Short-Term Managerial Contracts and Cartels

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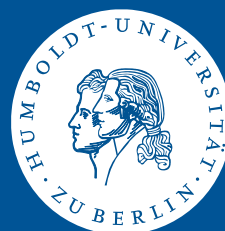
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Abstract

This paper shows how a series of commonly observed short-term CEO employment contracts can improve cartel stability compared to a long-term employment contract. When a manager's short-term appointment is renewed if and only if the firm hits a certain profit target, then (i) defection from collusion results in superior firm performance, thus reducing the chance of being fired, while (ii) future punishment results in inferior firm performance, thus increasing the chance of being fired in the future. The introduction of this re-employment tradeoff intertwines with the usual monetary tradeoff and can improve cartel stability. Studying the impact of fixed versus variable salary components, I find that fixed components can facilitate collusion with a short-term contract, while not affecting cartel stability with a long-term contract. Moreover, an extension of the model shows that short-term, renewable contracts can be a source of cyclical collusive pricing. Finally, interpreting the results in light of firm financing suggests that debt-financed firms can form more-stable cartels than equity-financed firms.

Keywords: cartels, collusion, managerial contracts, price wars
JEL codes: L13, L22, L41

1 Introduction

The majority of the literature on cartels and collusion treats the firm as a profit-maximizing decision maker, thereby deriving key insights on cartel stability and behavior from a profit-maximizing perspective. However, cartels often involve firms having separated ownership and control in such a way that the incentives of the key decision maker (CEO, manager) are not fully aligned with those of the profit-maximizing shareholders. The resulting corporate governance factors can have a key impact on the operation of cartels.[1]

This paper studies how short-term, renewable employment contracts affect cartel stability and behavior. Although one may expect that short-sighted CEOs are incapable of running a stable cartel,[2] I show how *short-termism* generated through such contracts can in fact improve cartel stability. Moreover, contrary to conventional wisdom that profit-dependent remuneration can incentivize CEOs to misbehave, the model shows that short-term contracts with fixed (as opposed to: variable) salary components can improve cartel stability.

From a sample of 375 CEO employment contracts of large public corporations, Schwab and Thomas (2006) find that 81% specify a length of five years or less, with a mean of 3.6 years. Similarly, Gillian, Hartzell and Parrino (2009) find that the median and mean length in a sample of 184 S&P 500 CEO contracts is 3.4 and 3.0 years, respectively. Moreover, recent work by Jenter and Lewellen (2010) indicates that CEO turnover decisions are very sensitive to stock price performance: from a sample of 2,569 publicly traded U.S. firms from 1992 to 2005, they find that 44% of CEOs left the firm within 4 years as a result of bad firm performance.[3] These empirical findings show that executives typically have a *short-term, renewable employment contract*, that is, a contract for a finite period of time which is renewed if and only if the firm performs sufficiently well.

In this paper, I take such a typical CEO contract as exogenously given and aim to understand its impact on the operation of cartels.[4] Assuming that managerial remuneration as well as the probability of contract renewal is positively related to firm profit, the manager can stochastically increase profit by forming a cartel with rival firms, while even further stochastically increasing profit by defecting from the collusive agreement. Two interrelated forces then dictate cartel stability. The manager compares the immediate expected salary gain resulting from defection, with the future expected salary losses resulting from punishment

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[1] See Buccirossi and Spagnolo (2007) for a research agenda on corporate governance factors and collusion.

[2] For example, Aubert, Rey and Kovacic (2006) argue that short-term contracts may incentivize managers to apply for leniency as they may leave the firm anyway; this effect tends to destabilize collusion.

[3] For additional evidence on the relationship of CEO turnover and firm performance, see Lausten (2002), Farrell and Whidbee (2003), Jenter and Kanaan (2010), and Kaplan and Minton (2010).

[4] The model abstracts away from the underlying motivation of adopting short-term, renewable contracts over long-term contracts or no contract at all. Such motivations include risk sharing or adverse selection—see the papers referenced above.

(monetary tradeoff). The manager also compares the immediate increase in the probability of contract renewal resulting from the higher expected profit during defection, with the future decrease in the probability of contract renewal resulting from the lower expected profits during future punishment (re-employment tradeoff). While the monetary tradeoff parallels the familiar problem faced by integrated, profit-maximizing firms engaging in cartelization, the re-employment tradeoff originates from the manager's fear of not being rehired.

Whether a series of short-term, renewable contracts strictly enhance cartel stability compared to a long-term contract depends on two effects. First, the manager is unsure whether he will be rehired even if he colludes and, hence, the game ends for him with some positive probability: this is a collusion-destabilizing effect. Second, noting that after defection the manager only cares about re-employment if the expected remuneration during punishment is not too small, the re-employment tradeoff can dominate the collusion-destabilizing effect if the probability of re-employment is relatively low during punishment, while the expected remuneration during punishment is indeed not too small. This ensures that the manager misses out (in expectation) on a substantial amount of future salary as he is fired in the future with a high probability.

The model also shows how a fixed salary component can stabilize collusion when a short-term contract is in place, while not affecting cartel stability when a long-term contract is in place. The intuition is that with a long-term contract, the fixed salary component is paid out in every period independent on managerial behavior and, therefore, does not affect the manager's incentives to collude. However, with a short-term contract, the fixed component is only paid out in periods in which the manager is indeed working for the firm. The manager anticipates that defection leads to a higher probability of being fired in the future—that is, losing out on future fixed salary components—which may amount to a large expected loss when he is relatively patient. In that case, the board of shareholders (more generally: the principal) optimally makes the fixed component an important part of the manager's salary so as to stabilize collusion.

In addition, this paper studies the case in which managers may revert from punishment to collusion when one of the managers is fired and replaced by another. The rationale behind such "serial collusion" is that managerial replacement restores the trust needed for a cartel to work. Such restoration of trust destabilizes collusion. The reason is that serial collusion increases the continuation value of defection, because (i) defection instantaneously increases the probability that the rival manager is fired, in which case collusion is immediately restored, and (ii) punishment is less fierce as it ends when the rival manager is fired at some point.

Finally, I consider the case in which managers engage in multiple sequential interactions within the span of the employment contract, thereby showing that short-term employment

contracts may be an explanation for cyclical collusive pricing. Suppose, for example, that the manager is halfway through his employment contract and has been colluding up until now, but that earlier firm profits have been extremely low due to random market conditions. In such a case, the profits during the second half of his employment contract should be extremely high for the manager's contract to be renewed. Since extremely high profits are very unlikely to occur even with collusion, the manager anticipates that his contract is unlikely to be renewed, resulting in defection from the collusive agreement. However, rational managers fix such destabilization by *ex ante* agreeing that the collusive strategy entails collusion if and only if earlier firm profits during the same employment contract have not been too low. The optimal collusive strategy then entails waves of competition, i.e., price wars, in equilibrium.

This paper is organized as follows. Section 2 discusses related literature. Section 3 presents the model, identifies the key tradeoff, and shows how short-term contracts can increase cartel stability. Section 4 investigates the impact of fixed salary components and serial collusion on cartel stability. Section 5 considers an employment contract covering multiple interactions on the product market over the contractual period, thereby allowing for cyclical collusive pricing. Section 6 reinterpret the results in light of firm financing, thereby arguing how debt-financed firms can form more-stable cartels than equity-financed firms. Section 7 concludes.

2   Related Literature

This paper relates to two strands of literature: (i) managerial incentives in cartels, and (ii) collusion and price wars. I discuss how my work relates to each in turn.

Managerial incentives in cartels.   This paper departs from the traditional literature on cartels and collusion by separating the firm's ownership and control so as to focus on the impact of short-term contracts on cartel stability and behavior. The papers discussed hereafter deal with the impact of several other common characteristics of managerial compensation on cartels.[5]

Spagnolo (2000) shows that stock-related compensation improves the stability of collusion: if stock markets have perfect foresight and are informed about the collusive agreement, then future punishment following a defection is immediately discounted in current stock prices,

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[5]The strategic delegation literature considers a related issue of how delegation affects the competitive outcome on the product market. The seminal papers are Fershtman and Judd (1987) and Sklivas (1987), which were preceded by Fershtman (1985) and Vickers (1985). Lambertini and Trombetta (2002), De Lamirande, Guigou and Lovat (2011), and Han (2011) extend the seminal strategic delegation models to a repeated setting so as to allow for collusion.

thereby instantaneously reducing the gain from defection.[6] Moreover, Spagnolo (2005) argues that collusion is more stable when managers have a preference for income smoothing, that is, when managers are provided with low-powered incentives so that they prefer a smooth stream of profits over time. The manager is then averse to variance in profits, which disincentivizes him to defect as that leads to a high profit today, followed by low punishment profits in the future. Also, Spagnolo (2005) shows that well-chosen capped bonus plans allow collusion to be stable for any discount factor, because the gain from defection will be capped. In contrast to Spagnolo's work, this paper specifically allows contracts to be finite, thereby introducing a collusion-stabilizing tradeoff based on the manager's fear to be fired.

