Organize to Compete*

Ricardo Alonso
University of Southern California

Wouter Dessein
Columbia University

Niko Matouschek
Northwestern University

First version: April 2008
This version: August 2009

Abstract

We examine the effect of competition on the internal organization of a multi-divisional firm. Managers need to adapt production to demand but also to cooperate and coordinate production across divisions. Because headquarters is imperfectly informed about demand, centralization performs poorly in terms of adaptation. And because division managers are biased and imperfectly informed about demand in each others' markets, decentralization performs poorly in terms of cooperation and coordination. The effect of competition depends on the underlying reasons for the increase in competition. If it simply lowers demand, it favors decentralization. But if it also makes demand more price sensitive, it can favor centralization.

Keywords: competition, centralization, decentralization

JEL classifications: D23, D83, L23

*We thank the participants of various seminars for comments on earlier versions of this paper.

Firms are organized to compete with their rivals. In spite of this simple fact, we know little about how competition affects the internal organization of firms. This is true especially for large scale, multi-divisional firms such as General Motors, Johnson & Johnson, and Unilever that consist of a headquarters and multiple divisions that operate in different markets. Such multi-divisional firms barely existed in the early 19th century but have since come to dominate many US industries (Chandler 1977). How does a firm like General Motors organize to compete with its rivals? And how does an increase in competition, such as the US entry of Hyundai or the introduction of a competing model by Toyota, affect its internal organization? Does it induce General Motors to decentralize control to division managers, for instance, or might it have the opposite effect? To better understand the economics of industries that are dominated by multi-divisional firms, we need to understand the answers to such questions. In this paper we try to do so.

Alfred Sloan, the longtime Chairman and President of General Motors, is widely regarded as one of the inventors of the multi-divisional firm. Before he became Chairman in 1923, General Motors was a loose collection of different businesses that operated independently of each other. Soon after he became Chairman, Sloan replaced this organization with one in which a strong headquarters ensured that the activities of the different divisions were coordinated − either by making decisions itself or by encouraging collaboration between the divisions − but in which divisions also had enough independence to adapt quickly to changes in the business environment. As he put it at the end of his autobiography:

"It has been the thesis of this book that good management rests on a reconciliation of centralization and decentralization. [...] From decentralization we get initiative, responsibility, development of personnel, decisions close to the facts, flexibility − in short, all the qualities necessary for an organization to adapt to new conditions. From co-ordination we get efficiencies and economies." (Sloan 1990, p.429).

In this view a successful organization ensures that managers adapt quickly to new conditions but also cooperate and coordinate across divisions. Informational imperfections and incentive conflicts limit how well different organizations perform in terms of adaptation, cooperation, and coordination. Since headquarters is far from the facts, centralization results in poor adaptation. And since division managers are far from each other, decentralization results in too little cooperation and coordination. The relative importance of adaptation, cooperation, and coordination then determines the internal organization of a multi-divisional firm.

It is often argued that competition makes it more important that firms adapt quickly to new conditions. Since centralization results in poor adaptation, one might then expect that competition favors decentralization. This popular view is supported by anecdotal evidence that many firms do indeed respond to competition by decentralizing.[1] In his recent book, for instance, Roberts (2004) describes the highly decentralized organization of the consumer goods company Johnson & Johnson and then argues that:

"In the last decade [...] many more firms have adopted this design model in response to increased needs to improve performance. Falling barriers to international trade and investment and the increased ease of long distance communication and transportation have allowed firms to enter new foreign markets. This has increased competition in product and service markets around the world, making improved efficiency necessary for success and even survival" (Roberts 2004, p.181).

We agree with the view that competition can make adaptation more important. What is easily overlooked, however, is competition can also make it more important that divisions cooperate and coordinate their decisions. Competition might, for instance, increase the need for divisions to realize scale economies or to coordinate the use of scarce resources that are used by both divisions, such as capital or managerial know-how. Since decentralization results in too little cooperation and coordination, a firm might then respond to competition by centralizing rather than decentralizing. Unilever, one of Johnson & Johnson's competitors, is an example of such a firm. Until 1999 Unilever was very decentralized and division managers had vast decision making authority. Since then, however, Unilever has gone through a series of reorganizations that have centralized authority and limited the power of division managers. Recently, Unilever Chief Executive Patrick Cescau explained these reorganizations:

"Historically, Unilever's business had been built up around highly autonomous operating companies, with their own portfolio priorities and all the resources they needed – marketing, development, supply chain – to develop their business in whatever way they saw fit. This was a highly effective way of building a truly multinational business almost 50 years before the term was invented. But it had become less suited to an increasingly globalised, competitive landscape, where battles were being fought and won with global scale and know-how, and top-down, strategically driven allocation of resources. In today's world, a hundred different portfolio strategies run the risk of adding up to no strategy at all. It's not efficient, it doesn't leverage your best assets and it doesn't build strong global positions."[2]

[1] For the argument that competition makes quick adaptation more important and therefore favors decentralization see, for instance, Guadalupe and Wulf (2009) and Bloom, Sadun, and Van Reenen (2008).

[2] This quote is taken from a presentation that Patrick Cescau gave at the Unilever Investor Seminar on 13 March 2007. The transcript is available at www.unilever.com. For more on the reorganizations at Unilever see, for instance, "Too Many Cooks: Despite Revamp, Unwieldy Unilever Falls Behind Rivals; Consumer-Products Giant Labors to

Both casual theorizing and anecdotal evidence therefore suggest that the effect of competition on the internal organization of multi-divisional firms is in general ambiguous. To shed more light on this issue, we examine a firm that consists of two divisions and potentially one headquarters. The divisions operate in different markets with independent demands. They might therefore sell the same good in different countries or they might sell independent goods in the same country. In each market the divisions compete with local firms. Production by each division imposes externalities on the costs of the other. Externalities can be negative, for instance, because production depletes scarce resources. Or they can be positive because of learning effects or other scale economies. Headquarters cares about overall firm profits but is imperfectly informed about the demand conditions. Each division manager, in contrast, knows the demand conditions in his markets. He is, however, imperfectly informed about the demand conditions in the other market. Moreover, each division manager is biased towards his own division. In this setting, the firm must decide whether headquarters or the division managers should make the production decisions.

This simple model captures Sloan's view of what determines the internal organization of multi-divisional firms. In particular, to be successful an organization must ensure that managers adapt production to demand conditions but also cooperate and coordinate production across divisions. Because headquarters does not know the exact demand conditions, centralization results in poor adaptation. And because division managers are biased towards their divisions, they do not fully internalize the externalities that their decisions impose on each other. Decentralization therefore results in too little cooperation. And finally, because division managers are biased towards their divisions and do not know the exact demand conditions in each others' markets, they do not coordinate production sufficiently. Decentralization therefore also results in too little coordination.

To understand the central results in this paper, we first need to better understand the role of coordination. Coordination matters because it facilitates adaptation. To see this, suppose that there is a positive demand shock in Market 1 but not in Market 2 and that the cost externalities are negative. Naturally, the firm should adapt to the demand shock by increasing production by Division 1. The firm should also, however, reduce production by Division 2 since this lowers the marginal costs of Division 1 and allows that division to further increase production. Coordination therefore facilitates adaptation. And because coordination facilitates adaptation, centralization may actually result in better adaptation than decentralization. In particular, this will be the case if headquarters' ability to reallocate resources across divisions outweighs the division managers' informational advantage. A centralized behemoth like Unilever may therefore prove a nimbler

Slim Operations; Two Chairmen in Charge; A Deodorant With 48 Formulas," *Wall Street Journal*, January 3, 2005.

competitor than its decentralized rivals.

The key question we are interested in is how competition affects the choice between centralization and decentralization. The effect of competition depends on how it affects demand for the divisions' goods. And how competition affects demand for the divisions' goods, in turn, depends on why competition increased in the first place. A reduction in entry costs, for instance, shifts the divisions' inverse demand curves downwards but does not change their slopes. It therefore affects the level of demand but not its price sensitivity. Because a reduction in entry costs does not affect the price sensitivity of demand, it has no effect on how well the centralized organization adapts to demand shocks and how well the decentralized organization coordinates production. Because a reduction in entry costs reduces the level of demand, however, it does reduce the externalities that the division managers impose on each other. It therefore reduces the costs of the division managers' failure to cooperate. As a result, a reduction in entry costs favors decentralization.

The effect of an increase in competition is different if it increases the price sensitivity of demand. This is the case, for instance, if competition increases because of an increase in market size. Such an increase in market size rotates the divisions' inverse demand curves anti-clockwise. It therefore reduces the level of demand, at least for high prices, but also makes demand more price sensitive. The increase in price sensitivity makes it more important that production is adapted to the demand conditions. In line with the standard argument, this hurts the performance of the centralized organization. Crucially, however, the increase in price sensitivity also makes it more important that production is coordinated across divisions. This, of course, hurts the performance of the decentralized organization. To see both effects, suppose again that there is a positive demand shock in Market 1 but not in Market 2 and that the cost externalities are negative. The more price sensitive demand, the more the firm should increase production by Division 1. To be able to do so, however, the firm also needs to reduce production by Division 2 and it needs to reduce production by more, the more price sensitive demand. An increase in the price sensitivity therefore makes both adaptation and coordination more important. The central result in the paper is that the increased need for coordination can outweigh the increased need for adaptation. A firm such as Unilever may therefore respond to competition by centralizing because it makes it more important that resources are allocated in a "top-down, strategically driven" way.

In summary, the effect of competition on the internal organization of a multi-divisional firm depends on why competition increases in the first place. If the increase in competition simply lowers demand, it favors decentralization. But if it also increases the price sensitivity of demand, it can favor centralization.

1 Literature Review

Informational asymmetries and production interdependencies are the key factors that determine the internal organization of the multi-divisional firm in our model. This modeling approach is motivated by the empirical accounting literature which has identified these factors as important drivers of decentralization in divisionalized firms (see Baiman et al. 1995, Nagar 2002, Abernethy et al. 2004, Bouwens and Van Lent 2008). Our approach further builds on a growing theoretical literature in organizational economics that analyzes how firms are designed to coordinate decisions across divisions and other sub-units. Coordination requires the aggregation of dispersed information but is imperfect because of physical communication constraints (Aoki 1986, Hart and Moore 2005, Crémer et al. 2006, and Dessein and Santos 2006) or because sub-unit managers are biased and communicate strategically (Alonso et al. 2008, Friebel and Raith 2008, Rantakari 2008, Dessein et al. 2009).[3] A key argument in this literature is that centralization performs better in terms of coordinating decisions while decentralization performs better in terms of adapting decisions to the circumstances and opportunities of different sub-units and the preferences of the managers that lead them. We further develop this argument by showing that coordination facilitates adaptation. As a result, centralization may actually perform better in terms of adaptation than does decentralization.

An assumption that the papers in this literature share is that firms exist in a bubble and are shielded from all external influences. The key contribution of this paper is that we burst this bubble and embed the multi-divisional firm in a market in which it competes with, and is influenced by, other firms. This allows us to examine the effect of competition on the internal organization of the firm. By doing so we are able to connect with a growing empirical literature which addresses this question (see for instance Bloom et al. 2008 and Guadalupe and Wulf 2009). A common argument in this empirical literature is that competition may favor decentralization because it makes adaptation more important. We explore when this is indeed the case and when, instead, competition favors centralization because it makes coordination more important. We hope that our theoretic framework can be used to guide current and future empirical work on multi-divisional firms.

Many of the organizational economics papers that we discussed above, and a number of recent papers in other fields, model the need for adaptation and coordination by assuming a particular payoff function.[4] Another contribution of our paper is that we derive the payoff function by

[3] More generally, the literature on team theory examines decision making in firms in the presence of informational constraints. See Van Zandt (1999) for an overview.

