DISCUSSION PAPER SERIES

No. 6019

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INDUSTRIAL ORGANIZATION

Centre for Economic Policy Research

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ISSN 0265-8003

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Discussion Paper No. 6019
December 2006

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CEPR Discussion Paper No. 6019

December 2006

ABSTRACT

Organizing for Synergies*

Multi-product firms create value by integrating functional activities such as manufacturing across business units. This integration often requires making functional managers responsible for implementing standardization, thereby limiting business-unit managers' authority. Realizing synergies then involves a tradeoff between motivation and coordination. Motivating managers requires narrowly-focused incentives around their area of responsibility. Functional managers become biased toward excessive standardization and business-unit managers may misrepresent local market information to limit standardization. As a result, integration may be value-destroying when motivation is sufficiently important. Providing functional managers only with "dotted-line control" (where business-unit managers can block standardization) has limited ability to improve the tradeoff.

JEL Classification: D2, D8 and L2
Keywords: communication, coordination, incentives, incomplete contracts, merger implementation, organizational design, scope of the firm and task allocation

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* We thank Bob Gibbons, John Levin, Ilya Segal, Michael Whinston and participants in seminars at Cambridge, Columbia, Duke, Duke/Northwestern/Texas IO Theory Conference, ECARES, Gerzensee, Harvard/ MIT Organizational Economics, INSEAD, London School of Economics, Northwestern, Oxford, Purdue, UC San Diego, Stanford Institute for Theoretical Economics, Universite de Toulouse-IDEI, University of Chicago, University College London, University of Southern California and Wisconsin for their comments, and the University of Chicago GSB for financial support.

Submitted 28 November 2006

1 Introduction

Mergers are often motivated by potential synergies from integrating or standardizing R&D, manufacturing, purchasing, marketing, distribution, or other activities. A simple (or simplistic) justification is that the two firms can do everything as before except the narrow combination of activities needed to exploit a synergy. Yet failure to implement the organizational strategies required to realize the potential gains is common in many of the most spectacular merger disasters.[1]

The recent merger between AOL and Time Warner is a particularly prominent example of what appears to be quite common. A claimed source of increased value would be synergies from selling advertising packages that included all media encompassed by the merged company's divisions. Centralized ad-selling was thwarted by divisional advertising executives who felt they could get better deals than the shared revenue from centralized sales. An outside advertising executive was quoted by the Wall Street Journal, stating, "[t]he individual operations at AOL Time Warner have no interest in working with each other and no one in management has the power to make them work with each other."[2] AOL Time Warner could have chosen to provide greater control to the centralized advertising unit, but this too is not without cost and significant peril. Taking control away from business units over such an important source of revenue could reduce the sensitivity of decisions to local information, reduce the coordination among the different activities of a business unit, and blunt incentives.

The traditional explanation of why all mergers with potential synergies do not enhance value is that there are costs associated with expanding the scale of the firm; there is some discussion about managerial diseconomies of scale that derive from increased bureaucracy and limited spans of control, and perhaps less financial market discipline if both merging companies are public. These answers are mostly imprecise and they are not very satisfying. They do not explain why bureaucracy increases if most everything is the way it was before the merger. They do not tell us when these costs are relatively important and when they are not. They cannot make predictions about when mergers will be efficiency-enhancing because they can only speak to the details of one side of the trade-off.

Our model provides a more precise explanation. On the one hand, integration requires making functional managers responsible for implementing standardization, thereby limiting business-unit managers' control. On the other hand, motivating managers requires narrowly focused incentives around their areas of responsibility. But if the organization combines

[1] The anecdotal evidence of failed synergy implementation is also consistent with the broader empirical literature on merger performance in corporate finance. See Andrade, Mitchell, and Stafford (2001).

[2] See Rose, Matthew, Julia Angwin and Martin Peers. "Bad Connection: Failed Effort to Coordinate Ads Signals Deeper Woes at AOL – Infighting Among Divisions Derails Key Merger Goal; Board Considers Shake-Up – Moment of Truth for Pittman." Wall Street Journal (July 18, 2002): A1.

the division of labor needed to implement synergies with strong local incentives, functional managers implement excessive standardization and business-unit managers misrepresent local market information to limit standardization. Better coordination among managers to make efficient standardization decisions demands muting local incentives. Realizing value-increasing synergies thus involves a trade-off between motivation and coordination.[3]

We model a firm organized around two product units – one can think of two distinct products or two distinct locations. Each product requires two activities such as manufacturing and marketing. We assume that optimal organizational structure requires that one activity – the "local" activity – be organized by products because business-unit managers must make decisions based on local information. But there may be benefits from standardizing the second activity – the "synergistic" activity – across products. Synergies can only be realized if the synergistic activities for each product are integrated (e.g. in a single manufacturing plant), and a functional manager specialized in that activity is put in charge. Once the organizational structure and incentives are set, managers obtain information that determines whether or not standardization is efficient. In an integrated structure, the functional manager obtains information about the cost savings that may be attained through standardization and each business-unit manager learns about the cost of standardization to his business unit – the lost value of local adaptation to the needs of the individual market. The cost saving from standardization is private information to the functional manager and the local information (the value of adaptation) is private to the business-unit managers. An efficient decision whether to implement standardization or not requires that such information be aggregated.

Furthermore, managers need to be motivated to carry out their activities, so compensation must be linked to performance.[4] However, and this is key, motivating managers by linking compensation to performance makes them care about their own output, thereby making communication strategic and biasing decision-making away from joint objectives. When the incentives of individual managers are sufficiently narrow, the interests of the functional manager and the business-unit managers are directly in conflict. A manufacturing manager who is given a stake in low-cost production will be biased in favor of standardization, while business-unit managers will be biased in favor of adaptation to local market conditions. As a result of this conflict of interest, communication (which is cheap talk) may not be credible. Moreover, decisions are suboptimal, as the manager who controls the standardization decision does not value cost savings and local adaptation equally. Only if the link between pay and

[3] We build on a previous literature on multitask incentives (Holmstrom and Milgrom (1991, 1994), Holmstrom (1999)). This literature models the tradeoff among multiple tasks, some of which cannot be affected by incentives directly, in a reduced-form setting. Our model provides content to this broad multitasking intuition, by focusing on the conflict that we believe is particularly relevant to organizational design: the conflict between effort incentives on one side and communication and efficient decision making on the other.

[4] We assume that only the task allocation is contractible. In contrast, the way the task is carried out (which includes the effort provided, and whether or not to limit local adaptation) can only be indirectly influenced through output incentives.

performance is weakened, can managers' incentives become more aligned with one another, improving communication and decision-making.

Thus the trade-off between incentives and coordination takes two forms. First, as local incentives become stronger, standardization decisions become more biased. Second, as local incentives become stronger, credible communication is more difficult. Integration is more attractive when expected synergies are high. It is also more likely if the uncertainty over the value of synergies is high because contingent decision-making to either adapt production to the local circumstances or standardize becomes more important. Integration is less likely when motivation is important. When motivation is sufficiently important, integration, which requires weakening local incentives to reduce bias in decision-making and make communication credible, becomes too costly.

For much of our analysis, implementing synergies requires a functional manager who has full control of the standardization decision. In Section 6 we weaken the strong link between authority and task allocation; we model an organizational structure that allows business-unit managers to block any standardization initiative. In this structure, they retain sufficient control that their cooperation is required for standardization to succeed. In general providing local managers with veto power makes efficient standardization decisions more difficult as only standardization which benefits both managers will be accepted. Still we show that if motivation is important, this structure may be preferred as it allows the organization to implement some standardization that is contingent on business-unit managers' information while maintaining reasonably high-powered incentives.

Our paper contributes to a small, recent literature that has studied jointly the incentive problems and the coordination costs that follow from the design decision.[5] Hart and Moore (2006) study how to allocate authority over the use of assets when agents with several assets (coordinators) can have ideas involving the common use of several of these assets, and when agents are motivated by their own interest rather than that of the organization. Hart and Holmstrom (2002), in a framework centering on the managers' private benefits of control, show that independent firms coordinate their activities insufficiently, integrated firms have a tendency to realize too many synergies, neglecting private benefits of mangers and workers. Our work differs from these two papers in two major respects. First, the incentive conflict in

[5] A related strand of literature, under the broad heading of team theory (Marshack and Radner, 1972), studies coordination problems absent incentive issues. For example, Cremer (1980), Genakoplos and Milgrom (1991) and Vayanos (2002) study the optimal grouping of subunits into units in the presence of interdependencies; Harris and Raviv (2002) study the organizational structure that best appropriates synergies when managers are expensive; Qian, Roland and Xu (2006) study how the grouping of units (M-form versus U-form) affects how organizations coordinate changes; Dessein and Santos (2006) study the trade-off between ex ante coordination, through rules, and ex post coordination, through communication; Cremer, Garicano and Prat (2007) study the limits to firm scope due to the loss of specificity in organizational languages as firm scope grows. Outside of economics an old literature (e.g. Chandler's 1962 and and Lawrence and Lorsch's 1967) studies coordination and integration mechanisms in organizations.

our analysis is endogenous – agents prefer different decisions only if they are given incentives to do so. Second, we focus on communication and the possibility of aggregating information. Alonso, Dessein, and Matoushek (2006) compare centralized and decentralized coordination between business units and show that decentralization may be preferred regardless of the importance of coordination. Information aggregation plays a key role in their model, but again they do not endogenize incentives. Also, control is allocated to an unbiased principal under integration, whereas we emphasize that integration requires a functional manager who is endogenously biased because of the need to motivate him.

We follow Athey and Roberts (2001) in focusing on the trade-off between high-powered incentives to induce effort and biased decision-making that impacts other parts of the organization. Specialization in our framework is endogenous, as are the information structure and the incentives of agents. These features, together with the presence of strategic communication and the more tractable framework we develop, distinguish our paper.

2 Synergies and organization: two examples

In our view, developing a framework that can deal both with the synergies that are the reason the organization is actually set up as well as with the informational asymmetries and incentive conflicts that emerge as a result of the design decision is an important step towards a deeper understanding of both organizations and incentives. We present below two examples that illustrate the incentive and communication challenges involved in integrating separate units to attain synergies.

2.1 Jacobs Suchard

Consider Jacobs Suchard attempt to capture synergies in the late 1980s. Suchard was a Swiss coffee and confectionery company with the leading European market share in confectionery products.[6] It had a decentralized organizational structure with largely independent business units organized around products and countries run by a general manager, so that for example, there was a French confectionery business unit and a German beverage business unit. The general managers received compensation based on business unit and corporate profits. Each business unit had its own sales, marketing, and manufacturing divisions. This decentralized structure facilitated measurement and strong local incentives, but made cross-country synergies hard to capture. The tariff reductions, open borders, and standardization of regulation of the upcoming 1992 European integration created the opportunity for Jacobs Suchard to achieve cost savings by combining manufacturing plants across countries. The company planned to shift from 19 plants to six primary plants that would serve all of Europe.

[6] What follows comes from Eccles and Holland (1989).

General managers were to lose responsibility for manufacturing, but maintain control of sales and marketing. Profit measurements for business units would be based on transfer prices from the manufacturing plants.

Jacobs Suchard's experience with its new organizational structure demonstrates the trade-offs that arise in attempts to organize to realize synergies: business unit marketing managers were unable to make decisions because the general manager would disagree. General managers fought standardization in manufacturing that they believed would harm their unit's profits. The outcome was reduced coordination within business units; increased time and effort to communicate, defend, and debate strategic choice which threatened the firm's entrepreneurial culture; and blunted incentives for general managers. While it is difficult to determine if the organizational change was a good decision or not, it is clear that the benefits from the attempt to create cross-border synergies did not come without costs. These costs take the form that is the focus of this paper – poorer coordination and incentives within business units, increased conflict from centralized decision-making, and the communication costs that go with it.

2.2 Consolidation and synergies in vehicle manufacturing

Mergers and alliances in the automobile and truck manufacturing industries aim to achieve synergies by standardizing and sharing components across multiple vehicles. Most notably, the so called 'platform' strategies reduce manufacturing costs by using a common platform to manufacture different vehicles across multiple brands.[7] Of course, as we discuss in this paper, extracting such cost savings requires incurring substantial organizational costs and adaptation losses.

A case in point is the Commercial Vehicles Division (CVD) of Daimler Chrysler (Hannan, Podolny and Roberts, 1999). Since the mid-1990s, managers at Daimler recognized it could capture large global economies of scale in the heavy vehicle area by standardizing production, information technology, purchasing, and other functions.[8] However, Daimler Chrysler was organized around fiercely independent divisions. This allowed it to adapt the trucks pro-

[7] For example, Volkswagen uses the same platform for the VW Golf and Jetta, the Audi A4 and Audi TT sports car, the Seat Leon and Toledo, and the Skoda Octavia. After GM purchased Daewoo, GM Daewoo it produced under the same platform the Daewoo Kalos, the Chevrolet Aveo, the Chevrolet Kalos, the Suzuki Swift, the Pontiac Wave and the Holden Barina (see "Same skeleton, different skin", William Kimberley, Financial Times, February 28, 2006.) Discussions in the Summer and Fall of 2006 about a possible merger or alliance between Renault-Nissan and GM focused on the extent to which common components and common platforms could be used (see e.g. 'Higher Stakes' WSJ Sept 27, 2006, by Monica Langley and Joseph B. White).

