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Organizational Design and the Intensity of Rivalry

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We analyze the effect of managerial compensation schemes and organizational structure on competitive behavior in imperfectly competitive product markets. Previous research suggests that in cases of strategic substitutability, firms tend to choose organizational structures and compensation systems that commit the firm to behaving aggressively in the product market, reducing firm and industry profits. In contrast, we show that while compensation and structure in isolation lead to excessive aggressiveness, the combination of these two internal choice variables may reverse the outcome—organizational design can be used as a commitment device to reduce competitive rivalry. Finally, we find that in equilibrium, firms may choose to be different; one firm is decentralized and uses incentives that commit it to being aggressive, while the other is centralized and uses incentives that commit it to being soft. Hence, endogenous firm heterogeneity in the form of organizational differentiation allows firms to avoid a mutually detrimental outcome.

Key words: incentives; strategic delegation; organizational design; competitive strategy
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1. Introduction

In this paper, we study the relationship between organizational design and interfirm rivalry. Specifically, we explore how the *inside* of the firm—its actors, organization, and compensation systems—and the *outside* of the firm—product-market competition between rivals in the same industry—are interrelated. The objective of this study is to better understand both the forces shaping rivalry and those shaping organizational design.

A stream of economic research referred to as *strategic incentives theory* has examined how managerial incentives affect competitive interaction. The seminal papers in this field are Fershtman and Judd (1987), Sklivas (1987), and Vickers (1985). Typical strategic incentives models consist of a two-stage game. In the first stage, firms determine some element of the organizational design, e.g., the managers' compensation schemes or the organizational structure; in the second stage, managers compete in an imperfectly competitive product market. Organizational design serves as a commitment device, credibly binding the firm to more or less aggressive behavior. A central notion in this stream of research, dating back to Schelling (1960), is that firms may gain from distorting their managers' incentives relative to profit maximization because of its effect on strategic interaction. The main conclusion from this stream of research critically depends on the nature of competition. When firms choose output, and hence choices are strategic substitutes, the firm wants to motivate its manager to be *more* aggressive and to increase output in order to decrease the output of rival firms. In contrast, when managers choose prices, and hence choices are strategic complements, the firm wants its manager to be *less* aggressive and to increase the firm's price, which in turn leads rival firms to increase their prices. While the intensity of rivalry thus diminishes in the case of strategic complements, in the substitutes case, the strategic use of organizational design leads to a prisoner's dilemma; the desire of both firms to commit to high output results in excessive aggressiveness and reduced firm and industry profits.

A potential shortcoming of the extant literature is that each paper studies compensation systems or organizational structure in isolation. Arguably, this may result in misleading conclusions because firms typically make decisions about both their managerial remuneration system and their organizational structure. If the interaction between compensation systems and structure is nontrivial, the combination of these two organizational features may generate unexpected results.

Consider, for example, the electronics company Philips. Between 1970 and 2000, this company went through seven large restructuring processes, changing from national organizations via a matrix organization to global product divisions. These structural modifications were followed by changes in the responsibility and accountability of the organization and the implementation of different performance incentive systems. While many other examples are known of large organizations that have changed their organizational structure and compensation systems, such as IBM, Chrysler, and BP, organizational design involves choices about both structure and incentives in virtually all business organizations.

The questions that are addressed in this paper are the following: How does the combination of organizational structure and compensation systems affect competition, and how does competition affect these two elements of organizational design? Does a multifaceted organizational design create the opportunity to avoid the prisoner's dilemma that occurs when either structure or remuneration systems are studied in isolation? Does the simultaneous endogeneity of structure and compensation systems lead to firm homogeneity, as suggested in previous research, or does it encourage firms to differentiate their organizational form, resulting in firm heterogeneity? In this paper, we explore these specific questions while acknowledging that many other factors such as organizational complexity and bounded rationality—not modeled in this paper—affect the optimal design of business organizations.

To further our understanding of the relationship between the inside and the outside of the organization, we develop a model in which both organizational structure and managerial compensation systems are endogenized. In the model, two firms first determine whether their organizational structure is vertically centralized or decentralized, i.e., whether the production and marketing departments are treated as a single profit center or as two distinct profit centers having the autonomy to make operating decisions (Williamson 1985).[1] Subsequently, firms choose whether to use relative performance evaluation as a basis for their managerial remuneration system. Relative performance evaluation is a compensation scheme in which the performance of the manager is compared to an external benchmark by placing a weight, typically negative, on the rivals' profits (see, for example, Holmström 1979 in an agency context; Salas Fumás 1992, Miller and Pazgal 2001 in a strategic incentives context). Some form of relative performance evaluation or competitor orientation is used frequently as an objective in compensation schemes. For example, the use of external benchmarks in the case of executive compensation is well documented (Aggarwal and Samwick 1999). The use of market share objectives is also considered a competitor-oriented compensation scheme because it is a function not only of the sales of its own firm, but also of the sales of rival firms. Market share is one of the most commonly used objectives for sales organizations (see, e.g., Dalrymple and Cron 1995, Kaplan and Norton 1996). An example of a firm that has used competitor-oriented objectives for business unit managers is General Electric, which used the mantra "number 1 or number 2" for individual businesses. In the third stage of the model, the production and marketing departments negotiate the transfer price used to establish the performance of each profit center. This stage obviously only takes place if the decentralized structure is implemented. The last stage of the model is Cournot quantity competition. Thus, the model is a nonrepeated multistage game with simultaneous moves.

While our model is not meant to reflect a specific industry or specific companies, the following example might be illustrative of some of the aspects the model captures. For many decades, the turbine generator industry operated as a typical duopoly, with General Electric and Westinghouse as the two main competitors. This industry is part of the heavy-manufacturing sector and is generally characterized by strategic substitutability (Zitzewitz 2001). The two companies had very different organizational designs. While General Electric emphasized decentralization and competitor orientation, Westinghouse was characterized by tight central control (Bartlett and Ghoshal 1995). In this study, we explore what the effect of such differences in organizational design is on the intensity of rivalry, and under what circumstances firms choose to be organized so differently.

We find that the interaction of organizational structure and compensation systems is nontrivial and may reverse previously found results. While centralization typically dominates decentralization in strategic delegation games, in the equilibrium of this model at least one firm is decentralized. If the production department has enough bargaining power for there to be sufficient double marginalization, this decentralization softens competition to such an extent that profits are higher, not lower, than Cournot profits. Moreover, otherwise identical firms may choose different organizational designs, leading to asymmetric subgame-perfect equilibria; one firm chooses to decentralize and places a negative weight on rivals' performance, while its centralized rival uses a positive weight. This endogenous firm heterogeneity is associated with a further diminished intensity of rivalry, approaching the maximum industry profits despite the perfectly noncooperative setting. Thus, even though organizational structure and managerial reward systems may each in isolation have a detrimental effect on firms'

[1] The literature may use different terms for what we call *firms*. Fershtman and Judd (1987) use the term *owners*, distinguishing them from *managers*. Agency theory usually uses the terms *principal* and *agent*. Finally, in the organizational literature, the entity that determines structure and incentives is usually described as the *head office*. We will use the more neutral word, *firm*, and have a body in mind that cares about firm profits and sets the organizational structure and the managerial incentives.

profits, the combination of these two elements of organizational design may actually increase profits.