[4] See, for example, Morris and Shin (2002), Dessein and Santos (2006), Alonso et al. (2008), Rantakari (2008), Calvó-Armengol et al. (2009), Bolton et al. (2008), and Hagenbach and Koessler (2009).

explicitly modeling the production interdependencies and the variability in demand that create the need for adaptation and coordination. While the payoff function that we derive is similar to the one that is used in the literature, there are also important differences. These differences shed light on the assumptions about the underlying coordination problem that are implicit in the payoff function used in the literature. We discuss this issue in Section 7.

We are of course not the first to link competition to organizational features of firms. Hicks (1935) famously observed that "The best of all monopoly profits is a quiet life." This captures the widely held belief that there is a link between competition and managers' incentives to work hard. To explore this link, a number of papers examine how competition affects managers' incentives to reduce costs both directly − for given incentive schemes − and indirectly − by changing the managers' incentive schemes (Schmidt 1997, Raith 2003).[5,6] The organizational design problem that these papers focus on − how to design financial incentives to motivate managers to reduce costs − is of course very different from our problem. It turns out though that the economic forces that determine the effect of competition on the solutions to the different problems are very similar. Specifically, Raith (2003) shows that the effect of competition on managerial incentives depends on how it affects the level and the price sensitivity of demand. A reduction in the level of demand reduces the benefits of a lower marginal cost and thus favors low powered incentives simply because it reduces the scale of production. An increase in price sensitivity, in contrast, makes low marginal costs more important and thus favors high powered incentives.[7] Similarly, in our setting the effect of competition is determined by the relative importance of the level effect − which favors decentralization − and the price sensitivity effect − which favors centralization. Raith (2003) and our paper therefore complement each other; each paper examines an important organizational design problem and abstracts from the other; in the end, however, they both identify the same channels through which competition affects organizational design.

Related the above literature, Marin and Verdier (2008) and Ruzzier (2009) study the effect of competition on a principal's incentives to monitor an agent who is in charge of cost-reducing projects. Monitoring is valuable because the agent may choose a project that yields private benefits, but does not minimizes the marginal cost. As in Aghion and Tirole (1997), however, monitoring

[5]A related strand of the literature examines how competition can generate information about demand or cost conditions and therefore enhance efficiency in incentive contracting (Hart 1983, Scharfstein 1988, Hermalin 1992 and 1994 and Meyer and Vickers 1997).

[6]Hubbard and Palia (1995) and Cuñat and Guadalupe (2009) provide empirical evidence that competition favors high powered incentives. Also, Bloom and Van Reenen (2007) provide evidence that competition is a strong determinant of managerial performance.

[7]Vives (2008) generalizes the demand structure in Raith (2003). He shows that in this more general environment the effect of competition on managers' incentives to reduce costs continues to be determined by the level and price sensitivity effects.

also reduces "initiative," that is, the agent's incentives to identify any cost-reducing projects in the first place. As competition increases, so do the principal's incentives to monitor. Marin and Verdier (2008) show that delegation may therefore become optimal as markets expand. Ruzzier (2009) takes delegation as given, and analyzes how the autonomy of the agent varies as a function of various drivers of competition. Since these papers examine the relationship between a principal and a single agent, they do no speak to the organization of the large scale multi-divisional firms that we are interested in. In addition, their focus is on the delegation of cost-reducing projects, not on the coordination and adaptation of product-market decisions.

The link between competition, or "globalization," and organizational features of firms is also being examined in an emerging literature on the intersection between international trade and organizational economics (see Antràs and Rossi-Hansberg 2009 for a survey). The focus of this literature is on how organizational features of firms – such as the extent to which they outsource production – affects the mapping from factors of production into goods. In this sense, this literature tries to endogenize the international production function. The effect of globalization on the internal organization of firms has received less attention. One exception is Antràs et al. (2007) who study how globalization affects organizational hierarchies and the size distribution of firms.

Finally, our paper is related to the literature on exchange of information between firms in oligopolistic industries (Vives 1984, Gal-Or 1985 and 1986, Shapiro 1986, and Raith 1996 among others). This literature typically assumes that firms are privately informed about demand or cost conditions and examines when firms have an incentive to share their private information. Similarly, in our setting each division manager is privately informed about the demand conditions in his market. In an extension we then explore the division managers' incentives to share their information. Importantly, we model communication explicitly as a cheap talk game and allow the division managers to decide how much information to communicate after they have learned their private information. In contrast, in the existing literature firms commit to how much information to share before they learn their demand or cost conditions.

2 The Model

We consider a multi-divisional firm that operates in two oligopolistic markets, Market 1 and Market 2, in which it faces competition from local firms. To serve each market, the firm is divided into two operating divisions and, potentially, a headquarters. Division 1 produces a single good and sells it in Market 1 and Division 2 produces a single good and sells it in Market 2. Demand for each good is independent of that for the other. As such, Markets 1 and 2 may be different countries or they may be markets for independent products that are sold in the same country. While demands for the divisions' goods are independent, their costs are not. Our assumptions about market structure, demand, and costs are therefore similar to those in Bulow, Geanakoplos, and Klemperer (1985). In contrast to the operating divisions, headquarters does not produce anything and therefore does not generate any profits. Headquarters tries to maximize overall firm profits but is imperfectly informed about the demand conditions in each market. Each division manager knows the demand conditions in his market but is also biased towards his division's profits. The firm must decide whether headquarters or the division managers should make the production decisions.

Technology: Divisions 1 and 2 produce q_1 and q_2 units of their respective goods. The production costs of Division $j = 1, 2$ are given by

$$c_j = cq_j + b_c q_j^2 + g q_1 q_2, \tag{1}$$

where $c \geq 0$, $b_c \geq 0$, and $g \in (-1, 1)$ and where the subscript "c" stands for "costs." If $g > 0$, an increase in production by one division increases the average and marginal costs of the other division. Such negative cost externalities may arise, for instance, because both divisions use a common input with a price that is increasing in the firm's total demand for the input. Cost externalities in multi-divisional firms are also associated with the utilization of common services, such as personnel and IT departments and managerial supervision and know-how. Headquarters' effectiveness in providing these services to one division may decline the more the service is used by the other division (see, for instance, Gal-Or 1993).[8] If, instead, $g < 0$, then an increase in production by one division reduces the total and marginal costs of the other division. Such positive cost externalities may arise, for instance, because of learning and scale effects in the production of inputs used by both divisions.

In each market the firm faces a continuum of potential competitors. Each potential competitor consists of a single division and can only operate in one market. To enter a market, a competitor has to pay entry costs $K \geq 0$. We denote the measure of competitors that enter Market $j = 1, 2$ by n_j. The production costs of competitor $k \in [0, n_j]$ in Market j are given by

$$c_{jk} = c_l q_{jk} + b_l q_{jk}^2, \tag{2}$$

where $c_l \geq 0$ and the subscript "l" stands for "local competitor." As long as the parameter b_l is not negative, the value that it takes is irrelevant for our analysis. To ease notation, we therefore set $b_l = 0$.

[8] Managerial know-how and skills are rival factors of production: time and attention spent on one task entails an opportunity cost in another. Burstein and Monge-Naranjo (2009), for example, provide evidence on how multinationals reallocate managerial know-how across divisions and countries. Also, the large literature on firm-size distribution emphasizes the rival nature of firm-embedded productivity (see for instance Lucas 1978 and Atkeson and Kehoe 2005).

Consumers and Demand: In each market there is a measure m of consumers. The utility function of each consumer in Market $j = 1, 2$ is given by

$$U = \alpha_j q_j + \int_0^{n_j} q_{jk} \mathrm{d}k - \frac{1}{2}\left(q_j^2 + \int_0^{n_j} q_{jk}^2 \mathrm{d}k + 2\gamma q_j \int_0^{n_j} q_{jk} \mathrm{d}k\right), \tag{3}$$

where $\gamma \in [0, 1]$. The parameters α_j are independently drawn from a probability distribution with support $[\underline{s}, \overline{s}]$, where $\overline{s} > \underline{s} > c$. We assume that $\underline{s}$ and $\overline{s}$ are such that both divisions produce positive quantities. The distribution of α_j is characterized by the cumulative density function $H(\alpha_j)$ and it has a mean $\mathrm{E}[\alpha_j] = \mu$. The utility function implies that in each market the goods produced by the competitors are perfect substitutes for each other. Moreover, in each market the goods produced by the competitors are imperfect substitutes for the good produced by the local division unless $\gamma = \alpha_j = 1$ in which case they are perfect substitutes.

Consumers take the prices charged by the divisions and the competitors as given and make the consumption decisions that maximize their utility. The first order conditions for this maximization problem gives the inverse demand functions for the various goods. Specifically, the inverse demand function faced by Division $j = 1, 2$ is given by

$$p_j = \alpha_j - \frac{1}{m} q_j - \frac{\gamma}{m} Q_j, \tag{4}$$

where $Q_j = \int_0^n q_{jk} \mathrm{d}k$ is the total amount produced by the competitors in Market j. Similarly, the inverse demand function faced by competitor $k \in [0, n_j]$ in Market j is given by

$$p_{jk} = 1 - \frac{1}{m} Q_j - \frac{\gamma}{m} q_j. \tag{5}$$

Note that the randomly drawn parameter α_j only affects the intercept of the inverse demand function faced by Division j. The parameter α_j therefore determines the local demand conditions that Division j faces. In contrast, the parameter γ determines the substitutability between the good produced by each division and its competitors.

Managerial Preferences: Each division is run by a single manager. Manager 1 − the manager in charge of Division 1 − aims to maximize $\lambda\pi_1 + (1 - \lambda)\pi_2$ and Manager 2 aims to maximize $\lambda\pi_2 + (1 - \lambda)\pi_1$, where π_1 and π_2 are the profits of Divisions 1 and 2 and $\lambda \in [1/2, 1]$ is a parameter that captures the extent to which each division manager is biased towards his own division. The manager in charge of headquarters aims to maximize overall firm profits $\pi_1 + \pi_2$. We follow the modelling approach in Alonso et al. (2008) and Rantakari (2008) and assume that the own-division bias is exogenously given. There are many factors that explain why division managers are often biased towards their own divisions but we do not model these factors explicitly.[9] In the absence of these factors, the firm would always set $\lambda = 1/2$ if it could influence the own-division bias through the division managers' compensation. We will see below that our main result − that an increase in competition can favor centralization − also holds in this case. Finally, in contrast to the divisions, their competitors are run as standard, profit maximizing firms.

Decisions and Contracts: The firm must decide on the production levels of the two divisions. We follow the property rights literature (Grossman and Hart 1986 and Hart and Moore 1990) and assume that the goods that the divisions produce are sufficiently complex that they cannot be fully described in a written contract ex ante. In fact, we go further than the traditional property rights literature and follow a number of recent papers in assuming that the divisions' goods are non-contractible even ex post (see, for instance, Holmström 1999 and Aghion, Dewatripont, and Rey 2004). The firm can therefore only commit to the allocation of decision rights. We focus on two allocations. Under Decentralization Manager 1 has the right to decide on the production level of Division 1 and Manager 2 has the right to decide on the production level of Division 2. Under Centralization headquarters decides on the production levels of both divisions. Finally, we assume that the allocation of decision rights that is chosen ex ante cannot be changed ex post.

Notice that the assumption that decisions are non-contractible even ex post rules out the use of transfer pricing schemes. While firms often do use schemes to motivate divisions to internalize cost externalities they are necessarily imperfect if headquarters does not know the opportunity costs of the different decisions. Moreover, some of the underlying reasons for cost externalities, such as managerial know-how, are difficult to measure and price appropriately. Finally, note that while we do not allow for transfer pricing explicitly, in one important case we allow for it implicitly. In particular, the case in which the own-division λ is equal to $1/2$ can be interpreted as one in which the division managers incentives are aligned by an optimal transfer pricing scheme in which transfer prices are set before uncertainty is realized. As mentioned above, our main result continues to hold in this case.