Since cartels are illegal, a written contract between the firm owner and the manager that explicitly induces the manager to form a cartel is not enforceable in court. Therefore, the firm owner needs to rely on a relational contract with the manager to induce cartelization. Chen (2008) shows how such a relational contract between the owner and the manager facilitates collusion as (i) it prevents the manager to cheat on the product market, because defection results in collusion breaking down in which case the owner will pay nothing to the manager and the relational contract breaks down, while (ii) the owner cannot cheat on the relational contract by inducing the manager to defect, because the owner cannot credibly commit to rewarding the manager for a defection. Thus, Chen (2008) concludes that there exists no self-enforcing relational contract that can induce the manager to cheat on the product market. This paper, however, circumvents the need for a relational contract as contracting on profits in a short-term contract introduces a new tradeoff that can be used to stabilize collusion.

The manager's decision to form a cartel may interfere with other managerial duties. Aubert (2009) builds an elegant model of double moral hazard in which the manager chooses whether to exert costly effort which increases profits, while either competing or colluding on the product market. In such a scenario, a high-powered incentive contract aimed at inducing the manager to exert effort has the perverse effect of also inducing the manager to form a cartel. This conflict between incentives results in equilibrium contracts inducing a suboptimal effort level, leading to welfare losses even if there is no collusion in equilibrium. In a similar model of (single) moral hazard, Angelucci and Han (2011) consider a three-tier hierarchy, *authority-shareholder-manager*, so as to study the effects of intra-firm monitoring on fighting corporate crime, such as cartels. While Aubert (2009) and Angelucci and Han (2011) take a general approach to open up the black box of the profit-maximizing firm so as to endogenously determine the optimal contract, this paper takes the short-termism and renewability of observed CEO contracts as exogenously given.

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[6]In a market with stochastic, autocorrelated demand development, Neubecker (2005) confirms Spagnolo's (2000) finding that stock-based compensation facilitates collusion.

More generally, Bull (1987) and Baker, Gibbons and Murphy (2002), for instance, study relational contracts. They argue that such informal agreements and unwritten codes of conduct are widespread within firms and have an important impact on the incentives of individuals. Baker, Gibbons and Murphy (2002) show that the optimal allocation of decision rights minimizes the maximum temptation to renege on relational contracts. This paper takes the perspective of common formal, short-term, renewable CEO contracts.

Cartels and price wars. Empirical work shows that episodes of collusion often involve price wars—see, for example, Slade (1990), Harrington (2006), and Levenstein and Suslow (2006).[7] As a founder of cartel theory, Stigler (1964) pointed out that prices are high during cartelization, while *out-of-equilibrium* price wars occur after cartel breakdown. Since then, many authors have contributed to explaining patterns of elevated prices and price wars *in equilibrium*.

Such explanations include imperfect monitoring with demand uncertainty (Green and Porter, 1984; Abreu, Pearce and Stacchetti, 1986), demand cyclicity (Rotemberg and Saloner, 1986; Haltiwanger and Harrington, 1991), learning about unknown demand parameters with exogenous demand shocks (Slade, 1989), renegotiation of the collusive pie (Levenstein, 1997), and inducing exit of "dying" cartel members (Fershtman and Pakes, 2000).[8] These contributions treat the firm as profit-maximizing integrated entities.

In contrast, this paper presents an explanation for equilibrium price wars based on managerial issues. Since executives' compensation depends on their performance during the *full* contractual employment period, they optimally condition their pricing decision on profits realized earlier during their contractual employment period.

3   A Model of Cartel Stability with Short-Term Contracts

This section introduces the model (3.1); identifies the tradeoff associated with short-term contracts and cartel stability (3.2); shows that short-term contracts can improve cartel stability (3.3); and performs comparative statics of the key proposition (3.4).

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[7]I follow the literature by using the term "price wars" for episodes of lower prices than the collusive price, which can be caused by cartel break-down or endogenously arising as part of the collusive equilibrium.

[8]More recent contributions include the cartel members' concerns about detection by the antitrust authority (Harrington, 2004a), lifting prices after detection to push for lower damages in court (Harrington, 2004b), and cost variability in the presence of buyer detection (Harrington and Chen, 2006).

3.1 Set-up of the Model

Outline & players. Consider two firms $i \in \{1, 2\}$, where each firm i is owned by shareholder i who employs a manager i to run the firm. In an infinitely repeated game, the managers interact with each other on the product market in each period $t \in \{1, ..., \infty\}$. I refer to shareholders in the female form (she/her), managers in the male form (he/his) and firms in the neutral form (it/its). Figure 1 graphically summarizes the players.
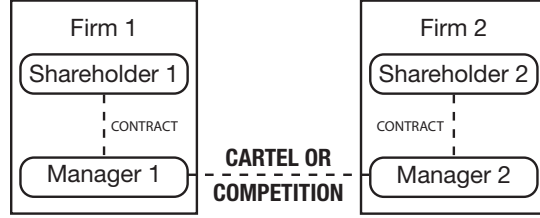
Figure 1. The players: shareholders and managers.

Managerial action. In each period $t \in \{1, ..., \infty\}$, both managers simultaneously decide whether to compete or collude on the product market. Managerial behavior stochastically affects the realization of the firms' profits.[9] Let profit of firm i in period t be a random variable $\pi_t \geq 0$ with cumulative distribution function (CDF)

$$F_a\left(x\right) = \Pr\left[\pi_t \leq x \middle| a\right], \forall x \geq 0,$$

where $a \in \{N, C, D, T\}$ represents the combination of behavior of manager i and j on the product market,

1. $a = N$ if both managers compete (<u>N</u>ash competition);

2. $a = C$ if both managers collude (<u>C</u>ollusion);

3. $a = D$ if manager i competes and manager j colludes (<u>D</u>efection by manager i);

4. $a = T$ if manager i colludes and manager j competes (manager i has been <u>T</u>ricked, because manager j defected).

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[9]Gillian, Hartzell and Parrino's (2009) empirical results show that an explicit short-term contract is more likely to be implemented when there is greater uncertainty about firm performance.

Assume that $F_a(x)$ is increasing over the entire domain $x \geq 0$, i.e., $\frac{\partial F_a(x)}{\partial x} > 0$ has full support. Defection is more profitable in expectation than collusion, which is, in turn, more profitable in expectation than Nash competition, in the sense of first order stochastic dominance, that is,

$$F_D(x) \leq F_C(x) \leq F_N(x),$$

for every $x \geq 0$, with a strict inequality for at least one value of x. By definition of stochastic dominance, expected profit in period t, $E_a(\pi_t)$, then satisfies $E_D(\pi_t) > E_C(\pi_t) > E_N(\pi_t)$. Moreover, collusion stochastically dominates being tricked, that is,

$$F_C(x) \leq F_T(x), \tag{1}$$

for every $x \geq 0$, with a strict inequality for at least one value of x. Thus, expected profits are such that $E_C(\pi_t) > E_T(\pi_t)$.

To stay in line with the literature and to focus on the impact of short-term contracts on cartel stability, both managers adopt the grim-trigger collusive strategy: a manager colludes as long as his rival colluded in all previous periods, but reverts to Nash forever after a defection.

Shareholder's actions. The shareholder appoints her manager for one period by offering a contract that is renewed for another period if and only if the firm's profit π_t is above some threshold profit level $\underline{\pi} \in [0, \infty)$ chosen by the shareholder in period $t = 0$. Otherwise, the manager is fired and replaced by a new manager. This simple rule of *perform well or beat it* is motivated by (i) observations of CEOs and managers being fired after bad firm performance;[10] (ii) the debate in academic journals as well as in the popular press that shareholders are focused on the short-term;[11] and (iii) the fact that the stock market allows investors (shareholders) to invest in a variety of financial products, thus rationalizing the shareholder to require a minimum threshold profit level that at least *beats the stock market.*[12]

In period $t = 0$, the shareholder also sets the managerial per-period salary scheme, consisting of a fraction $\beta \in [0, 1]$ of per-period profit π_t, plus a fixed component $\alpha \geq 0$ in each period.[13,14]

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[10]See, for example, Lausten (2002), Farrell and Whidbee (2003), and Jenter and Kanaan (2010).

[11]See, for example, Bolton, Scheinkman and Xiong (2006).

[12]Kaplan and Minton (2010) make the specific point that CEO replacement is related to firm performance relative to the performance of the overall stock market.

[13]This paper does not consider shareholders colluding in setting managerial incentive schemes. See Lambertini and Trombetta (2002) and Han (2011) for models in which firm owners collude on this.

[14]To focus on the impact of short-term managerial contracts on cartel stability, the model abstract away from dynamic contracting and does not allow managerial compensation to be based on profit realizations in previous or future periods. Section 5 considers the contract to be contingent on *previous* profit realizations;

Information. Managerial behavior is observable to the rival manager, but unobservable to shareholders. The motivation is that close managerial interaction on the product market reveals their actions to each other. However, as cartels are illegal, it would be virtually impossible for managers to credibly communicate to shareholders that there is a cartel without creating suspicion from the law enforcers.