A way to understand the underlying mechanism of this paper is by examining the quasi-reaction curves of the managers when they compete in the final stage of the game. More specifically, one may explore how firms influence managerial behavior through the manipulation of managers' reaction curves. In the literature, many different degrees of control over reaction curves have been identified and studied. On the one hand, there is very limited control over the reaction curves in studies such as Fershtman and Judd (1987) and Salas Fumás (1992). On the other hand, studies such as Fershtman et al. (1991) and Miller and Pazgal (2001) investigate the characteristics of delegation games in which firms have far less restricted control over managers. Miller and Pazgal (2001) study games in which the firm can independently control the reaction function's slope and intercept. They show that any solution, e.g., the collusive outcome, to the demand system is an equilibrium of such a game. By allowing managers' actions to depend on both their own and their rivals' compensation schemes, Fersthman et al. (1991) also find an equilibrium that yields the collusive outcome.

This paper is motivated by both streams of research. Organizational designs that are composed of two elements rather than a single one confer more control over managers' behavior. While choices of organizational structure and remuneration systems increase the level of control, they do not allow firms to independently set reaction curves, as will be explained in detail below. This paper thus focuses on how different elements of organizational design may extend the control over management. At the same time, by distinguishing between organizational decisions taken centrally and decentrally, the study also highlights the limits of this control. For example, whereas the firm in this model determines organizational structure and compensation schemes, decisions about the transfer price and output quantity are taken decentrally and may or may not be in line with the firm's direct objectives. Moreover, the use of decentralization and transfer pricing creates an internal conflict and, thus, inefficiencies from the firm's point of view. The strategic use of these organizational inefficiencies lies at the heart of this paper. This paper complements well another recent theoretical paper that examines the deliberate design of organizational inefficiencies (Balasubramanian and Bhardwaj 2004). These authors conclude that "the firm's resulting profits in this setting of [internal] conflict can be higher than those obtained when the decisions of the managers are perfectly coordinated" (p. 489).

This paper is organized as follows. In §2, we introduce the model. Section 3 contains an analysis, a discussion, and some special cases of the model. The results are discussed in §4. Proofs are included in an online appendix, which is available on the *Management Science* website (http://mansci.pubs.informs.org/ecompanion.html).

2. Model

There are two firms, indexed $i = 1, 2$. The stages of the model are as follows. In Stage 1, the firms simultaneously decide whether to centralize ($O_i = C$) or to decentralize ($O_i = D$). The outcome of this stage determines whether transfer pricing (Stage 3) takes place. In Stage 2, the firms determine the weight μ_i placed on relative performance in the marketing managers' contracts. In Stage 3, if the firm is decentralized, a transfer price w_i is determined through negotiations between the production and marketing managers. In Stage 4, the marketing managers set the output quantity q_i. The market price P of the homogeneous good is determined by the total output quantity $Q = q_1 + q_2$ and market demand. Inverse demand is given by $P = a - bQ$, $a > 0$, $b > 0$. The production costs of firm i are given by cq_i, where, for simplicity, $c = 0$. The stages of the model are depicted in Figure 1.

We provide some additional information and notation for each stage.

Stage 1. Decentralization is modeled as vertical separation in production and marketing departments, rather than horizontal separation in product divisions. This choice allows us to draw insights from and contribute to both the vertical integration/separation and the strategic incentives literatures. If the organizational structure is centralized, i.e., the production and marketing departments are combined and managed by the same manager, no transfer pricing takes place. The organizational structure thus affects the marginal costs as perceived by the manager who decides the market quantity. While the perceived marginal costs equal the transfer price in the case of decentralization, in the case of centralization the perceived and actual marginal costs do not differ.

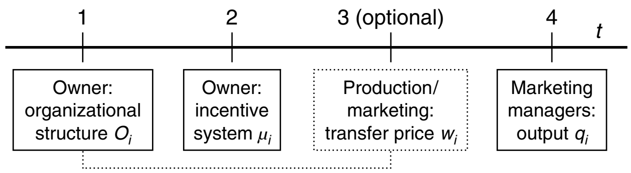
Stage 2. Following Salas Fumás (1992), the incentive contract for the marketing managers of firm $i = 1, 2$ has the following form:[2]

$$I_i^M = \pi_i^M + \mu_i \pi_j.$$

Here, π_i^M is the profits of the focal marketing department, π_j $(j \neq i)$ is the profits of the rival firm, and

[2] Following Fershtman and Judd (1987), one could write a manager's reward scheme as $A_i^D + B_i^D I_i^D$ for some constants A_i^D, B_i^D, where $B_i^D > 0$ and the superscript D stands for the respective department (P = production, M = marketing). Because the manager is riskneutral and efforts are not modeled in this paper, he or she maximizes I_i^D, regardless of the value of A_i^D and B_i^D.

Figure 1 **Stages of the Model**



$\mu_i \in \Re$ is the weight put on the rival's profits.[3] Departmental profits are defined as follows: $\pi_i^M = (P - w_i)q_i$ and $\pi_i^P = (w_i - c)q_i$ (thus, $\pi_i^M + \pi_i^P = \pi_i$). For simplicity, the production manager has a contract based on absolute performance rather than relative performance (i.e., $I_i^P = \pi_i^P$).[4]

A positive value for μ_i is expected to make marketing manager i less aggressive, i.e., set a smaller output quantity because he or she is rewarded for an increase in the rival's profits. In the extreme case, if all firms in an industry could credibly commit to setting $\mu_i = 1$, the collusive outcome, in which industry profits are maximized, would be attained. A negative value for μ_i obviously has the opposite effect because the reward increases as the rival's profits decrease. Finally, $\mu_i = 0$ would lead to an incentive that is equal to absolute performance evaluation, putting no weight on the performance of other firms in the industry. While agency theory has provided a rationale for using relative performance evaluation to reduce the effect of common noise (e.g., Holmström 1979), this study focuses on the effect of these schemes on the manager's behavior in competition, as proposed by Salas Fumás (1992). We explore relative performance evaluation with external benchmarks, whereas Faulí-Oller and Giralt (1995) study internal comparison between product divisions.

Stage 3. Because the production and marketing departments are at the same time autonomous and mutually dependent, transfer pricing is necessary to determine the profitability of each department and to achieve accountability. A widely used practice to determine transfer prices is through negotiation (Kaplan and Atkinson 1998, Vaysman 1998). While the bilateral bargaining game is not explicitly modeled, it is assumed that the production department receives a fraction $\alpha \in [0, 1]$ of the surplus, leaving a fraction $1 - \alpha$ for the marketing department (Van Mieghem 1999).

The lower bound of the bargaining outcome is given by the minimum transfer price that is acceptable to the production department, which is the marginal costs of production. The maximum transfer price that is acceptable to the marketing department would in theory be the transfer price at which the marketing department would make zero profits. However, it is Pareto inefficient to increase the transfer price to a level higher than what would maximize the production department's profits. Consequently, the upper bound of the bargaining outcome is given by the transfer price that maximizes the production department's profits.

The transfer price of firm i is thus assumed to be

$$w_i = \alpha w_i^o + (1 - \alpha)c,$$

where α is an exogenously given parameter that is equal for both firms, and w_i^o is the transfer price that maximizes the profits of production manager i. If both firms are decentralized, w_i^o is determined as the Nash equilibrium of the simultaneous move by the production managers. If only one firm is decentralized, w_i^o is determined as the maximum of a single-player optimization problem. If a firm is centralized, this stage is omitted (i.e., the transfer price is equal to marginal costs).