[8] For a recent example of a multitude of statements in this direction consider the 2004 Management Report: "The second cornerstone of [our strategy for Commercial Vehicles] consists of deriving appropriate cost advantages from the large volumes that DaimlerChrysler realizes as the world's leading producer of commercial vehicles. The core of this strategy is to use as many identical parts and shared components as possible, and to use existing vehicle concepts for the maximum possible production volumes while protecting the identity of our brands and products." See http://www.daimlerchrysler.com/Projects/c2c/channel/documents/629779_management_report.pdf

duced to the widely heterogeneous local demands from differences in laws, tastes, and road characteristics.[9] Yet Daimler group management was aware that cross-regional economies of scale could not be realized under such a decentralized structure, as there was no incentive for divisional managers in different regions to cooperate. For example, under the old structure the CEO of Daimler's US subsidiary would simply refuse to return the calls from the head of the Division in Germany (Hannan et al, 1999:1).

By the late 1990s, Daimler group management decided to undertake a first of many reorganizations with the objective of centralizing certain functions and achieving cross unit synergies. In early 2004, it took a major step with the launch of a new intracompany unit, the Truck Product Creation organization, responsible for networking product planning, product development, production strategy, and purchasing across the various divisions. As part of the restructuring, the company introduced the "Lead Engineering" concept in which "each part in the vehicle is assigned to a Lead Engineering Team whose task it is to modify and implement the module for all regions, the aim being system commonality....[providing] for regionally specific adaptation and integration of the module in question"[10]

Both examples show the intimate connection between synergies and organization. In both these and many other examples, achieving synergies requires centralizing some function or functions and putting an agent in charge of them. The challenge is to preserve local incentives and to ensure communication between the local managers and the new centralized functions. We turn next to developing a framework that allows us to study organizational design when agents are self-interested and coordination matters.

3 The model

Organizations are set up in our model to process information and adapt to that information. We consider two separate units that may or may not be integrated. If integrated, the organizational design problem is to set incentives and allocate tasks and control among managers. After the organizational structure is in place, there is an opportunity to standardize an activity. Managers learn about the benefits of standardization and local adaptation after the organizational structure is fixed. That is, the designer only knows the probability distribution of future synergies, not their realization, and chooses a structure that shapes how decisions to

[9] For example, in the US regulation requires long cabs, while in Europe it requires they be as short as possible (Hannan et al., 1999:5)). A result of this demand heterogeneity is that products designed centrally without sufficient local input, were not fit for the local markets. For example, a seven tonne truck designed in Germany for poorer markets failed entirely in Indonesia, as those designing it did not predict adequately the loads and road conditions to which it would be subjected.

[10] Page 6, DaimlerChrysler Communications: Strategies for the commercial vehicle markets in America, Asia and Europe; presented at the VDA International Commercial Vehicle Press Workshop in Frankfurt on July 8/9, 2004.

standardize are made once managers learn the specific costs and benefits. For example, the organizational design problem may be whether or not to have manufacturing in a single plant with a single manager for both domestic and foreign markets. The standardization decision may be whether or not this year's products for the domestic and foreign markets will have the same packaging or not.

Production. Production of goods 1 and 2 requires two activities or functions. Potential economies of scope exist in one of the activities – the 'synergistic activity;' the other 'local activity' requires business-unit managers to adapt to local conditions, so no scope economies are possible. For example, potential synergies may arise in manufacturing from producing the two products in a single plant in a standardized manner while marketing must be designed for specific markets. Output of product $i, i = 1, 2$, depends on unobservable and private efforts e_{iL} and e_{iS} exerted in the local (L) and synergistic (S) activity. The marginal product of effort in each activity is v, so output in activity $A \in \{L, S\}$ for good i is ve_{A_i}; v thus determines the importance of providing strong effort incentives for managers' activities. We adopt the convention that the local activities produce (net) revenue and the synergistic activities reduce cost.[11]

Task Allocation. Each 'business-unit' manager is in charge of the local activity for his good, and may also be in charge of the synergistic activity. However, realizing economies of scope requires a 'functional' manager who is in charge of the synergistic activity for both products; the business-unit managers are then only in charge of their local activity. For example, as in the Daimler Chrysler or Suchard examples, the manufacturing facilities must be integrated or consolidated in one location with a single manager in control. We assume that it is impossible for one manager to control more than two activities or the local activities for both products. The local activity requires local market knowledge and managers cannot acquire local knowledge about two markets. This means that we restrict our attention to two organizational forms, non integrated (NI) where each one of two managers undertakes activities (L_i, S_i) for product $i = 1, 2$ and integrated (I) where each business-unit manager i undertakes activity L_i and the function manager undertakes task (S_1, S_2).[12]

A manager is allocated tasks from $\{(L_1, S_1), (L_2, S_2), (S_1, S_2), (L_1), (L_2)\}$. His utility is

[11] The key feature is that output from each activity is observable and contractible. Although imperfect performance measurement may result from task reallocation, we choose to focus on incentive-coordination tradeoff that exists even without these measurement problems.

[12] Note that, unlike in most of the previous literature on decision-making authority (e.g. Aghion and Tirole (1997); Dessein (2002)), we take the view that authority over actions stems directly from task allocation rather than being allocated contractually. This distinction is important because it implies that decision-making regarding a task is inalienable from the agent who provides task-specific effort. In particular, this link between task allocation and decision-making is likely to distort decision-making and communication since agents' incentives are typically narrowly focused on their own task.

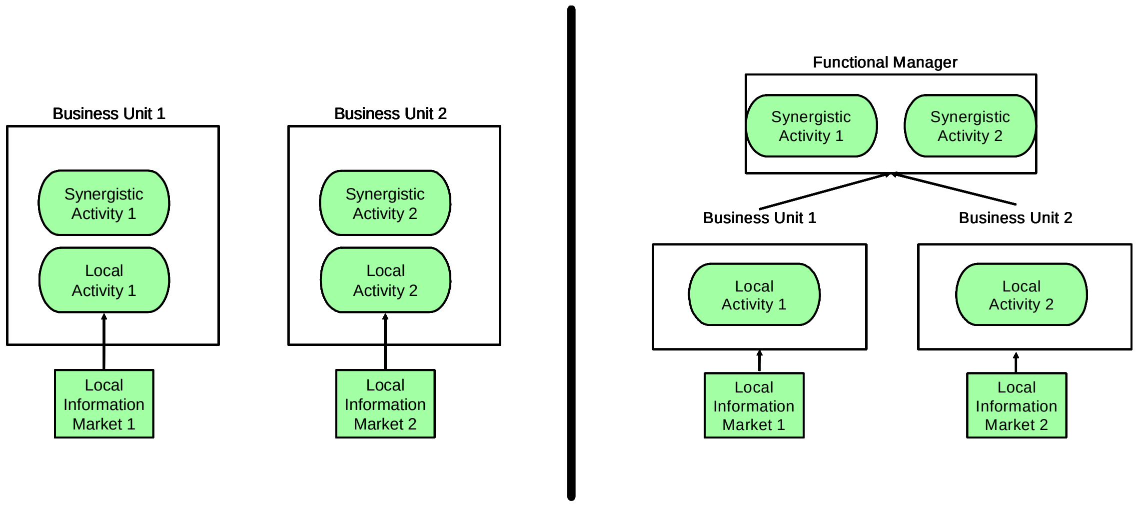

Figure 1: Non integrated structure Integrated structure

(with a small abuse of notation for t):

$$U = w - \sum_t \frac{1}{2} e_t^2 \tag{1}$$

where w is the wage and t is an index that sums over all the tasks allocated to the manager.

Synergies. The functional manager, if employed, may standardize his two activities. The organization then attains total cost savings k on those activities. Instead, he may decide to undertake each activity independently. No economies of scope can be achieved if the two synergistic efforts are undertaken by different managers. k is a random variable drawn from a uniform distribution $k \backsim U[0, K]$ and privately privately observed by the functional manager.

Standardization results in revenue losses Δ_i for product i. Δ_i represents the cost of not being *adapted* to the local environment, thereby producing a product that is not ideal for local market conditions. Each business-unit manager privately observes his product's realized adaptation costs Δ_i, where each Δ_i is either Δ_L or Δ_H, Δ_H has probability $p = 1/2$,and the mean is $\overline{\Delta} = 1/2(\Delta_L + \Delta_H)$. In the equations we write p rather than 1/2 when it makes the equations more transparent. We assume that $0 < \Delta_L < \Delta_H$, and that Δ_1 and Δ_2 are independent. We will say that synergies are positive whenever $k - (\Delta_1 + \Delta_2) > 0$. We assume that $K - 2\Delta_H > 0$, so the support of the synergies is such that it is sometimes optimal to implement synergies ex post regardless of Δ. This assumption reduces the number of cases to consider, thereby simplifying the analysis without affecting the results.

Profits. Production generates four value streams: two cost streams (generated by the synergistic activities) and two revenue streams (generated by the local activity). Business unit revenue derives from the effort of the business-unit manager on the local activity minus the potential loss due to lack of adaptation:

$$R_i = ve_{iL} - \Delta_i I \tag{2}$$

for $i = 1, 2$, where

$$I = \begin{cases} 0 & \text{under non-integration} \\ 0 & \text{under integration if standardization is not implemented} \\ 1 & \text{under integration if standardization is implemented} \end{cases}$$

The costs to produce each product depend on the effort of the manager in charge of the synergistic activity (the business-unit managers under non-integration, and the functional manager under integration) and the cost savings if standardization is implemented:

$$C_i = \mathbb{C} - ve_{iS} - \frac{k}{2} I. \tag{3}$$

We can normalize the constant $\mathbb{C}$ to 0 without loss of generality; both ex ante and ex post lump-sum transfers are allowed, so the constant plays no role in the analysis. We can also normalize the reservation utilities of all agents to 0. Then, using (1) we have that $w_i = E \sum_t e_{it}^2$. Profits can then be written in general as:

$$\pi = (k - \Delta_1 - \Delta_2) I + \sum_{i=1,2} \left(ve_{iL} + ve_{iS} - \frac{e_{iL}^2}{2} - \frac{e_{iS}^2}{2} \right). \tag{4}$$

Note that the number of agents (whether or not there is a functional manager) has no direct effect on profits– only the total amount of effort involved matters for cost, rather than who undertakes it.[13]

Contracts and Communication.

Total revenues and costs are contractible, but both effort and standardization are non-verifiable. We use the word standardization as shorthand for the myriad of tasks that must be undertaken to capture synergies. For an outsider, it is impossible to tell whether two widgets are customized in a meaningful way (hence, allowing the business-unit managers to benefit from local adaptation) or only in appearance. In other words, a judge will always observe that products are in fact different without knowing the extent to which their designs or production processes have been harmonized to produce cost savings. Second, we have in mind that functional managers continually make choices which involve a trade-off between

[13] In particular, this means that, holding effort fixed, profits are the same under integration without implementing standardization and non-integration. There are no losses in local adaptation from shifting control, just from implementing standardization. If employing a functional manager increases wage costs, our results are unchanged, since it would result in a fixed reduction of integration profits.

adaptation and standardization. To the extent that these choices are hard to anticipate, contracting on standardization is not feasible from a practical point of view. Instead, the organization is a governance structure which manages standardization decisions ex post.[14]

We further assume that contracts are linear in costs and revenues[15] and that budget balance holds.[16] Since manager 1 and 2 are identical, we restrict attention to symmetric contracts. Under integration, business-unit manager $i's$ contract then consists of a fixed wage and a share s_{bu} of R_i and a share $(1-s_f)$ of C_i. In choosing local effort e_{iL} and communicating with the functional manager, business-unit manager i then maximizes

$$\begin{aligned} \pi_{bu}^i(s_{bu}, s_f) &\equiv s_{bu}R_i - (1-s_f)C_i - \frac{e_{iL}^2}{2} \\ &= s_{bu}\left[ve_{iL} - \Delta_i I\right] + (1-s_f)\left[\frac{k}{2}I + ve_{iS}\right] - \frac{e_{iL}^2}{2} \end{aligned} \tag{5}$$

It is never optimal to allocate business-unit managers a share of the revenues of each other's divisions.[17] Since the functional manager will choose equal effort for both activities, $C_1 = C_2$ under integration. Thus, it is without loss of generality to give manager i a share in C_i, and not in C_j. Given budget-balance, the functional manager's share in R_i is $1-s_{bu}$ and his share in C_i is s_f. In choosing efforts e_{iS}, $i=1,2$, and deciding whether or not to standardize, a functional manager then maximizes

$$\begin{aligned} \pi_f(s_{bu}, s_f) &\equiv \sum_{i=1,2}\left((1-s_{bu})R_i - s_f R_i - \frac{e_{iS}^2}{2}\right) \\ &= \sum_{i=1,2}\left((1-s_{bu})\left[ve_{iL} - \Delta_i I\right] + s_f\left[\frac{k}{2}I + ve_{iS}\right] - \frac{e_{iS}^2}{2}\right) \end{aligned} \tag{6}$$

Under integration, the first-best standardization decision is contingent on the information of all three managers. Since actions are not contractible, mechanisms are infeasible, so infor-

[14] Other papers which emphasize the importance of organizations as governance structures when actions are ex post non-contractible are Aghion, Dewatripont and Rey (2002), Hart and Holmstrom (2002), Hart and Moore (2006) and Baker, Gibbons and Murphy (2006).

[15] Linear shares simplify the analysis, but are unlikely to be optimal. Since standardization is a $0-1$ decision and adaptation costs are binomial, it is possible to make inferences about effort from the distribution of contractible outcomes. Such inferences will be impractical, however, if there is additional noise in the observables. Since we assume risk-neutrality, the noise would affect nothing else in the model.

