}{1-\delta} - [N\pi - \delta C] - \underline{b}_m(\delta)\,\delta\left[\frac{1}{1-\delta} - \phi\right],$$

Using the definition of $\overline{\delta}_{IC}$ and $\underline{b}_m(\cdot)$, it is easy to verify that

$$A\left(\overline{\delta}_{IC}\right) = \underbrace{\underline{b}_m\left(\overline{\delta}_{IC}\right)}_{>0}\overline{\delta}_{IC}\left[\phi - \frac{1}{1-\overline{\delta}_{IC}}\right] > 0 \quad \Leftrightarrow \quad \phi > \phi^*.$$

Hence, continuity of $A(\cdot)$, implies that for ϕ large enough and δ close enough to $\overline{\delta}_{IC}$ the optimal collusive strategy that is robust to renegotiation entails a strictly positive debt $\underline{b}_m(\delta) < \pi$ and $\underline{\alpha}_m(\delta) < 1$ for $\underline{u}$ not too large. ■

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