The exogenous parameter α can be interpreted as the relative bargaining power of the production department vis-à-vis the marketing department (Van Mieghem 1999).[5] If $\alpha = 1$, the production manager has all the bargaining power and sets a transfer price that will maximize the production department's profits. If $\alpha = 0$, all the bargaining power resides at the marketing department, which then pays a transfer price equal to marginal costs. Note that this latter case is equivalent to centralization.[6]

Whereas Alles and Datar (1998) study transfer prices that are determined by the CEO, in our case

[3] As a matter of definition, the unit of comparison for the performance of each marketing department could be either the rival firm as a whole or the rival marketing department specifically. This choice does not affect the incentives of the manager because marketing manager i maximizes $\pi_i^M + \mu_i^M \pi_j$, where π_j could be defined either as $q_j P - q_j c$ or $q_j P - q_j w_j$. Because q_j, c, and w_j are all treated as constants when marketing manager i solves the optimization problem, both expressions yield the same outcome. The outcome of the game is thus independent of this choice. In the present model, the marketing department's performance is compared to the performance of the rival firm as a whole, which facilitates the analysis of the model.

[4] The choice to introduce relative performance evaluation for the marketing department rather than for the production department is inspired by the direct competition between marketing departments, which, in this model, is absent between production departments.

[5] The relative bargaining power of the production and marketing departments could be seen as depending on the value added of each department in the value chain. Another complementary perspective is to assert that bargaining power depends on the *administrative heritage* of the company (Bartlett and Ghoshal 1989). While in some companies production traditionally plays a more important role, in other companies marketing, historically, is more dominant.

[6] As α gets smaller, the effect of decentralization diminishes, completely disappearing if $\alpha = 0$. The bargaining parameter α could thus be interpreted as a continuous measure of the degree of decentralization.

transfer prices are thus set in a decentralized fashion. Kaplan and Atkinson (1998) acknowledge that decentrally negotiated, linear transfer prices may lead to a suboptimal level of output from the firm's point of view. Dual-rate transfer prices (two-part tariffs) could solve this problem but, according to Kaplan and Atkinson (1998), are rarely used in practice. This study explores whether these internal inefficiencies could soften oligopolistic competition to the benefit of the focal firm.

Stage 4. Marketing manager i chooses output q_i to maximize $I_i^M = \pi_i^M + \mu_i \pi_j$.

The sequence of the modeling stages reflects the time horizon of the decisions that are made at each stage. In most cases, the choice of organizational structure represents a long-term decision, as costly to reverse as a major bricks-and-mortar investment. The design and implementation of a managerial compensation system represents a medium-term decision, which may be changed more often than the organizational structure. Note that a change in the organizational structure generally necessitates a restructuring of compensation schemes, while the opposite is not true. Transfer prices are typically determined once a year, while output decisions are short-term decisions that are taken on a day-to-day basis.

The model used in this paper is a game of complete information. We assume, for example, that incentive contracts can be observed by all the involved parties. Whether this is empirically true obviously depends on the specific situation. In studying strategic incentives in the gasoline industry, Slade (1993) argues that incentive contracts are observable and could, therefore, be used as a strategic commitment device. Moreover, even if information is incomplete, our results may still hold. Katz (1991) studies a principal-agent model with unobservable contracts and concludes that these contracts may have commitment value in spite of their unobservability.

3. Equilibrium Analysis

In this section, we first analyze the case in which organizational structure is endogenized, but compensation systems are treated as exogenously given (§3.1). Then, we endogenize the compensation system for exogenously given organizational structures (§§3.2–3.4). Finally, we present and discuss the overall solution to our model, endogenizing both organizational structure and compensation systems (§3.5).

Separately analyzing the special cases of our model allows us to link the present model to the existing literature to create a benchmark with which the solution of the overall model can be compared and to provide intuition for the building blocks of the model. Moreover, in some specific real-life situations, special cases of our model may be more applicable than the overall model. As mentioned earlier, the choice of organizational structure represents a long-term decision, while the compensation system could be modified in the medium term. Whereas strategic consequences of organizational design are the focus of this paper, many operational rather than strategic considerations may influence the choice of organizational form. Thus, when evaluating different compensation schemes, senior management may, in certain circumstances, take the existing organizational structure as given.

3.1. Endogenization of Organizational Structure

Throughout this section, we assume that there is no relative performance evaluation, i.e., $\mu_i = 0$. This special case of our model is equivalent to studies of vertical integration and separation by, among others, McGuire and Staelin (1983), Bonanno and Vickers (1988), and Moorthy (1988). However, our interpretation of the model is different in that we consider vertical separation *within* a firm (called *vertical decentralization*) as opposed to vertical separation *between* firms. Two firms choose whether to be centralized or to be decentralized, in which case the marketing department pays a negotiated transfer price to the production department. The outcome of this game could be that both firms are centralized (denoted $O_iO_j = \widehat{CC}$, where the superscript "^" signifies that $\mu_i = 0$), both are decentralized (denoted $\widehat{DD}$), or that one firm is decentralized while the other is centralized (denoted $\widehat{DC}$). Equilibrium values are denoted throughout this paper with the superscripts O_iO_j, where i represents the focal firm and j the rival firm.[7]

The question we address here is as follows. How does the choice of organizational structure affect the market outcome, specifically in terms of firm profitability?

Lemma 1. *If there is no relative performance evaluation, i.e.,* $\mu_1 = \mu_2 = 0$:

(i) *Two decentralized firms have profits that are higher than those of two centralized firms for* $0 < \alpha \leq 1$.

(ii) *There is a unique value of* $\alpha \in (0, 1)$, *such that two decentralized firms attain the collusive outcome, absent explicit coordination.*

(iii) *The subgame-perfect equilibrium of this case is that both firms are centralized* (CC), *leading to a prisoner's dilemma.*

It is well known that vertical separation creates a negative externality (*double marginalization*) that

[7] For example, q^{CD} is the equilibrium output quantity of a centralized firm with a decentralized competitor. Further, $\hat{q}^{CD}$ is the equilibrium output quantity of a centralized firm competing with a decentralized firm, in the absence of relative performance evaluation.

reduces output. The positive effect on price is confirmed in a number of empirical studies (discussed in Lafontaine and Slade 1997). This effect also holds in our situation of vertical decentralization within a firm. We now discuss the possible cases ($\widehat{CC}$, $\widehat{DD}$, and $\widehat{DC}$) in turn.

If both firms are centralized, transfer pricing does not take place, the value of α is not relevant, and the standard Cournot outcome is obtained for all α. If both firms are decentralized and $\alpha = 0$ (i.e., the sales manager has all the bargaining power), the transfer price is equal to marginal costs, and therefore, decentralization does not affect the incentives of the sales manager. Consequently, similar to the $\widehat{CC}$ case, the standard Cournot outcome is obtained. However, as α gets larger (i.e., the bargaining power of the production manager relative to the marketing manager increases), the transfer price becomes larger, which inflates the marginal costs as perceived by the marketing manager, and output decreases. Because the industry output in the standard Cournot context is larger than the monopoly output, the output reduction caused by decentralization has a positive effect on industry and firm profitability. In fact, there exists a value for α (denoted by $\hat{\alpha}$) such that when both firms are decentralized and $\alpha = \hat{\alpha}$, industry profitability is maximized (each firm obtains half of the monopoly profits). For $\hat{\alpha} < \alpha \leq 1$, the reduction effect is so large that the industry output is less than the perfectly collusive output, and profitability declines (remaining, nevertheless, larger than standard Cournot).

If one firm is decentralized while the other is centralized, the centralized firm obtains profits that are higher than those of the decentralized firm; the decentralized firm's output reduction benefits the centralized firm while hurting the decentralized firm. As α increases, the difference between the centralized and decentralized firms' profits increases.