[16] Requring budget balance is a standard assumption (see Holmstrom (1982) and Legros and Matthews (1993)). An agent with the function of breaking this balance would have a strong incentive to sabotage production or misreport to direct output to himself. Budget balance is a natural way to have imperfect alignment in models of team production since it prevents all agents from bearing the full costs and benefits of their decisions. Alternatively we could consider risk aversion which would complicate the analysis substantially. See also footnote (21).

[17] Under integration, for a given s_f, providing managers a stake in each other's revenue not only lowers effort, but also makes communication more difficult. Under non-integration, the only impact of providing such an incentive is to lower effort.

mation aggregation occurs through "cheap talk." The business-unit managers simultaneously send a message to the functional manager about the cost of standardization to their unit, Δ_i. Since standardization is not contractible the functional manager cannot commit to his reactions to these messages.

Non-Integration Benchmark: Under non-integration standardization cannot occur, so communication plays no role. Each business-unit manager is assigned both the local and the synergistic activity. Since synergies can never be realized, equation (4) with $I = 0$ implies that profits uniquely depends on the efforts e_{iL} and e_{iS}, $i = 1, 2$. Trivially, each business manager is optimally given a full share in his cost and revenues. business-unit manager i chooses efforts e_{iL} and e_{iS} to maximize:

$$\pi_i^{NI} = R_i - C_i = ve_{iL} + ve_{iS} - \frac{e_{iL}^2}{2} - \frac{e_{iS}^2}{2}.$$

This results in first best effort, $e_{iL} = e_{iS} = v$. Total organizational profits are simply

$$\pi^{NI} = \pi_1^{NI} + \pi_2^{NI} = 2v^2.$$

4 Integration

4.1 Managerial behavior: Effort and decision-making

Synergistic activities must be integrated and assigned to a functional manager to allow for synergies to be realized. Efficient standardization requires information aggregation and a functional manager with the incentives to make the right decision. Both are in conflict with providing effort incentives for all managers. We now analyze this conflict.

Output has two components: effort (ve) and expected realized synergy ($k - \Delta_1 - \Delta_2$). We consider them separately, as effort is additive.

Effort. The effort component is straightforward. From (5) and (6), and given s_{bu} and s_f, effort decisions by the business unit and functional managers, are determined by:

$$\begin{aligned} e_{bu} &= \arg\max_e s_{bu}ve - \frac{e^2}{2}, && (7) \\ e_f &= \arg\max_e sve - \frac{e^2}{2}, && (8) \end{aligned}$$

so

$$e_{bu} = s_{bu}v; \quad e_f = s_f v$$

The additivity of the effort component in (5) and (6) means that each manager's effort depends neither on the standardization decision nor on other managers' effort, but only on his incentives, s_{bu} and s_f.

Decision-making and communication. The functional manager's standardization decision depends on his information. If there is no communication, he compares the expected adaptation cost $2\overline{\Delta}$ to his observation of cost-savings from standardization k. If communication occurs, the functional manager can compare the cost savings from standardization with the realized adaptation costs $\Delta_1 + \Delta_2$.

First, consider no communication. Whenever $s_{bu} < 1$, there exists a cutoff k_{nc} such that if $k < k_{nc}$, the functional manager does not standardize and the business-unit managers can adapt locally, while if the cost savings are high enough, $k > k_{nc}$, the functional manager standardizes. The cutoff k_{nc} is the value of cost savings at which the functional manager is indifferent between standardizing operations or not. From (6) the functional manager obtains a share s_f of the cost savings from standardization, and suffers a share $(1-s_{bu})$ of the revenue losses for each product, so k_{nc} solves $s_f k_{nc} - 2(1-s_{bu})\overline{\Delta} = 0$, which implies:

$$k_{nc} = \frac{2(1-s_{bu})}{s_f}\overline{\Delta}. \tag{9}$$

In contrast, if business-unit managers send credible messages about the value of adaptation for their products, then from (6), the functional manager standardizes operations if $s_f k - (1-s_{bu})(\Delta_1 + \Delta_2) > 0$. This condition determines a decision rule with three cutoff points, k_{LL}, k_{LH} and k_{HH}, with

$$k_{ij} = \frac{(1-s_{bu})(\Delta_i + \Delta_j)}{s_f} \quad i, j = L, H. \tag{10}$$

If the functional manager learns that adaptation costs are Δ_i and Δ_j, he standardizes if cost savings k are above the cut-off value k_{ij}. Note that the first best standardization cut-off is $k_{ij}^{fb} = (\Delta_i + \Delta_j)$.The extent to which we have too much or too little standardization depends on whether $\frac{1-s_{bu}}{s_f} \gtreqless 1$. It follows that

$$\ell \equiv \frac{1-s_{bu}}{s_f} \tag{11}$$

is a measure of balanced incentives and $1/\ell$ is a measure of distortion in the functional manager's standardization incentives.

- If $\ell = 0$ the functional manager cares only about cost savings and always standardizes;
- If $\ell < 1$, $k_{ij} < k_{ij}^{fb}$, the functional manager standardizes too often;
- If $\ell = 1$ all managers maximize expected profits (revenues minus costs), so the cutoff values k_{ij} and k_{nc} for standardization are set at first-best (conditional on the functional

manager's information).[18]

Thus we have a trade-off between effort incentives (which requires $s_i = 1$) and efficient decision-making. The following proposition states, without proof, this result.

Proposition 1 *If first-best effort incentives are provided to all managers $s_{bu} = 1$ and $s_f = 1$, synergies are always implemented. Integration is value-destroying if $K/2 < 2\overline{\Delta}$.*

Standardization decisions sensitive to the size of synergies and benefits of adaptation require that the aims of the managers be somewhat aligned. Strong incentives are thus an obstacle to the organization's ability to implement trade-offs between synergies and adaptation.

Reducing the share of output that each manager obtains from his own unit can mitigate this problem. First, conditional on whatever communication occurs, such a reduction in effort incentives improves implementation, by giving the functional manager a stake in the organization-wide benefits from local adaptation. A functional manager that shares in profits from the local adaptation will give up on standardization (when k is low) and allow local adaptation by the business-unit managers. This occurs even if there is no communication from the business-unit managers (see (9)). Second, if incentives are sufficiently aligned, business- managers may be able to credibly represent the costs to them of not adapting to local conditions.

4.2 Incentives and decision-making with exogenous communication

We now analyze incentive design, taking as given the communication – or lack thereof – among business unit and functional managers. As argued above, with first-best effort incentives $s_f = s_{bu} = 1$, the functional manager always standardizes. If the functional manager is given a share in the revenues of the business units, however, he will not standardize if the cost savings k are sufficiently low.

Suppose first that there is no communication. Substituting e from (7) and (**??**) in (4) and integrating over the unknown Δ_i and k (recall that k is uniformly distributed on $[0, K]$), the incentive design problem of the organization is:[19]

$$\max_{s_{bu},s_f} \pi = \max_{s_{bu},s_f} \frac{(1-p)^2}{K} \int_{k_{nc}}^{K} (k - 2\Delta_L) dk + \frac{2(1-p)p}{K} \int_{k_{nc}}^{K} (k - \Delta_L - \Delta_H) dk + \quad (12)$$
$$+\frac{p^2}{K} \int_{k_{nc}}^{K} (k - 2\Delta_H) dk + v s_{bu}(2 - s_{bu}) + v s_f (2 - s_f).$$

[18] The case $\ell > 1$ is never optimal, as we show later. Intuitively, biases are always in the direction of encouraging effort and $s_i > 1/2$.

[19] To simiplify notation, we drop the superscript i in this section and write π for profits under integration.

Since the decision to impose standardization is taken whenever $k > k_{nc}$, all integrals (regardless of Δ) are taken between k_{nc} defined in (9) and K. If instead, product managers communicate their information, the organization's profits are:

$$\max_{s_{bu},s_f} \pi = \max_{s_{bu},s_f} \frac{(1-p)^2}{K} \int_{k_{LL}}^{K} (k - 2\Delta_L)\, dk + \frac{2\,(1-p)\,p}{K} \int_{k_{LH}}^{K} (k - \Delta_L - \Delta_H)\, dk \quad (13)$$
$$+\frac{p^2}{K} \int_{k_{HH}}^{K} (k - 2\Delta_H) dk + s_{bu}(2 - s_{bu})v + s_f(2 - s_f)v.$$

The standardization decision is now conditional on the realization of Δ_1 and Δ_2, and thus each one of the three integrals is taken over a different cutoff k_{ij} as given in (10).

Rather than using the shares s_{bu} and s_f, it is useful to maximize over $\ell \equiv (1-s_{bu})/s_f$ and s_f. Then, substituting the value for s_{bu} (11) and k_{nc} (9) into π, we have a function $\pi(\ell, s_f)$. Taking derivatives with respect to ℓ and s_f, we can write the first-order conditions of both of the above problems (12) and (13) in the same form:

$$\pi_\ell = \frac{1}{2}(1-\ell)\frac{\gamma}{K} - 2s_f^2 \ell v = 0 \quad (14)$$
$$\pi_{s_f} = 2\left[(1-s_f) - s_f \ell^2\right] v = 0. \quad (15)$$

The parameter γ summarizes the value of the decision, and depends on the available information regarding adaptation costs:

$$\gamma = \begin{cases} \gamma^{nc} \equiv 4\overline{\Delta}^2 & \text{no communication by business units,} \\ \gamma^{c} \equiv E[(\Delta_1 + \Delta_2)^2] & \text{communication by business units.} \end{cases}$$

We denote by s_f^{nc} and s_{bu}^{nc} the optimal shares when Δ_1 and Δ_2 are unknown (and thus $\gamma = \gamma^{nc}$) and $\tilde{s}_f^c$ and $\tilde{s}_{bu}^c$ the optimal shares when Δ_1 and Δ_2 are observable to the functional manager (and thus $\gamma = \gamma^c$). [20]

From these first-order conditions, two immediate results follow for both the communication and no communication cases. First, the effort incentives of all managers are not first-best, that is improving the standardization decision of the functional manager requires reducing effort incentives of all managers below first-best. To see this, it must be that $\ell > 0$, since otherwise $\pi_\ell > 0$. This means that $s_{bu} < 1$ and, since $\pi_{s_f} = 0$, it must also be that $s_f < 1$. Second, decision-making by the functional manager is biased towards cost savings. To see

[20] We reserve the notation s_f^c and s_{bu}^c for the optimal shares when communication is endogenous and s_f and s_{bu} must satisfy an additional communication constraint, so that is why we use $\tilde{s}_f^c, \tilde{s}_{bu}^c$ here.

this, we must have $\ell < 1$, otherwise $\pi_\ell < 0$. In sum, the organization trades off more efficient standardization decisions against better effort incentives for the managers.

Lemma 1 *The agents' optimal output shares have $s_{bu} < 1$ and $s_f < 1$, so that both types of agents exert less than first-best effort. Moreover, functional decision-making is distorted as incentives are never perfectly aligned, that is $\ell < 1$. Too much standardization is imposed in equilibrium, that is the equilibrium cutoff values for standardization are below the first-best: $k_{ij} < k_{ij}^{fb}$ for $i, j = L, H$ under communication and $k_{nc} < k_{nc}^{fb}$ under no communication.*

Intuitively, at $s_i = 1$ we have first-best incentives for effort; a decrease in s_i results in a second-order loss in effort incentives and a first-order gain in decision-making incentives (because the lower bound of the distribution of k is 0). At $s_f = 1 - s_{bu}$ we have first-best decision-making incentives; an increase in managers' own shares results in a first-order gain in effort incentives and a second-order loss in decision-making incentives. Thus in order to ensure more efficient ex-post decision-making, the organization chooses to distort somewhat effort incentives. The way incentives are misaligned, $\ell < 1$, implies that the functional manager cares more about his own output. Thus he chooses standardization even when, in fact, (expected) synergies are negative; his share of business unit profits is not high enough to compensate him completely for foregoing the standardization benefits. For example, without communication, the efficient decision is to standardize if $k - 2\overline{\Delta} > 0$; but the actual rule the functional manager follows is standardize if $s_f k > 2(1 - s_{bu})\overline{\Delta}$ which is easier to satisfy. As a result, sometimes standardization occurs when it is not efficient.

We next analyze what determines the extent of this distortion. From the first-order conditions (14) and (15), we have that

$$\frac{\partial^2 \pi(s_f, \ell)}{\partial(-\ell)\partial\tau} > 0 \quad \text{and} \quad \frac{\partial \pi(s_f, \ell)}{\partial s_f \partial\tau} > 0$$

for $\tau \in \{\nu, K, -\gamma\}$. Since also

$$\frac{\partial^2 \pi(s_f, \ell)}{\partial(-\ell)\partial s_f} > 0,$$

then $\pi(s_f, -\ell, \tau)$ is supermodular for $\tau \in \{\nu, K, -\gamma\}$. The following lemma follows immediately

Lemma 2 *Functional decision-making distortions, as given by $1/\ell = s_f/(1 - s_{bu})$, and functional effort incentives s_f are increasing in marginal product of effort v, expected value of standardization, K and value of adaptation $-\gamma$.*

Intuitively, providing balanced incentives to the functional manager (setting ℓ close to 1) is less important when the expected cost saving $K/2$ are high because it is efficient to standardize more often anyway. Providing balanced incentives is more costly when effort incentives are more important (v high). Moreover, providing balanced incentives is more valuable when the functional manager is informed about Δ_1 and Δ_2; since $\gamma^{nc} \equiv 4\overline{\Delta}^2 > \gamma^c = E(\Delta_1 + \Delta_2)^2$, we have that $\ell^{nc} > \ell^c$. For given incentives, the functional manager makes better decisions when he is better informed. Better information by the functional manager about the revenue losses associated with adaptation therefore raises the marginal value of more balanced incentives for standardization decisions without affecting the marginal cost in incentives for effort.[21]

Thus communication between business unit and functional managers results in reduced equilibrium effort incentives, even if communication is free. We next analyze when and how the organization may choose to further balance incentives in order to make communication effective.