Payoffs and objectives. In each period, the manager receives his salary, while the shareholder receives realized firm profit minus managerial salary. In period t, the shareholder's net profit $\Pi_t(\pi_t)$ and the manager's salary $S_t(\pi_t)$ are, respectively,

$$\Pi_t(\pi_t) = (1 - \beta)\pi_t - \alpha,$$
$$S_t(\pi_t) = \alpha + \beta\pi_t.$$

The manager has limited liability, which is taken care of by α and β being non-negative by assumption. The shareholder and the manager are risk neutral, have zero outside options, and discount payoffs with factor δ. The manager's objective is to maximize his discounted stream of expected payoffs. The owner's objective is to maximize cartel stability.[15]

Timing. In period $t = 0$, both shareholders independently set salary scheme (α, β), as well as the threshold profit level $\underline{\pi}$ that a manager needs to realize to be reappointed. In all subsequent periods $t \in \{1, ..., \infty\}$, (i) the managers interact on the product market by taking action pair $a \in \{N, C, D, T\}$; (ii) firm profit π_t is realized; and (iii) the manager is either fired or reappointed, depending on the realization of profit and the profit threshold level $\underline{\pi}$ set in period $t = 0$. The timing of the game is graphically depicted in Figure 2.

Period $t = 0$ ——— Each period $t \in [1, \infty)$

(i)   (ii)   (iii)

Shareholder sets   Manager takes   Profit π_t Manager is
profit threshold $\underline{\pi}$ action $a \in \{N, C, D\}$ realised   reappointed
and salary (α, β) iff. $\pi_t \geq \underline{\pi}$

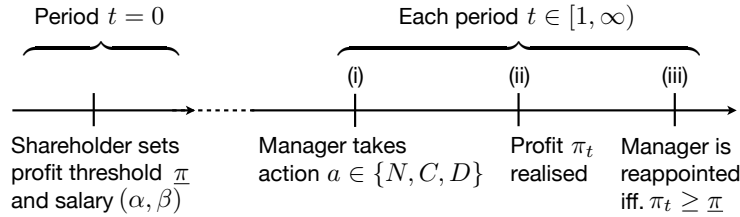*Figure 2. Timing of the game.*

for compensation schemes based on *future* profit realizations, see Spagnolo (2000), discussed in Section 2.

[15]It is left for future work to consider the owner to maximize her discounted stream of expected payoffs. The current model focuses on the impact of short-term contracts on cartel stability and behavior without fully endogenizing the employment contract.

3.2 Cartel Stability: Monetary and Re-employment Tradeoff

To focus on the main tradeoff, assume for now that managerial salary entails no fixed component, i.e., $\alpha = 0$. Subsection 4.1 relaxes this assumption.

As usual in the literature on collusion, the measure of cartel stability is the lowest discount factor δ such that the gain from defection does not exceed the expected discounted punishment: the lower is this discount factor, the more stable is the cartel.

Benchmark stability. Before solving the game outlined above, consider the benchmark model in which the manager has a long-term employment contract: he is hired forever without ever being fired.[16] In that case, the necessary and sufficient condition for collusion to be stable is

$$\sum_{t=1}^{\infty} \delta^{t-1} \beta E_C\left(\pi_t\right) \geq \beta E_D\left(\pi_t\right) + \sum_{t=2}^{\infty} \delta^{t-1} \beta E_N\left(\pi_t\right),$$

$$\text{iff. } \underbrace{\frac{\delta}{1-\delta}}_{A} \underbrace{\left(E_C\left(\pi_t\right) - E_N\left(\pi_t\right)\right)}_{B} \geq \underbrace{E_D\left(\pi_t\right) - E_C\left(\pi_t\right)}_{C}, \tag{2}$$

which represents the familiar result that collusion is stable if and only if the immediate expected monetary gain from defection (C) is not larger than the expected monetary loss from punishment in each future period (B), discounted to the present (A). Fraction β does not turn up in the stability condition as it cancels out in each term.

Stability with short-term contracts. For notational convenience, denote by $G_a\left(x\right) = 1 - F_a\left(x\right) = \Pr\left[\pi_t \geq x \mid a\right]$ the probability of realizing profit $\pi_t \geq x$ when the managers take action combination $a \in \{N, C, D, T\}$. Thus, given that the shareholder requires a profit of at least $\underline{\pi}$, the probability of re-employment for another period is $G_a\left(\underline{\pi}\right)$. The following lemma states the stability of collusion in the model with short-term contracts.

Lemma 1 *With short-term contracts, collusion is stable if and only if*

$$\delta\left(\frac{G_C\left(\underline{\pi}\right)}{1 - \delta G_C\left(\underline{\pi}\right)} E_C\left(\pi_t\right) - \frac{G_D\left(\underline{\pi}\right)}{1 - \delta G_N\left(\underline{\pi}\right)} E_N\left(\pi_t\right)\right) \geq E_D\left(\pi_t\right) - E_C\left(\pi_t\right). \tag{3}$$

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[16]In reality, even if the manager has a long-term employment contract, the shareholders may find some way to fire the manager, for example, by creatively interpreting the *just cause* doctrine to terminate the contract or to settle on an appropriate "golden handshake" with the manager. To focus on the impact of contract duration on cartels, this paper abstracts away from such behavior and implicitly assume that the termination costs of a long-term contract are infinitely high.

Proof. Collusion is stable if and only if the discounted expected payoff from defection is not larger than the discounted expected payoff from collusion, i.e., if and only if

$$\sum_{t=1}^{\infty} \left(\delta G_C\left(\underline{\pi}\right)\right)^{t-1} \beta E_C\left(\pi_t\right) \geq \beta E_D\left(\pi_t\right) + \delta G_D\left(\underline{\pi}\right) \sum_{t=1}^{\infty} \left(\delta G_N\left(\underline{\pi}\right)\right)^{t-1} \beta E_N\left(\pi_t\right),$$

$$\text{iff. } \frac{E_C\left(\pi_t\right)}{1 - \delta G_C\left(\underline{\pi}\right)} \geq E_D\left(\pi_t\right) + \delta G_D\left(\underline{\pi}\right) \frac{E_N\left(\pi_t\right)}{1 - \delta G_N\left(\underline{\pi}\right)},$$

which yields condition (3) when rearranging terms. ∎

The stability condition in Lemma 1 compares the immediate expected gain from defection (RHS) with the discounted expected future losses from punishment (LHS). As is the case in the benchmark stability condition, fraction β cancels out in each term. Stability now depends on two interrelated tradeoffs: (i) the immediate expected monetary gain from defection, compared with the discounted expected monetary loss from future punishment (monetary tradeoff), and (ii) the immediate increase in re-employment probability from defection, compared to the future decrease in re-employment probability due to punishment (re-employment tradeoff).

The monetary tradeoff and the re-employment tradeoff are intertwined. To gain intuition, condition (3) can be rewritten as

$$\underbrace{\frac{G_C\left(\underline{\pi}\right)\delta}{1 - G_C\left(\underline{\pi}\right)\delta}}_{C} \underbrace{\left(E_C\left(\pi_t\right) - E_N\left(\pi_t\right)\right)}_{B} + \left(\overbrace{\underbrace{\frac{G_C\left(\underline{\pi}\right)\delta}{1 - G_C\left(\underline{\pi}\right)\delta} - \frac{G_D\left(\underline{\pi}\right)\delta}{1 - G_N\left(\underline{\pi}\right)\delta}}_{E}}^{D}\right) \underbrace{E_N\left(\pi_t\right)}_{D,E}$$

$$\geq \underbrace{E_D\left(\pi_t\right) - E_C\left(\pi_t\right)}_{A}, \tag{4}$$

which shows that collusion is stable if and only if

(A) the immediate expected monetary gain from defection is not larger than

(B) the future per-period expected monetary loss from punishment, taking into account

(C) that the probability of re-employment is $G_C\left(\underline{\pi}\right)$ in each equilibrium period, which

(D) increases to $G_D\left(\underline{\pi}\right)$ in the period of defection, while

(E) decreasing to $G_N\left(\underline{\pi}\right)$ in all following punishment periods.

Below, I describe the intuition behind these effects and how they compare to the effects in the benchmark model.

(A) Monetary gain. The expected monetary gain from defection, $E_D(\pi_t) - E_C(\pi_t)$, is the same as in the benchmark model. The reason is that the immediate expected monetary gain is not contingent on whether the manager will be rehired in the future.

(B) Monetary loss. Provided that a punishment period is reached, the per-period expected monetary loss from punishment, $E_C(\pi_t) - E_N(\pi_t)$, is the same as in the benchmark model, because the expectations over profit realizations do not change by allowing managers to be fired.

(C) Continuation probability. In equilibrium, the probability that a manager is being reappointed is $G_C(\underline{\pi})$ in each period, whereas this probability is one in the benchmark model. When discounting the expected monetary losses from punishment (B) to the present, we should, therefore, premultiply the discount factor by $G_C(\underline{\pi})$. This decreases the manager's discounted expected loss of future punishment compared to the benchmark model and, thus, has a collusion-destabilizing effect.

(D) Re-employment gain. Defection results in a one-time *increase* in the probability of re-employment from $G_C(\underline{\pi})$ to $G_D(\underline{\pi})$. As a result, although the expected monetary payoff decreases to $E_N(\pi_t)$ after defection, the continuation probability of the game increases from $G_C(\underline{\pi})$ to $G_D(\underline{\pi})$. This effectively leads to a reduction in the expected loss from punishment, which is indicated by the numerators of the factors that premultiply $E_N(\pi_t)$ in condition (4). This reduction in the loss from punishment amounts to destabilizing collusion.

