Organizational Design and Environmental Volatility

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Abstract

We investigate complementarities in organizational design by analyzing how environmental volatility and the cost of information influence the optimal choice of three organizational parameters: the allocation of decision rights, the compensation structure of division managers and the degree of operational integration, such as the use of shared distribution and marketing channels among the operating divisions. The results highlight the importance of complementarities and fit. For example, centralized decision-making arises as the preferred authority structure only when the optimal degree of operational integration is sufficiently high, and the optimal compensation structure is highly dependent on both the degree of operational integration and the allocation of decision rights. The results also qualify the common association of decentralized decision-making with environmental volatility, with the likelihood of decentralization increasing in environmental volatility only if the optimal degree of operational integration is decreasing. The relationship of the predictions to the Bartlett and Ghoshal (1989/2002) typology of multinational corporations is discussed.

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"Achieving high performance in a business results from establishing and maintaining a fit among three elements: the strategy of the firm, its organizational design, and the environment in which it operates." (Roberts, 2004:12)

1 Introduction

The need for a 'fit' among organization's strategy, structure and its operating environment has been extensively discussed by business and strategy scholars at least since Chandler's *Strategy and Structure* (1962). Building on the existing work, this paper examines the interrelationships among an organization's operating environment and its preferred strategy and structure from an agency-theoretic perspective, by analyzing how the volatility of the organization's operating environment influences the choice of three organizational design parameters: the allocation of decision rights and the compensation structure of the organizational participants and the degree of operational integration, such as the use of shared distribution and marketing channels among the operating divisions.

We will frame the problem in terms of a multinational corporation (MNC) choosing its competitive strategy and organizational structure given its operating environment. Following the literature on MNCs, we will view the choice of strategy as choosing the balance between local responsiveness and global efficiency. As noted by Harzing (2000:103), "[S]ince the publications by Bartlett (1986) and Prahalad and Doz (1987), all authors implicitly or explicitly refer to a continuum of integration/coordination/globalization advantages versus differentiation/responsiveness/ localization advantages in describing [MNCs'] strategy at either headquarters or subsidiary level." In short, an MNC can generate value both through customizing its products and their marketing to meet varying and changing local tastes (increasing customer value) and through large-scale manufacturing and standardization (reducing production costs). As a result, one of the key strategic choices to any firm is choosing the right balance between the two.[1] As observed by Porter (1996:10): "Simultaneous improvement of cost and differentiation is possible only when a company begins far

[1]While we frame the problem as one faced by MNCs, this particular strategic dimension bears a close resemblance to many ideas discussed in the strategy literature, such as the choice between differentiation and cost leadership (Porter, 1980) and the choice between prospector and defender strategies (Miles and Snow, 1978)

behind the productivity frontier or when the frontier shifts outward. At the frontier, where companies have achieved current best practice, the trade-off between cost and differentiation is very real indeed."

We equate the choice of strategy with the choice of operational integration, which describes the degree of interdependence across the operating units. At the extreme of minimal operational integration, we have national operating units that are fully stand-alone entities, with their own R&D and manufacturing facilities and distribution channels. It is clear that such minimal operational integration maximizes the potential for local responsiveness as each unit is able to freely adapt to local conditions, while minimizing the potential for global efficiency because of the duplication of assets and lack of scale. This strategy of local responsiveness used to be exemplified by the highly autonomous operating units of multi-domestic corporations such as Philips. At the extreme of maximal operational integration, the national units are not much more than delivery pipelines for centrally produced and standardized products. Such an approach naturally maximizes the potential for global efficiency while minimizing the potential for local responsiveness. This strategy of global efficiency used to be exemplified by the highly centralized manufacturing operations of global corporations such as Matsuhita.

Given the choice of operational integration and thus the balance between local responsiveness and global efficiency, how much of the overall potential value is actually realized depends, in turn, on the remaining two choice parameters: the allocation of decision rights and the compensation structure. The reason for this result follows from the observation that the degree of operational integration influences both the nature and severity of agency conflicts inside the organization, which are best resolved through a particular allocation of decision rights and choice of compensation structure. Further, and indeed because, the allocation of decision rights and the choice of compensation structure influence the value actually realized at any given level of operational integration, all three need to be determined simultaneously. In this sense, structure does not simply follow strategy. Instead, the two are determined together by the underlying environment.

The organization we analyze consists of two operating divisions headed by division managers and an administrative headquarters. The particular question that we focus on is the ability of the organization to solve problems of coordinated adaptation, where the organization needs to first generate information about the local conditions faced by its divisions, then transmit that information to the decision-maker(s) and finally use that information appropriately in choosing how the divisions will respond. There are thus three levels of agency problems. First, the division managers can have suboptimal incentives to acquire information about their local conditions. Second, incentive conflicts can limit the accuracy of information transmission from the division managers to the decision-maker(s). Third, the decision-maker(s) can have suboptimal incentives to use that information in a profit-maximizing way.

To manage these agency problems, the organization has three control parameters at its disposal. The degree of operational integration influences how much coordination is needed between the divisional responses to start with, while both the allocation of decision-making authority and the compensation structure can be used to manage information acquisition, communication and decision-making conditional on the degree of operational integration. With respect to decision-making, we focus on two alternative arrangements. Under decentralization, decision-making authority is delegated to the local divisions, while under centralization, decision-making authority is retained at the level of headquarters. With respect to the incentive structure, we analyze both the strength of incentives, as determined the overall sensitivity of managerial compensation to performance, and the composition of incentives, as determined by the relative weight placed on divisional and firm-wide performance in the compensation contract.

The results shed light on both the interrelationships among the organizational design parameters and on the fit between strategy, structure and the environment. With respect to the design parameters, four general results can be derived. First, incentive strength and incentive alignment (firm-wide performance pay) are generally complements. In other words, the higher the equilibrium strength of incentives, the higher the fraction of that pay that is related to firm-wide performance, other things constant. Second, operational integration and incentive strength are generally substitutes while operational integration and incentive alignment are generally complements. Intuitively, increasing the degree of operational integration reduces the value of information about local conditions while increasing the agency conflicts between the two divisions. Third, centralization arises as the preferred allocation of decision rights only if the equilibrium degree of operational integration is sufficiently high and the equilibrium degree of incentive alignment is sufficiently low under both governance structures. Fourth, decentralization is generally associated with compensation contracts that both have higher pay-for-performance and place more weight on firm-level incentives than a corresponding centralized structure.

The fit between the operating environment and the preferred organizational design is, on the other hand, more ambiguous. Consider the role of environmental volatility, and assume first that the cost of information is not increasing too rapidly with volatility. In this case, the first-order impact of an increase in environmental volatility is to decrease the equilibrium degree of operational integration (to increase organizational flexibility). Also, if the optimal degree of operational integration becomes sufficiently low, the optimal governance structure switches from centralization to decentralization. The behavior of the equilibrium compensation contract, however, is generally non-monotone, with both the strength of incentives and the use of firm-level incentives being highest at intermediate levels of operational integration.

The equilibrium relationship between organizational design and environmental volatility is further complicated by the possibility that the cost of information varies with the environment. In this case, it is fully possible that sometimes the optimal degree of operational integration is actually increasing in environmental volatility. Intuitively, if the environment becomes too hard to predict, then flexibility loses its value and it becomes more attractive to simply integrate the operations. As a result, the preferred organizational design can fluctuate between centralization and decentralization as we increase the volatility of the environment.

The results are thus generally consistent with the Bartlett and Ghoshal (1989/2002) typology of multinational corporations, while extending it to account for the structure of compensation. In one end of the spectrum, we observe organizations that are centrally managed and tightly integrated, whose managerial compensation exhibits low pay-for-performance with little or some firm-wide incentives, and which operate in relatively stable environments (global corporations). In the other end of the spectrum, we observe organizations that are decentralized, exhibit low operational integration, provide strong pay-for-performance which is primarily tied on divisional performance, and which operate in highly volatile environments (multi-domestic corporations). In between, we have organizations that can be either centralized or decentralized, exhibit intermediate levels of operational integration and provide the strongest pay-for-performance with significant weight on firm-wide performance (transnational corporations).

However, these categories are further enriched by the observations that (i) decentralization can arise as the preferred governance structure for all levels of operational integration and that (ii) centralized and tightly integrated organizations can sometimes operate in highly volatile environments. These results thus qualify the common claims that coordination requires centralization of decision-making and that an increase in environmental volatility warrants decentralization of decision-making. Centralization is needed to resolve coordination problems only if incentive alignment is sufficiently costly to the organization. Environmental volatility warrants decentralization only when the optimal organizational design calls for a sufficiently low level of operational integration, and to be effective, such decentralization needs to be accompanied by a simultaneous adjustment in the compensation structure of the divisional managers.

2 Related Literature

The analysis builds directly on the framework developed in Alonso, Dessein and Matouschek (2008) and Rantakari (2008a). However, instead of focusing on the role of the allocation of decision rights in managing communication and decision-making in organizations, we focus on the interactions and potential complementarities among different organizational design parameters, and their joint fit with the environment. Because of this integrative nature of the framework, the analysis of the present paper is related to a number of different literatures.

A number of papers examine complementarities among different subsets of organizational design parameters. Milgrom and Roberts (1990, 1995) examine complementarities among different features of modern production technologies but pay only some attention to the organizational structure used to govern that production. Holmstrom and Milgrom (1991, 1994) analyze the joint determination of the levels of incentives provided for the performance of different tasks and extend those results to account for interactions among the level of incentives, asset ownership and job restrictions.[2] However, their primary focus is on examining how to manage the behavior of a single agent and they don't explicitly analyze the role of decision-making and communication in their framework. This paper can be seen as building on both strands, by extending the analysis to explicitly account for the interdependence between the

[2] See also Holmstrom (1999)

choice of operating technology and the choice of organizational structure that is used to manage that technology.

The papers most closely related to ours both in approach and content are Friebel and Raith (2007), Dessein, Garicano and Gertner (2007) and Athey and Roberts (2001), each of which looks at the simultaneous determination of incentives and decision-making authority from alternative angles. Friebel and Raith (2007) analyze a resource allocation problem, where divisional managers need to be motivated to exert effort to generate high-quality projects and then to communicate that information (truthfully) to the headquarters. Dessein, Garicano and Gertner (2007) analyze a synergy implementation problem, where again the managers need to be motivated to provide productive effort but have also private information regarding the costs and benefits of implementing synergies. In both papers, the basic tradeoff is between providing strong incentives to induce effort and to provide aligned incentives to induce truthful communication. Finally, Athey and Roberts (2001) combine the problem of inducing productive effort with a project selection problem. If one of the agents is allowed to make decisions, then he faces a multi-tasking problem analogous to the other papers, where the basic tension is between providing strong incentives to induce effort and providing aligned incentives to induce good project implementation decisions. Introducing a third agent as the decision-maker helps to solve this multi-tasking problem. Introducing a third agent as the decision-maker helps to solve this multi-tasking problem.

The incentive provision problem in our setting also faces the basic tension between strong incentives to motivate information acquisition and balanced incentives to motivate accurate transmission and use of that information. However, by examining a different problem, some of the insights and results differ. The strategic nature of communication limits the value of an uninformed principal relative to Athey and Roberts (2001). By looking at moral hazard in information acquisition instead of an effort provision problem that is unrelated to decision-making, we can analyze the links among the value of information, the value of incentive alignment and the allocation of decision rights, an issue that doesn't arise in Dessein, Garicano and Gertner (2007). Finally, even if some of these links are present in Friebel and Raith (2007), the frameworks are qualitatively different and yield different predictions. For example, in their model, decentralization is always associated with zero incentive alignment because if interim reallocation of resources is desired, the headquarters is always in a better position to do so. In contrast, in our model, decentralization can exhibit both more or less incentive alignment than a corresponding centralized structure and the equilibrium degree of incentive alignment under the two governance structures is one of the key determinants behind the choice between the two.

The role of authority and delegation in managing agency problems is also examined by a number of other papers. Building on the cheap talk literature that has followed Crawford and Sobel (1982), Dessein (2002), Alonso (2007) and Harris and Raviv (2005,2007) examine how the allocation of decision rights can be used to manage the tradeoff between biased decisions and information losses due to strategic communication.[3] Aghion and Tirole (1997) illustrate how delegation can be used as a motivational tool by allowing the agent to freely use the information he learns. Our framework embeds both aspects of the problem and joins them with the possibility of using monetary incentives, which allows us to examine the links between delegation and incentives. Rantakari (2008b) examines the impact of noisy performance measurement on the choice to delegate and Zabojnik (2002) examines the motivational impact that delegation has on the implementation effort by the agent.

Organizational structures have also been analyzed from various other angles, but with the exception of the papers already mentioned, primarily only from a team-theoretic perspective. The paper closest to ours is Dessein and Santos (2006), who examine a team-theoretic model that focuses on the limitations that the need for coordinated adaptation imposes on task specialization. Coordination in their model is, however, constrained only because information transmission is exogenously imperfect. Other perspectives include information processing (for example, Marshak and Radner, 1972, Bolton and Dewatripont, 1994), problem-solving (for example, Garicano, 2000), screening for interdependencies (Harris and Raviv, 2002) and coordination and experimentation (Qian, Ronald and Xu, 2006). However, by their nature, these frameworks pay only limited attention to incentive conflicts among the organizational participants and thus to the role of the allocation of authority and monetary incentives in managing those conflicts.

While the economic literature on organizational design is still relatively young, there is a long history of management and strategy scholars that have been analyzing the problem. As a result, this paper owes an intellectual debt to a long string of publications, including Simon (1947), Chandler (1962,1977), Woodward (1965), Lawrence

[3] See also Stein (1989) and Melumad and Shibano (1991)

and Lorsch (1967a,b), Thompson (1967), Miles and Snow (1978), Mintzberg (1979) and Porter (1980), among many others, in particular the later works of Nadler and Tushman (1997), Bartlett and Ghoshal (1989/2002), Brickley et al (2003) and Roberts (2004). Finally, a strand of the strategy literature has adapted Kauffman's NK model of local search (e.g. Kauffman 1993) for studying how organizational structure impacts the search for solutions to complex problems, where some closely related papers include Levinthal (1997), Rivkin and Siggelkow (2002,2003, 2006) and Siggelkow and Rivkin (2005). While their approach is methodologically very different to ours, it is encouraging that the results share many common themes.

3 The Model

The model consists of two divisions, each managed by a self-interested division manager, and headquarters, which aims maximize the overall profitability of the organization. This section outlines the payoffs, actors, available actions and the timing of events in detail.

Divisional profits and alternative governance structures: The organization consists of two (symmetric) divisions, i and j. The profitability of each division depends on both how well the activities of the division are aligned with local conditions and how well the divisions are coordinated with each other. Given the decisions d_i and d_j regarding the operations of divisions i and j, respectively, the ex post profit of division i is given by

$$\pi_i(\theta_i, d_i, d_j) = K(\beta) - \beta(d_j - d_i)^2 - \alpha(\theta_i - d_i)^2,$$

where $\theta_i \sim U\left[-\overline{\theta}, \overline{\theta}\right]$ indexes the locally optimal decision for division i, with θ_i and θ_j independently distributed. We will refer to $\alpha(\theta_i - d_i)^2$ as the adaptation component of the profit function, as it measures how well aligned the division is with local market conditions, where $\overline{\theta} > 0$ measures the volatility of local conditions and $\alpha > 0$ measures the value of adaptation. We will refer to $K(\beta) - \beta(d_j - d_i)^2$ as the coordination component of the profit function, as it measures how closely the divisions are aligned with each other.[4]

The first choice variable for the organization is $\beta \in [0, \infty)$, which captures the *degree of operational integration* and so the strategic orientation of the organization. Choosing a low β is equivalent to pursuing a strategy of local responsiveness: Divisional profits are primarily dependent on adaptation and the divisions are relatively free to pursue their individual goals without much concern for coordination with the rest of the organization. Choosing a high β is equivalent to pursuing a strategy of global efficiency: Divisional profits are highly dependent on smooth coordination with other parts of the organization and as a result, the divisions become highly constrained in their individual responses to local conditions.