4.3 Incentives and communication

We have so far demonstrated a trade-off between efficient decision-making by the functional manager and effort incentives for all managers, taking the quality of information aggregation as given. However, the organization must also decide whether or not to induce communication between business unit and functional managers.

Communication constraint We now analyze the truth-telling constraint of a business-unit manager who decides whether or not to truthfully report the cost of lost local adaptation from standardization. When the business-unit manager sends a message to the functional manager, he does not know the value of cost savings k; he must decide what to say based on the distribution of k. The business-unit manager who is tempted to lie is Δ_L because the business-unit manager wants less standardization than the functional manager whenever incentives are not completely balanced. Figure 2 below show the value of truthtelling versus lying graphically, conditional on the other manager having drawn Δ_L as well. By lying, the manager shifts the implementation rule from k_{LL} to k_{LH} if the other manager is Δ_L and

[21] In our model, budget balance imposes a mechanical link between providing balanced incentives to the business unit managers and providing balanced incentives for the functional manager. The above observation shows that this complementarity holds more generally if business managers need to be motivated to communicate $\Delta_1$and Δ_2. Providing business unit managers with balanced incentives is then more valuable if the functional manager is also induced to make efficient standardization decisions. It is for this reason that we believe budget balance is less restrictive than it may appear.

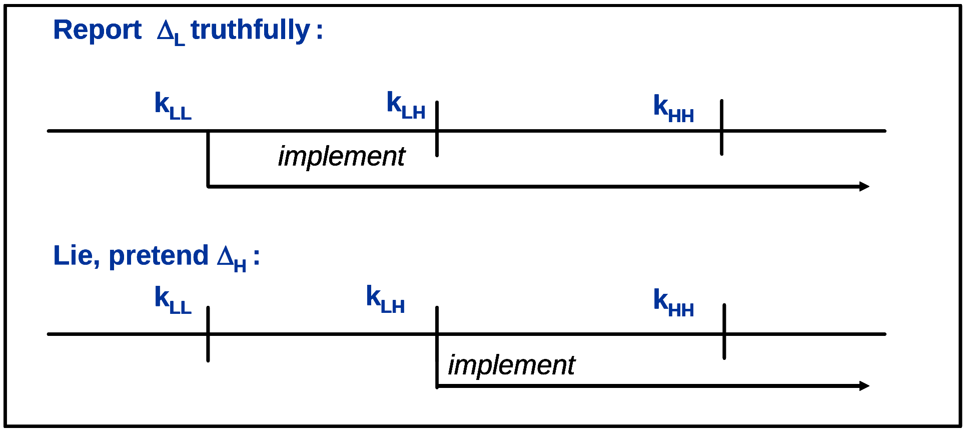

Figure 2: Communication choice of a business unit manager who draws Δ_L when the other manager draws Δ_L.By lying, the manager shifts upwards the threshold value of the standardization savings k.

from k_{LH} to k_{HH} if the other manager is Δ_H. Truthfully reporting Δ_L is preferred if:

$$\begin{aligned}
&\frac{(1-p)}{K}\int_{k_{LL}}^{K}\left((1-s_f)\frac{k}{2}-s_{bu}\Delta_L\right)dk+\frac{p}{K}\int_{k_{LH}}^{K}\left((1-s_f)\frac{k}{2}-s_{bu}\Delta_L\right)dk \\
\geq\ &\frac{(1-p)}{K}\int_{k_{LH}}^{K}\left((1-s_f)\frac{k}{2}-s_{bu}\Delta_L\right)dk+\frac{p}{K}\int_{k_{HH}}^{K}\left((1-s_f)\frac{k}{2}-s_{bu}\Delta_L\right)dk.
\end{aligned}$$

The left-hand side of this inequality is the payoff of correctly communicating Δ_L. In this case, with probability $(1-p)$ the other agent also reports Δ_L (the upper choice in Figure 2), in which case the probability of synergies being implemented is the probability that $k > k_{LL}$; while with probability p the other agent reports Δ_H, in which case the probability of synergies being implemented is the probability that $k > k_{LH}$. On the other hand, if the agent lies, the integral is taken over a smaller set of k's: in the first case (if, the other agent draws Δ_L) for values $k > k_{LH}$,(the lower 'pretend' choice in Figure 2) in the second (when, with probability p, the other agent draws Δ_H) over $k > k_{HH}$.

That is, the value of lying is in the increase in the value of k that the functional manager has to observe before he decides whether or not to implement synergies. The integrals simplify in the obvious way, and the IC constraint becomes:

$$\frac{(1-p)}{K}\int_{k_{LL}}^{k_{LH}}\left((1-s_f)\frac{k}{2}-s_{bu}\Delta_L\right)dk+\frac{p}{K}\int_{k_{LH}}^{k_{HH}}\left((1-s_f)\frac{k}{2}-s_{bu}\Delta_L\right)dk>0. \tag{16}$$

Since $p = 1/2$, the IC constraint becomes, after some simple manipulation:

$$\frac{(1-s_f)(1-s_{bu})}{s_{bu}s_f} \geq \frac{2\Delta_L}{\Delta_L + \Delta_H} \tag{17}$$

For given shares, the IC constraint is harder to satisfy when Δ_H and Δ_L are close to each other. Second, for a given pair of Δs, the constraint is easier to satisfy when the left-hand side is higher, that is when incentives are more balanced. In particular, if both shares are 1/2, the left hand side of the IC constraint is 1, and truthful communication is always incentive compatible regardless of the values of Δ.

Whether the constraint (17) binds is crucial for how incentives will be chosen. We consider the optimal choice of incentives in two cases: (1) when the optimal choice of s_{bu} and s_f for implementation is such that the constraint (17) is satisfied – in this case communication does not involve further distortions, and (2) when communication requires that the constraint binds.

Effort provision versus communication First, if the constraint (17) is satisfied given $\tilde{s}_f^c$ and $\tilde{s}_{bu}^c$ (the optimal incentives when the functional managers knows Δ_1 and Δ_2), then trivially, it is always optimal to induce communication and shares are $\tilde{s}_f^c$ and $\tilde{s}_{bu}^c$.

If on the other hand, (17) is not satisfied at $\tilde{s}_f^c$ and $\tilde{s}_{bu}^c$, then truthful communication requires greater balancing of incentives. Intuitively, a business-unit manager is more willing to tell the functional manager that adaptation costs are low if he shares more in the cost savings from standardization and if the functional manager internalizes more of the business units adaptation costs. Organizations then can choose between strong effort incentives with little information flow between units or weak effort incentives with better communication.

We denote by s_f^c and s_{bu}^c, the optimal incentives if the organization chooses to induce truthful communication. The next lemma shows how this requires dulling effort incentives, relative to a case where (i) the functional manager is uninformed about Δ_1 and Δ_2 (optimal incentives s_f^{nc} and s_{bu}^{nc}) and (ii) the functional manager publicly observes Δ_1 and Δ_2 (optimal incentives $\tilde{s}_f^c$ and $\tilde{s}_{bu}^c$).

Lemma 3 *Let s_f^c and s_{bu}^c be the optimal incentives if the organization induces communication, then*

$$s_f^c/(1-s_{bu}^c) \leq \tilde{s}_f^c/(1-\tilde{s}_{bu}^c) < s_f^{nc}/(1-s_{bu}^{nc})$$

where the first inequality is strict whenever the communication constraint (17) is not satisfied given $\tilde{s}_f^c$ and $\tilde{s}_{bu}^c$.

4.4 Effort, communication and decision-making: Comparative statics

Lemma 3 shows the cost of inducing communication. We now discuss the consequences of these costs for the choice of whether or not to induce communication. The following proposition establishes that as the average size of the synergies K increases and as the importance of effort v increases, inducing communication becomes less attractive to the organization:

Proposition 2

1. *If it is optimal for the organization to induce communication given K' and v', then it is also to induce communication for any (K, v) with $K \leq K'$ and $v \leq v'$.*

2. *If it is optimal for the organization to induce communication given (Δ_H, Δ_L) with mean $\bar{\Delta}$, then it is optimal to induce communication for any (Δ'_H, Δ'_L) with the same mean $\overline{\Delta}$ and $\Delta'_H - \Delta'_L > \Delta_H - \Delta_L$.*

3. *In contrast, if either $K > K'$ or $v > v'$ or $\Delta'_H - \Delta'_L < \Delta_H - \Delta_L$, then the organization may decide to forego communication. This is accompanied by a discrete increase in functional effort incentives, s_f, and distortions in decision-making, $1/\ell$.*

Figure 3 illustrates this result. In the example, when expected synergies are relatively low, making the standardization decision contingent on the associated adaptation costs is important. Moreover, it is relatively easy to align the incentives of functional and business-unit managers to ensure communication. Inducing communication then comes at no cost, and it is always optimal to do so. As expected synergies increase, functional managers are too prone to standardization, and thus it is difficult to motivate business-unit managers with low adaptation costs to communicate their type. Truthful communication requires distorting the incentives of managers to align both of them. In this case, the organization faces a trade-off between communication and effort incentives. If expected synergies are sufficiently high, ensuring communication about the local adaptation parameter becomes too costly, and the organization foregoes communication in order to allow for higher powered effort incentives. Similar intuition holds for the value of effort incentives v.

In Lemma 2, we have already shown how functional effort and decision-making distortions are increasing in the level of synergies K and the value of effort, v, when communication is exogenous. Similarly, Proposition 3 shows how an increase in K and v may result in a discrete jump in effort and decision-making distortions when the organizations decides to forego communication. The following proposition provides a full characterization of these comparative statics, where communication is an organizational choice and must be endogenously induced:

Proposition 3 *Let s_f and s_{bu} be optimal incentives for the functional and business-unit managers. Distortions in decision-making by the functional manager, as characterized by $s_f/(1 - s_{bu})$, and business unit effort incentives, s_{bu}, are increasing in value of effort v and* *the level of the synergies K. Effort incentives for the functional manager s_f are increasing in K and v, except when the communication constraint is binding and the organization chooses to induce communication.*

5 The costs and benefits of integration

An organization can realize synergies by reallocating tasks and employing a functional manager in charge of finding them. As we show, such a manager will be endogenously biased in favor of standardization. Because it is not possible to distinguish whether costs were low because the manager worked hard or because he standardized output and reduced adaptation, the only way to avoid bias is by dulling his incentives for cost reduction. Moreover in order to make decisions contingent on all available information, communication must be credible, which requires dulling the incentives of the business-unit managers. In other words, the benefit of integration is that synergies may be captured; the cost is that incentives must be dulled to achieve some incentive alignment, and local adaptation is neglected. As we show next, a firm may therefore strictly prefer to forego any potential synergies and stick to a non-integrated organization.

When is integration preferred? The following proposition states that integration is only useful if expected cost savings from standardization, measured by K, are sufficiently large, where the threshold value for K is increasing in the importance of incentives.

Proposition 4 *For any $K < 2(\Delta_L + \Delta_H)$, there exists a $\tilde{v}(K)$ with $\tilde{v}'(K) > 0$ such that non-integration is strictly preferred if and only if $v > \tilde{v}(K)$.*

That is, regardless of the importance of effort incentives, integration is always optimal if standardization savings are large enough. The example below illustrates the impact of incentives and standardization value on the integration decision and the communication rules.

Example 1. Let $\Delta_h = 3, \Delta_l = 1$. Figure 3 computes the optimal organizational structure for $k \in [6, 10]$, and $v \in [1, 3.5]$, and shows the incentive strength through the darkness of the color (the darker, the more high-powered managerial incentives). The example shows that the organizational design-incentive space is divided in three regions.

Note from the figure that in general, effort incentives (and effort distortions) are non-monotonic in standardization savings K. When K is low, two non-integrated business units are best, as they provide maximum incentives. When expected gains from standardization increase, contingent decision making is valuable. This requires providing low-powered incentives to the business units so that communication from them is credible. Finally, for high

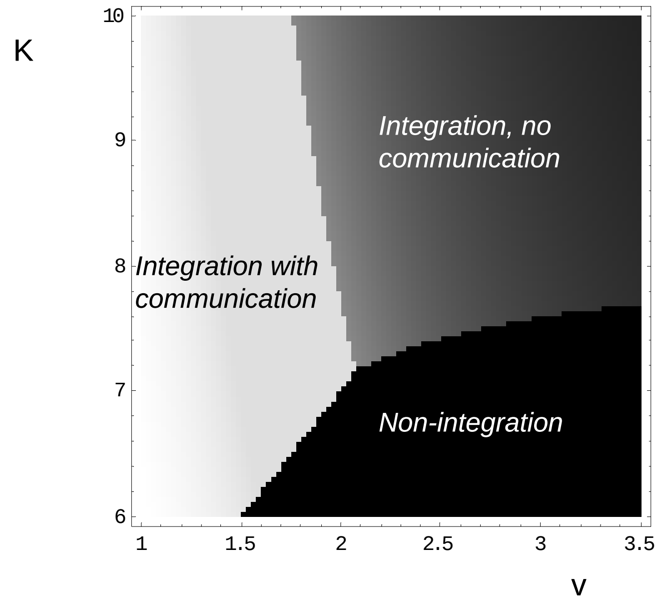

Figure 3: Integration choice and effort incentives as a function of the marginal value of effort, v, and the importance of the synergies, K. Darker color means higher effort incentives.

standardization savings and thus high expected synergies, the organization gives up on communication; this allows for a large discrete increase in incentives with little loss, since the likelihood that synergies are positive is high.