Information and Communication: Initially we take a reduced-form approach to communica-

[9] See, for instance, Athey and Roberts (2001), Alonso, Dessein, and Matouschek (2008), and Rantakari (2008). Also, Bushman et al. (1995), Abernethy et al. (2004), and Bouwens and Van Lent (2008) present empirical evidence that a substantial part of the compensation of division managers is linked to division specific performance measures. Finally, General Motors provides a historical example of a firm with a very large λ: "Under the incentive system in operation before 1918, a small number of division managers had contracts providing them with a stated share in the profits of their own divisions, irrespective of how much the corporation as a whole earned. Inevitably, this system exaggerated the self-interest of each division at the expense of the interests of the corporation itself. It was even possible for a division manager to act contrary to the interests of the corporation in his effort to maximize his own division's profits." (Sloan 1990, p.409).

tion and assume that the extent to which the various managers are informed about the divisions' demand conditions is exogenously given. In Section 8 we then model communication explicitly and thus endogenize the information structure. In our reduced-form approach each division manager learns the demand conditions in his market, that is, Manager 1 learns the realization of intercept α_1 and Manager 2 learns the realization of intercept α_2. Under Centralization, headquarters receives noisy and independent signals about the demand conditions in each market. Similarly, under Decentralization each division manager receives a noisy and public signal about the demand conditions faced by the other division. The signals that the division managers receive are independent of each other. We denote the signal about Division 1's intercept by $m_1 \in [\underline{s}, \overline{s}]$ and that about Division 2's intercept by $m_2 \in [\underline{s}, \overline{s}]$. We measure the quality of information flows by the residual variance

$$V = \mathrm{E}\left[(\alpha_j - \mathrm{E}\left[\alpha_j \left| m_j \right.\right])^2\right] \text{ for } j = 1, 2. \tag{6}$$

Since the division managers are biased towards their divisions, there is a stronger incentive conflict between the division managers than between each division manager and headquarters. It is therefore natural to assume that the quality of vertical information flows − between the division managers and headquarters − is better than the quality of horizontal information flows − between the division managers. We confirm this intuition when we model communication explicitly in Section 8. For the time being we capture this intuition by assuming that the residual variance under Decentralization V^D is weakly larger than the residual variance under Centralization V^C. In the absence of any incentive conflicts the assumption that $V^C \leq V^D$ can be motivated on grounds of bounded rationality and returns to knowledge specialization. Indeed, following Hart and Moore (2005) and Ferreira and Sah (2009), it is natural to think of division managers as specialists with deep knowledge of one but only one market and headquarter managers as generalists with superficial knowledge of both markets.[10]

Timing: The timing is as follows. First, decision rights are allocated to maximize the total expected profits $\mathrm{E}[\pi_1 + \pi_2]$. Second, the different managers learn their information about the demand conditions in both markets. Third, the divisions' production levels are set. Fourth, the competitors observe the divisions' production levels and then decide whether to enter the market. Those competitors that have entered the market then decide on their own production levels simultaneously. We assume that the divisions have a first mover advantage to abstract from the well-known strategic motives for delegation (Fershtman 1985, Vickers 1985, and Fershtman and

[10] This knowledge structure can easily be endogenized for $\lambda = 1/2$. Under appropriate assumptions a manager who decides on both q_1 and q_2 will choose to become a generalist who has some information about demand in both markets; in contrast, a manager who only decides on q_1, for instance, will prefer to be a specialist who perfectly observes demand in Market 1 but is less well informed about demand in Market 2.

Judd 1987). Finally, profits are realized and the game ends. We solve for the Perfect Bayesian Equilibrium of this game.

Comparative Statics: Our main interest is in how competition affects the firm's choice between Centralization and Decentralization. Competition increases either because of a reduction in entry costs K, an increase in market size m, or an increase in the degree of substitutability γ.[11] We will see below that the effect of an increase in competition on the firm's organization depends crucially on whether this increase is caused by a change in K, m, or γ.

3 The Competitors' Entry and Production Decisions

We solve the model by backward induction, starting with the competitors' production and entry decisions. Suppose that the firm has made production decisions q_1 and q_2 and that measures n_1 and n_2 of competitors have entered the respective markets. Each competitor $k \in [0, n_j]$ in Market $j = 1, 2$ then makes the profit maximizing production decision that solves

$$\max_{q_{jk}} p_{jk} q_{jk} - q_{jk}, \tag{7}$$

taking as given production of the firm and the other competitors. Using the inverse demand function (5), the first order condition is given by

$$q_{jk} = m(1 - c_l) - \gamma q_j - Q_j. \tag{8}$$

Note that this condition does not depend on the intercept α_j. It is therefore irrelevant whether the competitors observe α_j or not. Next we integrate over all n_j competitors to find that the total amount produced by the competitors in Market j is given by

$$Q_j = \frac{n_j}{n_j + 1} \left[m(1 - c_l) - \gamma q_j \right]. \tag{9}$$

We then have that any competitor k that enters Market j produces

$$q_{jk} = \frac{1}{n_j} Q_j = \frac{1}{n_j + 1} \left[m(1 - c_l) - \gamma q_j \right] \tag{10}$$

and realizes profits

$$\pi_{jk} = \frac{\left[m(1 - c_l) - \gamma q_j \right]^2}{m(n_j + 1)^2} - K. \tag{11}$$

Finally, setting π_{jk} equal to zero and solving for n_j we find that a measure

$$n_j = \frac{1}{\sqrt{mK}} \left[m(1 - c_l) - \gamma q_j - \sqrt{mK} \right] \tag{12}$$

[11] The literatures on the effect of competition on managerial incentives (Raith 2003) and on the incentives to innovate (Vives 2008) focus on the same parameter changes.

of competitors enters Market j. Naturally, for any given production by Division j, the number of competitors in Market j is decreasing in entry costs K and in the degree of substitutability γ and it is increasing in market size m.

4 The Firm's Demand and Profit Functions

We can now turn our attention to the firm and its divisions. We first work out the divisions' residual inverse demand functions and then derive expressions for their profits and expected profits.

4.1 Demand Functions

The residual inverse demand function of Division $j = 1, 2$ characterizes demand for its good given the competitors' behavior. Substituting the competitors' total production (9) in Division j's inverse demand function (4), we find that Division j's residual inverse demand function is given by

$$p_j = \alpha_j - a - b_d q_j, \tag{13}$$

where

$$a \equiv \gamma \left(1 - c_l - \sqrt{\frac{K}{m}}\right) \quad \text{and} \quad b_d \equiv \frac{1}{m}\left(1 - \gamma^2\right) \tag{14}$$

and where the subscript "d" stands for "demand." These expressions show that the effect of an increase in competition on demand depend on the underlying reason for the increase in competition. A reduction in entry costs K, for instance, leads to a parallel, downward shift of the residual inverse demand functions while an increase in substitutability γ or in market size m leads to an anti-clockwise rotation. We will see below that the effect of an increase in competition on the firm's organization depends crucially on whether it leads to a shift or a rotation of the residual inverse demand functions.

4.2 Profit Functions

Profits of Division 1 are given by

$$\pi_1 (q_1, q_2) = p_1 q_1 - c_1.$$

Substituting the cost function (1) for total costs c_1 and the residual inverse demand function (13) for the price p_1 we can rewrite Division 1's profits as

$$\pi_1 (q_1, q_2) = (\alpha_1 - a - c - b q_1 - g q_2)\, q_1, \tag{15}$$

where $b \equiv (b_c + b_d)$. The expression for Division 2's profits $\pi_2(q_1, q_2)$ is analogous. Total profits are then given by

$$\pi(q_1, q_2) = \pi_1(q_1, q_2) + \pi_2(q_1, q_2). \tag{16}$$

Each organizational structure that we examine below generates decision rules that map the information of the decision makers into production decisions. Abusing notation somewhat, we denote these decision rules by q_1 and q_2. It is useful to decompose the decision rules into two components: the average decisions $\overline{q}_1 = \mathrm{E}[q_1]$ and $\overline{q}_2 = \mathrm{E}[q_2]$ and the deviations from the average decisions $\Delta_1 = q_1 - \overline{q}_1$ and $\Delta_2 = q_2 - \overline{q}_2$. We can then write the decision rules as

$$q_j = \overline{q}_j + \Delta_j, \text{ for } j = 1, 2. \tag{17}$$

Substituting this expression into Division 1's profit function (15) and taking expectations we find that Division 1's expected profits are given by

$$\Pi_1(q_1, q_2) = (\mu - a - c - b\overline{q}_1 - g\overline{q}_2)\,\overline{q}_1 + \mathrm{E}[\Delta_1(\alpha_1 - \mu)] - b\mathrm{E}\left[\Delta_1^2\right] - g\mathrm{E}[\Delta_1\Delta_2]. \tag{18}$$

The first term on the right hand side are the profits that Division 1 would expect to realize if decision makers had to commit to a single production level for each division, regardless of the demand conditions. Accordingly, we refer to these profits as Division 1's "rigid profits" and we denote them by $\Pi_1(\overline{q}_1, \overline{q}_2)$. The remaining terms on the right hand side of (15) are the additional profits that Division 1 expects to realize if it is able to adjust production in response to demand shocks. We refer to these additional profits as Division 1's "expected gains from flexibility" and we denote them by F_1. To interpret the expected gains from flexibility, it is useful to rewrite them as

$$F_1 = \mathrm{Cov}(q_1, a_1) - b\mathrm{Var}(q_1) - g\mathrm{Cov}(q_1, q_2). \tag{19}$$

The extent to which Division 1 benefits from its ability to adjust production to demand shocks therefore depends on three factors: the extent to which its production is adapted to local demand conditions − as measured by $\mathrm{Cov}(q_1, a_1)$ − the variability of its production − as measured by $\mathrm{Var}(q_1)$ − and the extent to which production is coordinated across divisions − as measured by $\mathrm{Cov}(q_1, q_2)$.

The expressions for Division 2's expected profits $\Pi_2(q_1, q_2)$, its rigid profits $\Pi_2(\overline{q}_1, \overline{q}_2)$, and its expected gains from flexibility F_2 are analogous to those for Division 1. We can therefore write total expected profits as

$$\Pi(q_1, q_2) = \Pi(\overline{q}_1, \overline{q}_2) + F(\Delta_1, \Delta_2), \tag{20}$$

where $\Pi(\overline{q}_1, \overline{q}_2) \equiv \Pi_1(\overline{q}_1, \overline{q}_2) + \Pi_2(\overline{q}_1, \overline{q}_2)$ are the total rigid profits and $F(\Delta_1, \Delta_2) \equiv F_1(\Delta_1, \Delta_2) + F_2(\Delta_1, \Delta_2)$ are the total expected gains from flexibility.

5 The Firm's Production Decisions and Expected Profits

Having derived the firm's profit functions, we can now examine decision making and expected profits under Centralization and Decentralization and compare them to first best.

5.1 First Best

Suppose headquarters is perfectly informed about the demand conditions in both markets. It then makes the first best production decisions that maximize the firm's profits for any demand conditions. Formally, it solves

$$\max_{q_1, q_2} \pi (q_1, q_2) \tag{21}$$

for any α_1 and α_2. We denote the solution to this problem by q_1^{FB} and q_2^{FB}, where "FB" stands for "first best." We first examine the first best average decisions $\overline{q}_1^{FB}$ and $\overline{q}_2^{FB}$ and then the first best deviations from the average decisions Δ_1^{FB} and Δ_2^{FB}.