The benefits of operational integration are captured by an increasing and continuous function $K(\beta)$, which measures the maximal return to operational integration in terms of cost reductions that would follow from, for example, a given level of shared components, manufacturing facilities, distribution networks and sales forces. However, such integration introduces a coordination element to the organization, whereby the full benefits of integration can be realized only if the ex post behavior of the two divisions is sufficiently aligned. This effect is captured by the second part $\beta (d_j - d_i)^2$ of the coordination component. For example, the efficiency of a common sales force is compromised if conflicting demands are placed on it by competing divisions, introducing just-in-time manufacturing and inventory management relies on smooth functioning of the supply chain and the value of standardized production facilities is reduced if the products manufactured require conflicting customization.

The second choice variable for the organization is the allocation of authority over the divisions, captured by the right to make the decisions d_i and d_j. We consider two alternative arrangements. Under *centralization*, the headquarters retains control of both decisions. That is, conditional on the information available to her, she makes decisions that maximize the joint profitability of the two divisions. Under *decentralization*, control over the divisions is delegated to their respective divisional managers, who will then make decisions that maximize their individual payoffs, discussed next.

[4]In this symmetric formulation, the impact of $\overline{\theta}$ and α on the organizational performance is isomorphic, so we could normalize $\alpha = 1$. However, we carry it through the analysis so that we can avoid any confusion when talking about the relative importance of coordination, $\frac{\beta}{\alpha+\beta}$.

We will use superscript $g \in \{cent, dec\}$ to denote the two governance structures.[5,6]

Division managers and the timing of events: Each division is headed by a self-interested and risk-neutral division manager (managers i and j, respectively). Their behavior is managed through our third choice variable, which is their compensation structure. We assume that manager i is offered a linear incentive contract

$$T_i(\pi_i, \pi_j) = A_i + s_{ii}\pi_i(\theta_i, d_i, d_j) + s_{ij}\pi_j(\theta_j, d_i, d_j),$$

where (s_{ii}, s_{ij}) are the weights placed on the profitability of the two divisions. We can normalize this contract by rewriting it as

$$T_i(\pi_i, \pi_j) = A_i + \lambda(s\pi_i(\theta_i, d_i, d_j) + (1-s)\pi_j(\theta_j, d_i, d_j)),$$

where $\lambda = s_{ii} + s_{ij}$ measures the strength of incentives, while $s \in [1, 1/2]$ measures the *composition* of incentives.[7] In particular, while the contract is based on the profits of the two divisions, it is identical to a contract that would place a weight $2(1-s)$ on firm-wide performance $\pi_i + \pi_j$ and a weight $2s - 1$ on divisional performance π_i, for an overall pay-for-performance sensitivity λ. The closer s is to $1/2$, the more weight is placed on firm-wide performance (and the more aligned the interests of the divisional managers). As a result, we will be referring to λ as the strength of incentives and to s as the degree of incentive alignment.

As with the benefits of operational integration, we take a reduced-form approach to the cost of incentives and simply assume that providing managerial compensation costs the organization $G(\lambda)$, where $G'(0) = 0$, $G'(2) = \infty$ and $G''(\lambda) \geq 0$, so that providing first-best incentives (making each manager a full residual claimant) is infinitely costly. We take this reduced-form approach because we recognize that organizations

[5] Because of the symmetry of the divisions, asymmetric governance structures, where authority was allocated asymmetrically, do not arise as equilibrium governance structures.

[6] The analysis thus assumes that the headquarters is able to commit to the delegation of decision rights to the divisional managers in the case of decentralization. This assumption is often criticised on the basis that, in the end, the headquarters retains formal authority. However, in particular in the context of MNCs, there are several examples where the national subsidiaries have utilized both their direct control over national resources and their separate legal incorporation to explicitly disobey the instructions of the parent organization. One of the more flagrant cases of disobedience was the refusal by Philips North America to adapt the internally developed V2000 videocassette standard, and instead decided to sell a VHS product supplied by Matsushita, the archrival of Philips.

[7] A symmetric contract turns out to be optimal because of the assumed symmetry of the divisions.

can vary in their ability to provide incentives and to achieve incentive alignment and don't want the results to be driven by assuming a particular source for this cost.[8]

The organizational design parameters (g, β, s, λ) are then used to manage the unfolding of events summarized in figure 1. First, the divisional managers invest in acquiring information about their local market conditions. In particular, manager i acquires a signal t_i of the realized state θ_i that is correct with probability q_i and a random draw from $U\left[-\overline{\theta}, \overline{\theta}\right]$ with probability $1-q_i$ at a personal cost of $C\left(\overline{\theta}, q_i\right)$. The manager does not learn whether the signal is correct or not, so that upon observing a signal t_i, his posterior expectation about the local state is given by $E_i\left(\theta_i|t_i\right) = q_i t_i$.[9] Forecasting the results, the value of accuracy in terms of expected profits will be linear in q_i^2. As a result, define $p_i = q_i^2$ and write the cost of information as $C\left(\overline{\theta}, p_i\right)$. We will refer to p_i as *the quality of primary information*. To guarantee a unique solution, we make the technical assumptions that, for $\overline{\theta} > 0$, $C_{p_i}\left(\overline{\theta}, p_i\right) \geq 0$ and $C_{p_i^2}\left(\overline{\theta}, p_i\right) > 0$, with $\lim\limits_{p_i \to 1} C_{p_i}\left(\overline{\theta}, p_i\right) = \infty$, so that knowing the truth is prohibitively costly. Finally, we assume that $C_{\overline{\theta} p_i}\left(\overline{\theta}, p_i\right) \geq 0$, so that as the environment becomes more volatile, the marginal cost of information does not decrease. Since the managers are self-interested, they choose p_i to

$$\max_{p_i} E\left(T_i\left(\pi_i^g, \pi_j^g\right)\right) - C\left(\overline{\theta}, p_i\right).$$

We assume that p_i is observable but not verifiable to the organizational participants.

Having acquired their private information, the division managers strategically communicate their information to the decision-maker(s). In case of centralization, this communication occurs vertically to the headquarters, while in the case of decentralization, this communication occurs horizontally between the divisional managers. To reflect the soft nature of information, this communication is modeled as one round of simultaneous cheap talk.[10]

After communication, the decision-maker(s) choose their decisions conditional

[8]For example, limited liability or the restriction to profit-sharing rules where $s_{ii} + s_{ji} \leq 1$, so that the divisional profits can be freely divided between the two managers but that the profit streams cannot be leveraged.

[9]We use this particular acquisition technology for two reasons. First, for purely technical reasons, the smooth posterior facilitates the analysis. Second, for descriptive purposes, having a belief over the reliability of information appears for many settings more plausible than knowing whether a piece of information is correct or not.

[10]Simultaneous talk dominates sequential talk in the present setting.

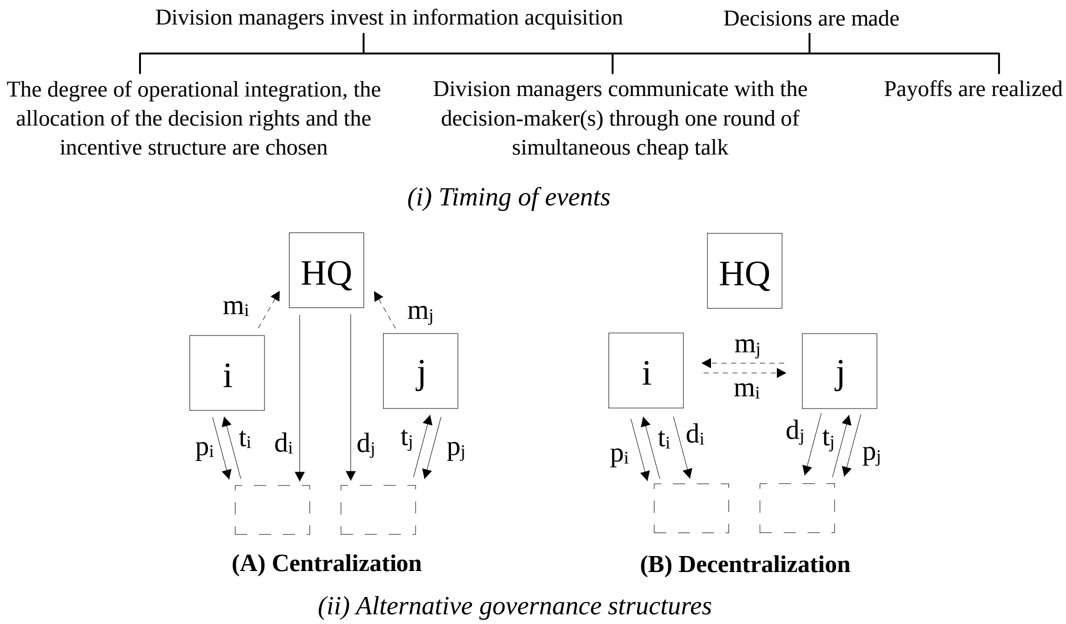


Figure 1: The timing of events and the alternative governance structures.

on their information. In the case of centralization, the headquarters makes decisions to maximize $E\left(\pi_i^{cent}+\pi_j^{cent}\right)$ conditional on the messages (m_i, m_j) that she received in the communication stage regarding the local conditions of the two divisions. In the case of decentralization, the division managers make decisions to maximize $E\left(T_i^{dec}\left(\pi_i^{dec}, \pi_j^{dec}\right)\right)$ conditional on their information, which consists of their private signal t_i and the messages (m_i, m_j) exhanged in the communication stage. Finally, the payoffs are realized.

Organizational design problem: The organizational design problem is then to maximize the expected net surplus in the Perfect Bayesian Game outlined above. That is, before the local conditions are realized and the division managers engage in information acquisition, the headquarters chooses the governance structure g, the compensation structure (s, λ), and the degree of operational integration β to

$$\max_{g,\beta,s,\lambda} E\left(\pi_i^g(\beta, s)+\pi_j^g(\beta, s)\right)-C\left(\overline{\theta}, p_i^g(\beta, s)\right)-C\left(\overline{\theta}, p_j^g(\beta, s)\right)-2G(\lambda).$$

4 Expected Profitability and Organizational Design

The first step in the analysis is to derive the expression for the expected profit conditional on the design parameters (g, β, s, λ). The solution follows through backward-induction. We first discuss the equilibrium decisions, conditional on the information available to the decision-makers (4.1). Second, we discuss the features of the communication equilibrium (4.2) and the expected profitability of the divisions (4.3). These three steps are identical to those in Alonso, Dessein and Matouschek (2008) and Rantakari (2008a), with the exception of introducing imperfect information at the divisional level, and are independent of the strength of incentives λ. However, we revisit these results here because the insights underlying their determination play a key role in understanding the managerial information acquisition problem (4.4) and the solution to the overall organizational design problem derived in section 5.

4.1 Equilibrium decisions

In the decision-making stage, the decision-maker(s) use the information available to them to maximize their individual payoffs, conditional on the accuracy $\left(q_i^g, q_j^g\right)$ of signals (t_i, t_j) obtained at the divisional level regarding the local conditions and the messages (m_i, m_j) sent regarding the the realization of those signals by the division managers.

Centralization: Because the headquarters (P) has no direct access to information, her decisions are solely based on the messages m_i and m_j sent by the divisional managers. Thus, she solves

$$\max_{d_i, d_j} E\left(\pi_i + \pi_j | m_i, m_j\right),$$

solution to which is given by

$$d_i^{cent}(s, \beta) = \tfrac{(\alpha+2\beta)E_P\theta_i + 2\beta E_P\theta_j}{\alpha+4\beta}, \text{ where } E_P\theta_i = q_i^{cent} E\left(t_i | m_i\right).$$

Conditional on the available information, these decisions are profit-maximizing. While immediate, it is worth noting how an increase in the degree of operational integration β reduces the sensitivity of the decision to information about its own local conditions because of the increasing need for coordination, while becoming increasingly responsive to the local conditions of the other division.

Decentralization: The information available to manager i consists of his private signal t_i and the messages exchanged in the communication stage. Given the compensation contract (s, λ), he solves

$$\max_{d_i, d_j} \lambda E\left(s\pi_i + (1-s)\,\pi_j | t_i, m_i, m_j\right)$$

and similarly for manager j. The equilibrium decisions are given by

$$d_i^{dec}(s,\beta) = \tfrac{s\alpha}{(s\alpha+\beta)} E_i\theta_i + \tfrac{\beta}{(s\alpha+2\beta)} E_i E_j \theta_j + \tfrac{\beta^2}{(s\alpha+\beta)(s\alpha+2\beta)} E_j E_i \theta_i,$$

where $E_i E_j \theta_j = q_j^{dec} E(t_j | m_j)$.

It is clear from the objective function of the managers that as long as $s > 1-s$, they place relatively too much weight on the performance of their own division and so generally use the available information in a suboptimal way. We will refer to this suboptimal use of available information as *the quality of decision-making*, taking both the accuracy of the signals and the accuracy of their transmission as given.

Despite this own-division bias, the equilibrium decisions converge to the joint-profit maximizing decisions both when $\beta \to 0$ and when $\beta \to \infty$. In the first case, no coordination is needed and the division managers are free to do what they perceive to be individually optimal. In the second case, since the divisional payoffs are fully dependent on coordination, the managers are willing to coordinate their behavior even absent any profit-sharing. However, whenever some incentive conflict is present and β is interior, the decisions exhibit too little coordination (and correspondingly, excessive adaptation). The quality of decision-making under decentralization is worst when the relative importance of coordination $\beta/(\alpha+\beta)$ is intermediate, or when the tension between adaptation and coordination is the largest.[11] Finally, the role of incentive alignment in the decision-making stage is immediate: the quality of decision-making

[11] This observation that the quality of decision-making can actually improve in the degree of operational integration can be linked to the observation of Bartlett and Ghoshal (2002:69) that while some interdependencies "are automatic outcomes of the specialized and distributed configuration of

is monotonically improving in the relative weight placed on firm-wide performance and converges to profit-maximizing when only firm-level incentives are used.

4.2 Equilibrium communication

The communication stage is modeled as a cheap-talk game between the privately informed division managers and the decision-maker(s). Knowing how the equilibrium decisions depend on the beliefs of the decision-maker(s), the division managers send simultaneously non-verifiable messages regarding their local information in an attempt to induce more favorable decisions.

In this paper, we focus on the most informative partition equilibrium of this cheap talk game. As shown in Alonso, Dessein and Matouschek (2008) and Rantakari (2008), the coarseness of the partition (and so the accuracy of information transmission) can in the present framework be characterized by a single coefficient, $\varphi_i^g(s,\beta)$, which depends on the particular governance structure g, the degree of incentive alignment s and the degree of operational integration β. We will refer to $\varphi_i^g(s,\beta) \in (0,\infty)$ as *the quality of communication*, given the accuracy of the managers' private signals t_i and t_j. As $\varphi_i^g(s,\beta)$ increases, the communication becomes more accurate and becomes perfectly informative as $\varphi_i^g(s,\beta) \to \infty$.