Beyond the expected value of synergies, a second important determinant of the choice of functional form is the variance of foreseeable adaptation costs $(\Delta_1 + \Delta_2)$ as characterized by $\Delta_H - \Delta_L$. This variance measures the value of ex post (conditional on realized k and Δ) decision making for the organization. Intuitively, increasing this variance makes it easier to satisfy the communication constraint. Moreover, it also makes it more valuable to make decisions ex post. As a result, when the spread increases, the organizational design shifts towards functional control, as the next proposition shows.

Proposition 5 *An increase in the variance of adaptation costs as characterized by* $(\Delta_H - \Delta_L)$ *for a given* v, K, *and* $\overline{\Delta}$, *may lead to a shift from non-integration to integration but never the other way around.*

Example 2. Figure 4 presents illustrates this result for some parameter values. In particular, $k = 6, \overline{\Delta} = 2, v \in [0.25, 4]$, *and* $\Delta_H - \Delta_L \in [0.25, 1]$. *The figure shows two of the regions described in Figure 1. As we increase the spread of* Δ *we move from non-integration towards integration with communication. Intuitively, the latter form allows contingent decision-making which is both cheaper (as the incentive constraint is less likely to*

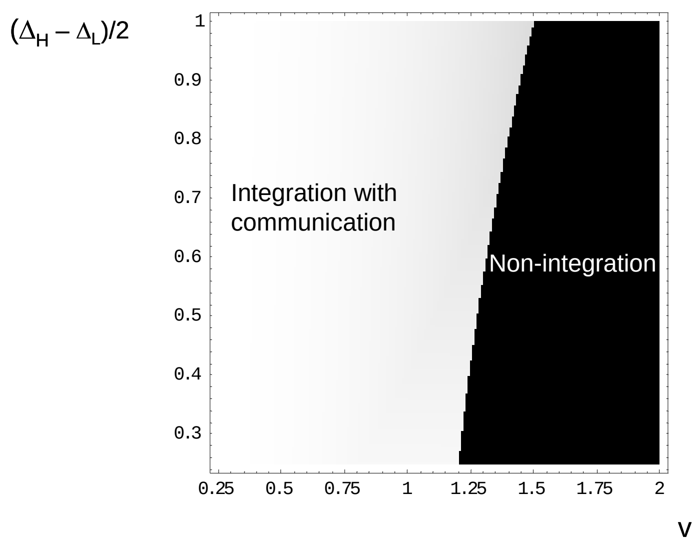

Figure 4: Organizational choice and communication regime as a function of the value of the marginal value of effort v and the spread $\Delta_H - \Delta_L$

bind) and more profitable (as contingent decision-making is more valuable) when uncertainty is higher.

Since equilibrium behavior by managers results in second best effort and standardization decisions, the value increase from the merger will be less than the size of the potential synergies. This gap is the 'organizational discount' that must be applied in valuing a merger. The analysis in the propositions above provides some insights into the size of this organizational discount.

First, the higher the synergies, the lower the 'organizational discount' that must be applied to a merger, all else constant (see e.g. Fig 3). The reason is that, as synergies get sufficiently high, contingent decision-making is less important and so are balanced incentives. For sufficiently high synergies, providing the functional managers with high-powered incentives has low cost in terms of inefficient decisions and of non-credible communication from business-unit managers (it can be ignored with a high likelihood anyway). Second, the organizational discount increases with the importance of incentives, and integration decisions are less likely to be undertaken where incentives matter. Third, as Proposition 5 shows, more uncertainty in the form of ex ante variability of adaptation costs favors the merger, as part of the merger upside is that by undertaking it one preserves the option to standardize production processes and capture potentially large synergies, and as credible communication is facilitated when the variance in outcomes is high.

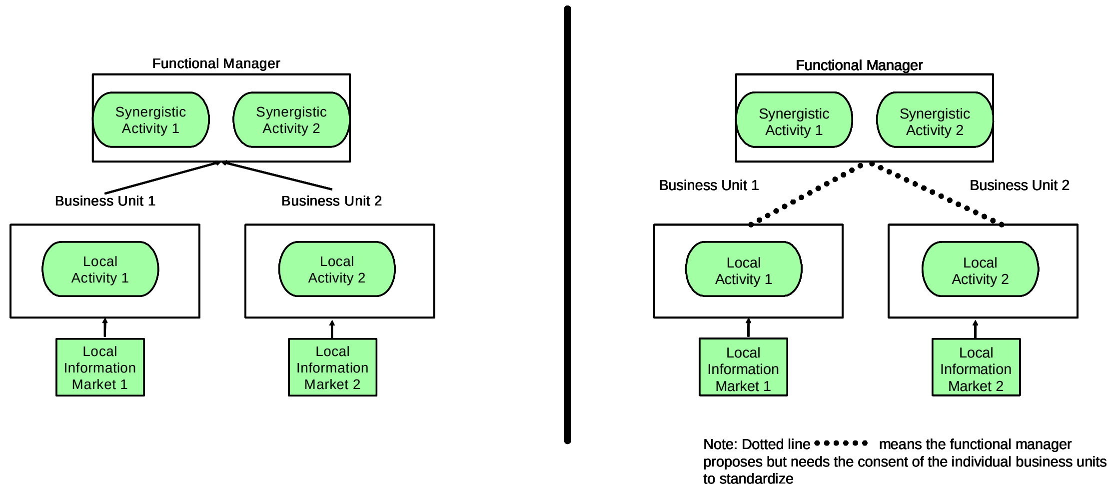

Figure 5: Integration– Functional Control Integration– Functional Initiative

6 Functional initiative

Organizations may try to achieve synergies without providing control to the functional managers. For example, Suchard tried a different approach to attain marketing synergies than its approach to manufacturing synergies. In manufacturing, as we already discussed, Suchard consolidated production and shifted control to new plant managers. In marketing, it appointed "global brand sponsors" for each of the five major confectionery brands. These were general managers of geographically-defined business who were given the additional responsibility to promote their brands globally, develop new products, and standardize brands and packaging across countries. However, control remained with the country general managers; the sponsors could only suggest standardization initiatives. Similarly, after the first World Trade Center attack in 1993, the FBI, which previously was structured in a decentralized way around field offices, determined that this organization served the counterterrorism task poorly. It thus created a separate Counterterrorism and Counterintelligence Division "intended to ensure sufficient focus on these two national security missions." However, the FBI changed neither the career incentives nor the authority of the local offices,[22] and by all accounts, it captured very few between-office synergies (particularly in counterterrorism). In this section we study the extent to which this type of 'dotted-line' control or 'functional initiative' can succeed, and when such a design may be preferred to providing the functional managers with the control to implement standardization.

We show that it is very costly in terms of effort incentives to implement win-lose syn-

[22] All of the information on the FBI comes from the National Commission on Terrorist Attacks upon the United States, Staff Statement No. 9: "Law Enforcement, Counterterrorism, and Intelligence Collection in the United States Prior to 9/11."

ergies – where one business unit is a loser from standardization ($\Delta = \Delta_H$) and the other is a winner ($\Delta = \Delta_L$) – without providing control to the functional manager. In contrast, implementing only win-win synergies – where both business units have low adaptation costs ($\Delta_1 = \Delta_2 = \Delta_L$) – can be achieved with relatively low incentive costs. When effort incentives are not very important, it is desirable to implement win-lose synergies and functional control is preferred. When effort incentives become more important, however, it may be optimal to shift control to the business-unit managers and standardize only if both managers face low adaptation costs. This allows for high-powered incentives and may be better than simply letting the functional manager impose standardization unilaterally (functional control without communication).

Previously we assumed that realizing synergies required a functional manager to undertake the synergistic activities for both products. As part of his task assignment, the functional manager exerts effort in each of the synergistic activities and decides whether or not to standardize. Implicit in this view is that business-unit managers have no power to affect this standardization. Under 'dotted-line' control, we continue to assume a functional manager is needed to identify cost-saving opportunities and undertake the synergistic activities. However, it is now possible for the business-unit managers to block standardization. For example, the business-unit managers could be left in control of some inputs in production, so their cooperation is needed for standardization. As before, we assume that cooperation by the business-unit manager with the functional manager is non-contractible, and can only be affected by output incentives. Standardization only occurs if both business-unit managers agree to it.

We need to modify the extensive form of the game slightly to incorporate functional initiative. We add a final stage in which each business-unit manager decides whether or not to block standardization. The preceding stages are as before: First, the business-unit managers have the opportunity to communicate their types to the functional manager. Second, the functional manager decides if he wants to standardize. If he does, each business-unit manager then decides whether or not to block standardization.[23]

Our analysis of this game divides into three cases. The simplest case is if business-unit managers never cooperate with standardization. In this case, it is optimal to set s_f and s_{bu} equal to 1, so business-unit managers indeed never benefit from any potential synergy. This is equivalent to the non-integration benchmark we analyzed in Section 3. The second case is where only business-unit managers with low standardization costs ($\Delta = \Delta_L$), cooperate with a standardization initiative by the functional manager. The third case is where business-unit

[23] The value of functional initiative cannot be increased by changing the timing of communication. We show in the Appendix that it is weakly optimal to let the business unit managers communicate before the functional manager takes an initiative. Moreover, except for letting the functional manager express his desire about whether or not to implement standardization (by initiating a standardization or not), it is without loss of generality to ignore any communication from the functional manager to the business unit managers.

managers always cooperate with a standardization initiative by the functional manager.[24]

6.1 Win-win synergies and functional initiative

We now study the case where only business-unit managers with low standardization costs $(\Delta = \Delta_L)$, cooperate with a functional manager's standardization initiative. We show that the organization can implement this win-win standardization at a lower cost than functional control.

Acceptance constraint We first characterize the conditions under which a Δ_L manager cooperates with the functional manager. If only Δ_L managers cooperate, we can neglect the first communication stage where business-unit managers transmit information about the value of adaptation to them. Since this information only matters if both business-unit managers are Δ_L, the functional manager proposes to standardize only if it is valuable for him assuming that both business unit face revenue losses Δ_L, that is if $s_f k > 2(1 - s_{bu})\Delta_L$ or:

$$k > k_{LL} = \frac{(1 - s_{bu})}{s_f}[2\Delta_L]$$

Given this cut-off, the Δ_L manager compares expected profits if standardization takes place $\frac{1}{2}(1 - s_f)E[k]$, with his adaptation losses $s_{bu}\Delta_L$. It follows that a Δ_L product manager will accept standardization if and only if

$$\frac{K + k_{LL}}{4} > \frac{s_{bu}}{1 - s_f}\Delta_L$$

or

$$K > \left[\frac{2s_{bu}}{1 - s_{bu}} - \frac{1 - s_f}{s_f}\right] 2\Delta_L \tag{AC}$$

We refer to the above incentive constraint as the 'acceptance constraint' (AC). It plays a similar role in the analysis as the communication constraint in the case of integration with functional control.

The following lemma shows that the acceptance constraint is always easier to satisfy than the communication constraint.

[24] So far we have assumed that business units managers did not share in each other's revenues. This was without loss of generality in the functional control case as we discussed in footnote (17). Under functional initiative, if business unit managers receive a share in each other's revenues, it may be feasible to implement a structure where standardization efforts are blocked only when $(\Delta_i, \Delta_j) = (\Delta_H, \Delta_H)$. As we will show, however, such a structure is always dominated by functional control when effort incentives are not very important. Since giving business unit managers a share in each other's revenues dilutes effort incentives, we conjecture that such a structure will also be rarely valuable if effort incentives are important. Revenue sharing between business unit managers is not valuable in the other three cases we analyze in the text.

Lemma 4 *A Δ_L manager is willing to accommodate a standardization initiative for any s_f and s_{bu}, (with $s_f + s_{bu} > 1$, which always holds in equilibrium) such that the communication constraint (16) is satisfied.*

Under functional initiative, a Δ_L manager who blocks standardization prevents standardization for any value of k. In contrast, under functional control, a Δ_L manager who lies does not block standardization when k is large; he only induces the functional manager to have a more conservative threshold (moving it from k_{LL} to k_{LH} or from k_{LH} to k_{HH}). Therefore, under functional control incentives must be quite close to balanced in order to induce a Δ_L manager to reveal his type, while under functional initiative a Δ_L manager will be reluctant to block all standardization unless incentives are very unbalanced. Thus, it is less costly in incentive terms to meet the acceptance constraint than the communication constraint. More generally, giving control over actions to those with private information allows for a better use of this information.[25]

Optimization The design problem now involves choosing incentives that trade off efficient standardization decisions and effort, conditional on the Δ_L manager being willing to rubberstamp a standardization initiative. Analogously to Section 4, the expected profits of the organization can now be written as:

$$\max_{s_{bu},s_f} \pi = \max_{s_{bu},s_f} \frac{(1-p)^2}{K} \int_{k_{LL}}^{K} (k - 2\Delta_L)\, dk + s_{bu}(2 - s_{bu})v + s_f(2 - s_f)v \qquad (18)$$

subject to (AC).