5.1.1 First Best Average Decisions

We will see below that the first best, as well as the centralized and decentralized, decision rules are linear in the demand conditions. This implies that the average decisions are equal to the decisions under average demand conditions. To derive the first best average decisions, suppose therefore that demand conditions in both markets are average, that is, $\alpha_1 = \alpha_2 = \mu$. The first order conditions of (21) are then given by

$$\frac{\mathrm{d}\pi (\overline{q}_1, \overline{q}_2)}{\mathrm{d}q_1} = \mu - a - c - 2b\overline{q}_1 - 2g\overline{q}_2 = 0 \tag{22}$$

and

$$\frac{\mathrm{d}\pi (\overline{q}_1, \overline{q}_2)}{\mathrm{d}q_2} = \mu - a - c - 2b\overline{q}_2 - 2g\overline{q}_1 = 0. \tag{23}$$

We can rewrite these first order conditions as

$$\overline{q}_1 = \frac{\mu - a - c}{2b} - t\overline{q}_2 \quad \text{and} \quad \overline{q}_2 = \frac{\mu - a - c}{2b} - t\overline{q}_1, \tag{24}$$

where $t \equiv g/b$. The parameter t captures the degree of interdependence between the first best average decisions and, as we will see below, between the first best deviations from the average decisions. Note that an increase in competition that makes demand more price sensitive, also makes first best decisions more interdependent, that is, it increases $|t|$. This feature will be important for some of our main results below.

Given the first order conditions (24), first best average decisions are given by

$$\overline{q}_1^{FB} = \overline{q}_2^{FB} = \overline{q}^{FB} \equiv \frac{\mu - a - c}{2b(1+t)} \tag{25}$$

and first best rigid profits are given by

$$\Pi\left(\overline{q}^{FB}, \overline{q}^{FB}\right) = \frac{(\mu - a - c)^2}{2b\,(1+t)}. \tag{26}$$

These are the maximum profits that the firm could expect to realize if it had to commit to a single production level for each division, regardless of the demand conditions.

5.1.2 First Best Deviations

Suppose next that the firm faces a demand shock in at least one of the markets, that is, $\alpha_1 \neq \mu$, or $\alpha_2 \neq \mu$, or both. The first order conditions of (21) are then given by

$$\frac{\mathrm{d}\pi\,(q_1, q_2)}{\mathrm{d}q_1} = [\mu - a - c - 2b\overline{q}_1 - 2g\overline{q}_2] + [\alpha_1 - \mu - 2b\Delta_1 - 2g\Delta_2] = 0 \tag{27}$$

and

$$\frac{\mathrm{d}\pi\,(q_1, q_2)}{\mathrm{d}q_2} = [\mu - a - c - 2b\overline{q}_2 - 2g\overline{q}_1] + [\alpha_2 - \mu - 2b\Delta_2 - 2g\Delta_1] = 0. \tag{28}$$

The first term on the right hand side of each of these expressions is zero because of the first order conditions (22) and (23). We can therefore rewrite (27) and (28) as

$$\Delta_1 = \frac{\alpha_1 - \mu}{2b} - t\Delta_2 \quad \text{and} \quad \Delta_2 = \frac{\alpha_2 - \mu}{2b} - t\Delta_1. \tag{29}$$

Solving these first order conditions then gives

$$\Delta_1^{FB} = \frac{\alpha_1 - \mu}{2b\,(1-t^2)} - t\frac{\alpha_2 - \mu}{2b\,(1-t^2)} \quad \text{and} \quad \Delta_2^{FB} = \frac{\alpha_2 - \mu}{2b\,(1-t^2)} - t\frac{\alpha_1 - \mu}{2b\,(1-t^2)}. \tag{30}$$

We saw earlier that the firm's expected profits depend on the extent to which the divisions' production decisions are adapted to local demand conditions and coordinated with each other. In each first order condition (29) the first term on the right hand side captures the need for adaptation and the second captures the need for coordination. Note that the more price sensitive demand, that is, the smaller b_d and thus b, the larger the absolute size of each term. Loosely speaking, the more price sensitive demand, the more important are both adaptation and coordination. The observation that more price sensitive demand makes adaptation more important is well known and is often used to explain why competition favors decentralization. The observation that more price sensitive demand also makes coordination more important, however, is to our knowledge new and is central to our argument that competition can favor centralization.

The above expressions show that in our setting adaptation facilitates coordination. In other words, an organization might perform well in terms of adaptation because it performs well in terms of coordination and not in spite of it. To see this, suppose that the firm experiences a positive demand shock in Market 1 but not in Market 2, that is, $\alpha_1 > \mu$ and $\alpha_2 = \mu$. An uncoordinated response would call for Division 1 to increase production above the average production level and for Division 2 to continue to produce the average. It follows from (29) that in this case Division 1 would increase production by $\Delta_1 = (\alpha_1 - \mu) / (2b)$. A coordinated response to the demand shock instead would call for Division 2 to also change its production level. It follows from (30) that in this case Division 1 would increase production by $\Delta_1 = (\alpha_1 - \mu) / \left(2b\left(1 - t^2\right)\right) > (\alpha_1 - \mu) / (2b)$. The ability to coordinate production across divisions therefore allows the firm to adapt production more aggressively to changes in demand. We will see below that because of this, and in spite of headquarters' informational disadvantage, Centralization may outperform Decentralization both in terms of coordination and adaptation.

All that remains to be done in this section is to work out the firm's first best expected gains from flexibility. Given the deviation strategies in (30), these are given by

$$F\left(\Delta_1^{FB}, \Delta_2^{FB}\right) = \frac{\sigma^2}{2b\left(1 - t^2\right)}. \tag{31}$$

Note that the first best expected gains from flexibility, and thus the firm's first best expected profits, are increasing in the variability of demand as measured by the variance σ^2. To the extent that the firm can adapt production to demand shocks, it therefore benefits from more demand variability.

5.2 Centralization

The decision problem that headquarters solves under Centralization is the same as the first best problem (21), except that headquarters now has to form expectations about the demand conditions in both markets. Formally, it solves

$$\max_{q_1, q_2} \mathrm{E}\left[\pi\left(q_1, q_2\right) | m\right], \tag{32}$$

where $m = (m_1, m_2)$ are the signals that headquarters observes. We denote the solution to this problem by q_1^C and q_2^C, where "C" stands for "Centralization." We again start by examining the average decisions $\overline{q}_1^C$ and $\overline{q}_2^C$ and then move on to the deviations Δ_1^C and Δ_2^C.

5.2.1 Average Decisions under Centralization

Suppose first that headquarters believes that demand conditions in both markets are average, that is, $\mathrm{E}\left[\alpha_1 | m\right] = \mathrm{E}\left[\alpha_2 | m\right] = \mu$. Headquarters' imperfect information about the demand conditions does not prevent it from making the right decisions on average and it therefore sets $\overline{q}_1^C = \overline{q}_2^C = \overline{q}^C \equiv \overline{q}^{FB}$. Imperfect information does, however, limit its ability to adapt production to demand shocks, as we will see next.

5.2.2 Deviations under Centralization

Suppose that headquarters believes that in at least one of the markets demand conditions are different from average, that is, $\mathrm{E}[\alpha_1 | m] \neq \mu$, or $\mathrm{E}[\alpha_2 | m] \neq \mu$, or both. The first order conditions of (32) can then be written as

$$\Delta_1 = \frac{\mathrm{E}[\alpha_1 - \mu | m]}{2b} - t\Delta_2 \quad \text{and} \quad \Delta_2 = \frac{\mathrm{E}[\alpha_2 - \mu | m]}{2b} - t\Delta_1. \tag{33}$$

These first order conditions are identical to the first best first order conditions (29) except that headquarters now relies on noisy signals of the demand conditions in each market. This limits its ability to adapt production to the actual demand conditions. It does not, however, affect its ability to coordinate production across divisions: since headquarters decides on the production levels for each division, it can choose any covariance between the production levels, independent of the quality of its information.

Headquarters' inability to perfectly adapt production to local demand conditions limits the extent to which the centralized firm can benefit from variability in demand. To examine the size of this inefficiency, we first solve the first order conditions to obtain

$$\Delta_1^C = \frac{\mathrm{E}[(\alpha_1 - \mu) | m] - t\mathrm{E}[(\alpha_2 - \mu) | m]}{2b(1-t^2)} \quad \text{and} \quad \Delta_2^C = \frac{\mathrm{E}[(\alpha_2 - \mu) | m] - t\mathrm{E}[(\alpha_1 - \mu) | m]}{2b(1-t^2)}. \tag{34}$$

Next we use these expressions to work out the expected total gains from flexibility under Centralization and compare them to those under first best. Doing so we find that

$$F\left(\Delta_1^{FB}, \Delta_2^{FB}\right) - F\left(\Delta_1^C, \Delta_2^C\right) = \frac{V^C}{2b(1-t^2)} \geq 0, \tag{35}$$

where the residual variance V^C measures the quality of vertical information flows. Since this inefficiency is solely due to headquarters' inability to perfectly adapt production to local demand conditions, we refer to it as the "adaptation loss" of the centralized organization. If the residual variance V^C is zero, information is perfect and headquarters can perfectly adapt production to local demand conditions. As a result, the adaptation loss is then equal to zero. An increase in the residual variance limits headquarters' ability to adapt production to local demand conditions. Accordingly, such an increase reduces the covariance between production by each division and its local demand conditions, that is, it reduces

$$\mathrm{Cov}\left(q_j^C, \alpha_j\right) = \frac{(\sigma^2 - V^C)}{2b(1-t^2)} \quad \text{for} \quad j = 1, 2. \tag{36}$$

Because an increase in the residual variance leads to worse adaptation, it increases the adaptation loss. Once the residual variance reaches its maximum $V^C = \sigma^2$, headquarters is entirely uninformed about the demand conditions in both markets and the adaptation loss is maximized.

5.3 Decentralization

Under Decentralization each division manager makes the production decision that maximizes his expected utility given the demand conditions in his market and his expectations of the demand conditions in the other market. Formally, Manager 1 solves

$$\max_{q_1} \mathrm{E}\left[\lambda \pi_1\left(q_1, q_2\right) + (1-\lambda)\, \pi_2\left(q_1, q_2\right) | \alpha_1, m\right] \tag{37}$$

and Manager 2 solves

$$\max_{q_2} \mathrm{E}\left[\lambda \pi_2\left(q_1, q_2\right) + (1-\lambda)\, \pi_1\left(q_1, q_2\right) | \alpha_2, m\right]. \tag{38}$$

We denote the solution to this problem by q_1^D and q_2^D, where "D" stands for "Decentralization." Once again we start by examining the average decisions $\overline{q}_1^D$ and $\overline{q}_2^D$ and then move on to the deviations Δ_1^D and Δ_2^D.