(E) Re-employment loss. Punishment leads to a *decrease* in the probability of reappointment from $G_C(\underline{\pi})$ to $G_N(\underline{\pi})$ in all future periods. Therefore, not only decreases the expected monetary payoff to $E_N(\pi)$, the continuation probability in all future periods of the game decreases from $G_C(\underline{\pi})$ to $G_N(\underline{\pi})$. This makes punishment fiercer through an increase in the expected loss from punishment, which is indicated by the denominators of the factors that premultiply $E_N(\pi_t)$ in condition (4). This increase in the loss from punishment amounts to stabilizing collusion.

3.3   Short-Term Contracts Can Increase Cartel Stability

Given profit threshold level $\underline{\pi}$, Proposition 1 states the characteristics of the probability distributions over profits $F_a(\cdot)$ such that collusion with short-term contracts is more stable than collusion with long-term contracts.

Proposition 1 *Collusion with short-term contracts and threshold profit level $\underline{\pi}$ is more stable than collusion with long-term contracts if and only if*

$$\frac{E_C\left(\pi_t\right)}{E_N\left(\pi_t\right)} < \frac{1-\delta G_C\left(\underline{\pi}\right)}{1-\delta G_N\left(\underline{\pi}\right)}\frac{1-\delta G_N\left(\underline{\pi}\right)-\left(1-\delta\right)G_D\left(\underline{\pi}\right)}{1-G_C\left(\underline{\pi}\right)}. \tag{5}$$

Proof. Collusion is more stable compared to the benchmark model if and only if condition (3) is satisfied for more discount factors than condition (2), i.e., if and only if

$$\delta\left(\frac{G_C\left(\underline{\pi}\right)}{1-G_C\left(\underline{\pi}\right)\delta}E_C\left(\pi_t\right)-\frac{G_D\left(\underline{\pi}\right)}{1-G_N\left(\underline{\pi}\right)\delta}E_N\left(\pi_t\right)\right) > \frac{\delta\left(E_C\left(\pi_t\right)-E_N\left(\pi_t\right)\right)}{1-\delta}, \tag{6}$$

which yields condition (5) when simplifying. ∎

Short-term contracts stabilize collusion if and only if (i) the increase in reappointment probability during defection from $G_C\left(\underline{\pi}\right)$ to $G_D\left(\underline{\pi}\right)$ is relatively small compared to the reduction in reappointment probability during punishment $G_C\left(\underline{\pi}\right)$ to $G_N\left(\underline{\pi}\right)$ (RHS), while (ii) the monetary loss during punishment from $E_C\left(\pi_t\right)$ to $E_N\left(\pi_t\right)$ is not too large (LHS). The intuition is based on the following three forces.

First, with a short-term contract, the manager is *ex ante* unsure whether he will be rehired even if he colludes. This has a destabilizing impact on collusion as it incentivizes the manager to deviate so as to grab as much salary as possible in the current period, while at the same time increasing the immediate probability of re-employment.

Second, short-term contracts introduce the re-employment tradeoff, which has a stabilizing impact on collusion if and only if the immediate increase in re-employment probability resulting from defection is small compared to the future reduction in re-employment probability resulting from punishment, that is, if and only if $G_D\left(\underline{\pi}\right)-G_C\left(\underline{\pi}\right)$ is small relative to $G_C\left(\underline{\pi}\right)-G_N\left(\underline{\pi}\right)$. If the re-employment tradeoff is sufficiently positive for collusive stability, it can offset the first force.

Third, the higher is the reduction in expected salary resulting from punishment, the less does the manager care about being rehired in the future, that is, the lower is the impact of the re-employment tradeoff, i.e., the second force.

Altogether, the re-employment tradeoff (force 2) stabilizes collusion by more than force 1 destabilizes collusion if and only if (i) the increase in reappointment probability during defection is small compared to the decrease in reappointment probability during punishment, provided that (ii) the monetary loss from punishment is not too large.

Proposition 2 *Short-term contracts can stabilize cartels compared to long-term contracts.*

Proof. If condition (5) holds for some $\underline{\pi}$, then the shareholder chooses one of those $\underline{\pi}$ such that (3) is satisfied. If condition (5) does not hold for any $\underline{\pi}$, then the shareholder sets $\underline{\pi} = 0$, thereby effectively mimicking a long-term contract. ∎

When there exists a profit level such that condition (6) is satisfied, then the optimal short-term contract stabilizes collusion. When no such profit level exists, the optimal short-term, renewable contract replicates an indefinite employment contract by setting the profit threshold level in such a way that even a manager that competes in the product market will achieve that profit level, i.e., $\underline{\pi} = 0$. A short-term contract then effectively mimics the collusive stability associated with a long-term contract. In that case, a *strict* short-term, renewable contract with $\underline{\pi} > 0$ would actually destabilize collusion.

3.4 Comparative Statics

The only assumptions on profit distributions are full support over the domain $\pi_t \geq 0$ and first order stochastic dominance of defection over collusion over Nash. Therefore, any change in profit distributions has an ambiguous impact on the *direction* as well as the *size* of the change of both $E_a(\pi_t)$ and $G_a(\underline{\pi})$. The ultimate impact on Proposition 1's condition (5) then depends on the relative changes in $E_a(\pi_t)$ and $G_a(\underline{\pi})$.

As a result, even very stylized comparative statics with respect to profit distributions leads to a large number of cases entailing tedious analyses without generating substantive insights in the model. The key point remains that changes in the parameters facilitate collusive stability if (i) the increase in reappointment probability during defection becomes smaller; (ii) the reduction in reappointment probability during punishment becomes larger; or (iii) the monetary loss from punishment becomes smaller—see the first paragraph after Proposition 1.

However, since the distribution over profit when defecting only appears once in condition (5) in the form of $G_D(\underline{\pi})$, some meaningful comparative statics are possible.

Proposition 3 *Cond. (5) is easier (more difficult) to satisfy if distribution $F_D(x)$ is*

1. *shifted to the left (right);*

2. *more (less) dispersed, provided that $\underline{\pi} < E_D(\pi_t)$ and keeping $E_D(\pi_t)$ fixed; or*

3. *less (more) dispersed, provided that $\underline{\pi} \geq E_D(\pi_t)$ and keeping $E_D(\pi_t)$ fixed.*

Proof. See Appendix A. ∎

The intuition is that changes entailing a reduction (increase) in $G_D(\underline{\pi})$, while not affecting the other parameters, make condition (5) easier (more difficult) to satisfy, because such changes make defection more attractive to the manager in the sense that the probability of re-employment increases after a defection.

4   Fixed Salary Components and Serial Colluders

This section considers the impact on cartel stability of fixed salary components (4.1), as well as the possibility to revert from punishment to collusion after replacement of a manager, which I refer to as "serial collusion" (4.2).

4.1   Fixed Salary Components Can Stabilize Cartels

This subsection relaxes the assumption that contracts contain no fixed salary component, that is, the shareholders are now free to set any $\alpha \geq 0$ and $\beta \geq 0$. This shows that a fixed salary component affects cartel stability when short-term contracts are in place, but not when long-term contracts are in place.

Benchmark stability.   First, consider long-term contracts. With long-term contracts, there exists a rather trivial optimal solution in which $\beta = 0$, because then the manager is indifferent between all possible actions as he is hired forever and earns α in every period. He has no incentives to defect, which makes collusion stable for all discount factors. This solution is not so interesting; therefore, I assume $\beta > 0$ from now on.

When $\beta > 0$ the stability with long-term contracts is unchanged when allowing for a fixed salary component, because collusion is stable if and only if

$$\frac{\delta}{1-\delta}\left[(\alpha + \beta E_C(\pi_t)) - (\alpha + \beta E_N(\pi_t))\right] \geq (\alpha + \beta E_D(\pi_t)) - (\alpha + \beta E_N(\pi_t)),$$

$$\text{iff. } \frac{\delta}{1-\delta}(E_C(\pi_t) - E_N(\pi_t)) \geq E_D(\pi_t) - E_C(\pi_t), \tag{7}$$

which is equivalent to benchmark stability condition (2). The reason is that the fixed salary component is paid out in every period and, thus, cancels out.

Stability with short-term, renewable contracts.   The following lemma states the stability condition with short-term contracts and a fixed salary component.

Lemma 2 *Allowing for a fixed salary component α, collusion is stable if and only if*

$$\delta\left(\frac{G_C(\underline{\pi})}{1 - \delta G_C(\underline{\pi})}E_C(\pi_t) - \frac{G_D(\underline{\pi})}{1 - \delta G_N(\underline{\pi})}E_N(\pi_t) + K\frac{\alpha}{\beta}\right) \geq \qquad (8)$$
$$E_D(\pi_t) - E_C(\pi_t),$$

where $K = \frac{G_C(\underline{\pi})}{1 - \delta G_C(\underline{\pi})} - \frac{G_D(\underline{\pi})}{1 - \delta G_N(\underline{\pi})}$.

Proof. Collusion is stable if and only if the discounted expected payoff from defection is not larger than the discounted expected payoff from collusion, i.e., if and only if

$$\delta\left(\frac{G_C(\underline{\pi})}{1 - \delta G_C(\underline{\pi})}(\alpha + \beta E_C(\pi_t)) - \frac{G_D(\underline{\pi})}{1 - \delta G_N(\underline{\pi})}(\alpha + \beta E_N(\pi_t))\right) \geq$$
$$\alpha + \beta E_D(\pi_t) - (\alpha + \beta E_C(\pi_t)),$$

which gives condition (8) when rearranging terms. ∎

For now, note that this stability condition differs from the stability condition without the fixed salary component in Lemma 1 by the term $\delta K\frac{\alpha}{\beta}$ on the LHS. I provide intuition for this difference below. Defining $\tilde{\delta} = \frac{G_D(\underline{\pi}) - G_C(\underline{\pi})}{G_C(\underline{\pi})(G_D(\underline{\pi}) - G_N(\underline{\pi}))}$, the following lemma states the optimal salary scheme from the shareholder's perspective and the impact of the fixed salary component α on the stability of collusion.