When the constraint does not bind, the first order conditions are analogous to the ones under functional control:

$$\begin{aligned} \pi_\ell &= \frac{1}{2}\left[1-\ell\right]\frac{\gamma^{fi}}{K} - 2s_f^2 \ell v = 0 & (19) \\ \pi_{s_f} &= 2\left[(1-s_f) - s_f \ell^2\right] v = 0, & (20) \end{aligned}$$

where $\gamma^{fi} = {\Delta_L}^2$

Note the similarity between these first order conditions and the ones under integration with functional control (14 and 15) – the only difference is here $\gamma = \gamma^{fi} = {\Delta_L}^2$ while

[25] That it may be useful to have control colocated with information is not surprising in contexts where communication is not possible or very expensive (e.g. Jensen and Meckling 1992). We show (as has Dessein 2002) that this is also the case when communication is not costly but strategic and hence agents are prone to distort their information to influence decision making.

under functional control with communication $\gamma = \gamma^c = E\left[(\Delta_1 + \Delta_2)^2\right]$. The benefit of high-powered effort incentives is as before; the cost is now less severe, as there is only standardization when both $\Delta_1 = \Delta_2 = \Delta_L$. Moreover as we have noted before, this optimization is subject to an incentive compatibility constraint that is strictly weaker than the one under separation.

Proposition 6 *Under functional initiative with win-win synergies, decision making distortions as measured by $s_f/(1 - s_{bu})$ are strictly increasing in K and v, and decreasing in Δ_L. They do not depend on Δ_H. Moreover, $s_f/(1 - s_{bu}) > 1$.*

Intuitively, as K increases, business-unit managers are more willing to accommodate standardization. So local incentives can be strengthened without violating the acceptance constraint. Moreover, if the acceptance constraint is non-binding, a larger K makes it less important to discipline the functional manager and improve the quality of his recommendation. In the same vein, a decrease in Δ_L makes it easier to satisfy the acceptance constraint and decreases the benefits from improving the functional manager's recommendation. Note that the intuition for the comparative statics with respect to K is similar to that provided under integration with functional control, except that there, K affects business-unit manager communication (as opposed to decision-making) and functional manager decision-making (as opposed to communication).

We now compare optimal incentives under integration with functional initiative with those under integration with functional control. Intuitively, there is now less value to align the incentives of the functional manager because his decision only matters if both types are Δ_L, which happens with probability p^2 under functional initiative. In addition, as we argued before, the acceptance constraint which guarantees that business-unit managers of type Δ_L are willing to accommodate the functional manager, is strictly weaker than the communication constraint under functional control. It follows that if the communication constraint is satisfied under functional control, it must be that incentives are higher under functional initiative.

Proposition 7 *Let s_f^c and s_{bu}^c be the optimal incentives under functional control with (Δ_L) communication and s_f^{fi} and s_{bu}^{fi} be the optimal incentives under functional initiative with Δ_L cooperation, then $s_f^{fi}/(1 - s_{bu}^{fi}) > s_f^c/(1 - s_{bu}^c)$.*

6.2 Implementing win-win and win-lose synergies

If business-unit managers always cooperate with the functional manager, it is *as if* the functional manager has control. We refer to this as "informal" functional control. The key difference with the "formal" functional control, analyzed in Section 4, is that s_f and s_{bu} must satisfy an additional constraint which guarantees that a Δ_H manager is effectively willing to cooperate with the functional manager. Hence, if it is optimal to induce all business-unit managers to cooperate with any standardization initiative, then we can do at least as well by giving the functional manager formal control. Clearly, then, formal functional control is at least as good as informal control.

Proposition 8 *If, under functional initiative, business-unit managers always cooperate, integration through functional control is weakly preferred.*

Functional initiative may, in fact, be strictly worse than functional control; the additional constraints will not typically be satisfied. Intuitively, for a given set of shares, when one manager has a high adaptation cost Δ_H, optimal standardization will often result in a winner and a loser among the business managers – that is the Δ_H business-unit manager will actually be better off without it. In this case, under 'dotted line' control, losers will block standardization moves. In contrast, under functional control this is not a problem, since the functional manager does not need the consent of the high cost business unit. Moreover, efficient information aggregation will take place, since the winner – the Δ_L manager who benefits from standardization – will be happy to reveal his type. It follows that, in order to implement win-lose synergies, the organization needs to distort effort incentives to a larger degree under functional initiative than under functional control.

To see this more formally, consider, for example, the case where $K = 2\Delta_H$. With balanced incentives, that is $s_f = s_{bu} = 1/2$, functional control implements first-best standardization decisions. The functional manager then puts as much weight on his cost savings as on the revenue losses in the two business units. Consider now the same balanced incentives under functional initiative and let business unit 1 faces a high adaptation cost Δ_H and business unit 2 a low adaptation cost Δ_L. Given $s_f = s_{bu} = 1/2$, the functional manager initiates standardization if and only if $k > \Delta_H + \Delta_L$. Note that this standardization cut-off is first best. Also business-unit manager 1, facing a low adaptation cost, is willing to cooperate. Unfortunately, business-unit manager 2, who faces a high adaptation cost, is strictly worse off with standardization and will block it. Indeed, his share in cost savings is only $(1 - s_f)/2$. Hence, given $s_{bu} = s_f = 1/2$, he will cooperate with a standardization initiative if and only if

$$s_{bu}\Delta_H = \frac{\Delta_H}{2} < \frac{1 - s_f}{2} E(k) = \frac{1}{4}\left[\frac{1}{2}\left(\Delta_H + \Delta_L + 2\Delta_H\right)\right]$$

which is always violated. The above argument can be extended for K close to $2\Delta_H$.

Only if K is much larger, a manager facing a high adaptation cost may be willing to cooperate provided that there is enough revenue sharing. Functional initiative may then be equally efficient as functional control at implementing win-lose synergies as long as s_f

and s_{bu} are sufficiently close to $1/2$ at the optimum. The following proposition provides a sufficient condition on K for functional initiative with full cooperation to be strictly worse than functional control. For larger values of K, functional initiative with full cooperation is at best equally efficient.

Proposition 9 *If under functional initiative business-unit managers always cooperate, integration through functional control is strictly preferred whenever $K \leq 2\Delta_H + (\Delta_H - \Delta_L)$.*

In the above discussion, it is presumed that the only way to achieve win-lose synergies is to ensure that business-unit managers always cooperate with the functional manager. If business-unit managers can be given a share in each other's revenues ("cross-sharing"), however, there is an alternative way to implement win-lose synergies.[26] In particular, it may then be feasible to implement a structure where standardization initiatives are blocked only when $(\Delta_i, \Delta_j) = (\Delta_H, \Delta_H)$, so some (Δ_L, Δ_H) implementation occurs. An important downside of achieving win-lose synergies in this manner is that it further dilutes effort incentives of business-unit managers. This implies that cross-sharing will not be optimal when incentives are sufficiently important. Less obviously, we show in the appendix that cross-sharing is also not optimal if incentives are sufficiently *unimportant.*

6.3 Organizational design

The above analysis has shown that functional initiative is relatively inefficient at implementing win-lose synergies, but often can achieve win-win synergies at a lower incentive cost than functional control. We now derive implications for organizational design: when is it desirable for the organization to limit the control of the functional manager over the synergistic activity? When should the functional manager only be allocated dotted line-control?

In what follows, we distinguish between organizations with low and high-powered effort incentives. If effort incentives are not very important, functional control is always optimal because it is important to standardize whenever synergies are positive, even if the costs of such standardization are asymmetrically distributed among business units. As effort incentives become more important, organizational design then trades off higher-powered incentives with efficient standardization decisions; functional initiative may then be preferred over functional control.

Functional initiative versus functional control: Low-powered incentives.

[26] Recall that giving business unit managers a share in each other's revenue was never optimal under functional control. Furthermore, under functional initiative, if both business unit managers only cooperate if they face low adaptation costs, the only impact of revenue-sharing between business unit managers is to weaken incentives. If business unit managers always cooperate, revenue-sharing weakens incentives and makes communication more difficult to sustain. As under functional control, it is then without loss of generality to ignore revenue sharing between business unit managers.

The following proposition establishes the optimality of functional control when incentives are sufficiently unimportant.

Proposition 10 There exists a $\tilde{v}$ such that functional control is preferred over functional initiative whenever $0 < v < \tilde{v}$. If $K \leq 2\Delta_H + (\Delta_H - \Delta_L)$, this preference is always strict.

Since functional initiative limits the ability of the organization to implement synergies, one might suspect that functional initiative would be more attractive when the expected value from standardization, K, is small. The proposition above shows this is incorrect; functional initiative is always strictly dominated for v small. Intuitively, when expected cost savings from standardization, $K/2$, are small, then whenever two business-unit managers face different adaptation costs, it may be impossible for standardization to be desirable for both of them. Specifically, if $\Delta_H > K/4$, a Δ_H manager will not accept standardization, even if $s_f = s_{bu} = 1/2$. In contrast if expected synergies are very large, everyone may benefit from standardization provided that there is enough revenue-sharing. Functional initiative will then be equally efficient as functional control, as long as s_f and s_{bu} are sufficiently close to $1/2$ at the optimum.

Functional initiative versus functional control: High-powered incentives

In Section 4, we have shown that as effort incentives become more important, at some point the organization optimally gives up on communication and forgoes fully contingent standardization decisions. In particular Proposition 1 shows that there exists a cut-off value $\tilde{v}$ such that whenever effort incentives $v > \tilde{v}$, standardization decisions are only contingent (since there is no credible communication) on the functional manager's information. Giving up on communication between the business-unit managers and the functional manager allows the organization to provide higher powered effort incentives. The organization thus trades off efficient standardization decision with higher powered effort incentives.

If functional initiative is feasible, the organization has another option to boost effort incentives. Rather than making standardization contingent only on associated cost savings k, standardization can be made somewhat contingent on the adaptation losses $(\Delta_1 + \Delta_2)$.[27] By requiring cooperation from the business-unit managers, the organization may choose to implement standardization only if both business units face low adaptation costs. Whereas only win-win synergies are then realized, this requires less effort distortions than functional control with fully contingent standardization, as shown in Proposition 7. Functional initiative with

[27] Under functional initiative with win-win implementation, the decision is also somewhat contingent on cost-savings, k.Since incentives are strong and the functional manager makes his proposal assuming both business units have low adaptation costs, the functional manager will propose implementation for most value of k. Thus, this organizational design leads to decisions that are, loosely speaking, mostly contingent on the adaptation costs $\Delta_1 + \Delta_2$.

win-win synergies is therefore an alternative to functional control without communication as a means to boost effort incentives.

The following proposition states that as effort incentives become more important, the organization moves from fully contingent standardization (functional control with communication) to an organizational design in which standardization is either contingent on the cost savings from standardization (functional control without communication) or an organizational design in which standardization is partly contingent on the adaptation costs associated with standardization (functional initiative with win-win synergies):

Proposition 11 *(i) An increase in v may result in a shift from Functional Control with communication (standardization contingent on k, Δ_1 and Δ_2) to Functional Initiative (with standardization only if $\Delta_1 = \Delta_2 = \Delta_L$, win-win synergies), but never the other way around (ii) An increase in v may result in a shift from Functional Control with communication (standardization contingent on k, Δ_1 and Δ_2) to Functional Control without communication (standardization contingent only on cost savings k) but never the other way around.*

Figure 3 shows graphically the optimal organizational design as a function of the value of effort and the variance in Δ. The size of K and the expected value of Δ is kept fixed so that the expected value of synergies, $E(k - \Delta_1 - \Delta_2)$, equals zero. This implies that integration is always optimal. The only question is whether integration is best achieved through functional control or functional initiative. From Proposition 11, when effort is unimportant, it is optimal for the organization to ensure that standardization decisions are based on the most complete information aggregation, and hence, functional control is optimal. As v increases, however, it is increasingly important to provide higher powered incentives. The organization then either gives up on communication in which case standardization decisions uniquely depend on the size of the cost savings k, or the organization moves to integration through functional initiative, where standardization only occurs if the resulting synergies are win-win, that is both business-unit managers face low adaptation costs Δ_L.