5.3.1 Average Decisions under Decentralization

Suppose first that each division manager observes average demand conditions in his market and also expects conditions in the other market to be average, that is,

$$\alpha_1 = \alpha_2 = \mathrm{E}\left[\alpha_1 | \alpha_2, m_1\right] = \mathrm{E}\left[\alpha_2 | \alpha_1, m_2\right] = \mu. \tag{39}$$

The first order conditions of (37) and (38) can then be written as

$$\overline{q}_1 = \frac{\mu - a - c}{2b} - t_D \overline{q}_2 \quad \text{and} \quad \overline{q}_2 = \frac{\mu - a - c}{2b} - t_D \overline{q}_1, \tag{40}$$

where $t_D \equiv t/\left(2\lambda\right)$ is the interdependence between the divisions' production decisions as perceived by the division managers. Note that the only difference between these and the first best first order conditions (24) is that the perceived interdependence is less than the first best interdependence, that is, $|t_D| \leq |t|$. Solving the first order conditions for $\overline{q}_1$ and $\overline{q}_2$ we find that under Decentralization the average decisions are given by

$$\overline{q}_1^D = \overline{q}_2^D = \overline{q}^D \equiv \frac{\mu - a - c}{2b\left(1 + t_D\right)}.$$

On average the division managers therefore produce more than first best if $g > 0$ and less if $g < 0$. Naturally, this distortion arises because neither division manager takes into account the full effect that his decision has on the costs of the other division. In this sense, the division managers fail to cooperate. Because of the division managers' failure to cooperate, rigid profits under Decentralization are less than what they are under first best. In particular, we have that

$$\Pi\left(\overline{q}^{FB},\overline{q}^{FB}\right)-\Pi\left(\overline{q}^{D},\overline{q}^{D}\right)=2b\left(1+t\right)\left(\overline{q}^{D}-\overline{q}^{FB}\right)^{2}\geq 0. \tag{41}$$

Since this discrepancy is due to the division managers' failure to cooperate, we refer to it as the "cooperation loss" of the decentralized organization.

5.3.2 Deviations under Decentralization

Suppose next that at least one of the division managers observes demand conditions that are different from average or expects demand conditions in the other market to be different from average. The first order conditions of (37) and (38) can then be written as

$$\Delta_1=\frac{\alpha_1-\mu}{2b}-t_D\mathrm{E}\left[\Delta_2\left|m\right.\right] \quad \text{and} \quad \Delta_2=\frac{\alpha_2-\mu}{2b}-t_D\mathrm{E}\left[\Delta_1\left|m\right.\right]. \tag{42}$$

The first term on the right hand side of each of these first order conditions captures the need to adapt production to local demand conditions and the second captures the need to coordinate production across divisions. The first terms on the right hand sides – the adaptation terms – are the same as in the first best first order conditions (33). This reflects the fact that each division manager perfectly observes the demand conditions in his market and is therefore able to perfectly adapt production to the local demand conditions. The decentralized first order conditions (42) then only differ from the first best first order conditions (33) because of the second term on the right hands sides – the coordination terms. There are two reasons why the coordination behavior of the division managers is different from first best. First, the division managers put less weight on coordination than headquarters does: perceived interdependence between the production decisions is less than first best interdependence, that is, $|t_D|\leq|t|$. This is so since neither division manager fully internalizes the effect of a change in production by his division on the other division. In this sense, the division managers are unwilling to efficiently coordinate production. Second, even if the division managers were willing to efficiently coordinate production, they would not be able to do so. This is the case since each division manager is uncertain about the production decision of the other. The division managers are therefore both unwilling and unable to efficiently coordinate with each other.

The division managers' failure to efficiently coordinate production limits the extent to which the decentralized firm can benefit from demand variability. To examine the extent of this inefficiency, we first solve the first order conditions (33) for

$$\Delta_1^D = \frac{\alpha_1 - \mu}{2b} - t_D \frac{\mathrm{E}\left[\alpha_2 - \mu\,|m\right] - t_D \mathrm{E}\left[\alpha_1 - \mu\,|m\right]}{2b\left(1 - t_D^2\right)} \tag{43}$$

and

$$\Delta_2^D = \frac{\alpha_2 - \mu}{2b} - t_D \frac{\mathrm{E}\left[\alpha_1 - \mu\,|m\right] - t_D \mathrm{E}\left[\alpha_2 - \mu\,|m\right]}{2b\left(1 - t_D^2\right)}. \tag{44}$$

The difference between the first best and the decentralized expected gains from flexibility are then given by

$$F\left(\Delta_1^{FB}, \Delta_2^{FB}\right) - F\left(\Delta_1^D, \Delta_2^D\right) = \frac{t^2 V^D}{2b\left(1 - t^2\right)} + \left(t - t_D\right)^2 \frac{1 + t_D\left(2t + t_D\right)}{2b\left(1 - t_D^2\right)^2\left(1 - t^2\right)}\left(\sigma^2 - V^D\right) \geq 0. \tag{45}$$

Since this inefficiency is solely due to the division managers' inability and unwillingness to coordinate, we refer to it as the "coordination loss" of the decentralized organization. Note that the coordination loss is only zero if both $t_D = t$ and $V^D = 0$, that is, if the division managers are both willing and able to coordinate efficiently.

We saw earlier that coordination facilitates adaptation. The division managers' failure to coordinate therefore limits their ability to adapt production to the local demand conditions. As a result, production may actually be less adapted to the local demand conditions under Decentralization than under Centralization. In particular, we have that

$$\mathrm{Cov}\left(q_j^C, \alpha_j\right) - \mathrm{Cov}\left(q_j^D, \alpha_j\right) = \frac{\sigma^2 - V^C}{2b\left(1 - t^2\right)} - \frac{\sigma^2 - t_D^2 V^D}{2b\left(1 - t_D^2\right)} \quad \text{for} \quad j = 1, 2. \tag{46}$$

Decentralized production therefore covaries less strongly with local demand conditions than does centralized production if the perceived interdependence $|t_D|$ is sufficiently small relative to first best interdependence $|t|$ and the quality of horizontal communication flows V^D is sufficiently low relative to the quality of vertical communication flows V^C.

6 The Internal Organization of the Firm

We can now address our main question of how competition affects the firm's internal organization. The firm decentralizes if the adaptation loss of the centralized organization is larger than the cooperation and coordination losses of the decentralized organization. Formally, the firm decentralizes if the gains from decentralization

$$G(a,t) = \underbrace{\frac{V^C}{2b(1-t^2)}}_{\text{adaptation loss}} - \underbrace{\frac{(t-t_D)^2}{(1+t_D)^2}\frac{(\mu-a-c)^2}{2b(1+t)}}_{\text{cooperation loss}} \tag{47}$$
$$-\underbrace{\left[\frac{t^2V^D}{2b(1-t^2)} + (t-t_D)^2\frac{1+t_D(2t+t_D)}{2b\left(1-t_D^2\right)^2(1-t^2)}\left(\sigma^2-V^D\right)\right]}_{\text{coordination loss}}$$

are positive. To answer our main question we have to examine how competition affects these gains from decentralization. We can do so most easily when the division managers are not biased towards their divisions, that is, when $\lambda = 1/2$. We first discuss this case and then allow for $\lambda > 1/2$.

6.1 Internal Organization without Incentive Conflicts

Suppose that $\lambda = 1/2$ and thus $t = t_D$. The decentralized organization then fails to realize first best expected profits because the division managers are imperfectly informed about the demand conditions and not because their decisions are biased. Accordingly, the cooperation loss is zero. Moreover, the coordination loss is only positive because the division managers are unable to coordinate and not because they are unwilling to do so. Formally, the gains from decentralization are now given by

$$G(a,t) = \underbrace{\frac{V^C}{2b(1-t^2)}}_{\text{adaptation loss}} - \underbrace{\frac{t^2V^D}{2b(1-t^2)}}_{\text{coordination loss}}. \tag{48}$$

The adaptation and coordination losses do not depend on the average intercept of the residual inverse demand functions. This is intuitive since these losses measure the failure of the different organizational structures to respond to demand shocks; as such they depend on the variance of the intercepts but not on their mean. An increase in competition that only affects the average intercept − such as a reduction in entry costs − therefore has no effect on the firm's internal organization. This result is summarized in our first proposition.

PROPOSITION 1: *Suppose that the own-division bias λ is equal to 1/2. A reduction in entry costs K then has no effect on the the firm's internal organization.*

In contrast, an increase in competition that makes demand more price sensitive can affect the firm's internal organization. As anticipated above, such an increase increases not only the adaptation loss but also the coordination loss. In fact, when $G(a,t) = 0$ it increases the coordination loss by more than it increases the adaptation loss. At the relevant margin, therefore, an increase in competition that increases the price sensitivity of demand − such as an increase in market size or in the degree of substitutability − favors Centralization. This result is summarized in our second proposition.

PROPOSITION 2: *Suppose that the own-division bias* λ *is equal to* $1/2$. *Then an increase in market size* m *or in the degree of substitutability* γ *can result in a shift from Decentralization to Centralization but never the reverse.*

This is the central result in our paper. It shows that competition can make both adaptation and coordination more important. And in line with the quote by the Unilever CEO in the introduction, the increased need for coordination can outweigh the increased need for adaptation. A firm may therefore respond to an increase in competition by centralizing, just as Unilever did.

6.2 Internal Organization with Incentive Conflicts

The main effect of allowing for $\lambda > 1/2$ is that the cooperation loss is then positive. This matters because the cooperation loss depends on the average intercept of the residual inverse demand functions. In particular, a reduction in the average intercept, reduces the profit margins and the production levels under both organizational structures and therefore reduces the cooperation loss. Since the adaptation and coordination losses are still independent of the intercept, this implies that an increase in competition that only lowers the average intercept favors Decentralization. We therefore have the following result.

PROPOSITION 3: *Suppose that the own-division bias* λ *is greater than* $1/2$ *and that* $t \neq 0$. *Then a reduction in entry costs* K *can result in a shift from Centralization to Decentralization but never the reverse.*

This proposition confirms the standard intuition that an increase in competition favors decentralization. Competition favors decentralization, however, because it reduces the costs of the division managers' failure to cooperate, not because it makes adaptation more important.

The cooperation loss also depends on the price sensitivity of demand. In particular, an increase in the price sensitivity of demand increases the cooperation loss. Such an increase also increases the adaptation and coordination losses, just as it does when $\lambda = 1/2$. In general, the effect of an increase in the price sensitivity of demand on the gains from decentralization are therefore ambiguous. At the relevant margin however, that is, when $G(a, t) = 0$, an increase in the price sensitivity of demand reduces the gains from decentralization. An increase in price sensitivity therefore favors Centralization.

It then follows that when $\lambda > 1/2$ an increase in competition that leads to an anti-clockwise rotation of the average residual inverse functions − such an increase in market size or the degree of substitutability − has two opposing effects on the gains from decentralization. On the one hand, it lowers the average intercept of the residual inverse demand functions which favors Decentralization. On the other, it increases the price sensitivity of demand which favors Centralization. To understand when the second effect dominates suppose that $G(a,t)=0$ and consider the effect of a marginal increase in the measure of consumers m:

$$\frac{\mathrm{d}G\left(a,t\right)}{\mathrm{d}m}=\frac{\partial G\left(a,t\right)}{\partial a}\frac{\mathrm{d}a}{\mathrm{d}m}+\frac{\partial G\left(a,t\right)}{\partial t}\frac{\mathrm{d}t}{\mathrm{d}m}. \tag{49}$$

Substituting for $\mathrm{d}a/\mathrm{d}m$ and $\mathrm{d}t/\mathrm{d}m$ we then have

$$\frac{\mathrm{d}G\left(a,t\right)}{\mathrm{d}m}=\frac{\partial G\left(a,t\right)}{\partial a}\underbrace{\frac{\gamma}{2m}\sqrt{\frac{K}{m}}}_{\mathrm{d}a/\mathrm{d}m}+\frac{\partial G\left(a,t\right)}{\partial t}\underbrace{t\frac{1-\gamma^2}{m\left(1-\gamma^2+mb_c\right)}}_{\mathrm{d}t/\mathrm{d}m}. \tag{50}$$

The first term on the right hand side is positive and captures the effect that works through the average intercept and the second term is negative and captures the effect that works through the price elasticity of demand. The next proposition characterizes conditions under which the second effect dominates the first.