Solving the special case that $\mu_i = 0$ by backwards induction shows that each firm wants to centralize, independent of the structure of the rival (indeed, $\hat{\pi}^{CD} > \hat{\pi}^{DD}$ and $\hat{\pi}^{CC} > \hat{\pi}^{DC}$ for $0 < \alpha \leq 1$). Centralization is thus the dominant strategy, and $\widehat{CC}$ is the subgame-perfect equilibrium. The general conclusion of the strategic incentives literature—increased aggressiveness in the case of strategic substitutes—thus holds in this special case of our model. We find that firms choose to be centralized, although decentralization could increase profits up to the level of perfect collusion. The intuition behind this result is that firms want to commit to aggressive behavior knowing that this will soften the rival's behavior, given the substitutes' nature of competition. However, because both firms simultaneously decide to centralize, industry and firm profits decline relative to the decentralization case. This is an example of the well-known prisoner's dilemma. In the absence of explicit collusive agreements, firms cannot avoid a mutually detrimental outcome.

3.2. Endogenization of Compensation Systems: *CC*-Subgame

We now endogenize compensation systems while treating the organizational structure as given. In this section, we discuss the situation in which both firms are centralized. This section thus considers a subgame of the overall model (referred to as the *CC*-subgame). The model in this section is equivalent to the special case of the model in Salas Fumás (1992), where managers are assumed to be risk neutral. Section 3.3 deals with the case that both firms are decentralized (the *DD*-subgame). The case in which one firm is decentralized while the other is centralized (the *DC*-subgame) is discussed in §3.4. Hence, the question addressed in this section is as follows: How does the use of relative performance evaluation affect the market outcome?

Lemma 2. *If both firms are centralized*:

(i) *In the continuum of solutions that are subgame-perfect equilibria, at least one of the firms chooses a negative* μ *and the incentive parameter used satisfies the following expression*:

$$\mu_1 = -\frac{1+\mu_2}{1-3\mu_2}, \quad \text{with } \mu_i < \frac{1}{3}.$$

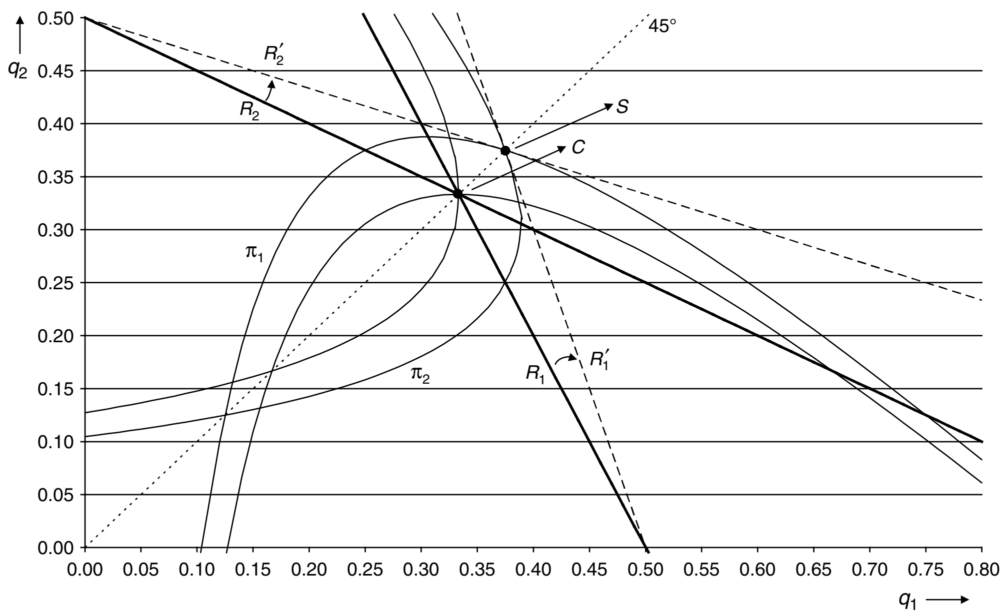
(ii) *There exists a unique symmetric equilibrium in which* $\mu_1 = \mu_2 = -1/3$.

(iii) *The use of relative performance evaluation increases industry output and decreases industry profits, relative to the standard Cournot outcome.*

An effective way to understand the intuition of this result is by examining a graph in which the managers' (quasi-)reaction curves and the firms' isoprofit curves are depicted (see Figure 2). In the figure, the standard Cournot outcome (point *C*) is compared to the outcome that is obtained when firms can use relative performance evaluation for their managers (point *S*).

R_1 and R_2 are the standard, downward-sloping Cournot reaction curves. The use of relative performance evaluation rotates the manager's reaction curve around the intersection with the firm's own quantity axis. The use of relative performance evaluation with $\mu_i < 0$ makes the managers' reaction less sensitive to changes in the rival's output (i.e., R_1' is steeper than R_1, and R_2' is flatter than R_2). The reason for this is that as q_j increases, firm j becomes more vulnerable to firm i's actions, providing the incentive to firm i's manager to increase output, which partially offsets the standard negative relationship between q_i and q_j in Cournot competition. The managers'

Figure 2 Relative Performance Evaluation Increases Equilibrium Output



reaction curves are given by the following expression:

$$R_i\colon\ q_i(q_j;\mu_i) = \frac{a}{2b} - \frac{1}{2}(1+\mu_i)q_j.$$

Note in Figure 2 that in point S, firm i has rotated R_i in such a way that at the intersection of R_i' and R_j', R_j' is tangent to firm i's isoprofit curve, which ensures that the profits of firm i are maximized, given R_j'.[8] In the unique symmetric solution to the CC-subgame (point S), $\mu_i = -1/3$, $q_i = 3a/8b$, and $\pi_i = 3a^2/32b$. This result confirms the conventional wisdom that firms that are competing in strategic substitutes have the incentive to make their managers more aggressive.

Salas Fumás (1992) shows that $(\mu_i, \mu_j) = (-1, 0)$ yields the Stackelberg outcome, with firm i being the leader. In this case, R_j and R_j' coincide, while R_i is zero sloped with regards to its own axis because the positive relative performance effect exactly offsets the standard negative Cournot effect, given that the sum of the weights on π_i and π_j equals zero ($I_i^M = \pi_i - \pi_j$). As $\mu_i < -1$, R_i becomes upward sloping; the relative performance effect dominates the standard Cournot effect. Thus, the use of relative performance evaluation makes it possible that the game changes from competition in strategic substitutes to competition in strategic complements.

While Salas Fumás (1992) only considers the abovementioned equilibria, in online Appendix 2 we show that there is in fact a continuum of solutions, as stated in Lemma 2, in which total industry output Q and profits Π are the same: $Q = 3a/4b$ and $\Pi = 3a^2/16b$.

In summary, while relative performance evaluation creates the potential for firms to collude through *positively* weighing the rival's profits in the manager's objective function, in equilibrium at least one of the firms provides a *negative* weight on the profits of the rival firm. Relative to standard Cournot without relative performance evaluation, output increases and profits decrease. Hence, equivalent to the case discussed in §3.1, endogenizing compensation systems leads to a prisoner's dilemma, decreasing each firm's profits.

3.3. Endogenization of Compensation Systems: *DD*-Subgame

While decentralization makes firms behave less aggressively, decreasing output, relative performance evaluation with $\mu_i < 0$ has the opposite effect; it encourages managers to behave more aggressively, thereby increasing output. In this section, we analyze the net effect of these two opposite forces. Is the effect of decentralization stronger, reducing output, or does the belligerent effect of relative performance evaluation prevail over decentralization, increasing output?