Lemma 3 *If $\delta > \tilde{\delta}$, collusion is stable and the optimal wage schedule entails an arbitrarily small fraction of firm profit $\beta > 0$ and a positive fixed salary component $\alpha > 0$. If $\delta \leq \tilde{\delta}$, collusion is stable if and only if condition (3) holds and the optimal wage schedule entails an arbitrarily small fraction of firm profit $\beta > 0$ and a zero fixed salary component $\alpha = 0$.*

Proof. We have that $K > 0 \Leftrightarrow \delta > \tilde{\delta}$. Therefore, if $\delta > \tilde{\delta}$, the LHS of condition (8) can be made arbitrarily large by setting α to any positive value and β arbitrarily small. However, if $\delta \leq \tilde{\delta}$, it is best to set $\alpha = 0$ (because $K < 0$), and collusion is stable if and only if condition (3) holds. ∎

The intuition for this result runs as follows. Dividing all managerial payoffs by β, we have that with action $a \in \{N, C, D\}$, the manager's expected payoff is $\frac{\alpha}{\beta} + E_a(\pi_t)$. The normalized fixed component $\frac{\alpha}{\beta}$ cancels out in "the gain from defection"—i.e., the RHS of condition (8)—because the fixed component is being paid in the current period independent of managerial behavior, that is, independent of whether the manager colludes or defects. However, the fixed component does not cancel out in the "future losses from punishment"—i.e., the LHS

of condition (8)—because the manager is being paid the fixed component in a future period if and only if the manager is actually hired in that future period, the probability of which depends on whether the manager colludes or defects in the current period.

If the "future losses from punishment with regard to the fixed component" is positive, i.e., if $K > 0$, then it is optimal for the shareholder to set $\alpha > 0$ so as to use the fixed salary component to increase stability. The shareholder can amplify this effect by making the fixed component a relatively important part of the wage schedule compared to the variable component, that is, by setting β sufficiently small relative to α. Note that if $\delta > \tilde{\delta}$, stability does not depend on the size of $\underline{\pi}$, because the shareholder can play around with α and β to make collusion stable for every $\underline{\pi}$. The next Proposition summarizes these results.

Proposition 4 *Allowing for a salary scheme with a fixed component weakly stabilizes collusion with short-term contracts, while not affecting collusive stability with long-term contracts.*

Proof. If $\tilde{\delta}$ satisfies condition (3), then we know from Lemma 3 that it is optimal to set $\alpha = 0$, resulting in condition (3) and (8) to be equivalent. If $\tilde{\delta}$ violates condition (3), then we know from Lemma 3 that it is optimal to set $\alpha > 0$, resulting in condition (8) to hold for a larger set of discount factor than condition (3). From (7) we know that a fixed salary component does not affect collusive stability. ∎

4.2 Serial Colluders Destabilize Cartels

This subsection assumes that managers revert from punishment to collusion after one of the managers has been replaced during the punishment phase. The motivation is that mistrust may be eliminated when a new manager is appointed; when a new manager enters the firm, he starts with a "clean sheet" and will restore collusion with his rival.

Proposition 5 *If replacement of a manager during the punishment regime results in the newly appointed manager to switch to collusion with his rival, then collusion is stable for less discount factors than if collusion is not restored after a managerial replacement.*

Proof. Let $V_C = \frac{E_C(\pi_t)}{1 - \delta G_C(\underline{\pi})}$ be the manager's continuation value of the collusive state. When collusion cannot (can) be restored, let V_D (V_D^r) and V_N (V_N^r) be the continuation value of the punishment state and defection state state, respectively. From (1), $G_T(\underline{\pi}) \leq G_C(\underline{\pi})$ is the probability of hitting at least profit level $\underline{\pi}$ when the rival manager defected from the collusive agreement.

Without restoration of collusion, collusion is stable if and only if $V_C \geq V_D$, where

$$V_D = E_D(\pi_t) + \delta G_D(\underline{\pi}) V_N.$$

With restoration of collusion, collusion is stable if and only if $V_C \geq V_D^r$, where

$$V_D^r = E_D\left(\pi_t\right) + \delta G_D\left(\underline{\pi}\right)\left[G_T\left(\underline{\pi}\right)V_N^r + \left(1 - G_T\left(\underline{\pi}\right)\right)V_C\right],$$

and V_N^r is determined by solving

$$V_N^r = E_N\left(\pi_t\right) + \delta G_N\left(\underline{\pi}\right)\left[G_N\left(\underline{\pi}\right)V_N^r + \left(1 - G_N\left(\underline{\pi}\right)\right)V_C\right],$$
$$\Leftrightarrow V_N^r = \frac{E_N\left(\pi_t\right) + \delta G_N\left(\underline{\pi}\right)\left(1 - G_N\left(\underline{\pi}\right)\right)V_C}{1 - \delta\left(G_N\left(\underline{\pi}\right)\right)^2}.$$

Noting that $V_N = \frac{E_N(\pi_t)}{1-\delta G_N(\underline{\pi})}$, straightforward algebra yields $V_N^r > V_N$, and, therefore, we have $V_D^r > V_D$. ∎

If a manager can switch from punishment to collusion with a newly appointed rival manager, this effectively results in the continuation value of defection to increase for two reasons. First, defection results in an immediate reduction in the probability that the rival manager is reappointed, that is, an increase in the probability that a *new* rival manager is appointed and collusion is restored instantaneously.[17] Second, the continuation value of defection is higher as in each punishment period collusion will be restored with probability $G_N\left(\underline{\pi}\right)$. In essence, Proposition 5 echoes McCutcheon (1997) who argues that meetings facilitate renegotiation, which effectively reduces the scope for punishment and thereby destabilizes collusion.

5 Short-Term Contracts Entail Equilibrium Price Wars

Typically, CEO contracts span several years.[18] Therefore, this section studies the model when managers interact *multiple* times on the product market *within* the course of their contractual employment period. This allows for dynamic pricing in the sense that a manager may find it optimal to make his behavior during his employment period contingent on profit realizations occurring earlier within the same contractual period.

5.1 Set-up of the Dynamic Model

To keep the analysis clean and to focus on the impact of multiple interactions within the same employment period on cartel behavior, managers are assumed to interact on the product market *twice* during their employment period, and that they do *not* discount their payoffs

---

[17]In the extreme case in which $G_T = 0$, collusion is unstable for every discount factor $\delta \in [0,1]$ as defection automatically results in a new rival manager being appointed immediately: collusion is restored instantaneously and no punishment occurs.

[18]See, for example, Schwab and Thomas (2006) and Gillian, Hartzell and Parrino (2009).

within the employment period. More than two interactions within the same contractual period and within-contract discounting would not bring essential insights, while mathematically complicating the model substantially.

Consider the model as outlined in Subsection 3.1, but now suppose that each period $t \in \{1, 2, ..., \infty\}$ consists of two sequential stages $k \in \{1, 2\}$. In both stages, the managers take action pair $a_k \in \{N, C, D\}$, resulting in profit $\pi_t^k \geq 0$, and the manager is reappointed for the next period $t+1$ if and only if $\pi_t^1 + \pi_t^2 \geq \underline{\pi}$. The conditional probability distributions over profit are the same as outlined in Subsection 3.1 and independent between periods and stages. Also, as before, managerial behavior is observed by the rival manager immediately after taking the action, thus allowing for punishment during the next interaction. The new timing of the game is depicted in Figure 3.

In terms of notation, define $G_{a_1 a_2}(\underline{\pi}) = \Pr[\pi_t^1 + \pi_t^2 \geq \underline{\pi} | a_1, a_2]$ as the *ex ante* probability of realizing at least aggregate profit $\underline{\pi}$ in period t, provided that the managers take action pair a_1 in stage 1 and a_2 in stage 2. Noting that $E_a(\pi_t^1) = E_a(\pi_t^2)$, I leave out the argument π_t^k in the expected value $E_a(\pi_t^k)$ for ease of notation, which then simply writes as E_a.

To derive more precise results, assume the following regularity condition,

$$\frac{\partial (G_D(x) - G_C(x))}{\partial x} > 0, \tag{9}$$

that is, the difference in re-employment probability between defection and collusion increases in the profit threshold $\underline{\pi}$. This means that increasing the profit threshold $\underline{\pi}$ reduces the probability of re-employment more when colluding than when defecting.
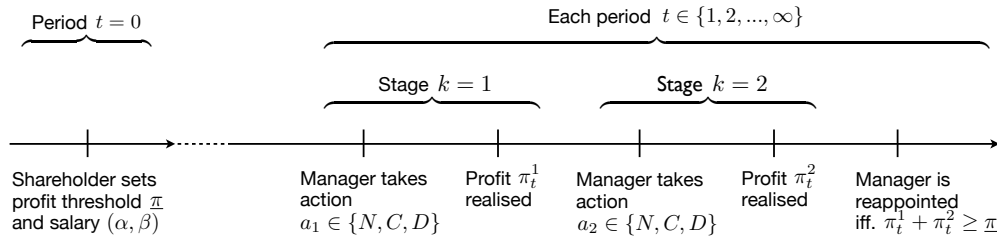

Figure 3. Timing of the dynamic game.