Centralization: In the case of centralization, communication is from the division managers to the headquarters (vertical). The quality of communication is given by

$$\varphi_i^{cent}(s,\beta) = \tfrac{s\alpha+\beta}{\beta(2s-1)} \in [1,\infty).$$

If $\beta = 0$, then this vertical communication is fully informative. In this case, the headquarters makes decisions that are fully responsive to local information without any concern for coordination, thus replicating the preferences of the division managers. However, if $\beta > 0$ and $s > 1/2$, then the own-division bias of the division managers leads them to prefer decisions that are more adapted to local conditions than what the headquarters will actually implement. This vertical conflict is increasing in the degree of operational integration and, as a result, the quality of vertical

assets and resources," others are "specifically designed to build self-enforcing cooperation among interdependent units."

communication is monotonically decreasing in β. Finally, the quality of communication is monotonically improving in degree of incentive alignment, becoming perfect when $s \to 1/2$.

Decentralization: In the case of decentralization, communication is between the division managers (horizontal). The quality of communication is given by

$$\varphi_i^{dec}(s,\beta) = \tfrac{\beta + s(1-s)\alpha}{(s\alpha+\beta)(2s-1)} \in [0,\infty).$$

Logically, the key difference in the communication stage between centralization and decentralization is that in the case of decentralization, the division manager is in control of the operations of his division. As a result, instead of needing to persuade the headquarters about the needs of his division, he is only trying to persuade the other division manager to be more accommodating to what he plans to do. This difference in the motives for communication is reflected in the quality of communication. Now, when β is low, this horizontal communication is at its worst because each division manager is simply doing what is individually optimal for him, largely disregarding any messages sent. As β increases, this increase in the value of coordination increases the responsiveness of the managers to each other's behavior, reducing the horizontal conflict. As a result, the quality of horizontal communication is monotonically increasing in β. The role of incentive alignment is the same as under centralization: as the goals of the division managers become more aligned, the quality of communication improves and becomes perfect when $s \to 1/2$.

4.3 Expected profits

Having derived the equilibrium decisions $\left(d_i^g(s,\beta), d_j^g(s,\beta)\right)$ and the equilibrium quality of communication $\left(\varphi_i^g(s,\beta), \varphi_j^g(s,\beta)\right)$, and assuming for now that given the organizational structure (g,β,s,λ), the quality of primary information acquired by the divisional managers is $\left(p_i^g, p_j^g\right)$, we can solve for the (ex ante) expected profits of the divisions, which are given by the following proposition:

Proposition 1 *Expected profits: The expected profit of division i under governance structure g is given by*

$$E\left(\pi_i^g(s,\beta)\right) = \left(K\left(\beta\right) - \frac{\alpha\bar{\theta}^2}{3}\right) + p_i^g\left[\alpha - \Lambda_i^g\left(s,\beta\right) - \Gamma_{ii}^g\left(s,\beta\right)V\left(\varphi_i^g\left(s,\beta\right)\right)\right]\frac{\bar{\theta}^2}{3}$$
$$- p_j^g\left[\Lambda_i^g\left(s,\beta\right) + \Gamma_{ij}^g\left(s,\beta\right)V\left(\varphi_j^g\left(s,\beta\right)\right)\right]\frac{\bar{\theta}^2}{3},$$

where $V\left(\varphi_i^g\left(s,\beta\right)\right) = \frac{1}{4+3\varphi_i^g(s,\beta)}$.

Proof. See Appendix ■

The expected profitability of the divisions can thus be seen as being determined by three components. The first component, $K\left(\beta\right) - \frac{\alpha\bar{\theta}^2}{3}$, gives the expected profit conditional on a given degree of operational integration β and no local information ($p_i^g\left(s,\lambda,\beta\right) = p_j^g\left(s,\lambda,\beta\right) = 0$). The other two components measure the impact on divisional profits caused by informative local signals t_i and t_j. While the expressions might appear cumbersome, they reflect a simple intuition: information about local conditions is valuable only to the extent that the equilibrium decisions actually respond to that information.

Consider first the second component, which reflects the value of information to the division doing the acquisition. Here, α reflects the value of information if the decisions were fully free to adapt to local conditions ($\beta = 0$). When the degree of operational integration is positive ($\beta > 0$), this value of information is constrained for two reasons: first, even conditional on perfect transmission of information, the decisions are no longer independent and instead need to balance adaptation and coordination. This loss in the value of information is captured by $\Lambda_i^g\left(s,\beta\right)$. Second, strategic communication causes a reduction in the quality of information reaching the decision-maker(s). This loss is captured by $\Gamma_{ii}^g\left(s,\beta\right)V\left(\varphi_i^g\left(s,\beta\right)\right)$, which depends on both the value of accurate communication ($\Gamma_{ii}^g\left(s,\beta\right)$) and the actual equilibrium quality of communication ($V\left(\varphi_i^g\left(s,\beta\right)\right)$). The third component, in turn, reflects the consequences of information acquisition by the other division. Intuitively, the impact again depends on how the equilibrium decisions would use that information ($\Lambda_i^g\left(s,\beta\right)$) and what are the consequences of strategic communication on the quality of information actually reaching the decision-maker(s) $\left(\Gamma_{ij}^g\left(s,\beta\right)V\left(\varphi_j^g\left(s,\beta\right)\right)\right)$.

Because the use of information is dependent on (β, s) and the governance structures differ in their use of information for given (β, s), understanding these differences plays an important role in understanding the equilibrium choices of (g, β, s, λ). Thus, before discussing the problem of managerial information acquisition, we will first analyze the true value of information, as determined by the chosen organizational structure.

4.3.1 True value of information and (g, s, β)

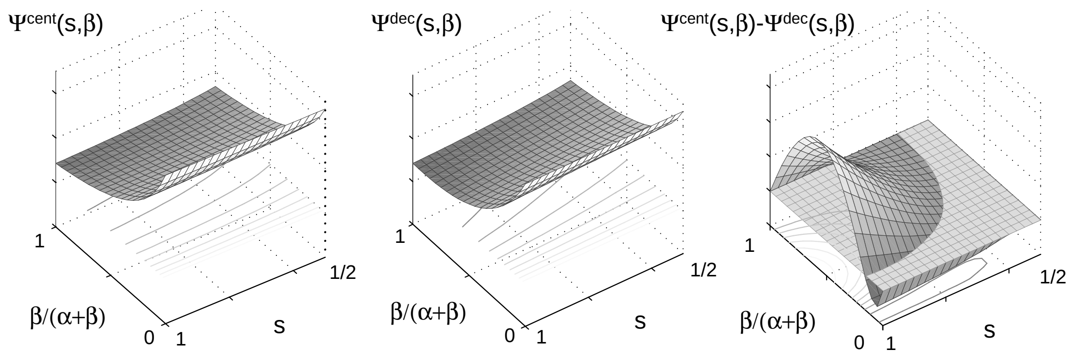
To simplify notation, let $\phi_i^g(s, \beta) = \Lambda_i^g(s, \beta) + \Gamma_{ii}^g(s, \beta) V(\varphi_i^g(s, \beta))$ denote the reduction in the value of information to division i relative to zero operational integration. Because the profitability of the divisions is linear in p_i^g, we can write the (marginal) value of information regarding θ_i to division i as $\alpha - \phi_i^g(s, \beta)$. Similarly, let $\phi_j^g(s, \beta) = \Lambda_j^g(s, \beta) + \Gamma_{ji}^g(s, \beta) V(\varphi_i^g(s, \beta))$ denote the (marginal) impact that information regarding θ_i has on the profitability of division j in equilibrium.

A key feature of the solution is that while $\alpha - \phi_i^g(s, \beta) > 0$, so that information is always valuable to the division whose manager is doing the acquisition, $\phi_j^g(s, \beta) \geq 0$, so that information acquisition by division i *reduces* the profitability of division j. Intuitively, the more accurate information division i holds, the more adaptive d_i will be and, as a result, the more accommodating division j needs to be, at the expense of its own adaptiveness. With this dual effect in mind, we can write the value of information as

$$\Psi_i^g(s, \beta) = \alpha - \phi_i^g(s, \beta) - \phi_j^g(s, \beta) > 0.$$

Figure 2 plots the value of information for both centralization and decentralization, together with the difference between the two. As the degree of operational integration increases, the value of information decreases under both governance structures. When $s = 1/2$, this result reflects the simple fact that the division doing the acquisition becomes less responsive to that information while the other division comes to face higher costs of accommodation. For $s > 1/2$, this reduction is coupled with the losses of information due to strategic communication and, in the case of decentralization, decision-making. Logically, the value of information is monotonically decreasing in s, as increasing divisional conflicts lead to worse use of the existing information.

While the two governance structures are similar in terms of how the value of information varies with both β and s, the key to understanding the differences between



(i) Value of information under centralization

(ii) Value of information under decentralization

(iii) Difference in the value of information

Figure 2: The relationship between organizational design and the value of information.

the two lies in examining $\Psi_i^{cent}(\beta, s) - \Psi_i^{dec}(\beta, s)$, which measures which governance structure makes *relatively* better use of the existing information. As discussed in Alonso, Dessein and Matouschek (2008) and Rantakari (2008), centralization makes better use of existing information (and is thus preferred over decentralization) if and only if the degree of operational integration is sufficiently high and the degree of incentive alignment is sufficiently low. The reason for this result follows from the differential impact of (β, s) on the quality of decision-making and communication. First, the quality of decision-making is improving at a relatively faster rate in the degree of incentive alignment than the quality of communication. Second, centralization is more dependent on accurate communication than decentralization. As a result, when we increase the degree of incentive alignment, the remaining agency losses are increasingly due to strategic communication, making decentralization increasingly attractive.

Similar logic holds in the dimension of operation integration. Recall that the equilibrium decisions under decentralization converged to profit-maximizing decisions both when $\beta \to 0$ and when $\beta \to \infty$. As a result, when β is low and, in consequence, adaptation is very valuable, it is better to allow for slightly biased decisions under decentralization than to suffer the loss of information due to strategic communication under centralization, independent of the degree of incentive alignment. It is only when β is sufficiently high that eliminating the bias in the equilibrium decisions under decentralization is valuable enough to outweigh the higher loss of due strategic communication under centralization. Similarly, because the quality of decision-making starts eventually improving in β under decentralization, the relative advantage of centralization is reduced. It is this simple differential impact of (β, s) on the quality of decision-making and communication and the differential dependency of the governance structures on the two that continues to drive the choice of governance structure even after we account for the endogeneity of p_i^g and $(\beta^g, s^g, \lambda^g)$. However, before getting there, we need to endogenize the quality of primary information p_i^g.

4.4 Managerial information acquisition

The final step of the game is to solve for the equilibrium level of information acquisition. Using the notation from above, define

$$\widetilde{\Psi}_i^g(s,\beta) = s\left(\alpha - \phi_i^g(s,\beta)\right) - (1-s)\,\phi_j^g(s,\beta) > 0$$

as the *perceived value of information*, reflecting the differential weights placed by the manager on the performance of the two divisions. Given that effort is observable, the manager of division i solves

$$\max_{p_i} \lambda p_i \widetilde{\Psi}_i^g(s,\beta)\frac{\overline{\theta}^2}{3} - C\left(\overline{\theta}, p_i\right).$$

Let $p_i^g\left(\beta, s, \lambda, \overline{\theta}\right)$ denote the solution. Examining the first-order condition, we can derive the following properties regarding the quality of information acquired:

Proposition 2 ***Properties of*** $p_i^g\left(\beta, s, \lambda, \overline{\theta}\right)$*:*

(i) $\frac{\partial p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial \lambda} \geq 0, \frac{\partial p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial \beta} \leq 0, \frac{\partial p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial s} \geq 0$ *and* $\frac{\partial p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial \overline{\theta}} \gtreqless 0$

(ii) $p_i^{dec}\left(\beta, s, \lambda, \overline{\theta}\right) \geq p_i^{cent}\left(\beta, s, \lambda, \overline{\theta}\right)$ *unless both* β *and* s *are sufficiently large, in which case* $p_i^{cent}\left(\beta, s, \lambda, \overline{\theta}\right) \geq p_i^{dec}\left(\beta, s, \lambda, \overline{\theta}\right)$

Part (i) of the proposition illustrates the features shared by both governance structures. In short, the amount of information acquired is (i) increasing in the strength of incentives λ, (ii) decreasing in the degree of operational integration β,

(iii) increasing in the degree of incentive conflict s and (iv) ambiguously related to the degree of environmental volatility. The first two are immediate. Increasing the strength of incentives leads the manager to internalize more of the perceived value of information and increasing the degree of operational integration decreases that value because of the reduced resonsiveness of the decisions.

The third result states information acquisition can also be motivated by increasing the inter-divisional conflict. Increasing s increases the perceived value of information because the manager now puts more weight on the value realized by his division and less weight on the negative externality that the information imposes on the other division, even if the true value of information is decreasing in s. Finally, the quality of information is ambiguously related to the amount of environmental volatility. This result follows because we have allowed the (marginal) cost of information to vary with volatility. If the cost does not increase too rapidly with volatility, then the quality of information will be increasing and vice versa.

The key result regarding the choice of governance structure is given by part (ii), which states that there is a systematic relationship between the underlying parameters and the amount of information acquired under the two governance structures. It states that for a given $\left(\beta, s, \lambda, \overline{\theta}\right)$, more information is acquired under decentralization unless both the degree of operational integration and the size of the incentive conflict between the divisions is sufficiently large, in which case the opposite holds.

This last result reflects the behavior of $\widetilde{\Psi}_i^{dec}(s, \beta) - \widetilde{\Psi}_i^{cent}(s, \beta)$. The first determinant of the difference is simply the differences in the true value of information, discussed earlier. The second determinant is the difference in the distribution of costs and benefits. We can show that if the true value of information is higher under decentralization, so is the perceived value of information and that if the perceived value of information is higher under centralization, so is the true value of information. The difference in the direction of implication is caused by the fact that under decentralization, both the benefit of information to the division doing the acquisition and the negative externality imposed by that information on the other division tend to be higher than under centralization. Because of this higher asymmetry in costs and benefits, more information is acquired under decentralization (because of the higher perceived value of information), even if the true value of information is lower. However, for sufficiently high (β, s), the true value dominates the comparison and more information is acquired under centralization.

5 Choice of Organizational Design

Having endogenized the equilibrium decisions, communication and information acquisition, we can finally move on the organizational design problem itself. Substituting the missing components into the net surplus function and utilizing the symmetry between the divisions, we can write the final design problem as

$$\max_{g}\left[\max_{\beta,s,\lambda}\left(K(\beta)-\tfrac{\alpha\overline{\theta}^{2}}{3}+p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)\Psi_i^g(s,\beta)\tfrac{\overline{\theta}^{2}}{3}-C\left(\overline{\theta},p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)\right)-G(\lambda)\right)\right]$$

$$\text{s.t.}\qquad C_{p_i}\left(\overline{\theta},p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)\right)=\lambda\widetilde{\Psi}_i^g(s,\beta)\tfrac{\overline{\theta}^{2}}{3}.$$

The key to the results is that because the benefits of operational integration $K(\beta)$, the cost of primary information $C\left(\overline{\theta},p_i\right)$ and the cost of incentive provision $G(\lambda)$ are common across the governance structures, the only sources for differential performance and choice of β,s,λ come from $\widetilde{\Psi}_i^g(s,\beta)$, which influences how much primary information is acquired, and differences in $\Psi_i^g(\beta,s)$, which measures how good use the organization makes of a given amount of primary information.