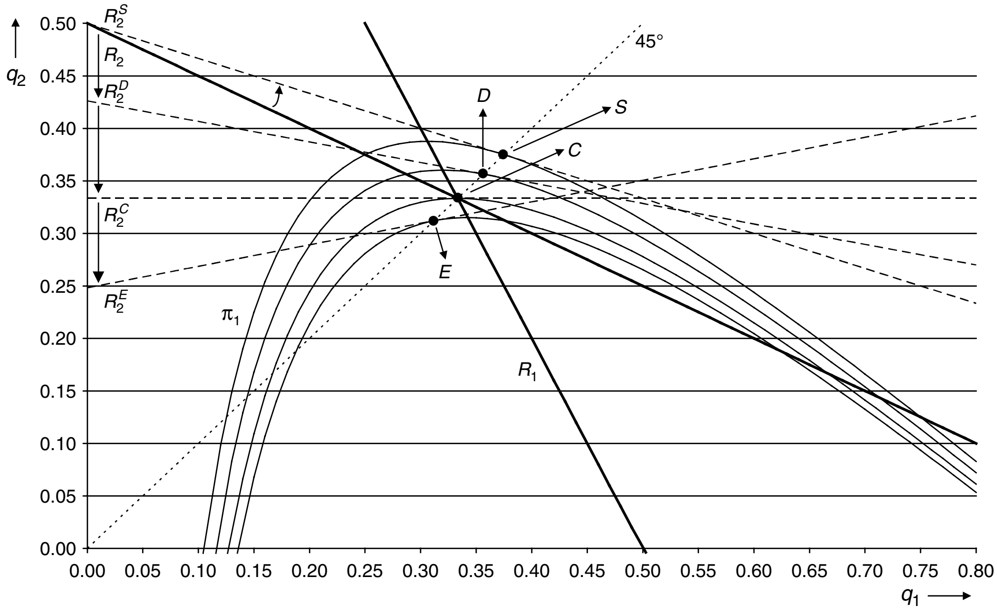
Lemma 3. *If both firms are decentralized, the unique symmetric subgame-perfect equilibrium is characterized as follows*:

(i) $\mu^{DD} < 0\ \forall\, \alpha \in [0, 1]$.

(ii) *As* α *increases from 0 to 1*, μ^{DD} *decreases monotonically*, w^{DD} *increases monotonically*, q^{DD} *decreases monotonically, and* π^{DD} *increases monotonically.*

[8] The profits of Firm 1 (2) increase in the southeast (northwest) direction. The isoprofit curves are zero sloped with regards to their own axis when they intersect the Cournot reaction curve; because reaction curves depict the optimal value of q_i given q_j, a change in q_i without changing q_j lowers π_i.

Figure 3 *DD*-**Subgame Equilibria for Different Values of** α



(iii) *There exists an* $\alpha^o \in [0, 1]$ *such that if and only if* $\alpha > \alpha^o$, *firm profits exceed the profits in standard Cournot* ($\pi^{DD} > \pi^{Cournot}$).

We explore the intuition of this subgame in a similar graph as above. For simplicity, we focus on Firm 1's profits and Firm 2's reaction curves. The reaction curves at the last stage of the game are as follows:

$$R_i\colon\ q_i(q_j; w_i, \mu_i) = \frac{a - w_i}{2b} - \frac{1}{2}(1 + \mu_i)q_j.$$

While the incentive parameter μ_i rotates the reaction curves as before, the transfer price shifts the intercept. In Figure 3, point S is the symmetric equilibrium when two firms compete using relative performance evaluation but no decentralization (CC-subgame).[9] The points D, C, and E are equilibria in the DD-subgame for different values of α.

If $\alpha = 0$, the transfer price is equal to marginal costs, and the equilibrium is identical to the equilibrium of the CC-subgame (point S). For larger values of α, the impact of transfer pricing increases, and the intercept of the reaction curve moves to the origin.

How does the equilibrium value for the incentive parameter change as α increases? Given the negative slope of R_1, if μ_2 would not change, the equilibrium would shift in the southeast direction (i.e., q_1 increases and q_2 decreases). This would obviously lower Firm 2's profits. By further decreasing μ_2, Firm 2 is able to compensate for the softening effect of decentralization and shift the outcome back in the northwest direction, increasing its profits. However, because the decrease in μ_2 has decreased the slope of R_2, the equilibrium will fall at point D rather than at point S.[10] Thus, the decrease in μ_2 only offsets part of the output-reducing effect of decentralization and transfer pricing. Compared to the case in which both firms are centralized (CC-subgame), decentralization (DD-subgame) increases profits.

For larger values of α, the softening effect of decentralization further increases. We denote α^o the value of α for which $\pi^{DD}(\alpha)$ equals the Cournot profits. If $\alpha = \alpha^o$, the total effects of decentralization and relative performance evaluation exactly balance each other out. The equilibrium obtained is the Cournot outcome (point C), $\mu_i = -1$, and the slopes of the reaction curves are zero. For values of α larger than α^o, the softening effect of decentralization outweighs the aggressive effect of relative performance evaluation, and profits are larger than the profits that are attained in standard Cournot ($\pi^{DD} > \pi^{\text{Cournot}}$).

In summary, $\pi^{DD}(\alpha)$ increases monotonically in α, with $\pi^{DD}(0) = \pi^{CC}$, $\pi^{DD}(\alpha) < \pi^{\text{Cournot}}$ for $0 < \alpha < \alpha^o$, and $\pi^{DD}(\alpha) > \pi^{\text{Cournot}}$ for $\alpha > \alpha^o$.

[9] For a specific range of α, apart from the unique symmetric solution, there are also asymmetric solutions. Even if these solutions form an equilibrium in the DD-subgame, they do not constitute a subgame-perfect equilibrium of the overall game. The symmetric and asymmetric solutions to the DD-subgame are provided in online Appendix 3. The determination of the subgame-perfect equilibrium of the overall game is discussed in online Appendix 5.

[10] In equilibrium, the slope of R_2 must be equal to the slope of Firm 1's isoprofit curve. Decreasing μ_2 changes the slope of R_2 toward zero as explained above. The slope of the isoprofit curve is given by $\partial q_2/\partial q_1|_{\pi_1=C} = (1-q_2-2q_1)/q_1$, which changes toward zero if one moves over the 45° line in the direction of point C. (Note that in the Cournot Nash equilibrium, the slope of each firm's isoprofit curve is zero.)

3.4. Endogenization of Compensation Systems: *DC*-Subgame

In §§3.2 and 3.3, we have discussed the cases where the firms are either both centralized or decentralized. The case where one firm is decentralized (Firm 1) while the other is centralized (Firm 2) is analyzed in this section. The questions we address here are as follows: What compensation systems are adopted by the centralized and decentralized firms? What is the market outcome?

LEMMA 4. *If one firm is centralized while the other is decentralized, the unique subgame-perfect equilibrium is characterized as follows*:

(i) *The centralized firm uses a compensation system that makes the manager behave less aggressively* ($\mu^{CD} > 0$). *The decentralized firm uses a compensation system that makes the manager behave more aggressively* ($\mu^{DC} < 0$).

(ii) *The decentralized firm's profits are given by* $\pi^{DC} = (a^2/8b)(2-\alpha)$, *which exceeds Cournot profits* $\forall\, \alpha \in [0, 1]$. *The centralized firm's profits are given by* $\pi^{CD} = (a^2/8b)\alpha$, *which exceeds Cournot profits iff* $\alpha > 8/9$.

(iii) *Industry profits are maximized, i.e., total profits equal the monopoly profits* ($\pi^{DC} + \pi^{CD} = \pi^M$).