Figure 3 suggests that for high-powered incentives, the choice between (i) making standardization decisions uniquely contingent on cost savings (functional control without communication) or (ii) making standardization contingent on both business units facing low adaptation costs (functional initiative with win-win synergies) depends on the variance in Δ. Intuitively, rather than boosting effort incentives by making standardization uniquely contingent on cost savings, as the spread in Δ increases, it may be optimal to boost effort incentives by having standardization only if both manager face low adaptation costs. The lower is Δ_L, the lower are the incentive costs of implementing such win-win synergies and the more valuable are win-win synergies. Indeed, when Δ_L is small, effort incentives only require marginal distortions for a Δ_L manager to be willing to cooperate with a standardization

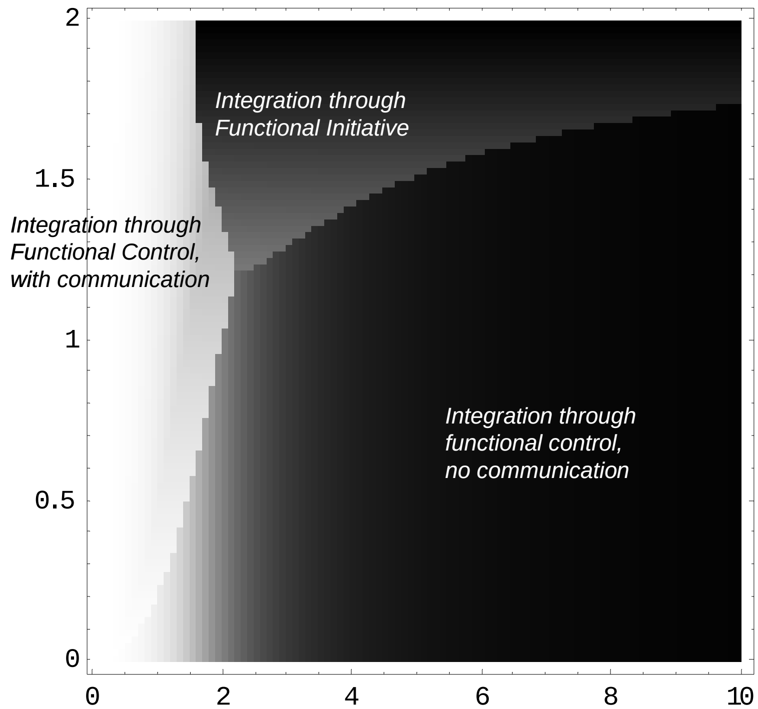

Figure 6: Organizational choice and communication regime as a function of the value of the marginal value of effort v and the spread $\Delta_H - \Delta_L$

initiative. Similarly, since Δ_H is increasing, synergies where at least one of the manager face high adaptation cost become less valuable on average. Ruling out such synergies is then less costly. Intuitively, for a given K and given incentives s_f and s_{bu}, making standardization contingent mainly on Δ will be more valuable if there is a large variance in adaptation costs.

Example 3. Figure 6 illustrates the impact of the spread Δ, $\Delta_H - \Delta_L$ *on organizational choice. It has* $\overline{\Delta} = 2$, $K = 8$, $\Delta_H - \Delta_L \in [0, 2], v \in [0, 10]$.

7 Conclusion

Organizations exist to coordinate complementary activities in the presence of specialization. Specialization expands the production frontier but results in many organizational challenges. In particular, information is dispersed among more agents and, since agents are in charge of a narrower set of activities, their objectives also become narrower if they are paid based on their own performance. In our paper, the purpose of organizational design is to govern these trade-offs. Employing a functional manager specialized in identifying synergies potentially increases the production possibilities. However, ensuring coordination between this manager and business-unit managers requires muting local incentives. As a result, the organizational costs of coordination may exceed the functional cost savings.

A wide range of organizational design problems revolve around trade-offs between providing local incentives and encouraging coordination among units. For example, extending the vertical scope of a firm can improve coordination by placing linked units under common control, but probably only at the cost of diluting incentives within links of the vertical chain. Similarly, grouping tasks into jobs and these into units involves trading off measurability by grouping similar jobs and tasks together, which enhances incentive provision, against achieving coordination, which requires grouping jobs and tasks that need to be coordinated with each other. Coordination and incentives should also be considered together when designing transfer prices, internal labor markets, the managerial hierarchy, or the internal allocation of capital. Most of the literature, however, considers coordination and incentive problems separately.

Our model allows us to characterize the extent to which organizational costs constrain the ability of firms to capture synergies through integration. When synergies are large and well-known, the organizational designer need not worry about ensuring truthful communication. As a result, it is possible for the organization to keep high-powered incentives without fearing the resulting conflicts, and a large share of the potential synergies may be captured though integration of previously separate units. Instead, if contingent decision-making is important, it is harder to capture synergies; managers' incentives must be sufficiently aligned that truthful communication is possible. This requires lowering local incentives, thereby reducing the gains from integration.

Contingent decision-making may be important when there are many small decisions that must be taken that may lead to synergies, rather than a small number of key, large decisions. We speculate that this may explain why cost synergies are easier to realize than revenue synergies. Cost synergies often involve a few key consolidation and standardization decisions, while revenue synergies (for example through cross-selling) may require determining repeatedly the benefits and costs of combined offerings.

We also study 'dotted line' control, in which functional managers may propose standardization but can not implement it without the consent of the business units. It can succeed at weakening the trade-off between coordination and motivation. We show that this structure is only efficient at implementing win-win standardization – functional initiative cannot impose synergies when at least one of the business units is opposed to standardization. But it can implement win-win synergies at relatively low cost, as communication is cheaper to sustain. As a result, the choice between functional initiative and functional control presents organizations with a trade-off between efficiently implementing synergies and providing strong local incentives. It follows that when incentives are not too important, functional control is always preferred; when they are important, functional initiative may be chosen.

We view this paper as a starting point to a deeper exploration of the way organizational structure can be designed to facilitate coordination while maintaining incentives. Much remains to be done. We have sought to present the simplest possible model involving the four elements we consider critical: synergies, adaptation, effort incentives and (strategic) communication. In doing this, we have drastically simplified incentive and information structures. Future work should explore the robustness of the model to larger, more complex organizations with richer incentive and information structures. It may also explore how other organizational design options, beyond the ones we have studied here, can allow organizations to capture synergies. We suggest one specific avenue.

The presence of both functional and business-unit managers creates a potential role of senior management in resolving disputes and coordinating activities. In the future, we plan to investigate a structure with centralized conflict resolution in which disagreements can arise between business unit and functional managers. We speculate that conflict resolution allows for an increase in incentive strength, as the main cost of strong incentives is worse ex post implementation of synergies, and conflict resolution allows for some ex post conditional implementation. However, conflict resolution reduces horizontal communication, since some ex post implementation can be ensured through the senior management intervention. Given this trade-off, a particularly interesting question is the extent to which introducing red tape, by increasing the costs of appealing to senior management, may be beneficial in facilitating communication among business unit and functional managers.

Another extension of the model would allow local managers' information to be correlated. This could help identify observable characteristics of the environment that affect the choice between functional control and functional initiative. If the local managers' information is positively correlated – so that when non-adaptation costs are low for one business unit they are also likely to be low for the other – win-win synergies are common and win-lose synergies are rare compared to the independent information case. Thus, correlation makes functional initiative relatively attractive. Empirically, the cost to business units from not tailoring elements of their information technology systems to local conditions may be similar across all business units. In contrast, the costs of not being able to tailor marketing or product design strategies to local conditions may vary widely across business units. If this is the case, functional initiative will more likely be optimal for IT integration and functional control or non-integration for product design and marketing.

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A Appendix

A.1 Proofs of Section 4

It will be useful to first prove the following lemma

Lemma A.1.1: *In a pooling equilibrium or separating equilibrium with non-binding communication constraint, s_f, s_{bu} and $1/\ell$ are increasing in $\tau \in \{v, K\}$. In a separating equilibrium with binding communication constraint, s_{bu} and $1/\ell$ are increasing, but s_f is decreasing in $\tau \in \{v, K\}$*

Proof: (1) Pooling equilibria or separating equilibria with non-binding communication constraint: From Lemma 2, proven in the text, $(-\ell)$ and s_f are increasing in v and K.[28] We now show that also s_{bu} increasing in v and K. Given that $\ell < 1$, the first order condition (15) implies that $s_f > 1/2$. Substituting s_{bu}, we have that

$$2\left[(1-s_f)s_f - (1-s_{bu})^2\right] v = 0$$

from which it follows that s_{bu} is increasing in $\tau \in \{v, K, -\gamma\}$.

(2) Separating equilibria with binding communication constraint: The communication constraint (17) can be rewritten as

$$\frac{2s_f s_{bu} - (1-s_f)(1-s_{bu})}{(1-s_f)s_f} - \frac{1-s_{bu}}{s_f}\frac{2\Delta_H}{2\Delta_L} \leq 0$$

or still, using $\ell = \frac{1-s_{bu}}{s_f}$ to substitute for s_{bu} :

$$\left[\frac{1-\ell s_f}{1-s_f} - \ell\right] - \ell\frac{2\Delta_H}{2\Delta_L} \leq 0 \tag{21}$$

Thus, when (17) is binding, profits can be rewritten as a function of ℓ

$$\pi^c = \pi^c(\ell^c, s_f^c(\ell^c)) \equiv \pi_i^c(\ell^c) + \pi_e^c(\ell^c, s_f^c(\ell^c))$$

where

$$s_f^c(\ell) = \frac{\ell + \frac{\ell\Delta_H}{\Delta_L} - 2}{\frac{\ell\Delta_H}{\Delta_L} - \ell} = \frac{1 + \frac{\Delta_H}{\Delta_L} - 2/\ell}{\frac{\Delta_H}{\Delta_L} - 1} \tag{22}$$

and where π_i^c reflects the impact of the equilibrium cut-off values of standardization and uniquely depends on ℓ, and π_e^c is the part of the profits function reflecting the impact on

[28] In particular, $\pi(s_f, -\ell, \tau)$ is supermodular for $\tau \in \{\nu, K, -\gamma\}$.

profits of effort provision. Thus

$$\pi_e^c(\ell, s_f^c(\ell)) = \left\{ \left[1 - \left(s_f^c(\ell) \right)^2 \ell^2 \right] + s_f(\ell)(2 - s_f(\ell)) \right\} v$$

Note first that since $s_f(\ell) < 1$, it follows from the expression of $s_f(\ell)$ that $\ell < 1$. Secondly, the following first order condition with respect to ℓ yields

$$\frac{1}{2} [1 - \ell] \frac{\gamma}{K} - 2s_f^2(\ell)\ell v + 2v \left[(1 - s_f(\ell)) - s_f(\ell)\ell^2 \right] \frac{1}{\ell^2} \frac{2}{\frac{\Delta_H}{\Delta_L} - 1} = 0$$

Since $\partial s_f(\ell)/\partial \ell > 0$, one can further verify that

$$\frac{d^2 \pi^c(s_f(\ell), \ell)}{d\ell^2} < 0$$

Since $\ell < 1$, it follows that in a separating equilibrium with binding communication constraint, ℓ and s_f are continuously decreasing in v and K, but increasing in γ. Since $\ell = (1 - s_{bu})/s_f$, this implies that s_{bu} is continuously increasing in $\tau \in \{v, K, -\gamma\}$ .QED.

Lemma 3 *Let s_f^c and s_{bu}^c be the optimal incentives if the organization induces communication, then*

$$s_f^c/(1 - s_{bu}^c) \leq \tilde{s}_f^c/(1 - \tilde{s}_{bu}^c) < s_f^{nc}/(1 - s_{bu}^{nc})$$

where the first inequality is strict whenever the communication constraint (17) is not satisfied given $\tilde{s}_f^c$ and $\tilde{s}_{bu}^c$.

Proof: A. $(1 - \tilde{s}_{bu}^c)/\tilde{s}_f^c > (1 - s_{bu}^{nc})/s_f^{nc}$: We have that $\tilde{s}_f^c$ and $\tilde{s}_{bu}^c$ are given by equations (14) and (15) with $\gamma = E(\Delta_L + \Delta_H)^2$. Since s_f^{nc} and s_{bu}^{nc} are also given by (14)and (15) but with $\gamma = 4\overline{\Delta}^2 < E(\Delta_L + \Delta_H)^2$, the inequality follows directly from lemma 2.

B. $(1 - s_{bu}^c)/s_f^c \geq (1 - \tilde{s}_{bu}^c)/\tilde{s}_f^c$: If the communication constraint (17) is non-binding, then trivially $s_f^c = \tilde{s}_f^c$ and $s_{bu}^c = \tilde{s}_{bu}^c$. Assume therefore that (17) is binding. Then s_f^c and $\ell^c = (1 - s_{bu}^c)/s_f^c$ satisfy the following Kuhn-Tucker conditions:

$$\frac{1}{2} [1 - \ell] \frac{\gamma}{K} - 2s_f^2 \ell v + \lambda \left[\frac{2s_f}{1 - s_f} + 1 + \frac{\Delta_H}{\Delta_L} \right] = 0 \tag{23}$$

$$2 \left[(1 - s_f) - s_f \ell^2 \right] v - \lambda \left[2 \frac{1 - \ell}{(1 - s_f)^2} \right] = 0, \tag{24}$$

where $\gamma = E(\Delta_L + \Delta_H)^2$. Similarly, $\tilde{\ell}^c$ and $\tilde{s}_f^c$ satisfy the following first-order conditions:

$$\pi_\ell = \frac{1}{2} [1 - \ell] \frac{\gamma}{K} - 2s_f^2 \ell v = 0 \tag{25}$$

$$\pi_{s_f} = 2 \left[(1 - s_f) - s_f \ell^2 \right] v = 0, \tag{26}$$

By assumption, $\tilde{\ell}^c$ and $\tilde{s}^c_f$, violate the communication constraint (17), which can be rewritten as

$$\left[\frac{1-\ell s_f}{1-s_f}-\ell\right]-\ell\frac{2\Delta_H}{2\Delta_L}\leq 0 \tag{27}$$

Since $\lambda > 0$, manipulating the Kuhn-Tucker conditions 23 and 24 and the first-order conditions 25 and 26, we obtain

$$\frac{1}{2}\left[1-\ell^c\right]\frac{\gamma}{K}-2(s^c_f)^2\ell^c v<\frac{1}{2}\left[1-\tilde{\ell}^c\right]\frac{\gamma}{K}-2(\tilde{s}^c_f)^2\tilde{\ell}^c v \tag{28}$$

or still

$$\ell^c\left(\frac{1}{2}\frac{\gamma}{K}+2(s^c_f)^2 v\right)>\tilde{\ell}^c\left(\frac{1}{2}\frac{\gamma}{K}+2(\tilde{s}^c_f)^2 v\right) \tag{29}$$

From Lemma 2 $\tilde{\ell}^c$ is decreasing and $\tilde{s}^c_f$ is increasing in v. It follows that if for $v=v'$ (27) is non-binding given $\tilde{s}^c_f$ and $\tilde{\ell}^c$ then (27) will also be non-binding for $v''<v'$. Furthermore, from Lemma A.1.1, $s^c_f=\tilde{s}^c_f$ is increasing in v if (27) is non-binding , but s^c_f is decreasing in v whenever (27) is binding. Since s^c_f is continuous in v, it follows that whenever (27) is binding, it must be that $\tilde{s}^c_f>s^c_f$. But from condition (29), it then must also be that $\tilde{\ell}<\ell^c$, or equivalently $\tilde{s}^c_f/(1-\tilde{s}^c_{bu})>s^c_f/(1-s^c_{bu})$. QED.