5.1 Choice of (s^g,β^g,λ^g)

Conditional on the governance structure, the choice of the other design parameters satisfy the following three first-order conditions:[12]

$$s^g:\left(\Psi_i^g(s,\beta)-\lambda\widetilde{\Psi}_i^g(s,\beta)\right)\tfrac{\partial p_i^g(.)}{\partial s}+p_i^g(.)\tfrac{\partial\Psi_i^g(s,\beta)}{\partial s}=0$$

$$\beta^g:K'(\beta)+\left[\left(\Psi_i^g(s,\beta)-\lambda\widetilde{\Psi}_i^g(s,\beta)\right)\tfrac{\partial p_i^g(.)}{\partial\beta}+p_i^g(.)\tfrac{\partial\Psi_i^g(s,\beta)}{\partial\beta}\right]\tfrac{\overline{\theta}^{2}}{3}=0$$

$$\lambda^g:\left(\Psi_i^g(s,\beta)-\lambda\widetilde{\Psi}_i^g(s,\beta)\right)\tfrac{\overline{\theta}^{2}}{3}\tfrac{\partial p_i^g(.)}{\partial\lambda}-G'(\lambda)=0.$$

Generally, it is impossible to derive general implications regarding the equilibrium values of any of the choice variables, either across governance structures or with respect to the environmental conditions. However, by understanding the basic tradeoffs

[12]Both s^g and β^g can also attain corner solutions, with $s^g\in\{1/2,1\}$ and $\beta^g\in\{0,\infty\}$.

and interdependencies, we can build a good intuition for the exact examples to be discussed in the next section. Because none of the results are fully general, we will only outline the intuition here, while discussing the tradeoffs in more detail in the appendix. The general interdependecies are:

(1) *The strength of incentives and the use of firm-wide compensation (incentive alignment) are complements.* That is, the higher the fraction of pay that is based on firm-wide performance, the higher the strength of incentives, other things constant. A decrease in s increases the true value of information while decreasing the perceived value of information, thus demotivating the manager and increasing the value of additional information acquisition.

(2) *The degree of operational integration and the strength of incentives are substitutes.* That is, the higher the degree of operational integration, the lower the strength of incentives, other things constant. An increase in β decreases both the true and perceived value of information. However, because the negative externality of information acquisition is generally increasing in β, the valuation gap $\Psi_i^g(s,\beta) - \lambda\widetilde{\Psi}_i^g(s,\beta)$ is also generally decreasing, lowering the value of incentives. Further, an increase in β makes the manager less responsive to incentives to acquire information.

(3) *The degree of operational integration and the use of firm-wide compensation are complements.* That is, the higher the degree of operational integration, the higher the fraction of pay that is based on firm-wide performance, other things constant. First, as argued above, the valuation gap is generally decreasing in β, reducing the value of motivating further information acquisition. Further, the value of incentive alignment is generally increasing in β because of the increasing size of the incentive conflicts between the divisions.

In addition, we can observe that an increase in the quality of primary information increases the value of incentive alignment and thus the use of firm-wide incentives while lowering the optimal degree of operational integration. Finally, a change in environmental volatility impacts directly the first-order conditions for operational integration and the strength of incentives, while impacting all first-order conditions indirectly if it changes the choice of information acquisition by the manager.

5.2 Choice of g

Having discussed the determination of β^g, s^g and λ^g, we can complete the design problem by choosing the optimal governance structure. Luckily, the solution turns out to be significantly simpler than the determination of the other parameters.

Proposition 3 ***Choice of governance structure:***

Centralization is preferred over decentralization if and only if $\beta^{cent} \geq \widetilde{\beta}(s)$ and $s^{cent} \geq \widetilde{s}(\beta)$. In other words, centralization arises as the preferred governance structure if and only if the equilibrium degree of operational integration is sufficiently large under both governance structures and the fraction of pay that is based on firm-wide performance is sufficiently low under both governance structures.

The proof of the proposition follows a replication argument and relates back to differences in the true value of information, $\Psi_i^g(s,\beta)$. Recall that if (β, s, λ, p_i) are the same across the governance structures, then decentralization is preferred to centralization iff $\Psi_i^{dec}(s,\beta) \geq \Psi_i^{cent}(s,\beta)$. In section 5.1, we showed that decentralization makes better use of a given amount of primary information whenever the degree of operational integration is sufficiently low, independent of the amount of profit-sharing, and also whenever the degree of profit-sharing is sufficiently high, independent of the degree of operational integration. Now, let the particular (s,β) equal $\left(s^{cent}, \beta^{cent}\right)$, the optimal centralized solution for the particular environment. Then, for that particular environment, decentralization is able to replicate the performance of the centralized solution by choosing $\left(s^{cent}, \beta^{cent}\right)$ and do even better by re-optimizing and choosing $\left(s^{dec}, \beta^{dec}\right)$. Similarly, the fact that $p_i^{dec} \geq p_i^{cent}$ further increases the preference for decentralization. Thus, whenever either s^{cent} or β^{cent} is sufficiently low, decentralization performs better than centralization. The proof in the other direction follows the same argument. Let (s,β) now equal $\left(s^{dec}, \beta^{dec}\right)$. Then, for s, β sufficiently large, centralization is able to replicate the performance of decentralization and do better by reoptimizing its design. Further, we have now that $p_i^{cent} \geq p_i^{dec}$, which completes the proof.

What is important to note is that the choice of governance structure depends only on s^g, β^g and p_i^g. It does not depend directly on either the environment, as characterized by $\overline{\theta}$, $C(\overline{\theta}, p_i)$, $K(\beta)$ and $G(\lambda)$, or on the chosen strength of incentives λ^g. However, because all these variables influence the optimal choice of s^g, β^g and the resulting p_i^g, they also impact the optimal choice of governance structure.

6 The link between organizational design and the environment

To illustrate the link between the environment and the choice of organizational design, we need to parameterize $K(\beta), G(\lambda)$ and $C\left(p_i, \overline{\theta}\right)$. To provide reasonable flexibility with a limited number of parameters, for the benefits of integration and the cost of incentives we use

$$K(\beta) = K\left(1 - e^{-\mu_1\left(\frac{r^{\mu_2}}{\overline{\mu} - r^{\mu_3}}\right)}\right) \text{ and } G(\lambda) = \frac{\psi_1 \lambda^{\psi_2}}{1 - \left(\lambda/\overline{\lambda}\right)^{\psi_3}},$$

where $r = \frac{\beta}{\alpha+\beta} \in [0,1]$, measuring the relative degree of operational integration. The cost of information is parameterized by

$$C\left(p_i, \overline{\theta}\right) = -\gamma_1 \overline{\theta}^{2\gamma_2} \left(p_i + \ln(1 - p_i)\right).$$

Figure 3 illustrates what could be considered a typical solution for the relationship between organizational design and environmental volatility. For this plot, we assume that the marginal cost of information is proportional to the environmental volatility ($\gamma_2 = 1$), so that $\partial p_i^g / \partial \overline{\theta} = 0$ and the only direct link between environmental volatility and organizational design is through the optimal strategy (degree of operational integration) and the optimal strength of incentives.[13]

When the environment is very volatile, the optimal degree of operational integration is low. Because the degree of operational integration is low, the agency conflict between divisions is low and, as a result, managerial pay is primarily based on divisional performance and decision-making authority is delegated to the divisional

[13] $K = 3.3, \mu_1 = 2.35, \mu_2 = 0.6, \mu_3 = 0.5, \overline{\mu} = 1.2, \psi_1 = 0.11, \psi_2 = 0.3, \psi_3 = 1, \overline{\lambda} = 1.07, \gamma_1 = 0.08,$ $\gamma_2 = 1$ and $\overline{\theta}^2/3 \in [2, 10]$

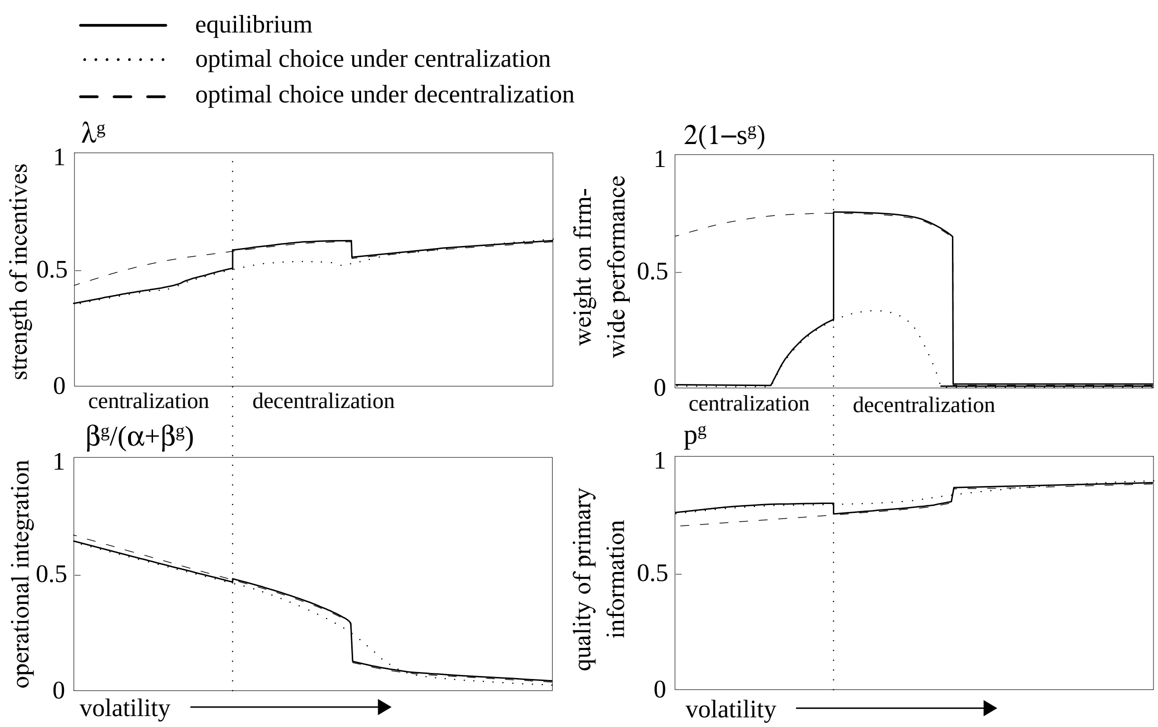


Figure 3: Environmental volatility and the choice of (g, β, s, λ)

managers. Finally, because information is very valuable, the strength of incentives is relatively high.

As the volatility decreases, the optimal degree of operational integration increases and, since the value of information goes down as well, the optimal strength of incentives decreases. As long as the degree of operational integration remains sufficiently low, firm-wide incentives need not be introduced and decentralization remains the optimal governance structure.

As the volatility keeps on decreasing further, two things happen. First, at some point, the optimal degree of operational integration becomes so large that the organization can no longer ignore the increasing inter-divisional conflicts. As a result, the organization introduces a firm-level component to the compensation contract. Further, because introducing firm-level compensation reduces the incentives to acquire information for a given strength of incentives, the organization complements this change by increasing the overall strength of incentives. In essence, the organization switches from an equilibrium where it generates a lot of information and uses it increasingly poorly to one where it generates less information but uses it better.

Second, when the optimal degree of operational integration becomes sufficiently large, then the optimal governance structure switches from decentralization to centralization, where the switch is generally associated with a drop in both the firm-level component of compensation and the strength of incentives. The reason for this drop follows again from the differential impact that incentive alignment has on the quality of decision-making and communication. Because the quality of decision-making is improving faster in the degree of incentive alignment than the quality of communication, decentralization benefits relatively more from achieving some incentive alignment. Indeed, this benefit is largest for the intermediate levels of dependency, where the decisional bias is largest for any given level of alignment. Thus, it is relatively more efficient for a decentralized structure to generate a little less information and use it better than for a centralized structure, which is more tolerant of inter-divisional conflict.

Finally, as the environment becomes sufficiently stable, the firm-wide component in the compensation contract starts to decrease and, in this case, eventually vanishes completely. The reason for this result follows from the complementarity between the strength of incentives, quality of information and the value of incentive alignment. As the value of information decreases with additional operational integration, the organization economizes on the strength of incentives and generates a lower quality of primary information. Both reduce the value of incentive alignment and, as a result, while the underlying agency conflict keeps on increasing, the equilibrium degree of incentive alignment decreases.

The two primary exceptions to the illustration above are contained in figure 4, where the marginal cost of information is increasing more than proportionately in environmental volatility ($\gamma_2 = 3$) and the preferred governance structure fluctuates between decentralization and centralization.[14] First, in extremely stable environments, decentralization arises as the preferred governance structure. The reason for this result is that information is now so cheap that the organization can afford to introduce a significant amount of incentive alignment through firm-level incentives and thus making decentralization to perform relatively better.

[14] $K = 3, \mu_1 = 2.5, \mu_2 = 0.6, \mu_3 = 0.5, \overline{\mu} = 1.2,\ \psi_1 = 0.05, \psi_2 = \psi_3 = 1, \overline{\lambda} = 1.02, \gamma_1 = 0.005$, $\gamma_2 = 3$ and $\overline{\theta}^2/3 \in [2, 25]$

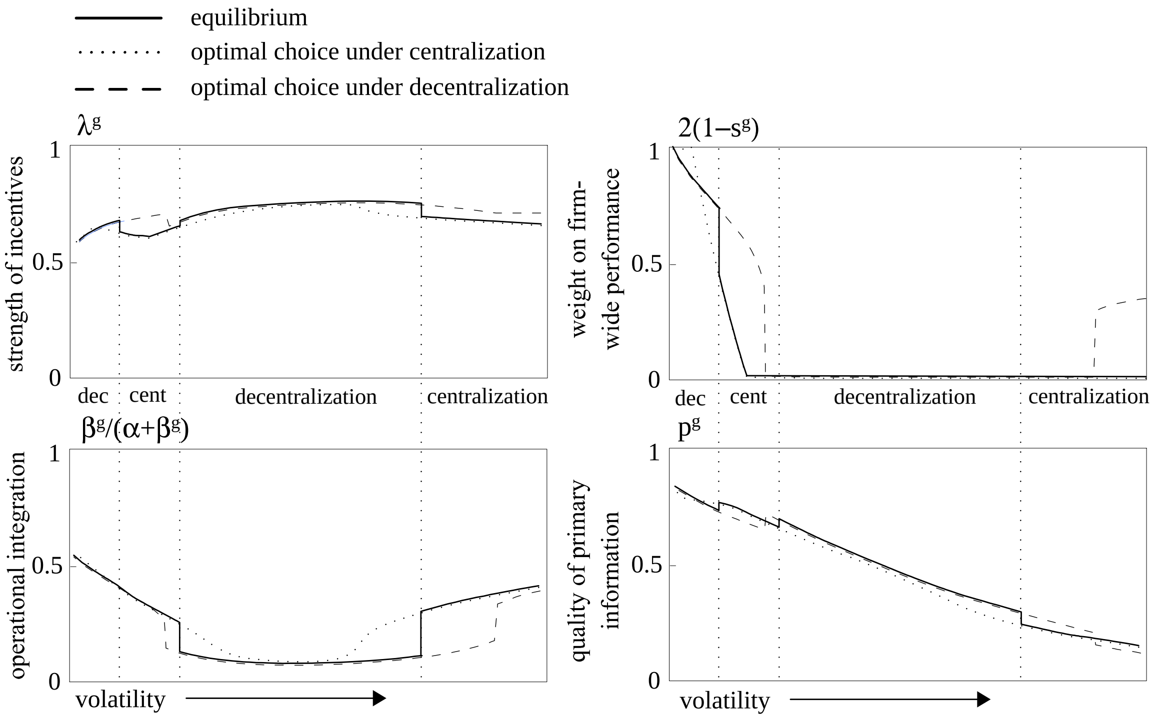


Figure 4: Environmental volatility and the choice of (g, β, s, λ)

As the volatility of the environment increases, the optimal degree of operational integration decreases but now, because the need to motivate information acquisition makes incentive alignment increasingly costly, the organization switches to a centralized structure, with a drop in firm-level compensation and the strength of incentives, but an increase in the quality of primary information. Finally, the optimal degree of operational integration becomes sufficiently low that it becomes optimal to switch back to decentralization, with strong incentives to motivate information acquisition and no firm-level incentives.