5.2   Collusion in Both Stages

The most straightforward grim-trigger collusive strategy is to collude in both stages as long as the rival manager colluded in all previous stages in all previous periods, while punishing forever otherwise. The stability of this strategy is pinned down by the following lemma.

Lemma 4 *Collusion in both stages is a stable strategy if and only if*

$$2\delta \left(\frac{G_C(\underline{\pi})}{1 - \delta G_{CC}(\underline{\pi})} E_C - \frac{G_D(\underline{\pi})}{1 - \delta G_{NN}(\underline{\pi})} E_N \right) \geq E_D - E_C. \tag{10}$$

Proof. See Appendix B. ∎

For a collusive strategy to be stable in the dynamic model, the manager must (i) not defect in stage 1, and (ii) not defect in stage 2 after *any* possible profit realization in stage 1, $\pi_t^1 \geq 0$. Consider first the managerial incentive to defect in stage 2. The *monetary tradeoff* is independent of the profit realization in stage 1: defection immediately increases the manager's expected salary from E_C to E_D, while decreasing it from E_C to E_N in each future punishment stage. However, the *re-employment tradeoff* does depend on the profit realization in stage 1: defection in stage 2 immediately increases the probability of re-employment from $G_C(\underline{\pi} - \pi_t^1)$ to $G_D(\underline{\pi} - \pi_t^1)$, while decreasing it from $G_{NN}(\underline{\pi})$ to $G_{CC}(\underline{\pi})$ in each future punishment period. Since defection increases the immediate re-employment probability more the higher is the profit level that needs to be attained (by the regularity condition), the manager finds it most attractive to defect when the profit realization in the first stage was the lowest realization possible—i.e., $\pi_t^1 = 0$—because then he must hit a high profit of at least $\underline{\pi} - \pi_t^1 = \underline{\pi}$ in the second stage, the probability of which is substantially increased when defecting.

Consider now the managerial incentive to defect in stage 1. This is lower than the managerial incentive to defect in stage 2 after the realization of profit $\pi_t^1 = 0$. The reason is two-fold. First, in stage 1, the manager has two interactions to attain aggregate profit $\pi_t^1 + \pi_t^2 \geq \underline{\pi}$, while after the realization of a zero profit in stage 1 the manager has only one interaction left to attain $\pi_t^2 \geq \underline{\pi}$. Second, defection in stage 1 is immediately followed by punishment in stage 2 *without* intra-period discounting, while defection in stage 2 is followed by punishment in the next period, which entails discounting.

Combining the arguments, collusion in both stages is a stable strategy if and only if the manager is patient enough not to defect in the second stage after the realization of a zero profit in the first stage, which is represented by condition (10).

5.3   Collusion Conditional on Profit Realization in Stage 1

The dynamic nature of the game allows the manager to condition his action in the second stage on the profit realization in the first stage. By the argument based on the regularity condition in the previous subsection, if the manager is patient enough to collude in stage 2 after profit realization $\pi_t^1 = \tau$, then he is also patient enough to collude in stage 2 after profit realization $\pi_t^1 > \tau$, but may not be patient enough to collude in stage 2 after any

profit realization $\pi_t^1 < \tau$. The intuition is that the closer is stage 1's profit realization to the profit threshold $\underline{\pi}$, the less attractive is defection in terms of increasing the immediate re-employment probability.

Compared to collusion in both stages, the manager potentially increases cartel stability by adopting a strategy that entails collusion in stage 2 only after profit realization $\pi_t^1 \geq \tau$, which I define as τ-*conditional collusion*. The reason is that the stability of collusion in both periods is determined by the manager's incentive to defect in stage 2 after a zero profit realization in stage 1, while τ-conditional collusion removes this concern as the manager competes as part of the collusive strategy for all $\pi_t^1 < \tau$. The next two subsections investigate the stability of τ-conditional collusion in stage 2 when the manager either colludes or competes in stage 1.

Collusion in stage 1 and conditional collusion in stage 2. Consider the collusive strategy in which the manager colludes in stage 1, while colluding in stage 2 if and only if $\pi_t^1 \geq \tau$. Define the *ex ante* re-employment probability of this strategy as $P_C(\underline{\pi}, \tau) = \int_\tau^\infty \Pr(\pi_t^1 = x \mid a = C) G_C(\underline{\pi} - x) dx + \int_0^\tau \Pr(\pi_t^1 = x \mid a = C) G_N(\underline{\pi} - x) dx$, & denote the *ex ante* expected per-period payoff as $K_C(\tau) = (1 + G_C(\tau)) E_C + (1 - G_C(\tau)) E_N$. The following lemma pins down the stability of this strategy.

Lemma 5 *Collusion in stage 1 and τ-cond. collusion in stage 2 is a stable strategy iff.*

$$
G_C(\tau)(E_C - E_N) +
$$

$$
\delta\left(\frac{P_C(\underline{\pi}, \tau)}{1 - \delta P_C(\underline{\pi}, \tau)} K_C(\tau) - \frac{G_{DN}(\underline{\pi})}{1 - \delta G_{NN}(\underline{\pi})} 2E_N \right) \geq E_D - E_C, \text{ and} \tag{11}
$$

$$
\delta\left(\frac{G_C(\underline{\pi} - \tau)}{1 - \delta P_C(\underline{\pi}, \tau)} K_C(\tau) - \frac{G_D(\underline{\pi} - \tau)}{1 - \delta G_{NN}(\underline{\pi})} 2E_N \right) \geq E_D - E_C, \tag{12}
$$

and is potentially more stable than collusion in both stages.

Proof. See Appendix C. ∎

By the regularity condition, the lower is stage 1's profit realization, the more attractive is defection in stage 2. Thus, the critical constraint for the manager's equilibrium behavior in stage 2 to be stable is determined by the lowest possible profit realization in stage 1 that still entails collusion in stage 2, that is, profit realization $\pi_t^1 = \tau$. This constraint is represented by condition (12): τ-conditional collusion in stage 2 (i) potentially makes collusion more stable than sure collusion in stage 2 as defection entails a lower increase in re-employment probability, that is $G_D(\underline{\pi} - \tau) - G_C(\underline{\pi} - \tau) < G_D(\underline{\pi}) - G_C(\underline{\pi})$, but (ii) may also decrease collusive stability as the equilibrium payoff is lower than collusion in both

stages, that is $K_C(\tau) < 2E_C$, and its equilibrium continuation probability is lower, that is $P_C(\underline{\pi}, \tau) < G_{CC}(\underline{\pi})$. The net effect depends on the precise specification of the density functions over profit and the level of τ.

If the manager is patient enough to collude in stage 2 after $\pi_t^1 \geq \tau$, he is not necessarily also patient enough to collude in stage 1. The intuition is that in stage 1, the manager has two interactions to achieve aggregate profit $\pi_t^1 + \pi_t^2 \geq \underline{\pi}$, while in stage 2 the binding constraint prescribes that the manager has one interaction to achieve profit $\pi_t^2 \geq \underline{\pi} - \tau$. Depending on the precise specification of the density functions over profit and the level of τ, the constraint in stage 1, i.e., (11), may or may not be the binding constraint.

Competition in stage 1 and conditional collusion in stage 2. If constraint (11) is the binding constraint for collusion in stage 1 and τ-conditional collusion in stage 2 to be stable, the manager may circumvent this and increase stability by constructing a collusive agreement that entails competition in stage 1 and τ-conditional collusion in stage 2. Define the *ex ante* re-employment probability associated with this strategy as $P_N(\underline{\pi}, \tau) = \int_\tau^\infty \Pr(\pi_t^1 = x \mid a = N) G_C(\underline{\pi} - x) dx + \int_0^\tau \Pr(\pi_t^1 = x \mid a = N) G_N(\underline{\pi} - x) dx$, and denote the *ex ante* expected per-period payoff as $K_N(\tau) = G_N(\tau) E_C + (2 - G_N(\tau) E_N)$. The following lemma pins down the stability of this strategy.

Lemma 6 *Competition in stage 1 and τ-cond. collusion in stage 2 is a stable strategy iff.*

$$\delta \left(\frac{G_C(\underline{\pi} - \tau)}{1 - \delta P_N(\underline{\pi}, \tau)} K_N(\tau) - \frac{G_D(\underline{\pi} - \tau)}{1 - \delta G_{NN}(\underline{\pi})} 2E_N \right) \geq E_D - E_C, \qquad (13)$$

and is potentially more stable than (i) collusion in both stages, and (ii) collusion in stage 1 and τ-conditional collusion in stage 2.

Proof. See Appendix D. ∎

Stability is not a concern in the first stage, simply because the collusive strategy prescribes competition in stage 1. Similarly to the argument presented in the previous subsection, the binding constraint for the collusive strategy to be stable in the second stage is determined by profit realization $\pi_t^1 = \tau$. If constraint (11) is the binding constraint in Lemma 5, then competition in stage 1 instead of collusion in stage 1 increases cartel stability provided that constraint (13) is satisfied for a larger set of discount factors than constraint (11), which depends on the precise specification of the density functions over profit and the level of τ.