Solving this subgame by backward induction yields the following expressions for the equilibrium output quantities in the last stage:

$$q^{DC} = \frac{a - 2w_1 - \mu_1}{b(3 - \mu_1 - \mu_2 - \mu_1\mu_2)},$$
$$q^{CD} = \frac{a + w_1 - a\mu_2 + \mu_2 w_1}{b(3 - \mu_1 - \mu_2 - \mu_1\mu_2)}.$$

Because only one firm is decentralized, the second stage involves a one-firm optimization problem rather than a two-firm Nash equilibrium. The negotiated value of the decentralized firm's transfer price is given by $w^{DC} = \alpha(a/4)(1-\mu_1)$. Substituting q^{DC}, q^{CD}, and w^{DC} in the profit functions and solving the first-order conditions simultaneously yields the following expressions of the equilibrium incentive parameters:

$$\mu^{CD} = 1, \qquad \mu^{DC} = -\frac{4-\alpha}{\alpha}.$$

Substituting these values in the above expressions yields

$$w^{DC} = a,$$
$$q^{DC} = \frac{a}{4b}(2-\alpha),$$
$$q^{CD} = \frac{a}{4b}\alpha.$$

Thus, the total industry output and the market price for $0 < \alpha \leq 1$ is given by

$$Q^{DC} = \frac{a}{2b} = Q^M \quad \text{and} \quad P^{DC} = \frac{1}{2}a = P^M,$$

where the superscript M denotes the monopoly outcome. If one firm is centralized and the other decentralized, in equilibrium and independent of the division of bargaining power, the industry attains the collusive or monopoly outcome. Thus, in an environment that is perfectly noncooperative and that is expected to make firms aggressive, tacit collusion occurs and industry profits are maximized.

The firms' equilibrium profits are given by

$$\pi^{DC} = \frac{a^2}{8b}(2-\alpha) \quad \text{and} \quad \pi^{CD} = \frac{a^2}{8b}\alpha.$$

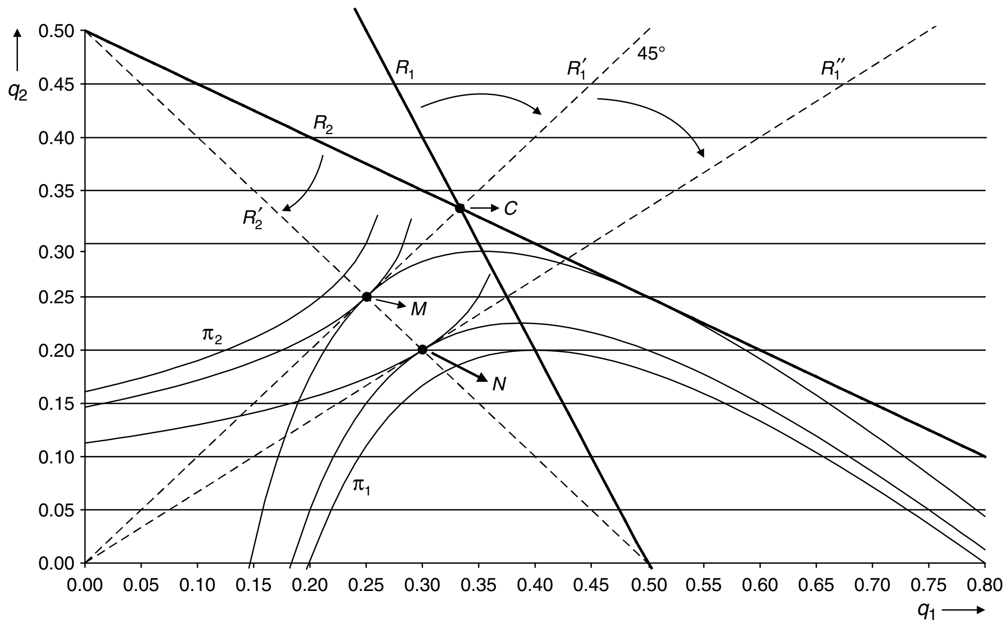
The division of the industry profits between the two firms thus depends on the parameter α. If $\alpha = 1$, i.e., if the production manager has all the bargaining power, profits are split evenly between the two firms: $\pi^{DC} = \pi^{CD} = a^2/4b$. As α decreases, the decentralized firm can set a more aggressive incentive structure and still compel the centralized firm to behave in a collusive fashion: $\pi^{DC} > \pi^{CD}$.

The equilibrium of the *DC*-subgame is surprising. While prior research shows that firms competing in strategic substitutes typically provide aggressive incentives to their managers, we find that the centralized firm sets $\mu^{CD} = 1$, which implies that the manager of Firm 2 is incentivized to maximize *industry* profits rather than *firm* profits. This compensation scheme rotates the manager's reaction curve inward, as shown in Figure 4. In contrast, the decentralized firm provides a highly aggressive compensation scheme with $\mu_1 < -1$, which means that R_1 is upward sloping. The decentralized firm's aggressive compensation scheme can be understood as a compensation for the softness resulting from its organizational structure, which is a disadvantage in the case of strategic substitutes. The centralized firm's cooperative compensation scheme is a logical consequence of the decentralized firm's upward-sloping reaction curve, which commits the decentralized firm's marketing manager to sell a quantity that is proportional to the centralized firm's output.

In Figure 4, two equilibria are shown. Point M represents the equilibrium for $\alpha = 1$, while point N depicts the equilibrium for $0 < \alpha < 1$. In both points M and N, the perfectly collusive outcome is obtained. In point M, the collusive profits are shared evenly, whereas the decentralized firm obtains more profits than the centralized firm in point N.

As can be seen from the figure, for different values of α, R_1' rotates around the origin, while R_2' does not depend on α. While the particular form of these reaction curves may seem surprising, they are the logical consequence of simple assumptions, such as decentralization, transfer pricing, and relative performance evaluation. To understand the intuition, we discuss

Figure 4 *DC*-**Subgame for Different Values of** α



the ability of the firms to control the managers' reaction curves. It will turn out that while firms in this model have more degrees of freedom than in most previous research (i.e., organizational structure and compensation schemes), there are still significant limitations to the level of control firms have over their managers, which plays an important role in determining the outcome.

When the firms determine the compensation schemes, i.e., μ_1 and μ_2, they foresee the effect on transfer pricing and, ultimately, on output decisions. Substituting the equilibrium value of the decentralized firm's transfer price ($w^{DC} = \alpha(a/4)(1-\mu_1)$) into the reaction curves yields the following expressions:

$$R_1\colon\ q_1(q_2;\mu_1,\alpha) = \frac{a}{2b} - \alpha(1-\mu_1)\frac{a}{8b} - \frac{1}{2}(1+\mu_1)q_2,$$

$$R_2\colon\ q_2(q_1;\mu_2,\alpha) = \frac{a}{2b} - \frac{1}{2}(1+\mu_2)q_1.$$

The effect of μ_1 and μ_2 on the slope of the reaction curves is as before. Note that a negative value of μ_1 decreases the intercept of R_1. Decreasing μ_1 will, ceteris paribus, shift market share from the centralized to the decentralized firm, which will induce the production manager to increase the transfer price, which in turn decreases the intercept. Changes in μ_1 thus affect both the intercept and the slope of R_1, while the centralized firm can only manipulate the slope of R_2.