The second exception occurs when the environment becomes extremely volatile. Now, predicting the environment becomes simply too costly to justify the investment in flexibility. As a result, it becomes optimal re-integrate operations and to re-centralize decision-making, with a drop in the strength of incentives since the value of information is now lower. Finally, note that while the equilibrium degree of operational integration comes to resemble that of low environmental volatility, the compensation structure will be different. In particular, because the equilibrium quality of information will be significantly lower, the organization will introduce less (if any) firm-wide incentives in the compensation contract.

In short, the link between environmental volatility and organizational design is relatively complex but amenable to simple economic intuition. Further, the remaining environmental variables have a significantly more straightforward impact on the equilibrium outcome.

Cost of incentives, the cost of information and benefits of operational integration: Recall that the choice between centralization and decentralization depends only on the equilibrium degree of incentive alignment and the degree of operational integration. Thus, any change in $K(\beta)$ that increases the optimal degree of operational integration also increases the preference for centralization for any given $G(\lambda), C\left(p_i, \overline{\theta}\right)$. Similarly, the less costly incentives are to provide (a decrease in $G'(\lambda)$) and the less expensive information is (a decrease in $C_{p_i}\left(p_i, \overline{\theta}\right)$), the higher the firm-level component in the performance contract and the more likely it is that decentralization is preferred for any given β.

7 Implications of the model

Having illustrated the equilibrium solution, we will now link the predictions of the model to the existing management literature on organizational design and strategy and discuss some of the emerging empirical evidence. Some additional observations are contained in Appendix B.

7.1 Relationship to management and organizational design literature

By analyzing both the fit between the various organizational design parameters and the fit between organizational design and the environment, the model is conceptually related to contingency theory and the broader management literature on organizational design, starting with the contributions Woodward (1965), Lawrence and Lorsch (1967) and Thompson (1967) on the role of technology, complexity, volatility and task interdependence in influencing organizational design and Minzberg (1979) on the importance of fit across organizational elements.

Relatedly, while organizational strategy (and so the associated literature) is multidimensional, one of the key dimensions is the choice between efficiency and responsiveness. This choice is reflected, for example, in the choice between differentiation and cost leadership strategies (Porter, 1980) and the choice between prospector and defender strategies (Miles and Snow, 1978), with the associated organizational structures. In short, "[c]ompetitive advantage is a function of either providing comparable buyer value to competitors but performing activities efficiently (low cost), or of performing activities at comparable cost but in unique ways that create greater buyer value than competitors and, hence, command a premium price (differentiation)." (Porter 1986:13).

The tradeoff between (global) efficiency and (local) responsiveness has received particular attention in the literature on multinational corporations. Following Bartlett (1986), Porter (1986), Prahalad and Doz (1987) and Bartlett and Ghoshal (1989/2002), the literature has discussed the various advantages arising from global efficiency (low cost) on one hand and from local responsiveness (differentiation) on the other, and how the allocation of assets and other organizational design variables can be used to facilitate the pursuance of such strategies. For example, Porter (1986:17) writes

> A firm faces an array of options in both configuration and coordination for each activity. Configuration options range from concentrated (performing an activity in one location and serving the world from it – e.g., one R&D lab, one large plant) to dispersed (performing each activity in each country). In the latter case, each country would have a complete value chain. Coordination options range from none to very high. For example, if a firm produces its product in three plants, it could, at one extreme, allow each plant to operate with full autonomy – e.g., different product standards and features, different steps in the production process, different raw materials, different part numbers. At the other extreme, the plants could be tightly coordinated by employing the same information system, the same production process, the same parts, and so forth.

The benefits of such integration are generally viewed to come from cost-savings through scale economies and specialization, while the costs come in terms of reduced local responsiveness, which is valuable because of differing and changing local conditions, arising from different customer tastes and needs, business practices, marketing systems, raw material sources, local infrastructure and the like.

The typology that has received the most attention is developed in Bartlett and Ghoshal (1989/2002), who distinguish between multi-domestic, transnational and global organizations.[15] In one end of the spectrum, multi-domestic organizations focus on realizing value through local responsiveness. The value chain is essentially duplicated in each country to minimize interdependencies and to maximize the potential for local responsiveness, while decision-making authority is delegated to the national level to utilize that potential. In the other end of the spectrum, global organizations focus on realizing value through global efficiency. Most strategic assets, resources, responsibilities and decisions are centralized, and the overseas operations are treated largely as delivery pipelines to a unified global market. Finally, the transnational organization attempts to achieve the best of both worlds, by centralizing "some resources at home, some abroad, and distributes yet others among its national operations. The result is a complex configuration of assets and capabilities that are distributed, yet specialized. Furthermore, the company integrates the dispersed resources through strong interdependencies." (Bartlett and Ghoshal, 2002:69).

Our results are generally consistent with this typology, as illustrated by figure 3. However, by focusing in detail on how the organization can solve a particular problem, it also extends the typology in two dimensions. First, it highlights the importance compensation structure. Second, it points out some potential pitfalls in the application of the typology.

Compensation structure: The results point out that the correct solution to the incentive provision problem can be more complex than simply increasing firm-wide incentives as the interdependency of operations increases. First, if the strength of incentives is decreasing in the degree of operational integration, then the firm-wide incentives should be generally strongest at intermediate levels of operational integration. Second, the optimal compensation structure is dependent on the optimal governance structure. Generally, a centralized organization provides optimally a compen-

[15] They also identify an international corporation, which has later received less attention. We ignore it because its main identifier (local adaptation and use of information and knowledge generated at the level of headquarters) doesn't fit in our framework. Some have also argued that the international form is simply transnational corporation done poorly.

sation contract that has both a lower overall pay-for-performance component and a lower weight on firm-wide incentives than a corresponding decentralized organization.

Some potential pitfalls: The results also identify three broad pitfalls related to the typology, with the first associated directly with the typology and the other two with incorrect generalizations. First, the higher the degree of incentive alignment the organization can achieve, the higher the degree of operational integration that the organization prefers to manage under a decentralized structure. Indeed, if incentive alignment is sufficiently easy, decentralization is preferred for all levels of operational integration.[16] Second, increased environmental volatility and thus increased potential value of local responsiveness need not imply a decrease in operational integration. If the environment becomes volatile but at the same time extremely costly to predict, it can be better to focus on global efficiency through operational integration, since any flexibility will now go largely unused because of the lack of actionable information.

Third, and related to the second, while the model predicts that there is, in equilibrium, generally a positive correlation between decentralization and volatility, there is no direct causal link between the two. In particular, decentralizing as a response to an increase in environmental volatility will generally worsen organizational performance unless accompanied by corresponding changes in compensation structure and operational integration. This result thus qualifies the current consensus from a causal link to correlation, where the correlation is driven by the link between environmental volatility and operational integration.[17]

7.2 Empirical evidence

While there are only a limited number of large-scale empirical studies on the determinants of organizational design, some common results are starting to emerge, with a detailed review provided by Colombo and DelMastro (2008). First, there is now

[16] As also discussed in Alonso, Dessein and Matouschek (2008) and Rantakari (2008a).

[17] The current consensus is broadly that "larger firms with greater local specific knowledge, higher diversification, and less regulation are more likely to are more likely to have a higher degree of decentralization. In unregulated industries, where market conditions and production technologies change frequently, the timely use of local knowledge will be particularly important. In more stable environments, companies use centralized decision making and concentrate on gaining economies of scale through large-scale standardized production." (Brickley et al 2003:76-77)

an increasing amount of evidence that firms that operate in environments that exhibit more volatility and higher informational asymmetries are more decentralized and that decentralization is generally associated with pay that is more tied to firm-level performance (Nagar 2002 and Wulf 2006, for example). Second, an increase in interdependence across operating units is generally associated with a decrease in delegation of decision-making authority and an increase in the use of firm-level performance measures (Bushman et al 1995, Christie et al 2003, Colombo and DelMastro 2004 and Abernethy et al 2004, for example). These correlations are consistent with our model. However, the existing studies have focused only on subsets of the variables in our model. In particular, delegation and incentives tend to be analyzed separately and the degree of interdependence is generally taken as an exogenous variable, if included at all. As a result, the predictions of our framework are yet to be subjected to rigorous empirical testing. Further, as discussed above, the results from the model suggest exercising caution in interpreting the existing correlations as evidence of causality before further evidence is gathered.

Multinational corporations: One of the key features of our model is the assumption that the organization is free to choose its degree of operational integration, and that the degree of operational integration can be broadly interpreted as the choice of organizational strategy. Evidence to support this assumption is provided in the literature on multinational corporations, both in terms of case studies and large-scale empirical work. Bartlett and Ghoshal (1989/2002) analyze in detail how different firms have historically adapted highly different strategies and corresponding asset configurations (operational integration) in the same industry, and how those same firms have changed their strategies (and the degree of operational integration) over time in response to changing market conditions. For example, Philips used to pursue a strategy of local responsiveness, supported by highly autonomous operating units responsible for R&D, production and marketing for their markets, while Matsushita used to pursue a strategy of global efficiency, focusing on selling centrally developed and manufactured products and supported by tightly controlled national units. During the 1980s, declining European trade barriers and converging tastes led Philips to start rationalizing its operations by reducing the self-sufficiency of its operating units while Matsushita attempted to increase its local responsiveness by pushing more authority down to the national level.

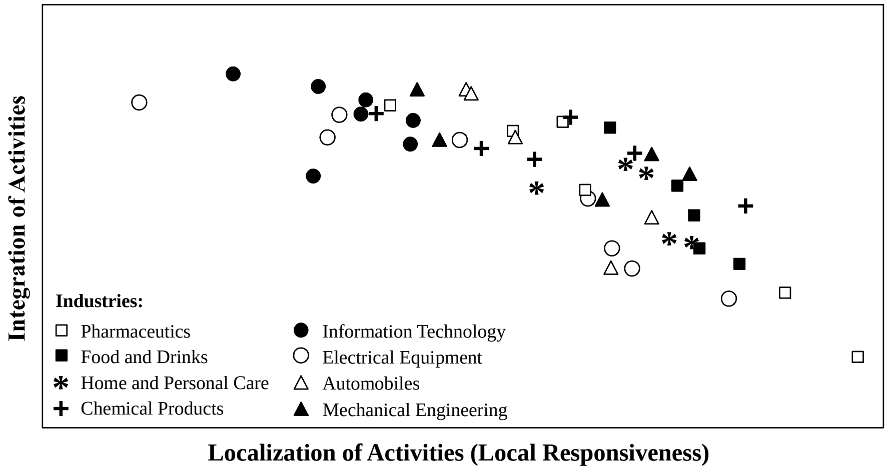


Figure 5: The tradeoff between global efficiency and local responsiveness (source: Jarillo and Martinez 1991)

In terms of large-scale studies, Martinez and Jarillo (1991) use a survey to construct measures of the strategy of various multinational corporations in the efficiency/responsiveness framework and link it to the use of coordination mechanisms, such as the degree of centralization of decision-making.[18] They find that the use of the various coordination mechanisms is increasing in the weight the organization places on efficiency/integration. Further, there is a clear tradeoff between efficiency and responsiveness, with (i) different industries belonging to different clusters, arguably reflecting industry-wide differences in the value of each, and (ii) firms within an industry still exhibiting heterogeneity in their positioning, arguably reflecting the idea that the exact position is still a choice variable to the firms. This tradeoff is summarized in figure 5, which is adapted from figure 3 in Martinez and Jarillo (1991:440).[19] However, they don't link the choice of strategy to environmental volatility.

In work complementary to Martinez and Jarillo (1991), Ghoshal and Nohria (1989) and Nohria and Ghoshal (1994) examine the link between centralization and environmental characteristics, but do not study the choice of strategy. They hypothesize and find that the degree of centralization is decreasing in both environmental complexity

[18]The strategy dimension is constructed through principal component analysis of several more objective measures such as the percentage of local content in products made locally, proportion of R&D performed by the subsidiary, level of integration of R&D, percentage of products specially created or substantially adapted to the domestic market of the subsidiary and so forth.

[19]See also Harzing (2000).

(importance of local knowledge) and resource levels (independence) of subsidiaries. Further, given the postulated fit, the organizational performance is positively related to the quality of the fit.

8 Conclusion

We have investigated both the interdependencies among organizational design parameters and their relationship to the environment, thus shedding some light on the links between strategy, structure and the environment. In particular, we examined how environmental factors such as the benefits to operational integration, environmental volatility, the cost of information about the environment and the difficulty of incentive alignment impacted the determination of three organizational design parameters: the degree of operational integration, the allocation of decision-making authority and the compensation structure of managers.

While the setting is sufficiently rich so that few unambiguous predictions can be made, the analysis still revealed a number of results. First, centralization of decision-making is preferred only when the optimal degree of operational integration is sufficiently high and the equilibrium degree of incentive alignment through firm-level compensation is sufficiently low. Second, the optimal compensation contract can be non-monotone in the degree of operational integration, with both the strength of incentives and the use of firm-level compensation being generally highest at intermediate levels of operational integration. Third, the optimal structure of compensation can be very sensitive to the chosen governance structure. Generally, the optimal compensation contract has both a lower strength and a lower weight on firm-level performance than a corresponding decentralized structure.

The link between environmental volatility and the preferred strategy and structure was more ambiguous. Generally, an increase in environmental volatility increases the value of local responsiveness and thus reduces the optimal amount of operational integration. This reduction in operational integration, in turn, triggers changes in the design of the rest of the organization. However, sometimes it can be optimal to increase operational integration in response to an increase in volatility. Intuitively, if the environment becomes volatile but also extremely hard to predict, then any organizational flexibility will go largely unused because of the lack of actionable information.

It is then better to focus on efficiency through highly integrated operations. Finally, the analysis revealed the importance of fit among the organizational design parameters. For example, simply decentralizing decision-making in response to an increase in environmental volatility will generally worsen organizational performance unless the degree of operational integration and the compensation structure of the division managers is adjusted accordingly. Similarly, changes in operational integration can fail to have the desired benefits if the compensation and governance structures are not adjusted accordingly. In other words, it is sometimes better to pursue a slightly wrong strategy with the right structure than the right strategy with the wrong structure.

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A Proofs and derivations

A.1 Expected profits

The derivation of the expected profits is detailed in Rantakari (2008a), so I will only outline the impact that imperfect primary information has on the solution.

Decision-making: Let m and n denote the decision-makers controlling decisions i and j respectively. Let m's objective function be of the form $s_{mi}\pi_i + s_{mj}\pi_j$. Then, we can write the first-order conditions for the two decisions as

$$d_i^m = a_1 E_m \theta_i + a_2 E_m d_j \qquad \textit{and} \qquad d_j^n = b_1 E_n \theta_j + b_2 E_n d_i,$$

so that the equilibrium decisions are given by (after repeated substitution)

$$d_i^m = \frac{a_1(1-b_2a_2)E_m\theta_i + a_2b_1E_mE_n\theta_j + a_2b_2a_1E_nE_m\theta_i}{1-b_2a_2},$$

where a_1 and a_2 (b_1 and b_2) are the relative weights placed on adaptation and coordination by m (n). The key is that the equilibrium responsiveness of the agent to changes in beliefs is independent of the accuracy of beliefs, so that the only difference to the full-information case is that all information is discounted by q_i, the accuracy of primary information.