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5.4 Equilibrium Price Wars, Stability, and Profitability

This subsection collects the results from the previous three lemmas and summarizes the behavioral implications when the managers adopt a strategy with τ-conditional collusion in stage 2.

Proposition 6 *Short-term contracts spanning multiple managerial interactions on the product market can entail price wars in equilibrium, thereby increasing cartel stability, while reducing cartel profitability.*

Proof. See Appendix E. ∎

Consider a manager colluding in both periods. Then, the critical constraint for collusion to be stable is whether the manager is patient enough to collude in stage 2 after a low profit realization in stage 1, because the manager has only one opportunity left to attain its contractual profit threshold level. However, if this jeopardizes cartel stability, then the managers may fix stability by adopting a collusive strategy in which they always collude in the first stage, while colluding in the second stage only if profit realization in the first stage was relatively high. In that way, they eliminate the concern of defection after a low profit realization, because the collusive equilibrium itself already specifies competition after a low profit realization.

It may be the case that such a strategy is still not stable, because the managers have incentives to defect in the first stage now. Then, the managers can change their strategy and compete in stage 1 as part of the collusive equilibrium, while colluding in stage 2 only if the profit realization in stage 1 is high enough.

Both strategies entail competition (price wars) as part of the collusive equilibrium. Although such price wars increase cartel stability, they decrease cartel profitability, because by stochastic dominance (i) expected profit of competition is lower than expected profit of collusion, and (ii) the continuation probability of collusion in both stages is higher than the continuation probability when the manager competes in the second (and possibly: the first) stage with some probability.

6 How Debt-Financed Firms Can Form Stable Cartels

The model can also be interpreted in light of firm financing, thereby showing how firms that are financed by debt, i.e., highly leveraged firms, can form more-stable cartels than firms financed by equity. This finding is consistent with Schleifer and Vishny (1992) and Khanna and Tice (2000), although through a different mechanism.

In the spirit of the model presented in this paper, consider the stylized situation of a firm fully financed by short-term debt. Assume that (i) the bank liquidates this firm immediately if it misses out on a periodical repayment, and (ii) all the profits left after the repayment are reinvested in the firm. Thus, to meet its repayment obligations, this debt-financed firm must each year make a profit of at least the amount that needs to be repaid. If such a firm colludes with its rivals, it faces the following tradeoff: defection makes it more likely to meet its current repayment obligation (due to a higher expected profit in the current period), but punishment makes it less likely to meet its future payment obligations (due to lower expected profits in future punishment periods). In other words, defection makes liquidation less likely in the current period, but more likely in future periods. This parallels the managerial tradeoff that defection makes being fired less likely in the current period, but more likely in future periods. Therefore, debt contracts can be designed in such a way to stabilize collusion and may be a source of cyclical pricing.[19]

7 Concluding Remarks

This paper has presented a mechanism through which commonly observed short-term, renewable employment contracts can improve cartel stability, while dynamically affecting firms' pricing behavior. Motivated by empirical observations, the model takes such short-term, renewable contracts as exogenously given, thereby abstracting away from the question which type of employment contracts would endogenously arise when the shareholders' main goal is to induce the CEO to either form or stay away from a cartel. This issue is at the center of the analysis in Aubert (2009) and Angelucci and Han (2011).

The model assumes that managers can observe each other's actions. However, if managers would not be able to observe the rival's action, Green and Porter (1984) suggest that the collusive strategy entails reversion to Nash for some periods after a low profit realization. How such unobservability of actions interacts with the impact of short-term, renewable contracts on cartel stability is left for future research.

In the current model, the shareholder's strategy to hire a new manager when profit turns out to be low is rational, because hiring costs are assumed to be zero and all managers are of the same type. It is then costless to hire a new manager. In contrast, if hiring costs are positive,[20] one may expect the current manager to haggle with the shareholder to renew his contract after a low profit realization; this is work for future research.

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[19]Apart from the described forces, another important force is that liquidation of the firm will result in a change of market structure, which would *ex ante* affect incentives. The impact of this force on overall cartel stability is an interesting avenue to explore in future research.

[20]This may be due to, for example, search costs or costs associated with drafting a new contract.

The model treats a long-term contract as an infinite contract such that the manager is never dismissed, thereby implicitly assuming that the termination cost of a long-term contract is infinitely high. However, sometimes a long-term contract can be terminated by paying some fixed firing cost, such as a "golden parachute". In such cases, a long-term contract may display the same collusion-stabilizing effect as a short-term contract as the contract is then effectively not indefinite.

Finally, the mechanism outlined in this paper implicitly assumes that employment contracts are observable to rival managers. Although recently, more and more firms publish the remuneration package and employment conditions of their executives, this may not always be the case. When rivals' employment contracts are not observable, then correct beliefs about these contracts may still induce the cartel-stabilizing mechanism.

Appendix

A Proof of Proposition 3

(1) Shifting $F_D(x)$ to the left (right) increases (decreases) $G_D(\underline{\pi})$, which in turn increases (decreases) the LHS of condition (5). (2) Suppose $\underline{\pi} < E_D(\pi_t)$. Making $F_D(x)$ more (less) dispersed increases (decreases) $G_D(\underline{\pi})$, which in turn increases (decreases) the LHS of condition (5). (3) Suppose $\underline{\pi} \geq E_D(\pi_t)$. Making $F_D(x)$ more (less) dispersed decreases (increases) $G_D(\underline{\pi})$, which in turn decreases (increases) the LHS of condition (5). ∎

B Proof of Lemma 4

The manager has no incentive to defect in stage 1 if and only if

$$\frac{2E_C}{1 - \delta G_{CC}(\underline{\pi})} \geq E_D + E_N + \delta G_{DN}(\underline{\pi}) \frac{2E_N}{1 - \delta G_{NN}(\underline{\pi})},$$

while, given the realization of π_t^1, he has no incentive to defect in stage 2 if and only if

$$E_C + \delta G_C \left(\underline{\pi} - \pi_t^1\right) \frac{2E_C}{1 - \delta G_{CC}(\underline{\pi})} \geq E_D + \delta G_D \left(\underline{\pi} - \pi_t^1\right) \frac{2E_N}{1 - \delta G_{NN}(\underline{\pi})}.$$

These two conditions rewrite as

$$\min \left\{ E_C - E_N + 2\delta \left(\frac{G_{CC}(\underline{\pi})}{1 - \delta G_{CC}(\underline{\pi})} E_C - \frac{G_{DN}(\underline{\pi})}{1 - \delta G_{NN}(\underline{\pi})} E_N \right); \right. \tag{14}$$

$$\left. 2\delta \left(\frac{G_C\left(\underline{\pi} - \pi_t^1\right)}{1 - \delta G_{CC}(\underline{\pi})} E_C - \frac{G_D\left(\underline{\pi} - \pi_t^1\right)}{1 - \delta G_{NN}(\underline{\pi})} E_N \right) \right\} \geq E_D - E_C \tag{15}$$

for every profit realization $\pi_t^1 \geq 0$. Subcondition (15) can be rewritten as

$$2\delta \left[\frac{G_C\left(\underline{\pi} - \pi_t^1\right) - G_D\left(\underline{\pi} - \pi_t^1\right)}{1 - \delta G_{NN}(\underline{\pi})} E_N + \right.$$

$$\left. G_C\left(\underline{\pi} - \pi_t^1\right) \left(\frac{E_C}{1 - \delta G_{CC}(\underline{\pi})} - \frac{E_N}{1 - \delta G_{NN}(\underline{\pi})} \right) \right] \geq E_D - E_C,$$

where we note that (i) $G_C\left(\underline{\pi} - \pi_t^1\right)$ is increasing in π_t^1, and (ii) $G_C\left(\underline{\pi} - \pi_t^1\right) - G_D \times \left(\underline{\pi} - \pi_t^1\right)$ is also increasing in π_t^1 by regularity condition (9). Thus, Subcondition (15) is most difficult to satisfy if $\pi_t^1 = 0$, that is, if

$$2\delta \left(\frac{G_C(\underline{\pi})}{1 - \delta G_{CC}(\underline{\pi})} E_C - \frac{G_D(\underline{\pi})}{1 - \delta G_{NN}(\underline{\pi})} E_N \right) \geq E_D - E_C. \tag{16}$$