PROPOSITION 4: *Suppose that the own-division bias λ is greater than 1/2. Then there exists a critical value of the degree of substitutability $\gamma^* > 0$ and a critical value of the entry costs $K^* > 0$ such that, if $\gamma \leq \gamma^*$ and $K \leq K^*$, an increase in market size m can result in a shift from Decentralization to Centralization but never the reverse.*

To get an intuition for this result, consider the extreme examples in which either the entry costs are zero or the competitors' goods are independent from the firms'. In both situations, an increase in market size flattens the residual inverse demand functions without reducing their average intercept. This change in the residual inverse demand functions, in turn, makes the division managers' failure to coordinate and cooperate more costly for the firm. As a result, it favors Centralization.

Next, suppose again that $G(a,t)=0$ and consider the effect of a marginal increase in the degree of substitutability γ:

$$\frac{\mathrm{d}G\left(a,t\right)}{\mathrm{d}\gamma}=\frac{\partial G\left(a,t\right)}{\partial a}\frac{\mathrm{d}a}{\mathrm{d}\gamma}+\frac{\partial G\left(a,t\right)}{\partial t}\frac{\mathrm{d}t}{\mathrm{d}\gamma}. \tag{51}$$

Substituting for $\mathrm{d}a/\mathrm{d}\gamma$ and $\mathrm{d}t/\mathrm{d}\gamma$ we then have

$$\frac{\mathrm{d}G\left(a',t'\right)}{\mathrm{d}m}=\frac{\partial G\left(a',t'\right)}{\partial a}\underbrace{\left(1-c_l-\sqrt{\frac{K}{m}}\right)}_{\mathrm{d}a/\mathrm{d}\gamma}+\frac{\partial G\left(a',t'\right)}{\partial t}\underbrace{2t\frac{\gamma}{\left(1-\gamma^2+mb_c\right)}}_{\mathrm{d}t/\mathrm{d}\gamma}. \tag{52}$$

The first term on the right hand side is again the positive effect that works through the intercept and the second is the negative effect that works through the price sensitivity of demand. The following proposition characterizes conditions under which the second effect dominates so that an increase in substitutability favors Centralization.

PROPOSITION 5: *Suppose that the own-division bias* λ *is greater than* $1/2$. *Then there exists a critical value of the degree of substitutability* $\gamma^* < 1$ *and a critical value of the cost parameter* $b_c^* \geq 0$ *such that, if* $\gamma \geq \gamma^*$ *and* $b_c \leq b_c^*$, *an increase in the degree of substitutability* γ *can result in a shift from Decentralization to Centralization but never the reverse.*

Essentially, when γ is very large − and the markets are therefore very competitive − a further increase in γ has much stronger effect on the price sensitivity of demand than on the average intercept of the residual inverse demand functions. The increase in price sensitivity favors Centralization because it makes it makes cooperation and coordination between the divisions very important.

In summary, competition can favor decentralization, as is often argued, although in our setting it can do so because it reduces the costs of the division managers' failure to cooperate, not because it makes adaptation more important. Competition can also favor centralization, though, because it makes coordination more important. Whether it favors decentralization or centralization depends on the underlying reasons for the increase in competition.

7 Discussion

We now turn to broader implications of our model. We first discuss the empirical implications of our model. We then point out that our model is more general than it may appear. In particular, similar insights hold if firms compete in prices rather than quantities and if there are demand rather than cost externalities between divisions. We also examine how the coordination problem in our model relates to the more abstract models of coordination used in the recent literature.

7.1 Empirical Implications

A growing empirical literature explores the impact of competition on organizational design. A popular notion in this literature is that competition favors decentralization (see for instance Bloom et al. 2008, Guadalupe and Wulf 2009). Our model examines this notion and shows when it holds and when, instead, competition favors centralization. As such, we hope that our model can provide guidance and interpretation for current and future empirical work on the effect of competition on organizational design and, more generally, on the organization of multi-divisional firms.

The key empirical implication of our model is that competition has two opposing effects on organizational design: a level effect which favors decentralization and a price sensitivity effect which favors centralization. It is therefore important for empirical research to distinguish pro-competitive changes in the environment that mainly shift demand from those that make it more price sensitive.

Our model provides a theory of a multi-divisional firms and therefore speaks mainly to the decentralization of authority to division managers rather than to the plant managers that most of the empirical literature has focused on (see Colombo and Delmastro 2004, Bloom et al. 2008, and Meagher and Wait 2008). Division managers typically have responsibility for sales, marketing, engineering, and manufacturing and report to a group manager or a Chief Operating Officer (COO) who has responsibility for multiple divisions.[12] The role of the group manager or COO is thus equivalent to that of headquarters in our model.[13] Plant managers, in contrast, typically run individual plants and report to division managers who coordinate the decisions of plant managers with those of other functional units such as marketing and sales. Our model is silent about how an increase in competition would affect the interdependencies between manufacturing and these other functional units; it therefore makes no predictions about how competition affects the allocation of decision rights between division and plant managers.

Two papers that do not focus on plant managers are Acemoglu et al. (2007) and Guadalupe and Wulf (2009). Acemoglu et al. (2008) measure decentralization by whether or not a firm is divisionalized. They do not distinguish between different degrees of decentralization in multi-divisional firms. Guadalupe and Wulf (2009) examine the effect of trade liberalization on the organization of multi-divisional firms and provide evidence that it reduces the role for group managers and COOs. In particular, the number of coordinating layers on top of a division has decreased most for those firms that saw the biggest reduction in trade barriers.[14] It seems plausible that the removal of a group manager leads to at least some additional decision making authority being delegated to division managers. To the extent that an increase in competition from imports mainly reduces the level of demand and has a limited effect on its price sensitivity, the findings of Guadalupe and

[12] See, for example, Bushman et al. 1995. In large organizations, several layers of group managers may exists, with higher level group managers coordinating the decisions of several lower level group managers (who in turn coordinate the decisions of several division managers).

[13] In contrast, in large firms, the role of the CEO tends to be strategic and he/she rarely gets involved with operational issues at the division level. Coordination of divisions by headquarters, if desired, is typically delegated to a chief operating officer or a number of group managers.

[14] Also Rajan and Wulf (2006) document a trend towards flatter hierachies with a diminshed role for group managers and COOs. This is consistent with more control being delegated to division managers. As argued by Garicano (2000) and Bloom and Van Reenen (2007), advances in information technology in the period under study may be at the source of this, rather than increased competition.

Wulf (2009) are broadly consistent with the predictions of our model.

7.2 Demand versus Cost Externalities

Multi-divisional firms exist because of interdependencies between the divisions. If there were no such interdependencies, there would be no reason for the divisions to be part of the same firm. So far we have focused on cost externalities but our main results would still go through if we instead allowed for demand externalities. To show this, we now take a reduced form approach to modeling competition and simply assume that it either shifts or rotates the inverse demand functions that the divisions face. Suppose then that the divisions have constant marginal costs c. Suppose also that the divisions' inverse demand functions are given by $p_1 = \alpha_1 - a - bq_1 - gq_2$ and $p_2 = \alpha_2 - a - bq_1 - gq_2$, where $g \in [-b, b]$ is now a parameter that measures the substitutability of the divisions' goods. Division 1's profits are then again given by (15) and Division 2's profits are again analogous. As a result, the expected profits under the different organizations are also the same as those derived above. And since the expected profits are the same, there is also no change in the effect of shifts and rotations of the inverse demand functions on the choice between the different organizations.

7.3 Prices versus Quantities

So far we have assumed that the firm needs to decide on the divisions' production levels rather than on the prices they charge. This assumption is also not crucial for our main results. To see this, note first that it cannot make a difference whether division managers set prices or production levels. This is so since each division manager knows the demand conditions in his market and therefore knows the exact mapping from production levels into prices and vice versa. The same price-production pairs are therefore implemented – and the same expected profits are realized – whether division managers set production levels or prices. In contrast, under Centralization it does matter what decisions headquarters makes. If headquarters sets production levels, prices vary depending on the demand conditions. And if headquarters sets prices, production levels vary depending on the demand conditions. When the divisions' costs are linear, that is, when $b_c = 0$, profits are linear in each division's production for given prices and they are linear in each division's prices for given production. Expected profits are then the same whether headquarters sets production and faces varying prices or whether headquarters sets prices and faces varying production. When the divisions' costs are convex, however, expected profits are naturally lower if headquarter sets prices and faces varying production than if it sets production. Specifically, if headquarters sets prices expected profits are $2b_cV^C/b_d^2$ lower than if it sets quantities. Even in this case though the results that we derived above therefore continue to hold provided that the cost parameter b_c is sufficiently small.

7.4 Coordinating Decisions in Organizations

A number of recent papers examine decision making in settings in which decisions have to be both coordinated and adapted.[15] To do so, these papers assume different variations of a basic payoff functions which can be written as

$$\pi(q_1, q_2) = K - (q_1 - a_1)^2 - (q_2 - a_2)^2 - 2\delta(q_1 - q_2)^2,$$

where K is a constant, q_1 and q_2 are the decisions, a_1 and a_2 are the states, and $\delta \geq 0$ is a parameter that measures the interdependence between the decisions. Given this payoff function, expected profits are given by

$$\begin{aligned} \mathrm{E}[\pi(q_1, q_2)] &= \mathrm{E}[\pi(\overline{q}_1, \overline{q}_2)] + 2(\mathrm{Cov}(q_1, a_1) + \mathrm{Cov}(q_1, a_1)) \\ &\quad - (1 + 2\delta)(\mathrm{Var}(q_1) + \mathrm{Var}(q_2)) + 4\delta\mathrm{Cov}(q_1, q_2). \end{aligned} \tag{53}$$

This way of expressing the payoff function shows that an increase in δ makes coordination more important − by putting more weight on the covariance between the decisions − but also makes variability in decision making more costly − by putting more weight on the variance of the decisions. In contrast, in the expected profit function

$$\begin{aligned} \mathrm{E}[\pi(q_1, q_2)] &= \mathrm{E}[\pi(\overline{q}_1, \overline{q}_2)] + (\mathrm{Cov}(q_1, a_1) + \mathrm{Cov}(q_1, a_1)) \\ &\quad -b(\mathrm{Var}(q_1) + \mathrm{Var}(q_2)) - 2g\mathrm{Cov}(q_1, q_2) \end{aligned} \tag{54}$$

that we derived in this paper, an increase in the interdependence parameter $|g|$ only makes coordination more important. This small difference has important implications for the underlying coordination problem. In particular, an increase in the interdependence parameter δ increases the first best covariance between the decisions but it reduces the first best covariance between each decision and its state. In this sense, stronger interdependencies lead to a trade-off between coordination and adaptation. In contrast, in our setting an increase in the interdependence parameter $|g|$ increases both the first best covariance between the decisions and between each decision and its state. Stronger interdependencies therefore do not lead to a trade-off between coordination and adaptation; instead they generate a need for more of both.

[15] See, for example, Morris and Shin (2002), Dessein and Santos (2006), Alonso et al. (2008), Rantakari (2008), Calvó-Armengol et al. (2009), Bolton et al. (2008), and Hagenbach and Koessler (2009).

8 Strategic Communication

Lew Platt, the former CEO of Hewlett-Packard, famously observed that "if HP knew what HP knows, we would be three times as profitable."[16] In the age of email and video conferencing, why does information still not flow more freely within firms? The answer probably lies in the old saying that "knowledge is power:" managers limit and distort the information they communicate to influence decision making in their favor, not to economize on communication costs. How freely information flows within firms therefore depends intricately on the managers' incentives. Since the managers' incentives in turn depend on the competitive environment their firms are operating in, this suggests a link between competition and communication. In this section we explore this link. We first examine the effect of an increase in competition on communication and show that it depends on the underlying reasons for the increase in competition. We then revisit the main results of the previous sections and show that for most of the parameter space they hold even if managers communicate strategically.