Communication: Communication is modeled as one round of simultaneous cheap talk. The equilibrium takes a partition structure, where the cutoffs of the partition are determined by the sender's indifference condition

$$\begin{aligned} &E_i\left(s_{ii}\pi_i\left(t_i^M, d_i(., m^L), d_j(., m^L)\right) + s_{ij}\pi_j\left(t_j, d_i(., m^L), d_j(., m^L)\right)|., m^L\right) \\ &\quad = E_i\left(s_{ii}\pi_i\left(t_i^M, d_i(., m^H), d_j(., m^H)\right) + s_{ij}\pi_j\left(t_j, d_i(., m^H), d_j(., m^H)\right)|., m^H\right). \end{aligned}$$

That is, given that the realized signal t_i^M falls on the boundary of two intervals of the partition, then the manager needs to be indifferent between saying that the realized state belongs to the lower interval ($m^L \rightarrow t_i \in (t_i^L, t_i^M]$) or the higher interval ($m^H \rightarrow t_i \in (t_i^M, t_i^H]$). The solution is equivalent to the full information-case ($t_i = \theta_i$). The reason for this result follows from the fact that because both the sender and the receiver discount information at the rate q_i, the accuracy of information cancels out in determining the relative incentive conflict between the sender and the receiver.

Expected profits: Substituting the equilibrium decisions into the profit function, we can write the decision-dependent component (in loss terms) as

$$\frac{k_i b_1^2\left((1-r_i)a_2^2+r_i a_1^2\right)}{(1-b_2a_2)^2}\left((E_nE_m\theta_i)^2+(E_mE_n\theta_j)^2\right)$$
$$+k_i\left((1-r_i)\,a_2^2+r_ia_1^2\right)(E_m\theta_i-E_nE_m\theta_i)^2+k_ir_ib_1^2\left(E_n\theta_j-E_mE_n\theta_j\right)^2$$
$$+k_i\left(1-r_i\right)Var_m\theta_i,$$

where $k_i=(\alpha+\beta)$ and $r_i=\beta/\left(\alpha+\beta\right)$, with (a_1,a_2,b_1,b_2) as given by the first-order conditions for the equilibriumd decisions. Because the communication equilibrium is unchanged as a result of inaccurate primary information, the first two lines are identical to the full-information case, with the exception that all components are scaled by $p_i=q_i^2$. This result follows because the first two lines reflect only the differences in the posterior *beliefs* held by the sender and the receiver. The only component that depends directly on the quality of primary information is $Var_m\theta_i$. When $m=i$, so that manager i decides d_i (decentralization), then

$$E\left(\theta_i-E_i\theta_i\right)^2=q_iE\left(\theta_i-q_i\theta_i\right)^2+\left(1-q_i\right)E\left(\theta_i-q_ix_i\right)^2,$$

where x_i is a random draw from $\left[-\overline{\theta},\overline{\theta}\right]$. As a result,

$$E\left(\theta_i-E_i\theta_i\right)^2=\left(1-q_i^2\right)\frac{\overline{\theta}_i^2}{3}=\left(1-p_i\right)\frac{\overline{\theta}_i^2}{3}.$$

When $m=P$ (centralization), we have that

$$E\left(\theta_i-E_m\theta_i\right)^2=E\left(\theta_i-q_iE_ms_i\right)^2=q_iE\left(\theta_i-q_iE_m\theta_i\right)^2+\left(1-q_i\right)E\left(\theta_i-q_iE_mx_i\right)^2.$$

Now, note first that $E\left(\theta_i-q_iE_mx_i\right)^2=E\theta_i^2+q_i^2E\left(E_mx_i\right)^2$. Second, note that

$$E\left(\theta_i-q_iE_m\theta_i\right)^2=E\left(\theta_i-E_m\theta_i\right)^2+\left(1-q_i\right)^2E\left(E_m\theta_i\right)^2$$

Adding the two components together and adding and subtracting $q_i^2E\left(\theta_i-E_m\theta_i\right)^2$ gives

$$\left(1-q_i^2\right) E\theta_i^2+\left(1-q_i\right) q_i^2 E\left(E_m x_i\right)^2-q_i^2\left(1-q_i\right) E\left(E_m \theta_i\right)^2+q_i^2 E\left(\theta_i-E_m \theta_i\right)^2 .$$

Finally, noting that $E\left(E_m x_i\right)^2=E\left(E_m \theta_i\right)^2$, this simplifies to

$$E\left(q_i \theta_i-q_i E_m \theta_i\right)^2+\left(1-q_i^2\right) \frac{\bar{\theta}_i^2}{3}=p_i E\left(\theta_i-E_m \theta_i\right)^2+\left(1-p_i\right) \frac{\bar{\theta}_i^2}{3}$$

The first component reflects the inaccuracy of information transmission while the second component gives the additional loss due to inaccurate primary information. The expected profit can be thus written as if information was perfect but distributed on $U\left[-q_i \bar{\theta}_i, q_i \bar{\theta}_i\right]$ and a common extra component reflecting the inaccuracy of primary information. Thus, we can write the expected profit as

$$\begin{aligned} E\left(\pi_i^g(s, \beta)\right)= & \left(K(\beta)-\frac{\alpha \bar{\theta}^2}{3}\right)+p_i^g\left[\alpha-\Lambda_i^g(s, \beta)-\Gamma_{ii}^g(s, \beta) V\left(\varphi_i^g(s, \beta)\right)\right] \frac{\bar{\theta}^2}{3} \\ & -p_j^g\left[\Lambda_i^g(s, \beta)+\Gamma_{ij}^g(s, \beta) V\left(\varphi_j^g(s, \beta)\right)\right] \frac{\bar{\theta}^2}{3},\end{aligned}$$

where $V\left(\varphi_i^g(s, \beta)\right)=\frac{1}{4+3 \varphi_i^g(s, \beta)}$, reflecting the accuracy of information transmission $\left(V\left(\varphi_i^g(s, \beta)\right)=3 E\left(t_i-E_{recevier}\left(t_i \mid m_i\right)\right)^2\right)$.

Under centralization, the coefficients are

$\Lambda_i^{cent}=\frac{\alpha \beta}{(\alpha+4 \beta)}, \ \Gamma_{ii}^{cent}=\alpha-\Lambda_i^{cent}$ and $\Gamma_{ij}^{cent}=-\Lambda_i^{cent}$,

while under decentralization, the coefficients are:

$\Lambda_i^{dec}=\frac{\alpha \beta\left(\beta+s^2 \alpha\right)}{(s \alpha+2 \beta)^2}, \ \Gamma_{ii}^{dec}=\frac{\beta \alpha\left(\beta+s^2 \alpha\right)}{(s \alpha+\beta)^2}-\Lambda_i^{dec}$ and $\Gamma_{ij}^{dec}=\beta\left(\frac{s \alpha}{s \alpha+\beta}\right)^2-\Lambda_i^{dec}$

A.2 Information acquisition

The solution to the manager's information acquisition problem is given by

$$\lambda\widetilde{\Psi}_i^g(s,\beta)\frac{\overline{\theta}^2}{3}-C_{p_i}\left(\overline{\theta},p_i\right)=0.$$

Using the implicit function theorem, we can then write

$$\begin{aligned}
\frac{\partial p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial\lambda} &= \frac{\widetilde{\Psi}_i^g(s,\beta)\frac{\overline{\theta}^2}{3}}{C_{p_i^2}\left(\overline{\theta},p_i\right)}\geq 0\\
\frac{\partial p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial\beta} &= \frac{\lambda\frac{\partial\widetilde{\Psi}_i^g(s,\beta)}{\partial\beta}\frac{\overline{\theta}^2}{3}}{C_{p_i^2}\left(\overline{\theta},p_i\right)}\leq 0 \text{ iff } \frac{\partial\widetilde{\Psi}_i^g(s,\beta)}{\partial\beta}\leq 0\\
\frac{\partial p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial s} &= \frac{\lambda\frac{\partial\widetilde{\Psi}_i^g(s,\beta)}{\partial s}\frac{\overline{\theta}^2}{3}}{C_{p_i^2}\left(\overline{\theta},p_i\right)}\geq 0 \text{ iff } \frac{\partial\widetilde{\Psi}_i^g(s,\beta)}{\partial s}\geq 0\\
\frac{\partial p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial\overline{\theta}} &= \frac{\lambda\widetilde{\Psi}_i^g(s,\beta)/3-C_{p_i\overline{\theta}}\left(\overline{\theta},p_i\right)}{C_{p_i^2}\left(\overline{\theta},p_i\right)}\gtreqless 0.
\end{aligned}$$

Intuitively, because both the true and perceived value of information are positive, $\widetilde{\Psi}_i^g(s,\beta)>0$ and, as a result, the stronger the incentives (the bigger the share internalized by the manager), the more primary information is acquired. In contast to λ, which simply impacts the share of the perceived value of information that is internalized by the manager, β and s alter both the true and perceived value of information. An increase in β restricts the responsiveness of the decisions to the information generated, thus reducing the value of information. An increase in s, on the other hand, increases the amount of information acquired. Thus, in addition to increasing the strength of incentives, information acquisition can also be motivated by increasing the inter-divisional conflict. The reason for this result comes from the fact that while information is valuable to the division doing the acquisition, it imposes a negative externality on the other division. As s increases, more of the benefits and less of the costs enter the perceived value of information. The sign of the derivatives is numerically verified in figure 6.[20] As to the role of environmental volatility, the derivative is ambiguous because volatility can impact also the marginal cost of information. The quality of primary information acquired is increasing in environmental volatility if $\lambda\widetilde{\Psi}_i^g(s,\beta)/3>C_{p_i\overline{\theta}}\left(\overline{\theta},p_i\right)$, so that the marginal value is increasing faster than the marginal cost.

[20] While the solution under centralization is generally tractable, the solution under decentralization is unfortunately extremely cumbersome.

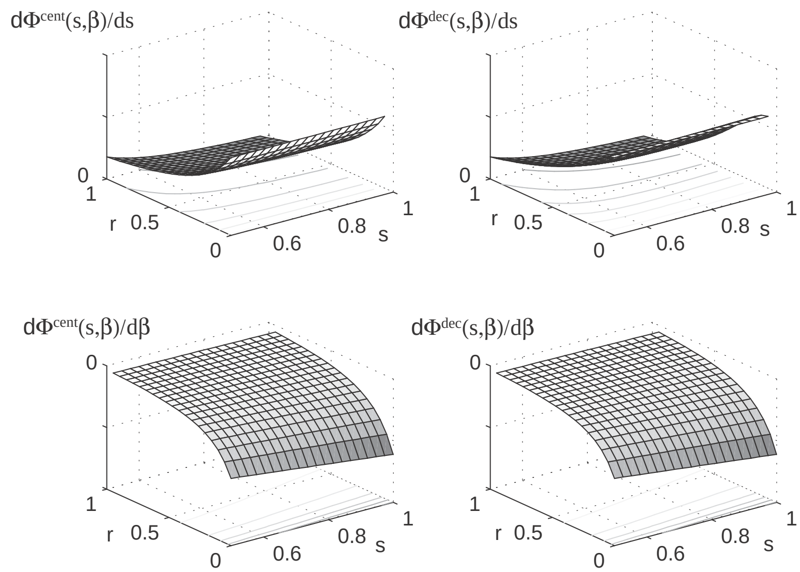

Figure 6: Partial derivatives of perceived value of information

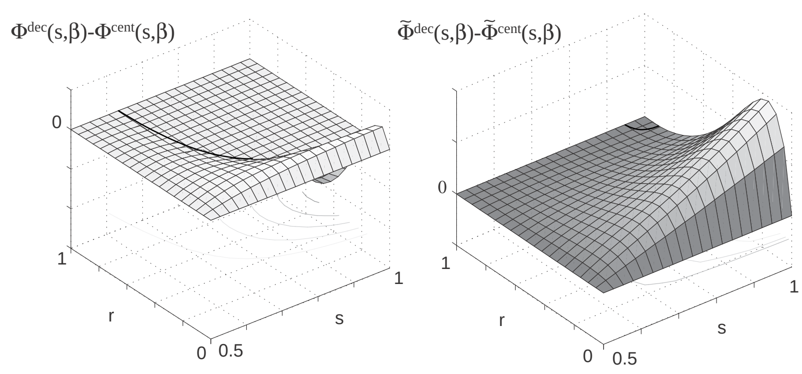

Figure 7: differences in the true and perceived value of information

Finally, the result that $p_i^{dec}\left(\beta, s, \lambda, \overline{\theta}\right) \geq p_i^{cent}\left(\beta, s, \lambda, \overline{\theta}\right)$ unless both β and s are sufficiently large, in which case $p_i^{cent}\left(\beta, s, \lambda, \overline{\theta}\right) \geq p_i^{dec}\left(\beta, s, \lambda, \overline{\theta}\right)$ follows from comparing $\widetilde{\Psi}_i^{cent}(s, \beta)$ and $\widetilde{\Psi}_i^{dec}(s, \beta)$, since these are the only sources of difference given the other design parameters. This difference is plotted in figure 7, together with the true value of information to highlight the motivational advantage of decentralization: while the true value of information varies quite a bit, the perceived value of information is almost always higher under decentralization. This result follows from the observation that the negative externality of information is generally higher under decentralization, at least as long as s is sufficiently large.

A.3 Interactions among (β, s, λ)

The final step is then to illustrate the interactions among the different design parameters. The solution given follows from noting that $C_{p_i}\left(\overline{\theta}, p_i\right) = \lambda \widetilde{\Psi}_i^g(s, \beta)\frac{\overline{\theta}^2}{3}$. Thus, we have that

$$s^g : \left(\left(\Psi_i^g(s, \beta) - \lambda \widetilde{\Psi}_i^g(s, \beta)\right)\frac{\partial p_i^g(.)}{\partial s} + p_i^g(.)\frac{\partial \Psi_i^g(s,\beta)}{\partial s}\right)\frac{\overline{\theta}^2}{3} = 0$$

$$\beta^g : K'(\beta) + \left[\left(\Psi_i^g(s, \beta) - \lambda \widetilde{\Psi}_i^g(s, \beta)\right)\frac{\partial p_i^g(.)}{\partial \beta} + p_i^g(.)\frac{\partial \Psi_i^g(s,\beta)}{\partial \beta}\right]\frac{\overline{\theta}^2}{3} = 0$$

$$\lambda^g : \left(\Psi_i^g(s, \beta) - \lambda \widetilde{\Psi}_i^g(s, \beta)\right)\frac{\overline{\theta}^2}{3}\frac{\partial p_i^g(.)}{\partial \lambda} - G'(\lambda) = 0.$$

To simplify the notation further, recall that $\Psi_i^g(s, \beta) = \alpha - \phi_i(s, \beta) - \phi_j(s, \beta)$, while $\widetilde{\Psi}_i^g(s, \beta) = s(\alpha - \phi_i(s, \beta)) - (1-s)\phi_j(s, \beta)$. Thus, we can write

$$\Psi_i^g(s, \beta) - \lambda \widetilde{\Psi}_i^g(s, \beta) = (1 - \lambda s)\Psi_i^g(s, \beta) - \lambda(2s-1)\phi_j^g(s, \beta).$$

Now, note that $\Psi_i^g(s, \beta) - \lambda \widetilde{\Psi}_i^g(s, \beta)$ measures simply the value of additional information acquisition (as determined by the gap between $\Psi_i^g(s, \beta)$ and $C_{p_i}\left(\overline{\theta}, p_i\right)$), which in turn is composed of the fraction of the true value of information not internalized by the agent $(1 - \lambda s)$, minus the negative externality not internalized by the agent, providing free incentives for information acquisition, $\lambda(2s-1)\phi_j^g(s, \beta)$. It is the presence of this latter component that complicates some of the interactions. Let $\Delta\Psi_i^g(s, \beta) = \Psi_i^g(s, \beta) - \lambda \widetilde{\Psi}_i^g(s, \beta)$ denote this valuation gap.