It is clear from Figure 4 that the centralized firm cannot increase its profits by changing μ_2, given R_1'. A change in μ_2 would rotate R_2, which would shift the equilibrium to a lower isoprofit curve. From the figure, it seems that the decentralized firm would be able to profitably change μ_1. However, it turns out that for given α between zero and one, the effect of a change in μ_1 on the intercept would exactly offset the effect on the slope, evaluated at the intersection with R_2. For example, if $\alpha = 1$ and $q_2 = a/4b$, $q_1(q_2;\mu_1,\alpha) = a/4b$ (point M) independently from μ_1. The same holds for any other value of $0 < \alpha < 1$ (e.g., point N). In other words, given the specific effect of μ_1 on both the intercept and the slope of R_1, the decentralized firm is indifferent in its choice of μ_1. However, to preclude the centralized firm from defecting, only one value of μ_1 is possible in equilibrium (i.e., $\mu^{DC} = -(4-\alpha)/\alpha$).

The equilibrium value of the decentralized firm's transfer price is given by $w^{DC} = a$ for $0 < \alpha \leq 1$, where the demand parameter a equals the market choke price. It seems unlikely that a transfer price that is as high as the choke price allows for positive output by Firm 1. However, the market price could be lower than the transfer price without forcing Firm 1 to shut down because the incentive of the marketing manager could be negative, i.e., $I_i^M \in \Re$. The participation constraint of the marketing manager requires that $A_i^M + B_i^M I_i^M$ be larger than or equal to the reservation value of the manager but does not impose restrictions on I_i^M. Moreover, the use of relative performance evaluation makes Firm 1's marketing manager care not only about the profits of Firm 1, but also about the profits of Firm 2. In particular, because $\mu^{DC} < 0$ for $0 < \alpha \leq 1$, shutting down would benefit the rival firm and therefore diminish the compensation of the marketing manager of Firm 1.

Table 1 Stage 1 Firm Payoffs

	Centralization	Decentralization
Centralization	(π^{CC}, π^{CC})	(π^{CD}, π^{DC})
Decentralization	(π^{DC}, π^{CD})	(π^{DD}, π^{DD})

In §§3.2–3.4, we have discussed the three distinct subgames of the overall model. In the next section, the subgame-perfect equilibrium of the overall game, i.e., endogenizing both compensation systems and organizational structure, is discussed.

3.5. Solution of the Overall Model

In the first stage of the overall model, the firms simultaneously determine the organizational structure before the compensation schemes, transfer prices, and output quantities are established. Given the optimal actions in the latter stages, one can describe the first-stage choices in a 2×2 matrix containing the four subgames (*CC*, *DD*, *DC*, and *CD*). The Nash equilibrium of this game constitutes the subgame-perfect equilibrium of the overall game. The payoffs are summarized in Table 1.

The questions we address are as follows: If two competing firms simultaneously establish first their organizational structure and second their compensation systems, what structures and systems do they use? How does their choice affect the market outcome?[11]

Proposition 1. *There exists a pair of values* (α^o, α^*) *satisfying the property that* $0 < \alpha^o < \alpha^* < 1$, *such that the subgame-perfect equilibrium outcome of the game in which both organizational structure and compensation systems are endogenized is characterized as follows.*

Equilibrium outcome:

(i) *If* $0 \leq \alpha < \alpha^*$, *both firms are decentralized and use a negative incentive parameter* $(\mu^{DD} < 0)$.

(ii) *If* $\alpha^* \leq \alpha \leq 1$, *one firm is decentralized and uses a negative incentive parameter* $(\mu^{DC} < 0)$, *while the other firm is centralized and uses a positive incentive parameter* $(\mu^{CD} > 0)$.

Equilibrium profits:

(iii) *If* $0 \leq \alpha \leq \alpha^o$, *both firms attain profits lower than or equal to standard Cournot* $(\pi_i^* \leq \pi^{Cournot})$.

(iv) *If* $\alpha^o < \alpha \leq 1$, *both firms attain profits higher than standard Cournot* $(\pi_i^* > \pi^{Cournot})$.

(v) *If* $\alpha^* < \alpha < 1$, *the decentralized firm's profits exceed those of the centralized firm. Otherwise, the firms' profits are equal.*

[11] For ease of exposition, we restrict the characterization of the subgame-perfect equilibrium to symmetric strategies on the off-equilibrium path in the *DD*- and *CC*-subgames, without imposing symmetry restrictions on the equilibrium subgame itself. The full, unrestricted characterization of the equilibrium is included in online Appendix 5.

We determine for each subgame whether it comprises a subgame-perfect equilibrium of the overall game. The *CC*-subgame does not constitute a subgame-perfect equilibrium because at least one firm in the *CC*-subgame would want to defect to the *DC*-subgame, i.e., choose decentralization rather than centralization because $\pi^{DC} > \pi^{CC}\ \forall \alpha$.

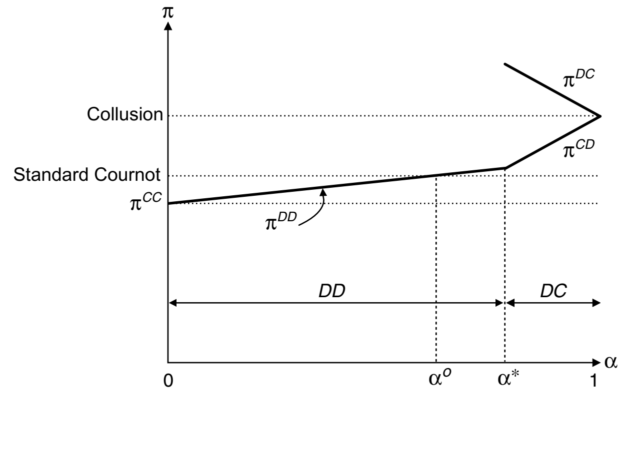
The *DD*-subgame has a unique symmetric equilibrium and may have up to four asymmetric solutions (i.e., $\mu_1 \neq \mu_2$) depending on α (see online Appendix 3). The asymmetric solutions can never constitute a subgame-perfect equilibrium of the overall model because for $0 < \alpha \leq 1$, the less aggressive firm (which has profits smaller than the more aggressive firm) could always increase its profits by defecting to the *DC*-subgame $(\pi^{CD} > \pi_L^{DD})$.

We define α^* as the value of α for which the profits of the centralized firm in the *DC*-subgame equal those of the symmetric *DD* solution, i.e., $\pi^{CD}(\alpha^*) = \pi^{DD}(\alpha^*)$. For $0 < \alpha \leq \alpha^*$, the symmetric solution to the *DD*-subgame constitutes a subgame-perfect equilibrium of the overall model because then $\pi^{DD} \geq \pi^{CD}$. For $\alpha^* \leq \alpha \leq 1$, the *DC*- and *CD*-subgames are subgame-perfect equilibria $(\pi^{CD} \geq \pi^{DD})$. It is not surprising that the *DC*-subgame is a Nash equilibrium for large α because both firms get approximately half of the monopoly profits. Defecting (either to *CC* or to *DD*) would lower profits for either firm. However, as α gets smaller, in the *DC*-equilibrium the centralized firm gets significantly less profits than the decentralized firm. At some point (α^*), the centralized firm would want to defect to the *DD*-subgame because that would increase its profits. Thus, for $\alpha < \alpha^*$, the *DD*-subgame is a Nash equilibrium.

Figure 5 shows how the profits of both firms in the equilibrium of the overall model vary with parameter α.

Lemmas 1 and 2 suggest that profits decrease if firms use a single element of organizational design as a strategic commitment device. This is consistent with previous research, which consistently finds that in the

Figure 5 Equilibrium Profits of the Overall Model



case of competition in strategic substitutes, endogenizing organizational structure or compensation systems in isolation increases firm aggressiveness and decreases profits. In contrast, we show that endogenizing both organizational structure and compensation systems softens competition and increases firm profits for $\alpha^o < \alpha \leq 1$. In the situation discussed in this paper, the ubiquitous prisoner's dilemma of strategic incentives is solved. Moreover, if the effect of decentralization is sufficiently important, otherwise identical firms choose different organizational structures and compensation schemes, i.e., endogenous firm heterogeneity arises.