To examine these issues, we make two changes to the model. First, we assume that the demand conditions α_1 and α_2 are independently drawn from a uniform distribution with support $[\mu - 1/2,\ \mu + 1/2]$. Second, we assume that Manager 1 learns the realization of α_1 but he does not receive any signal about the realization of α_2. Similarly, Manager 2 observes α_2 but not receive any signal about α_1. Headquarters does not observe any signals about α_1 nor α_2. Since contracts are incomplete, the decision makers are not able to commit to paying transfers that depend on the information they receive or to make their decisions depend on such information in different ways. Communication therefore takes the form of cheap talk. For simplicity we assume that there is only one round of cheap talk communication. In particular, under Decentralization Manager 1 sends message $m_1 \in M_1$ to Manager 2 and, simultaneously, Manager 2 sends message $m_2 \in M_2$ to Manager 1. Under Centralization, Managers 1 and 2 simultaneously send messages $m_1 \in M_1$ and $m_2 \in M_2$ to headquarters.[17]

These changes do not affect the decision rules or the profit functions that we derived above. The only change is that the residual variances now depend on the underlying parameters. Below

[16] See, for instance, "Getting Tacit Knowledge to Work," in the *Financial Times*, March 28, 2004.

[17] It is well known in the literature on cheap talk games that repeated rounds of communication may expand the set of equilibrium outcomes even if only one player is informed. However, even for a simple cheap talk game such as the leading example in Crawford and Sobel (1982), it is still an open question as to what is the optimal communication protocol. Since it is our view that communication is an informal mechanism which cannot be structured by the mechanism designer, it seems reasonable to focus on the simplest form of informal communication. In this sense, we take a similar approach as the property rights literature which assumes that players engage in ex post bargaining but limits the power of the mechanism designer to structure this bargaining game.

we therefore focus on how the residual variances depend on the underlying parameters and, in particular, on the degree of competition. Once we have explored the effect of competition on communication, we revisit the effect of competition on the firm's decision to decentralize.

8.1 Competition and Communication

The quality of communication is determined by the managers' incentives to misrepresent their information: the stronger their incentives to misrepresent their information, the less information is communicated in equilibrium. To understand the effect of competition on communication, we therefore need examine how competition affects the managers' incentives to misrepresent their information.

8.1.1 Vertical Communication

Suppose that when Manager 1 communicates with headquarters, he can credibly misrepresent his information, in the sense that he can choose headquarters' posterior beliefs about the demand conditions in his market. Formally, let $\nu \equiv \mathrm{E}[\alpha_1 | m_1]$ be headquarters' posterior belief about α_1 after receiving message m_1 and suppose that Manager 1 can choose any ν. Manager 1 would then choose the posterior belief ν^* that solves

$$\max_{\nu} \mathrm{E}[\lambda \pi_1 + (1-\lambda) \pi_2 | \alpha_1] \tag{55}$$

subject to the production decisions being equal to q_1^C and q_2^C. In equilibrium the expected posterior of α_2 is equal to the expected value of α_2, that is, $\mathrm{E}_{m_2}[\alpha_2 | m_2] = \mu$. Assuming that this relationship holds, the solution to (55) satisfies

$$v^* - \alpha_1 = (t - t_D)(\mu - a - c). \tag{56}$$

The absolute value of the right hand side of this expression is the division managers' "communication bias" under Centralization. The communication bias measures the division managers' incentives to misrepresent their information. A key feature of the communication bias is that it is independent of the demand conditions. It is then intuitive that the communication equilibria between each division manager and headquarters are analogous to those of the constant bias example in Crawford and Sobel (1984) where the constant bias is given by the communication bias. It is well known that the quality of communication in the constant bias example is determined by and decreasing in the bias. To understand the quality of vertical communication, we therefore have to examine the factors that determine the magnitude of the communication bias.

The magnitude of the communication bias depends on two factors. First, it depends on the sensitivity of headquarters' decision making to the divisions managers' information: the more sensitive q_1^C and q_2^C to changes in headquarters' posterior, the less need to mis-report and thus the smaller the communication bias. Second, the magnitude of the communication bias depends on the difference between the decisions that the division managers expect headquarters to make and the decisions they would like it to make. Naturally, the larger this difference, the more division managers misrepresent their information and the larger the communication bias.

A change in demand for the divisions' goods can affect communication through both of these channels. A reduction in the average intercept of the residual inverse demand functions, for instance, does not affect how sensitive headquarters' decision making is to the divisions managers' information. It does, however, reduce the difference between the decisions that the division managers expect headquarters to make and the decisions they would like it to make. A reduction in the intercept of the residual inverse demand functions therefore reduces the communication bias.

An increase in the price sensitivity of demand, in contrast, increases the communication bias. On the one hand, an increase in price sensitivity makes headquarters' decisions more sensitive to the division managers' information. On the other hand, however, it also increases the difference between the decisions that the division managers expect headquarters to make and the decisions they would like it to make. An increase in the price sensitivity of demand increases the communication bias because the first effect dominates the second.

A central result of the first part of this paper was that the effect of an increase in competition on the firm's decision to decentralize depends on the underlying reasons for the increase in competition. The same is true for the effect of an increase in competition on vertical communication. A reduction in the competitors' entry costs, for instance, improves vertical communication because it shifts the residual inverse demand functions downwards. In contrast, an increase in market size or in the substitutability between the goods produced by the divisions and their competitors can worsen vertical communication because it makes demand more price sensitive.

8.1.2 Horizontal Communication

Suppose now that Manager 1 can credibly misrepresent his information when he communicates with Manager 2. In particular, let $\nu \equiv \mathrm{E}\left[\alpha_1 \,|m_1\right]$ be Manager 2's posterior belief about α_1 after receiving message m_1 and suppose that Manager 1 can choose any ν. Manager 1 would then choose the belief v^* that solves (55) subject to the production decisions being equal to q_1^D and q_2^D.

This problem does not have a solution if $t_D^2\left(1-t^2\right)-\left(t-t_D\right)^2 \leq 0$ which would be the case, for instance, if $\lambda = 1$. The objective function in (55) is then convex in v and as a result there is no interior maximum. Essentially, Manager 1 would like Manager 2 to believe that demand conditions in Market 1 are infinitely strong to induce him to shut down production, if $t > 0$, or to produce an infinite amount, if $t < 0$. Naturally, informative communication between the division managers is not possible under such conditions.

There can, however, be informative communication if $t_D^2 \left(1 - t^2\right) - (t - t_D)^2 > 0$. In this case the objective function in (55) is concave and the optimal belief v^* that Manager 1 would like Manager 2 to have satisfies

$$v^* - \alpha_1 = 2t \frac{t - t_D}{t_D^2 \left(1 - t^2\right) - (t - t_D)^2} \left[(\alpha_1 - a - c) - t_D (\mu - a - c)\right] \geq 0.$$

The right hand side of the equality is the division managers' communication bias under Decentralization. The communication equilibria under Decentralization are qualitatively similar to those under Centralization. Note, however, that the communication bias now depends on the demand conditions. This makes it more cumbersome to characterize the quality of horizontal communication. In the appendix we show that the residual variance under Decentralization is larger than that under Centralization. Division managers therefore share more information with headquarters than they do with each other. The effect of competition on the quality of horizontal communication, however, is similar to its effect on the quality of vertical communication. In particular, an increase in competition that simply shifts the residual inverse demand functions downwards improves horizontal communication while an increase in competition that increases the price sensitivity of demand can worsen horizontal communication. Once again, therefore, the effect of competition on communication depends on the underlying reasons for the increase in competition.

8.2 Internal Organization Revisited

The fact that competition affects communication forces us to revisit our discussion of how competition affects the firm's decision to decentralize. The main concern, of course, is whether the effect of competition on communication changes our insights about its effect on the firm's decision to decentralize. It turns out that in general it does not.

Even if managers communicate strategically, the firm's decision to decentralize still depends on the gains from decentralization (47). The only difference with our earlier discussion is that the residual variances in that expression now depend on the underlying parameters. Because of this difference the firm is now indifferent between Centralization and Decentralization if $\lambda = 1/2$. In this case there is no incentive conflict between the division managers. As a result, horizontal and vertical communication are perfect and the firm can realize first best profits under either organizational structure.

The fact that the residual variances now depend on the underlying parameters therefore does change some of our insights about when the firm decentralizes. In general it does not, however, change our insights about the effect of an increase in competition on the firm's decision to decentralize. This is the case because of the following lemma.

LEMMA 1. Suppose that either $t < 0$ and $\lambda > 1/2$ or $t > 0$ and $\lambda > 0.52$. Then, if informative vertical communication is feasible, Decentralization is optimal.

Essentially, the lemma shows that if the incentive conflict between the division managers is sufficiently small for informative vertical communication to be feasible, it is in fact so small that the firm is better off just letting the division managers make the production decisions. This implies that when the gains from decentralization are zero, there is no informative vertical or horizontal communication. This, in turn, implies that when the gains from decentralization are zero, a marginal change in the environment that increases competition does not have an effect on the quality of communication. To examine the effect of competition on the firm's decision to decentralize we can therefore hold the quality of communication constant even if managers communicate strategically. For most of the parameter space our previous results about the effect of competition on the firm's decision to decentralize therefore continue to hold even if managers communicate strategically.

9 Conclusions

Industrial Organization has much to say about the interaction between firms but it generally treats these firms as black boxes that convert inputs into outputs according to given production functions. Similarly, Organizational Economics has much to say about the interaction between managers and workers within firms but it generally treats these firms as isolated operators that are shielded from the forces of the market place. The aim of this paper was to contribute to a small but growing literature that tries to bridge these two fields and thereby improve our understanding of both, competition between, and organization within firms.

The specific issue we focused on was the effect of competition on the allocation of decision rights in multi-divisional firms. Multi-divisional firms are an important feature of many industries and the allocation of decision rights is an organizational issue that managers of these firms are very concerned with (Chandler 1977 and Sloan 1990). Our model shows that the effect of competition on the allocation of decision rights depends on the underlying reason for the increase in competition. An increase in competition that reduces demand, but does not affect its price sensitivity, favors decentralization. It does so, however, for different reasons than are sometimes given. In particular, such an increase in competition favors decentralization because it reduces the externalities that divisions impose on each other and not because it makes adaptation more important. An increase in competition that increases the price sensitivity of demand does make it more important that divisions adapt to changes in the environment. It also makes it more important, however, that the decisions of the different divisions are coordinated with each other. In fact, it is the close coordination between divisions that allows them to adapt aggressively to changes in the environment. The central result in the paper is that the effect of competition on the need for coordination can be so strong that competition favors centralization. As mentioned in the Introduction, this argument is consistent with anecdotal evidence from the consumer goods company Unilever which recently went through a series of reorganizations that centralized authority and limited the power of division managers. According to its CEO it did so in response to an "increasingly globalised, competitive landscape, where battles were being fought and won with global scale and know-how, and top-down, strategically driven allocation of resources."[18]

The organization of a firm is intimately tied to its product market strategy (Chandler 1973). And obviously it consists of many features other than just the allocation of decision rights. It might therefore be tempting to explore the effect of competition on the organization of firms in a more general model that takes into account that "structure follows strategy" and that allows for other organizational features. Subtle and model-specific complementarities, however, are likely to make such an exercise very challenging and possibly futile. For example, an increase in competition that makes demand more price sensitive can lead to more high-powered incentives (Raith 2003) which may complement decentralization (Jensen and Meckling 1992).[19] But then such an increase in competition can also increase a principal's incentives to invest in monitoring technologies (Ruzzier 2009) which, in turn, can complement centralization (Baker and Hubbard 2004). Before exploring such complementarities in a general model, it is important to examine organizational features in isolation. This is the approach that we took in this paper and that Raith (2003) took in his paper on the effect of competition on managerial compensation. Together his paper and ours suggest that the effect of competition on the organization of firms depends crucially on whether competition simply reduces demand or also makes it more price sensitive. Whether this is also true for other organizational features and whether complementarities between organizational features overturn

[18] For the complete quote and the reference see the Introduction.
[19] Though not necessarily, as observed by Athey and Roberts (2001).

these insights remains to be explored in future research.