Using the implicit function theorem, we can then examine the sign of the interactions between the various design parameters. Let us begin with λ^g.

$$sign\left(\frac{\partial\lambda}{\partial s}\right) = sign\left(\underset{<0}{\frac{\partial\Delta\Psi_i^g(s,\beta)}{\partial s}}\underset{>0}{\frac{\partial p_i^g(.)}{\partial\lambda}} + \underset{>0}{\Delta\Psi_i^g(s,\beta)}\underset{>0}{\frac{\partial^2 p_i^g(.)}{\partial\lambda\partial s}}\right).$$

The sign of $\partial\lambda/\partial s$ is thus ambiguous but generally positive. On one hand, an increase in s increases the incentives to acquire information, decreasing the valuation gap and thus the value of incentive strength. On the other hand, a decrease in firm-level incentives also increases the margin that the agent receives from any given amount of information acquisition and thus increases his sensitivity to incentives to acquire information:

$$\frac{\partial^2 p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial\lambda\partial s} = \frac{\frac{\partial\widetilde{\Psi}_i^g(s,\beta)}{\partial s}\frac{\overline{\theta}^2}{3}}{C_{p_i^2}\left(\overline{\theta},p_i\right)} \geq 0.$$

However, unless the manager is extremely sensitive to incentives to acquire information through $C_{p_i^2}\left(\overline{\theta},p_i\right)$ small, the first (value) effect generally dominates and $\partial\lambda/\partial s < 0$, reflecting that information acquisition can be motivated either through conflict or through the share of the overall pie.

Second, we have that

$$sign\left(\frac{\partial\lambda}{\partial\beta}\right) = sign\left(\underset{\gtreqless 0\ (<0)}{\frac{\partial\Delta\Psi_i^g(s,\beta)}{\partial\beta}}\underset{>0}{\frac{\partial p_i^g(.)}{\partial\lambda}} + \underset{>0}{\Delta\Psi_i^g(s,\beta)}\underset{<0}{\frac{\partial^2 p_i^g(.)}{\partial\lambda\partial\beta}}\right)$$

Thus, $\partial\lambda/\partial\beta$ is generally negative. First, an increase in β makes the manager less responsive to incentives to acquire information since

$$\frac{\partial^2 p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial\lambda\partial\beta} = \frac{\frac{\partial\widetilde{\Psi}_i^g(s,\beta)}{\partial\beta}\frac{\overline{\theta}^2}{3}}{C_{p_i^2}\left(\overline{\theta},p_i\right)} \leq 0.$$

Second, an increase in β generally decreases the valuation gap $\Delta\Psi_i^g(s,\beta)$. Recalling that

$$\Delta\Psi_i^g(s,\beta) = (1-\lambda s)\,\Psi_i^g(s,\beta) - \lambda(2s-1)\,\phi_j^g(s,\beta),$$

we have that $\frac{\partial\Delta\Psi_i^g(s,\beta)}{\partial\beta} < 0$ iff

$$(1-\lambda s)\frac{\partial\Psi_i^g(s,\beta)}{\partial\beta} - \lambda(2s-1)\frac{\partial\phi_j^g(s,\beta)}{\partial\beta} < 0.$$

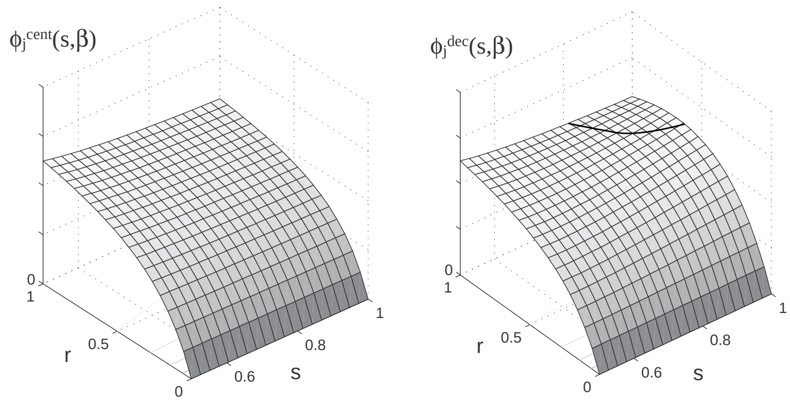

Figure 8: dependency of the negative externality on (s, β)

Now, it is clear that for s, λ sufficiently small, this will always hold because $\frac{\partial \Psi_i^g(s,\beta)}{\partial \beta} < 0$. Also, it will always hold under decentralization because $\frac{\partial \phi_j^{cent}(s,\beta)}{\partial \beta} > 0$ – the size of the negative externality is monotonically increasing under centralization, thus providing additional free incentives. The qualification arises from the fact that for β and s sufficiently large, $\frac{\partial \phi_j^{dec}(s,\beta)}{\partial \beta} < 0$. Because decision-making starts improving under decentralization after a certain level of operational integration, the negative externality actually decreases. This result arises, however, only for β, s so large that if the parameter configuration would be desired in equilibrium, centralization would be preferred over decentralization.

The behavior of $\phi_j^{cent}(s, \beta)$ and $\phi_j^{dec}(s, \beta)$ is plotted in figure 8 to highlight the region for which the negative externality is decreasing under decentralization. The negative externality is generally increasing in β because increase in dependency forces the divisions to be more accommodating to each other. Similarly, from the perspective of communication, the size of the externality is increasing in incentive alignment because more accurate transmission implies more adaptation and thus more accommodation. However, for decentralization, we see that the decisional bias, largest for small s and intermediate β, can reverse these trends.

Finally, we have that

$$sign\left(\frac{\partial s}{\partial \beta}\right) = sign\left(\underset{(<0)}{\frac{\partial \Delta \Psi_i^g(s,\beta)}{\partial \beta}} \underset{>0}{\frac{\partial p_i^g(.)}{\partial s}} + \underset{>0}{\Delta \Psi_i^g(s,\beta)} \underset{<0}{\frac{\partial^2 p_i^g(.)}{\partial s \partial \beta}} + \underset{<0}{\frac{\partial p_i^g(.)}{\partial \beta}} \underset{<0}{\frac{\partial \Psi_i^g(s,\beta)}{\partial s}} + \underset{>0}{p_i^g(.)} \underset{(<0)}{\frac{\partial^2 \Psi_i^g(s,\beta)}{\partial s \partial \beta}}\right),$$

which is again inherently ambiguous but generally negative. There now four effects.

First, an increase in β, as discussed above, generally decreases the valuation gap $\Delta\Psi_i^g(s,\beta)$, thus reducing the value of further information acquisition ($s\downarrow$). Second, a change in β changes the agent's responsiveness to the composition of compensation in terms the quality of information acquired. From above, we have that

$$\frac{\partial^2 p_i^g\left(\beta,s,\lambda,\overline{\theta}\right)}{\partial s\partial\beta}=\frac{\lambda\frac{\partial\widetilde{\Psi}_i^g(s,\beta)}{\partial s\partial\beta}\frac{\overline{\theta}^2}{3}}{C_{p_i^2}\left(\overline{\theta},p_i\right)},$$

so that the change is determined by the sign of $\frac{\partial\widetilde{\Psi}_i^g(s,\beta)}{\partial s\partial\beta}$. This component is unambiguously negative, with an increase in β reducing the sensitivity of the perceived value of information to the composition of compensation and thus further supporting shift to firm-wide incentives ($s\downarrow$). Third, an increase in β directly reduces the amount of information acquired, leading to a reduction in the value of incentive alignment, countering the first two effects ($s\uparrow$). Finally, an increase in β changes the responsiveness of the true value of information to changes in the composition of compensation. In this regard, $\frac{\partial^2\Psi_i^g(s,\beta)}{\partial s\partial\beta}$ is generally negative. An increase in β makes the true value of information to deteriorate faster with increases in s because of the increasing agency conflicts. This effect further supports a shift to firm-wide incentives ($s\downarrow$). Again, however, in the case of decentralization, the non-monotone relationship between operational integration and the bias in decision-making can make this component positive.[21] These cross-partials are summarized in figure 9. In summary, unless the demotivating effect of an increase in β is extremely large, we would expect that $\partial s/\partial\beta<0$.

With respect to environmental variables, we can observe the following. First, an overall increase in $K'(\beta)$ will directly increase the optimal degree of operational integration, which then triggers changes in the rest of the design parameters .Second, a decrease in $G'(\lambda)$ will directly increase the equilibrium strength of incentives, which then triggers corresponding changes in the rest of the design parameters. Third, a change in the cost of information which increases p_i but leaves other parts of the solution unchanged directly decreases both s and β since it makes any constraints on the use of information more damaging, which then leads indirectly to adjustments in the rest of the design parameters.

The consequences of changes in $\overline{\theta}$, while the most interesting, are also the most

[21] Much like with the negative externality, this switch in sign occurs generally in regions where centralization would otherwise be preferred.

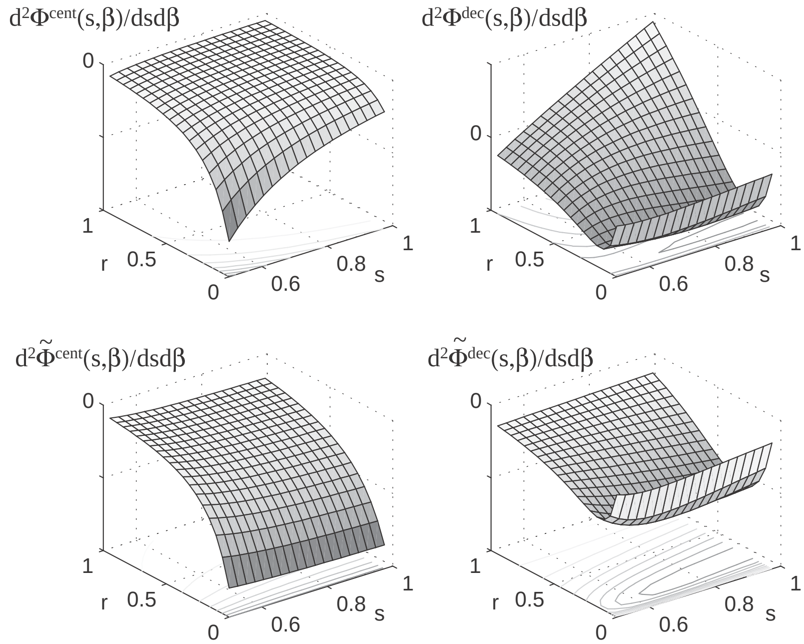

Figure 9: cross-partials for true and perceived value of information

complex to analyze. From the first-order conditions one sees that the direct impact is to make integration more costly, reducing β, while increasing the value of incentive strength, increasing λ. There is no direct impact on s, because the optimal composition of incentives is simply determined by the balance between motivating information acquisition and motivating good use of that information, both of which are proportional to the volatility. However, there are also indirect effects to each condition because changes in volatility can alter the amount of information acquired by the agent and the responsiveness of the agent to any of the control parameters. For example, the impact on s would be determined by sign of

$$\left(\underset{>0}{\Delta\Psi_i^g(s,\beta)}\underset{\gtreqless 0}{\frac{\partial^2 p_i^g(.)}{\partial s\partial\overline{\theta}}} + \underset{\gtreqless 0}{\frac{\partial p_i^g(.)}{\partial\overline{\theta}}}\underset{<0}{\frac{\partial\Psi_i^g(s,\beta)}{\partial s}}\right),$$

where $sign\left(\frac{\partial p_i^g(.)}{\partial\overline{\theta}}\right) = sign\left(\lambda\widetilde{\Psi}_i^g(s,\beta)/3 - C_{p_i\overline{\theta}}\left(\overline{\theta},p_i\right)\right)$ and

$$sign\left(\frac{\partial^2 p_i^g(.)}{\partial s\partial\overline{\theta}}\right) = sign\left(2C_{p_i^2}\left(\overline{\theta},p_i\right) - \overline{\theta}C_{p_i^2\overline{\theta}}\left(\overline{\theta},p_i\right)\right).$$

For example, if $C_{p_i^2\overline{\theta}}\left(\overline{\theta},p_i\right) = 0$, so that the convexity of the cost function is independent of $\overline{\theta}$, then $\frac{\partial^2 p_i^g(.)}{\partial s \partial \overline{\theta}} > 0$, supporting increased conflict to motivate information acquisition. However, if $\frac{\partial p_i^g(.)}{\partial \overline{\theta}} > 0$ as well, then conflict becomes increasingly costly because more information is wasted. Similar considerations carry over to the other two first-order conditions. Coupled with the interactions among the three design parameters, it is easy to see why very few general results can be derived for the relationship between $(\beta^g, s^g, \lambda^g)$ and $\overline{\theta}$.

A natural benchmark is provided by the case of $C\left(\overline{\theta}, p_i\right) = \tau\overline{\theta}^2\ C\left(p_i\right)$, so that the information acquisition solution is independent of environmental volatility. This result was illustrated in the analysis, showing that even when the complications of information acquisition are suppressed, the comparative statics can still remain very complex. For example, as argued above, a reduction in β supports an increase in s, but an increase in λ supports a decrease in s. Whatever the equilibrium effect on s, this then further feeds to the choice of β and λ, leading to the potential non-monotonicity of the compensation contract.

B Some further observations

Cost of incentives $G(\lambda)$: The standard economic interpretation of incentives is that of monetary incentives. In this respect, $G(\lambda)$ is the cost of providing monetary incentives of size λ to the divisional managers, where the cost can arise either because of limited liability, absence of a budget breaker or other reasons. While the economics literature has focused on the provision of monetary incentives, the management literature provides an alternative interpretation for the function, which is the costs of *socialization*. The basic idea behind socialization is simple: the goals and objectives of organizational participants can be manipulated by the organization over and above changes in the structure of monetary compensation. For example, a manager can exhibit loyalty to his division or to the firm as a whole. Under this interpretation, the assumed reduced-form structure of these costs would appear less controversial, since these now become true costs of educating and molding the managers.

The downside of this interpretation is that, in general, we would assume such costs to be asymmetric with respect to the two divisions (it is commonly argued that people come to associate with their immediate social group). That is, it could well be that $G(\lambda)$ is not additive but of the form $G(s_{ii}, s_{ij})$, where $G_{s_{ii}}(s_{ii}, s_{ij})$ and

$G_{s_{ij}}(s_{ii}, s_{ij}) > 0$ as before, so that increasing the internalization of either division's objectives is costly, but that $G_{s_{ii}}(s_{ii}, s_{ij}) < G_{s_{ij}}(s_{ii}, s_{ij})$, so that it is more costly to get managers to internalize the objectives of the other division. It appears natural to continue to assume that $G_{s_{ij}s_{ii}}(s_{ii}, s_{ij}) > 0$, so that making the manager to internalize the other division's objectives becomes increasingly costly as the internalization of the own division's objectives becomes stronger (this was immediately the case with the additive structure). When this situation continues to hold, the multiplicity of local optima continues to hold – one peak can occur with strong internalization of own objectives but with limited alignment, while another peak can occur with weaker internalization of own division's objectives but greater alignment of the objectives across the divisions.

The consequences of allowing such asymmetries in the analysis are immediate. In particular, the presence of any such asymmetry would increase preference for centralization, which is able to better manage conflicts between the divisional managers' objectives. Similarly, the asymmetry in the compensation structure between centralization and decentralization would generally be amplified. Otherwise, the comparative statics would remain unchanged.