Is (16) more difficult to satisfy than Subcondition (14)? Subtracting the LHS of (14) from the LHS of (16) yields

$$A := E_C - E_N + 2\delta \left(\frac{G_{CC}(\underline{\pi}) - G_C(\underline{\pi})}{1 - \delta G_{CC}(\underline{\pi})} E_C - \frac{G_{DN}(\underline{\pi}) - G_D(\underline{\pi})}{1 - \delta G_{NN}(\underline{\pi})} E_N \right),$$

which can be rewritten as

$$G_{CC}(\underline{\pi}) - G_C(\underline{\pi}) = \int_0^\infty \Pr\left(\pi_t^1 = x \mid a = C\right) G_C(\underline{\pi} - x) \, dx - G_C(\underline{\pi}) \tag{17}$$

$$= \int_0^{\underline{\pi}} \Pr\left(\pi_t^1 = x \mid a = C\right) G_C(\underline{\pi} - x) \, dx \tag{18}$$

$$+ \int_{\underline{\pi}}^\infty \Pr\left(\pi_t^1 = x \mid a = C\right) G_C(\underline{\pi} - x) \, dx - G_C(\underline{\pi})$$

$$= \int_0^{\underline{\pi}} \Pr\left(\pi_t^1 = x \mid a = C\right) G_C(\underline{\pi} - x) \, dx \tag{19}$$

$$+ \int_{\underline{\pi}}^\infty \Pr\left(\pi_t^1 = x \mid a = C\right) dx - G_C(\underline{\pi})$$

$$= \int_0^{\underline{\pi}} \Pr\left(\pi_t^1 = x \mid a = C\right) G_C(\underline{\pi} - x) \, dx + G_C(\underline{\pi})$$

$$- G_C(\underline{\pi}) \tag{20}$$

$$= \int_0^{\underline{\pi}} \Pr\left(\pi_t^1 = x \mid a = C\right) G_C(\underline{\pi} - x) \, dx, \tag{21}$$

where (17) follows by definition, (18) follows by splitting up the integral, (19) follows by noting that $G_C(\underline{\pi} - x) = 1$ for every $x \in [\underline{\pi}, \infty)$, (20) follows by definition, yielding (21). Similarly,

$$G_{DN}(\underline{\pi}) - G_D(\underline{\pi}) = \int_0^\infty \Pr\left(\pi_t^1 = x \mid a = D\right) G_N(\underline{\pi} - x) \, dx - G_D(\underline{\pi})$$

$$= \int_0^{\underline{\pi}} \Pr\left(\pi_t^1 = x \mid a = D\right) G_N(\underline{\pi} - x) \, dx + G_D(\underline{\pi})$$

$$- G_D(\underline{\pi}).$$

Therefore, $G_{CC}(\underline{\pi}) - G_C(\underline{\pi}) \geq G_{DN}(\underline{\pi}) - G_D(\underline{\pi})$, because by stochastic dominance we have (i) $\int_0^{\underline{\pi}} \Pr\left(\pi_t^1 = x \mid a = C\right) dx \geq \int_0^{\underline{\pi}} \Pr\left(\pi_t^1 = x \mid a = D\right) dx$, and (ii) $G_C(\underline{\pi} - x) \geq G_N(\underline{\pi} - x)$ for every $x \in [0, \underline{\pi}]$. Thus, noting that $E_C > E_N$ and $\frac{E_C}{1 - \delta G_{CC}(\underline{\pi})} > \frac{E_N}{1 - \delta G_{NN}(\underline{\pi})}$, we have $A > 0$ and, thus, (16) is the binding constraint. ∎

C   Proof of Lemma 5

The manager has no incentive to defect in stage 1 if and only if

$$\frac{E_C + G_C\left(\tau\right)E_C + \left(1 - G_C\left(\tau\right)\right)E_N}{1 - \delta P_C\left(\underline{\pi},\tau\right)} \geq E_D + E_N + \delta G_{DN}\left(\underline{\pi}\right)\frac{2E_N}{1 - \delta G_{NN}\left(\underline{\pi}\right)},$$

where $P_C\left(\underline{\pi},\tau\right) = \int_\tau^\infty \Pr\left(\pi_t^1 = x\,|\,a = C\right)G_C\left(\underline{\pi} - x\right)dx + \int_0^\tau \Pr\left(\pi_t^1 = x\,|\,a = C\right)\times G_N\left(\underline{\pi} - x\right)dx.$

Given the realization of π_t^1, he has no incentive to defect in stage 2 if and only if

$$E_C + \delta G_C\left(\underline{\pi} - \pi_t^1\right)\frac{E_C + G_C\left(\tau\right)E_C + \left(1 - G_C\left(\tau\right)\right)E_N}{1 - \delta P_C\left(\underline{\pi},\tau\right)} \geq E_D + \delta G_D\left(\underline{\pi} - \pi_t^1\right)$$

$$\times \frac{2E_N}{1 - \delta G_{NN}\left(\underline{\pi}\right)},$$

which rewrites as

$$\delta\left(\frac{G_C\left(\underline{\pi} - \pi_t^1\right)}{1 - \delta P_C\left(\underline{\pi},\tau\right)}K_C\left(\tau\right) - \frac{G_D\left(\underline{\pi} - \pi_t^1\right)}{1 - \delta G_{NN}\left(\underline{\pi}\right)}2E_N\right)\right\} \geq E_D - E_C$$

for every profit realization $\pi_t^1 \geq \tau$. By the regularity condition, this boils down to combined conditions (11) and (12) in Lemma 5.

Noting that $P\left(\underline{\pi},\tau\right) < G_{CC}\left(\underline{\pi}\right)$ and $E_C < K_C\left(\tau\right)$, we have that (11) is more difficult to satisfy than (14). However, constraint (14) is not the binding constraint for the "always collusion strategy" to be stable; constraint (15) with $\pi_t^1 = 0$ is the binding constraint. Thus, constraint (11) does not make the "$\tau-$conditional collusion strategy" less stable than strategy "always collusion strategy" as long as τ is such that (11) is easier to satisfy than (15) with $\pi_t^1 = 0$, which depends on the precise specification of the density functions.

Fixing $\pi_t^1 \geq 0$, constraint (12) is more difficult to satisfy than constraint (15), because $P\left(\underline{\pi},\tau\right) < G_{CC}\left(\underline{\pi}\right)$ and $E_C < K_C\left(\tau\right)$. However, depending on the precise specification of the density functions, constraint (12) may be easier to satisfy than constraint (15), because (i) both constraints are more difficult to satisfy the lower is π_t^1; and (ii) constraint (15) needs to be satisfied for every $\pi_t^1 \geq 0$; while (iii) constraint (12) needs only to be satisfied for every $\pi_t^1 \geq \tau$.

Thus, depending on the precise specification of the density functions, choosing an appropriate τ potentially results in both constraints (11) and (12) to be satisfied for a larger set of discount factors than constraint (15). ∎

D Proof of Lemma 6

Given the realization of π_t^1, the manager has no incentive to defect in stage 2 if and only if

$$E_C + \delta G_C \left(\underline{\pi} - \pi_t^1 \right) \frac{E_N + G_N \left(\tau \right) E_C + \left(1 - G_N \left(\tau \right) \right) E_N}{1 - \delta P_N \left(\underline{\pi}, \tau \right)} \geq E_D + \delta G_D \left(\underline{\pi} - \pi_t^1 \right)$$

$$\times \frac{2 E_N}{1 - \delta G_{NN} \left(\underline{\pi} \right)},$$

which rewrites as

$$\delta \left(\frac{G_C \left(\underline{\pi} - \pi_t^1 \right)}{1 - \delta P_N \left(\underline{\pi}, \tau \right)} K_N \left(\tau \right) - \frac{G_D \left(\underline{\pi} - \pi_t^1 \right)}{1 - \delta G_{NN} \left(\underline{\pi} \right)} 2 E_N \right) \geq E_D - E_C,$$

for every profit realization $\pi_t^1 \geq \tau$. By the regularity condition, we have that the above constraint is most difficult to satisfy if $\pi_t^1 = \tau$; thus, stability is determined by condition (13) in Lemma 6. ∎

E Proof of Proposition 6

First claim: price wars in equilibrium. The collusive strategies described in Lemmas 5 and 6 entail competition in stage 2 after the realization of profit $\pi_t^1 < \tau$ in stage 1; also, the collusive strategy described in Lemma 6 always entails competition in stage 1. Moreover, the collusive strategies described in Lemmas 5 and 6 are potentially more stable than collusion in both stages. Thus, contracts that span multiple managerial interactions potentially entail price wars in equilibrium.

Second claim: if managers adopt a strategy entailing price wars in equilibrium, then cartel stability is increased. The collusive strategies described in Lemmas 5 and 6 are potentially more stable, but entail a lower profitability—see the proof below. Thus, if managers adopt such a strategy, it means that they are not patient enough to collude in both stages, and thus adopt a strategy entailing equilibrium price wars, while compromising on cartel profitability.

Third claim: price wars reduce cartel profitability. The profitability of (i) collusion in both stages; (ii) collusion in stage 1 and τ-conditional collusion in stage 2; and (iii) competition in stage 1 and τ-conditional collusion in stage 2 is, respectively,

$$\frac{2 E_C}{1 - \delta G_{CC} \left(\underline{\pi} \right)} > \frac{K_C \left(\tau \right)}{1 - \delta P_C \left(\underline{\pi}, \tau \right)} > \frac{K_N \left(\tau \right)}{1 - \delta P_N \left(\underline{\pi}, \tau \right)},$$

because $2 E_C > K_C \left(\tau \right) > K_N \left(\tau \right)$ and $G_{CC} \left(\underline{\pi} \right) > P_C \left(\underline{\pi}, \tau \right) > P_N \left(\underline{\pi}, \tau \right)$. ∎

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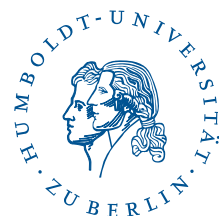# SFB 649 Discussion Paper Series 2012

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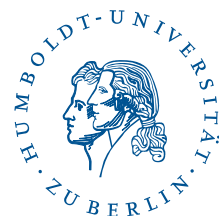
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