4. Discussion and Conclusion

The internal organization of a firm and the compensation schemes used for its management affect the incentives that guide managers' decision making. In this study, we aim to elucidate how organizational design characteristics, i.e., the organizational structure and compensation systems, affect the competitive interaction between firms.

One of the main conclusions of the strategic incentives literature is that the strategic use of organizational design makes firms overly aggressive if they compete in strategic substitutes. This finding is based on the notion that organizational design is used as a commitment device, permitting the firm to benefit from its rivals' reactions. One problem with these studies, however, is that organizational features are studied in isolation, i.e., neglecting a possible interaction between them. This is potentially misleading because firms typically face multiple, possibly interdependent decisions about their organizational design, such as the organizational structure and reward systems.

In our model, organizational structure and compensation schemes are studied simultaneously. In this setting, we show that the interaction between organizational structure and compensation systems is nontrivial. Indeed, we find that simultaneous determination of organizational structure and compensation systems may enable firms to tacitly collude and achieve the perfectly collusive outcome despite the noncooperative setting.

Firm heterogeneity is an important phenomenon in the strategy literature and, to some extent, in the economics literature. For example, Hermalin (1994) aims to find an answer to the question of "why otherwise identical firms choose different incentives for their managers" (p. 518). One of our findings is that identical firms, for certain parameter values, choose to be different. If the bargaining power of the production department in determining the transfer price that the marketing department pays is large enough, in equilibrium, one firm is centralized while the other is decentralized. Moreover, the centralized firm uses an incentive scheme that encourages cooperation between the firms, while the decentralized firm encourages its manager to compete fiercely.

It is interesting to note that the effect of the organizational structure in the asymmetric equilibrium is opposite to that of the incentive schemes. Decentralization, because of double marginalization, makes firms less aggressive, which is counteracted by the aggressive incentive scheme with which the manager is provided. Similarly, the firm with the more aggressive centralized structure has a softening compensation arrangement. Indeed, in the extreme case where the production department has all the bargaining power, these effects cancel each other out, leading to equal division of the collusive profits.

Another noteworthy facet of our model is that firm heterogeneity and performance are positively associated: Both firms' profits are larger if the firms are structured differently than if they are similar in terms of organization and compensation systems. The decreasing effect of various forms of differentiation on competition has previously been established: for example, product differentiation (Hotelling 1929), strategic dissimilarity (Gimeno and Woo 1996), and differentiation of organizational form, size, and therefore resource dependence (McPherson 1983). To our knowledge, a decreasing effect of organizational differentiation per se, i.e., heterogeneity in organizational structure and managerial incentive schemes, on the intensity of rivalry has otherwise not been established. This could be a promising avenue for future research.

The concurrence of organizational differentiation and diminished intensity of rivalry could be compared to a phenomenon that often occurs in competitive sailing. Two boats sailing close to each other spoil each other's wind exposure, slowing down both vessels. If one boat tags—one firm chooses a different organizational structure—the negative externality is removed. Subsequently, both boats may tag again, sailing over different boards—firms use different incentive schemes—but aiming for a common windward destination. In the end, the boats may reach the same destination, but more rapidly than if they had chosen to sail similar routes. The use of different organizational structures and incentive schemes may reduce competition and increase profits, without necessarily benefiting one firm more than the other.

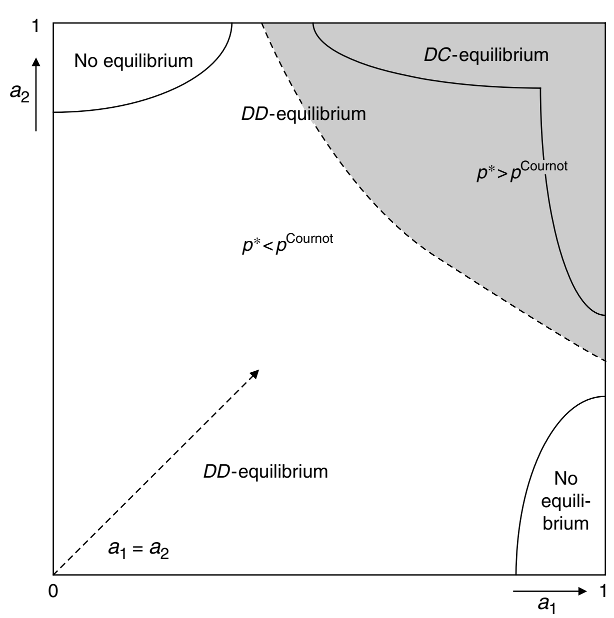
This paper can be seen as a first attempt to build a midrange theory of the interaction between multifaceted organizational design and interfirm competition, positioned between the stream that limits attention to one element of organizational design, such as Fershtman and Judd (1987), and the stream that explores unrestricted, independent-control delegation games, such as Miller and Pazgal (2001). In this paper, specific assumptions have been made about the elements of organizational design studied and the timing and information structure of the game. Obviously, many other assumptions could be made to explore the generalizability of our results in other multidimensional delegation games.

For example, the present model consists of a noncooperative, extensive game with simultaneous moves. Alternatively, one may wonder what results would obtain if cooperative, i.e., collusive, behavior were assumed, for example, in Stage 3, while owners and marketing managers compete noncooperatively. It turns out that the results are very similar whether noncooperative or cooperative behavior is assumed in Stage 3. The value of α^*, which delimits the *DD*-subgame from the *DC*-subgame, is slightly less in the case of collusion between production managers than in the case of noncooperative Nash equilibrium in this stage.

Another generalization of the model is to introduce asymmetry between the two firms. For example, one may let the relative bargaining power of the production and marketing departments differ for each firm, i.e., $\alpha_1 \neq \alpha_2 \in [0, 1]$. In Figure 6, the equilibrium outcome of the overall model is depicted as a function of α_1 and α_2.

The *DC*-equilibrium obtains in the northeast region of the graph, while the *DD*-equilibrium obtains in the remainder of the parameter space (except for a region where the values of α are very different and no equilibrium exists). In the shaded area, the equilibrium profits in the overall game exceed those of standard Cournot.

Figure 6 **The Overall Solution for** $\alpha_1, \alpha_2 \in [0, 1]$



Other generalizations of the model could encompass the inclusion of more than two firms, the modeling of other compensation schemes, or the study of price rather than quantity competition. It is possible, although not sure, that the heterogeneous equilibrium is not obtained if competition is modeled between more than two firms. It seems, however, that the softening effect of decentralization will be obtained in that more general setting because it relies on the very general double marginalization effect. The use of other compensation schemes may lead to different results. A crucial aspect of relative performance evaluation is that its use rotates reaction curves, which is not the case in the profit-cum-sales setup of Fershtman and Judd (1987). To the extent that other competitor-oriented compensation schemes, such as market share incentives, rotate reaction curves, results similar to those found in this paper are to be expected when these schemes are used. Studying quantity competition was particularly informative in this model because it showed that organizational design may dampen competition even in a situation that typically leads to overly aggressive behavior. However, it would be valuable also to explore the effect of multifaceted organizational design on price competition, which may lead to very different results.

Future research should further explore the relationship between multifaceted organizational design and product-market competition. The use of different, and potentially more general, assumptions could establish under what conditions the main contributions of this study hold: endogenous firm heterogeneity and collusive outcomes in a noncooperative context.

An online companion to this paper is available on the *Management Science* website (http://mansci.pubs.informs.org/ecompanion.html).

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