Asymmetries in dependency and the choice of β_i^g: To maintain some tractability, the model focused only on the situation where the divisions were symmetric in all respects, including the benefits of operational integration. If this were not the case, we would need to separate both the degree of operational integration $\left(\beta_i^g, \beta_j^g\right)$ and and the associated benefits $\left(K_i\left(\beta_i^g, \beta_j^g\right), K_j\left(\beta_i^g, \beta_j^g\right)\right)$. For example, one division might face significantly higher environmental volatility, which would warrant a lower degree of operational integration by that division, or integrating the operations of one division might be asymmetrically beneficial to the organization.

The final choice of $\left(\beta_i^g, \beta_j^g\right)$ would then be characterized by first-order conditions analogous to the one presented in the analysis. However, if such asymmetries arise in equilibrium, they introduce additional considerations to the governance problem. In particular, because asymmetries in the degree of dependency translate into differences in the importance of adaptation and coordination across the divisions and in the related relative importance of decision-making and communication, asymmetric compensation and authority structures can arise in equilibrium. This idea that asymmetries in the operating environment should be reflected in asymmetric governance structures has been stressed, among others, Bartlett and Ghoshal (1989/2002). The impact of such asymmetries on the optimal allocation of decision rights is analyzed in Rantakari (2008a), while the extension accounting for endogenous information acquisition and incentives is available from the author on request. In short, asymmetries in dependency and other environmental variables sometimes warrant asymmetric governance structures, where the headquarters delegates authority asymmetrically to the divisions, but the basic logic and the economic forces underlying the results are the same.

A more substantive question is raised by who should have the right to choose β_i^g. In the analysis, we assumed that the choice is made by the headquarters to maximize the total net surplus. In this sense, (i) there is a role for the headquarters even when the decision-making is delegated to the divisions and, as a result, (ii) the framework is more representative of the internal organization of firms instead of firm boundaries. Indeed, it is possible to view the separation of β_i^g from d_i^g as the distinction between strategic and operating decisions. The headquarters retains the right to choose the strategic direction of the firm, while the operating decisions can be retained either at the level of headquarters or delegated to the divisions. And because of the interaction between the two, the optimal strategic direction of the firm is going to depend on the location of authority with respect to the operating decisions.

In the present framework, it is optimal to have the right to choose β_i^g at the level of headquarters, so the assumption as such is without loss of generality. The reason for this result is that even if all the benefits of operational integration would accrue to the division choosing its β_i^g, a unilateral decrease in β_i^g improves the strategic position of the division.[22] Thus, decentralized decision-making with centralized choice of $\left(\beta_i^g, \beta_j^g\right)$ always dominates decentralized decision-making with decentralized choice of $\left(\beta_i^g, \beta_j^g\right)$. This conclusion can easily be reversed, however, if we introduce performance measurement problems into the picture. A promising extension currently under examination is the integration of asset ownership and performance measurement problems into the present framework, where asset ownership is linked to the right to choose β_i^g. This introduction of asset ownership is then able to separate between within-firm and between-firm relationships and thus shed further light on the determinants of the

[22] The relationship between dependency and the strategic position of the division is discussed in detail in Rantakari (2008a). See also Thompson (1967), who discusses in detail the relationship between power and dependency, a discussion that is closely related to the logic behind the present framework.

boundaries of firms.

Agency costs of operational integration and two applications: The analysis did not focus in any great detail on the agency costs of operational integration. We will now look at this problem in a little more detail, by examining how the agency costs vary with the degree of operational integration, as separate from the purely technological restrictions on the adaptiveness of the firm, and how the differences between the governance structures influence the optimal choice of operational integration. The analysis allows us also to consider Porter's (1980) argument that attempting to do both (local responsiveness and global efficiency) can lead to doing neither well, and relate it to Bartlett and Ghoshal's (1989/2002) argument that, to remain competitive, firms need to increasingly focus on both. The two arguments are easily reconciled by considering the changes in the nature of the underlying production technology and the associated shape of $K(\beta)$.

To examine how the costs of operational integration vary with the degree of integration, define the first-best solution as one where decisions are joint-profit-maximizing, communication is perfect and the quality of primary information is at the joint-profit-maximizing level given these assumptions. This solution gives us the purely technical cost of operational integration, given by

$$EL^{FB} = p_i^{FB}\left(\beta, \overline{\theta}\right) \Psi_i^{FB}(\beta) \tfrac{\overline{\theta}^2}{3} - \tfrac{\alpha \overline{\theta}^2}{3} - C\left(\overline{\theta}, p_i^{FB}\left(\beta, \overline{\theta}\right)\right).$$

Second, to isolate the impact of operational integration from the agency cost of information acquisition, define the constrained first-best as the solution under perfect decisions and communication but strategic information acquisition:

$$EL^{CFB} = p_i^{g}\left(\beta, s, \lambda, \overline{\theta}\right) \Psi_i^{FB}(s, \beta) \tfrac{\overline{\theta}^2}{3} - \tfrac{\alpha \overline{\theta}^2}{3} - C\left(\overline{\theta}, p_i^{g}\left(\beta, s, \lambda, \overline{\theta}\right)\right) - G(\lambda).$$

Then, $EL^g - EL^{CFB}$ gives the agency costs caused by the strategic use of information and $EL^{CFB} - EL^{FB}$ the agency cost of information acquisition.

An example of this decomposition is given in figure 10. From the picture it is clear that the primary driver of the cost of operational integration is purely technological reduction in adaptiveness. The size of the agency losses, on the other hand, is driven by both the cost of information and incentives. If $\lambda = 2, s = 1/2$ could be achieved at no cost, then the only source of costs would be this reduction in responsiveness,

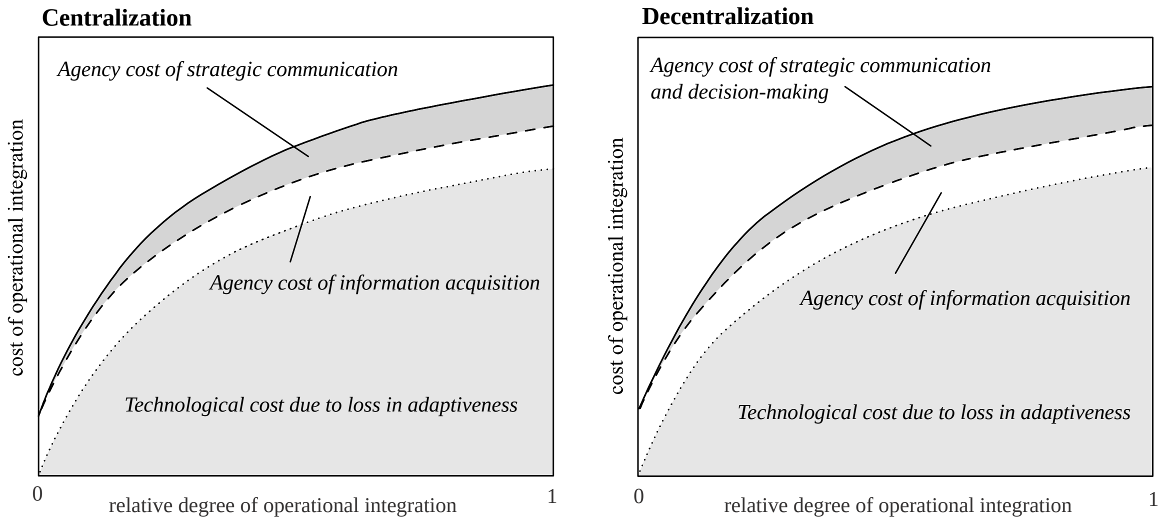

Figure 10: Composing costs of operational integration.

common across the governance structures.

The agency cost of information acquisition is similarly shared across the governance structures, since we assumed that information would get used in a profit-maximizing way after its acquisition. Where the governance structures do differ, however, is how the information gets used after its acquisition, resulting to differences in the overall cost of operational integration. From the figure it is clear how these costs rise rapidly in the initial operational integration while later flattening out. It is with respect to this component that the arguments of the main analysis applies: the agency costs are always lower under decentralization when the degree of operational integration is sufficiently low, and the higher the equilibrium degree of incentive alignment, the higher the degree of operational integration that the firm prefers to manage under a decentralized structure.

There are two observations that can be made regarding the choice of operational integration. First, because the costs are concave, the optimal degree of operational integration can be highly sensitive to small changes in the environment, at least for some benefit functions. Second, because the overall shape of the costs is the same across the governance structures, the optimal degree of operational integration is generally not going to be that different across the governance structures. However, because the governance structures *do* differ, sometimes there can be significant differences in the solution.

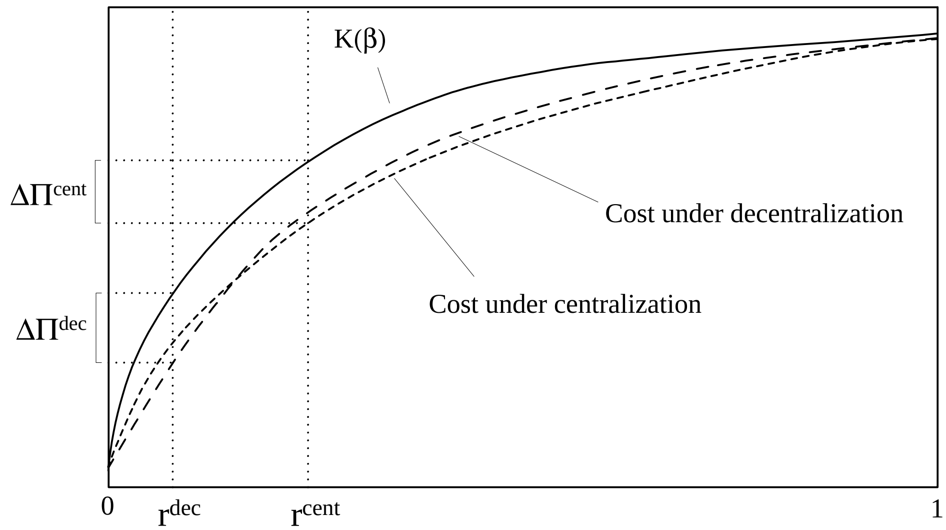

Figure 11: An example of lack of performance differentials across seemingly different firms

We will first consider the latter. An example of this result is given in figure 11. The figure illustrates the optimal choices of operational integration for the two governance structures, together with the improvement in performance over the zero-integration solution. We can observe two things. First, because both benefits and costs are concave, small differences in the costs of operational integration between the two governace structures translate into large differences in the optimal degree of operational integration (and the associated compensation structure, not depicted).

Second, these two seemingly different governance structures have almost identical expected performance. This result shows how seemingly very different enterprises operating in the same industry can have very similar overall performance. While the exact equivalence is clearly a knife-edge result (generally, there is a unique best way of doing things), this result highlights the importance of fit between strategy and structure. Further, if firms in a given industry face even slightly different $K_i(\beta)' s$, such differences can quickly get amplified through the overall organizational design problem and these firms with slightly different opportunities can end up pursuing very different (but now fully individually optimal) strategies with very different structures.

The first observation brings us back to Porter's argument that attempting to find a balance between responsiveness and efficiency can lead to achieving only a little of both. Indeed, it is clear from figure 11 that the optimal degree of operational integration can be very sensitive to small changes in the environment, in particular in the region of intermediate operational integration, leading to unraveling into very low or very high degree of operational integration. As a result, most environments are dealt best with either a highly loose or a highly integrated structure, as suggested by Porter.

The argument put forth by Bartlett and Ghoshal (1989/2002) is slightly different. They observe that the industry demands up until 1980s were quite unidimensional, with natural focus either on local responsiveness or global efficiency, but that changes in production technology and market conditions have made competition more multi-dimensional, with the importance of local responsiveness having increased in markets traditionally characterized by efficiency considerations and the importance of efficiency considerations having increased in markets traditionally characterized by the importance of local responsiveness. This argument, however, does not answer the question whether the firm is actually *able* to do both because of the inherent tradeoff between the two – more responsiveness by definition requires less efficiency as long as the firms are on the productivity frontier and the choice should be driven by the relative value of each.

These two observations can be consolidated into one by noting that the firms *have* been pushing the productivity frontier. In particular, the recent innovations in flexible manufacturing methods and modularization of products have not necessarily decreased the potential returns to integration, but they have changed how much of the potential efficiency benefits are achieved at a *given* level of integration. In other words, more of the potential efficiency benefits can now be realized at lower levels of overall integration, technically captured by increased concavity of the efficiency curve. The direct consequence of such a change is that firms that used to be very flexible find it beneficial to increase their degree of operational integration because of increased returns while firms that used to be highly integrated find it optimal to loosen the degree of integration because the same level of benefits can be realized at a lower level of operational integration. In other words, it is not necessarily that the competition has exogenously become multi-dimensional, but in pursuing the competitive edge, firms have pushed the productivity frontier in a way that has made such multi-dimensional competition strategically feasible.

The logic of this argument is illustrated in figure 12. The left-hand side illustrates the solution under, what could loosely be argued, pre-1980s production technology,

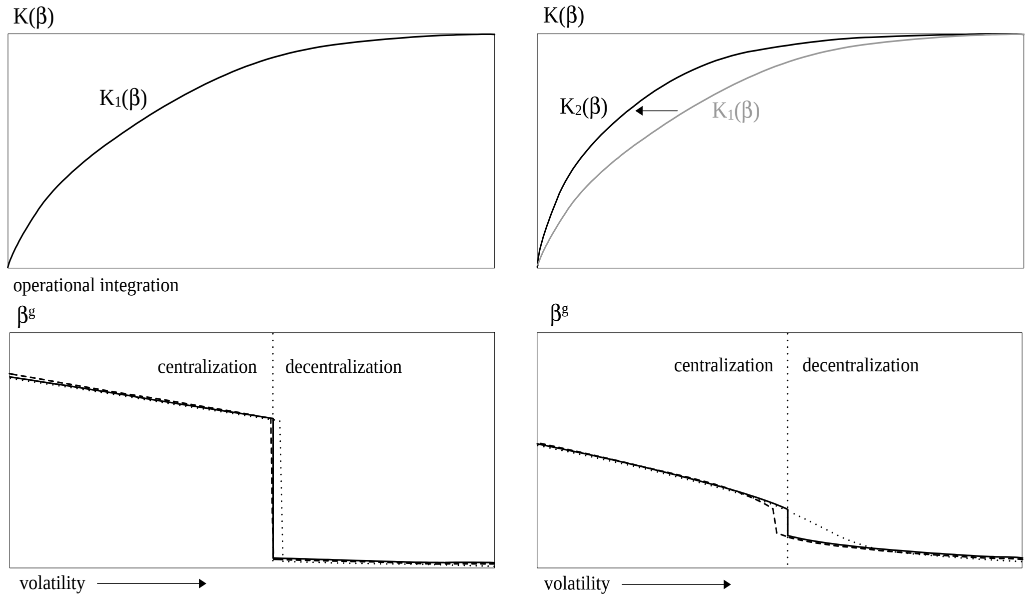

Figure 12: Impact of changes in the benefits of operational integration

where the benefits of operational integration accrue relatively slowly. As a result, there is a very strong division between the two types of firms. Highly integrated and centralized firms operating in relatively stable environments and very flexible and decentralized firms operating in more volatile environments. The right-hand side models the result of the recent innovations in production as increasing the concavity of the benefit function while leaving the maximal benefits unchanged. The consequences of this change are as discussed. Centralized firms find it optimal to relax their degree of operational integration while decentralized firms find it optimal to increase their degree of operational integration. The consequence is a significant thickening of the middle, where firms are indeed now pursuing a strategy that is balancing local responsiveness and global efficiency.