Many multi-divisional firms are in fact “multi-national enterprises” that manufacture and sell similar products in different countries. The before-mentioned General Motors, for instance, started out as a domestic firm that only served the US and Canadian markets. In the late 1920s, however, it became an early multi-national with different subunits producing and selling cars in England, Germany, and other markets. In recent years the role of multi-nationals in the globalized world economy has been hotly debated among the general public, policy makers, and academics (see, for instance, Navaretti and Venables 2004). While some see multi-nationals as catalysts for local economies that transfer know-how and create jobs, others view them as threats to local wealth and national identities. In spite of this debate and an accompanying surge in research on multi-nationals, little is known about what determines the horizontal size of multi-nationals.[20] When, for instance, does globalization induce multi-nationals to expand into ever more countries? And when, instead, does it induce them to divest of some of their divisions, as in the recent breakup of DaimlerChrysler? While our model is explicitly not about the boundaries of multi-divisional firms, it does suggest channels through which globalization may affect the horizontal size of multi-nationals. If, for instance, competition makes coordination more important, and coordination is more easily achieved in centralized multi-divisional firms than in stand-alone firms, then competition may lead to the emergence of new and the expansion of existing multi-nationals. But if, instead, competition merely reduces externalities between competitors in the same industries, then it may limit the growth of multi-nationals and even induce them to divest of some of their divisions. A model of the horizontal boundaries of multi-divisional firms that could confirm or reject these speculations awaits future research.

[20] The emerging literature on organizations and international trade focuses on the vertical size of multi-nationals, that is, the classic make versus buy decision, rather than on their horizontal boundaries (see Antràs and Rossi-Hansberg 2009 for a survey).

References

Abernethy, M., J. Bouwens, and L. Lent (2004): "Determinants of Control System Design in Divisionalized Firms," *The Accounting Review*, 79(3), 545–570.

Acemoglu, D., P. Aghion, C. Lelarge, J. Van Reenen, and F. Zilibotti (2007): "Technology, Information, and the Decentralization of the Firm," *Quarterly Journal of Economics*, 122(4), 1759–1799.

Aghion, P., M. Dewatripont, and P. Rey (2004): "Transferable Control," *Journal of the European Economic Association*, 2(1), 115–138.

Aghion, P., and J. Tirole (1997): "Formal and Real Authority in Organizations," *Journal of Political Economy*, 105(1), 1–29.

Alonso, R., W. Dessein, and N. Matouschek (2008): "When Does Coordination Require Centralization?," *American Economic Review*, 98(1), 145–179.

Antràs, P., L. Garicano, and E. Rossi-Hansberg (2006): "Offshoring in a Knowledge Economy," *Quarterly Journal of Economics*, 121(1), 31–77.

Antràs, P., and E. Rossi-Hansberg (2009): "Organizations and Trade," *Annual Review of Economics*, 1(1).

Aoki, M. (1986): "Horizontal vs. Vertical Information Structure of the Firm," *The American Economic Review*, 76(5), 971–983.

Athey, S., and J. Roberts (2001): "Organizational Design: Decision Rights and Incentive Contracts," *The American Economic Review Papers and Proceedings*, 91(2), 200–205.

Atkeson, A., and P. Kehoe (2005): "Modeling and Measuring Organization Capital," *Journal of Political Economy*, 113(5), 1026–1053.

Baiman, S., D. Larcker, and M. Rajan (1995): "Organizational Design for Business Units," *Journal of Accounting Research*, 22(2), 205–229.

Bloom, N., R. Sadun, and J. Van Reenen (2008): "The Organization of Firms Across Countries," *NBER Working Paper 15129*.

Bloom, N., and J. Van Reenen (2007): "Measuring and Explaining Management Practices Across Firms and Countries," *Quarterly Journal of Economics*, 122(4), 1351–1408.

Bolton, P., M. Brunnermeier, L. Veldkamp, and N. Princeton (2008): "Leadership, Coordination and Mission-Driven Management," *NBER Working Paper 14339*.

Bouwens, J., and L. van Lent (2008): "Assessing the Performance of Business Unit Managers," *Journal of Accounting Research*, 45(4), 667–697.

Bulow, J., J. Geanakoplos, and P. Klemperer (1985): "Multimarket Oligopoly: Strategic Substitutes and Complements," *Journal of Political Economy*, 93(3), 488–511.

Burstein, A., and A. Monge-Naranjo (2009): "Foreign Know-How, Firm Control, and the Income of Developing Countries," *Quarterly Journal of Economics*, 124(1), 149–195.

Bushman, R., R. Indjejikian, and A. Smith (1995): "Aggregate Performance Measures in Business Unit Manager Compensation: The Role of Intrafirm Interdependencies," *Journal of Accounting Research*, 33, 101–128.

Calvó-Armengol, A., and J. Beltran (2009): "Information Gathering in Organizations: Equilibrium, Welfare, and Optimal Network Structure," *Journal of the European Economic Association*, 7(1), 116–161.

Chandler, A. (1973): *Strategy and Structure*. MIT Press, Cambridge.

——— (1977): *The Visible Hand:The Managerial Revolution in American Business*. The Belknap Press, Cambridge.

Colombo, M., and M. Delmastro (2004): "Delegation of Authority in Business Organizations: An Empirical Test," *Journal of Industrial Economics*, 52, 53–80.

Crémer, J., L. Garicano, and A. Prat (2007): "Language and the Theory of the Firm," *Quarterly Journal of Economics*, 122(1), 373–407.

Cuñat, V., and M. Guadalupe (2009): "Globalization and the Provision of Incentives Inside the Firm: The Effect of Foreign Competition," *Journal of Labor Economics*, 27(2), 179–212.

Dessein, W., L. Garicano, and R. Gertner (2009): "Organizing for Synergies," *mimeo, Columbia University*.

Dessein, W., and T. Santos (2006): "Adaptive Organizations," *Journal of Political Economy*, 114(5), 956–995.

Ferreira, D., and R. Sah (2009): "Who Gets to the Top: Generalists versus Specialists in Organizations," *mimeo, University of Chicago.*

Fershtman, C. (1985): "Managerial Incentives as a Strategic Variable in Duopolistic Environment," *International Journal of Industrial Organization*, 3(2), 245–253.

Fershtman, C., and K. Judd (1987): "Equilibrium Incentives in Oligopoly," *The American Economic Review*, 77(5), 927–940.

Friebel, G., and M. Raith (2008): "Resource Allocation and Firm Scope," Discussion paper, mimeo, University of Rochester.

Gal-Or, E. (1985): "Information Sharing in Oligopoly," *Econometrica*, 53(2), 329–343.

——— (1986): "Information Transmission–Cournot and Bertrand Equilibria," *The Review of Economic Studies*, 53(1), 85–92.

——— (1993): "Internal Organization and Managerial Compensation in Oligopoly," *International Journal of Industrial Organization*, 11, 157–183.

Garicano, L. (2000): "Hierarchies and the Organization of Knowledge in Production," *Journal of Political Economy*, 108(5), 874–904.

Grossman, S. J., and O. D. Hart (1986): "The Costs and Benefits of Ownership - A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94(4), 691–719.

Guadalupe, M., and J. Wulf (2009): "The Flattening Firm and Product Market Competition: The Effect of Trade Costs and Liberalization," *NBER Working Paper 14491.*

Hagenbach, J., and F. Koessler (2009): "Strategic Communication Networks," *mimeo, University of Paris.*

Hart, O. (1983): "The Market Mechanism as an Incentive Scheme," *The Bell Journal of Economics*, 14(2), 366–382.

Hart, O., and J. Moore (1990): "Property Rights and the Nature of the Firm," *Journal of Political Economy*, 98(6), 1119–1158.

——— (2005): "On the Design of Hierarchies: Coordination versus Specialization," *Journal of Political Economy*, 113(4), 675–702.

Hermalin, B. (1992): "The Effects of Competition on Executive Behavior," *The RAND Journal of Economics*, 23(3), 350–365.

——— (1994): "Heterogeneity in Organizational Form: Why Otherwise Identical Firms Choose Different Incentives for their Managers," *The RAND Journal of Economics*, pp. 518–537.

Hicks, J. (1935): "Annual Survey of Economic Theory: The Theory of Monopoly," *Econometrica*, 3(1), 1–20.

Holmström, B. (1999): "The Firm as a Subeconomy," *Journal of Law, Economics, and Organization*, 15(1), 74–102.

Hubbard, R., and D. Palia (1995): "Executive Pay and Performance: Evidence from the US Banking Industry," *Journal of Financial Economics*, 39(1), 105–130.

Jensen, M., and W. Meckling (1992): "Specific and General Knowlege and Organizational Structure," in *Contract Economics*, ed. by L. Werin, and W. H. Blackwell, Oxford.

Lucas Jr, R. (1978): "On the Size Distribution of Business Firms," *The Bell Journal of Economics*, 9(2), 508–523.

Marin, D., and T. Verdier (2008): "Power Inside the Firm and the Market: A General Equilibrium Approach," *Journal of the European Economic Association*, 6(4), 752–788.

Meagher, K., and A. Wait (2008): "Who Decides about Change and Restructuring in Organizations?," *mimeo, University of New South Wales.*

Meyer, M., and J. Vickers (1997): "Performance Comparisons and Dynamic Incentives," *Journal of Political Economy*, 105(3), 547–581.

Morris, S., and H. Shin (2002): "Social Value of Public Information," *American Economic Review*, 92(5), 1521–1534.

Nagar, V. (2002): "Delegation and Incentive Compensation," *Accounting Review*, 77(2), 379–395.

Raith, M. (1996): "A General Model of Information Sharing in Oligopoly," *Journal of Economic Theory*, 71(1), 260–288.

——— (2003): "Competition, Risk, and Managerial Incentives," *American Economic Review*, 93(4), 1425–1436.

Rajan, R., and J. Wulf (2006): "The Flattening Firm: Evidence from Panel Data on the Changing Nature of Corporate Hierarchies," *The Review of Economics and Statistics*, 88(4), 759–773.

Rantakari, H. (2008): "Governing Adaptation," *Review of Economic Studies*, 75(4), 1257–1285.

Roberts, J. (2004): *The Modern Firm: Organizational Design for Performance and Growth.* Oxford University Press, Oxford.

Ruzzier, C. (2009): "Product-Market Competition and Managerial Autonomy," *mimeo, Harvard Business School.*

Scharfstein, D. (1988): "Product-Market Competition and Managerial Slack," *The RAND Journal of Economics*, 19(1), 147–155.

Schmidt, K. (1997): "Managerial Incentives and Product Market Competition," *The Review of Economic Studies*, 64(2), 191–213.

Shapiro, C. (1986): "Exchange of Cost Information in Oligopoly," *The Review of Economic Studies*, 53(3), 433–446.

Sloan, A. P. (1990): *My Years with General Motors.* Doubleday, New York.

Vickers, J. (1985): "Delegation and the Theory of the Firm," *The Economic Journal*, 95, 138–147.

Vives, X. (1984): "Duopoly Information Equilibrium: Cournot and Bertrand," *Journal of Economic Theory*, 34(1), 71–94.

——— (2008): "Innovation and Competitive Pressure," *The Journal of Industrial Economics*, 56(3), 419–469.