Proposition 1 *1) If it is optimal for the organization to induce communication given K' and v', then it is also to induce communication for any (K,v) with $K\leq K'$ and $v\leq v'$.*
2) If it is optimal for the organization to induce communication given (Δ_H, Δ_L) with mean $\bar{\Delta}$,then it is optimal to induce communication for any (Δ'_H, Δ'_L) with the same mean $\overline{\Delta}$ and $\Delta'_H-\Delta'_L>\Delta_H-\Delta_L$.
3) In contrast, if either $K>K'$ or $v>v'$ or $\Delta'_H-\Delta'_L<\Delta_H-\Delta_L$, then the organization may decide to forego communication. This is accompanied by a discrete increase in functional effort incentives, s_f, and distortions in decision-making, $1/\ell$.

Proof: We first show that an increase K or v may result in a shift from a separating equilibrium where the incentive constraint (17) is binding to a pooling equilibrium, but never the other way around. We denote by $\pi^c(\ell^c,s^c_f)$ profits in a separating equilibrium with binding communication constraint given optimal incentives ℓ^c and $s^c_f=s_f(\ell^c)$ and by $\pi^{nc}(\ell^{nc},s^{nc}_f)$ profits in a pooling equilibrium given optimal incentives $\tilde{\ell}^c$ and $\tilde{s}^c_f$. Using the envelope theorem and Proposition 3, it is easy to verify that both $d(\pi^c(\ell^c,s^c_f(\ell^c))-\pi^{nc}(\ell^{nc},s^{nc}_f))/dK<0$ and $d(\pi^c(\ell^c,s^c_f(\ell^c))-\pi^{nc}(\ell^{nc},s^{nc}_f))/dv<0$.

Second, we show that the same holds for an increase in the spread $\delta=\Delta_H-\Delta_L$, keeping $\bar{\Delta}$ fixed. Note first that profits in a pooling equilibrium are independent of $\delta=\Delta_H-\Delta_L$, that is $d(\pi^{nc}(\ell^{nc},s^{nc}_f))/d\delta=0$, hence it will be sufficient to show that $d(\pi^c(\ell^c,s^c_f(\ell^c)))/d\delta>0$.

From the envelope theorem, we have that

$$\begin{aligned}\frac{d\pi^c(\ell^c, s_f^c(\ell^c))}{d\delta} &= \frac{d\pi^c}{d\ell^c}\frac{\partial \ell^c}{\partial \delta} + \frac{\partial \pi^c}{\partial s_f^c}\frac{\partial s_f^c(\ell^c)}{\partial \delta} + \frac{d\pi^c}{\partial \delta} \\ &= \frac{\partial \pi^c}{\partial s_f^c}\frac{\partial s_f^c(\ell^c)}{\partial \delta} + \frac{\partial \pi^c}{\partial \delta}\end{aligned}$$

From (22), we have that $\partial s_f^c(\ell^c)/\partial\delta > 0$. Moreover, since from proposition 3 $\ell^c < \tilde{\ell}^c$ and $s_f^c < \tilde{s}_f^c$, where $\tilde{s}_f^c$ and $\tilde{\ell}^c$ satisfy the first order condition (15)

$$2(1-\tilde{s}_f^c)v - 2\tilde{s}_f^c\left(\tilde{\ell}^c\right)^2 v = 0,$$

it must be that

$$\frac{\partial \pi^c}{\partial s_f^c} = 2(1-s_f^c)v - 2s_f^c(\ell^c)^2 v > 0$$

Finally, we have that

$$\begin{aligned}\frac{\partial \pi^c}{\partial \delta} &= 2\ell^c\frac{1}{4K}\left(\ell^c 2\Delta_L - 2\Delta_L\right)dk \\ &\quad -2\ell^c\frac{1}{4K}\left(\ell^c 2\Delta_H - 2\Delta_H\right) + \frac{1}{4K}\int_{k_{LL}}^{k_{HH}} 2dk \\ &= \ell^c\left(2-\ell^c\right)\frac{[\Delta_H - \Delta_L]}{K} > 0\end{aligned}$$

It follows that $d\pi^c/d\delta > 0$. QED.

Proposition 3: *Let s_f and s_{bu} be optimal incentives for the functional and business-unit managers. Distortions in decision-making by the functional manager, as characterized by $s_f/(1-s_{bu})$, and business unit effort incentives, s_{bu}, are increasing in value of effort v and the level of the synergies K. Effort incentives for the functional manager s_f are increasing in K and v, except when the communication constraint is binding and the organization chooses to induce communication.*

Proof: From Lemma A.1.1. the above statements hold for a given equilibrium "regime" (that is "pooling", "separating with non-binding communication constraint", "separating equilibrium with binding communication constraint"). We now show that a regime shift induced by a change in K and v results in an increase in $1/\ell$ and s_{bu}.

1) From Proposition 1, an increase K or v may result in a shift from a separating equilibrium where the incentive constraint (17) is binding to a pooling equilibrium, but never the other way around. From lemma 3, such a shift from a separating equilibrium to a pooling

equilibrium results in a discrete increase in s_f, s_{bu} and $1/\ell$.
2) As long as it is optimal for the organization to induce communication s_f and s_{bu} are continuous in K and v. The comparative statics with respect to K and v then follow directly from the "within regime" comparative statics analyzed under (1) and (2) : s_{bu} is continuously increasing in K and v whereas s_f is continuously increasing in K and v as long as the incentive constraint is non-binding decreasing afterwards. Since the LHS of the incentive constraint (17) is decreasing in s_f and s_{bu}, and s_f and s_{bu} are increasing in K or v in a separating equilibrium with non-binding communication, an increase K or v may result in a shift from a separating equilibrium where the incentive constraint (17) is non-binding to a separating equilibrium where (17) is binding, but never the other way around. From (A) above, s_f is then decreasing in K and v. QED.

A.2 Proofs of Section 5

Proposition 4: *For any $K < 2\left(\Delta_L + \Delta_H\right)$, there exists a $\tilde{v}\left(K\right)$ with $\tilde{v}'\left(K\right) > 0$ such that non-integration is strictly preferred if and only if $v > \tilde{v}\left(K\right)$.*

Proof. Denote profits under non-integration as π^{NI} and under integration as π^I. Since $\lim_{v\to\infty} s_f = \lim_{v\to\infty} s_f = 1$ both under integration and non-integration, it follows that

$$\lim_{v\to\infty} \pi^{NI} - \lim_{v\to\infty} \pi^{I} = 2\left(\Delta_L + \Delta_H\right) - K$$

Hence, for v sufficiently large, non-integration is always preferred. To proof the proposition we thus only need to show that $d(\pi^I - \pi^{NI})/dK > 0$ and $d(\pi^I - \pi^{NI})/dv < 0$.

Since profits under integration are continuous in K and v even as we move from a separating to a pooling equilibrium, it will be sufficient to show that $d(\tilde{\pi}^c - \pi^{NI})/dK > 0$, $d(\pi^c - \pi^{NI})/dK > 0$ and $d(\pi^{nc} - \pi^{NI})/dK > 0$, and $d(\tilde{\pi}^c - \pi^{NI})/dv > 0, d(\pi^c - \pi^{NI})/dv > 0$, and $d(\pi^{nc} - \pi^{NI})/dv > 0$. Since $d\pi^{NI}/dK = 0$, we only need to show that $d\tilde{\pi}^c/dK > 0$, $d\pi^c/dK > 0$ and $d\pi^{nc}/dK > 0$. It follows from the implicit function theorem that

$$\begin{aligned}
\frac{d\pi^{nc}(K, s_f, s_{bu})}{dK} &= \frac{\partial\pi^{nc}(K, s_f, s_{bu})}{\partial K} + \frac{ds_f}{dK}\frac{\partial\pi^{nc}(K, s_f, s_{bu})}{\partial s_f} + \frac{ds_{bu}}{dK}\frac{\partial\pi^{nc}(K, s_{f^*}, s_{bu})}{\partial s_{bu}} \\
&= \frac{\partial\pi^{nc}(K, s_f, s_{bu})}{\partial K} \\
&> 0
\end{aligned}$$

The same can be shown for $d\tilde{\pi}^c/dK$ and $d\pi^c/dK$. Similarly, we have that

$$\begin{aligned}
\frac{d\pi^{nc}(v,s_f,s_{bu})}{dv} &= \frac{\partial\pi^{nc}(v,s_f,s_{bu})}{\partial v}+\frac{ds_f}{dv}\frac{\partial\pi^{nc}(v,s_f,s_{bu})}{\partial s_f}+\frac{ds_{bu}}{dv}\frac{\partial\pi^{nc}(v,s_f^*,s_{bu}^*)}{\partial s_{bu}} \\
&= \frac{\partial\pi^{nc}(v,s_f,s_{bu})}{\partial v} \\
&= s_{bu}\left[2-s_{bu}\right]+s_f(2-s_f) \\
&< 2=\frac{d\pi^{NI}}{dv}
\end{aligned}$$

The same can be shown for $d\tilde{\pi}^c/dv$ and for $d\pi^c/dv$. QED

Proposition 5: *An increase in the variance of adaptation costs as characterized by ($\Delta_H-\Delta_L$) for a given v, K and $\overline{\Delta}$, may lead to a shift from non-integration to integration but never the other way around.*

Proof. Note first that π^{NI} and π^{nc} are independent of $\delta=\Delta_H-\Delta_L$ for $\bar{\Delta}$ fixed. In contrast, equilibrium profits under integration are increasing in $\delta=\Delta_H-\Delta_L$ whenever there is communication (separating equilibrium). Consider first an equilibrium with communication where the communication constraint is non-binding. Then $\ell=\tilde{\ell}^c$ and $s_f=\tilde{s}_f^c$, and from the envelope theorem

$$\begin{aligned}
\frac{d\tilde{\pi}^c}{d\delta} &= \frac{d\tilde{\pi}^c}{d\tilde{\ell}}\frac{\partial\tilde{\ell}^c}{\partial\delta}+\frac{d\tilde{\pi}^c}{d\tilde{s}_f}\frac{\partial\tilde{s}_f^c}{\partial\delta}+\frac{\partial\tilde{\pi}^c}{\partial\delta} \\
&= \frac{\partial\tilde{\pi}^c}{\partial\delta}
\end{aligned}$$

where as shown in the proof of proposition 1

$$\frac{d\tilde{\pi}^c}{\partial\delta}=\tilde{\ell}^c\left(2-\tilde{\ell}^c\right)\frac{\delta}{K}>0>0$$

Similarly, if the communication constraint is binding, then $\ell=\ell^c$ and $s_f=s_f^c(\ell^c)$, in which case we have already shown in the proof of proposition 1 that

$$\begin{aligned}
\frac{d\pi^c}{d\delta} &= \frac{d\pi^c}{d\ell^c}\frac{\partial\ell^c}{\partial\delta}+\frac{\partial\pi^c}{\partial s_f^c}\frac{\partial s_f^c(\ell^c)}{\partial\delta}+\frac{d\pi^c}{\partial\delta} \\
&= \frac{\partial\pi^c}{\partial s_f^c}\frac{\partial s_f^c(\ell^c)}{\partial\delta}+\frac{\partial\pi^c}{\partial\delta}>0
\end{aligned}$$

QED.

A.3 Proofs of Section 6

Extensive form under functional initiative. We first prove, as claimed in footnote 23, that the extensive form assumed under functional initiative is without loss of generality. First, one might wonder whether it is sometimes optimal to let the functional manager initiate a standardization initiative before communication takes place. The following proposition shows that this is never optimal. Second, one might wonder whether, if communication is uninformative, the functional manager may be able to give guidance to the business managers as to when to accommodate his standardization initiative. For example, the functional manager could sometimes advise to Δ_H managers to block his standardization initiative. Again, the following proposition shows that if the communication constraint of the business-unit managers is violated, then the functional manager never can make his standardization initiative conditional on the business-unit manager's type:

Proposition A.3.1. *(1) If s_f and s_{bu} are such that the communication constraint of the business-unit managers is violated, then the functional manager has the choice between initiating standardization or not initiating standardization. However, he never can make a recommendation to the business-unit managers as when to accommodate his standardization initiative.*
(2) If s_f and s_{bu} are such that the communication constraint of the business-unit managers is satisfied, then it is always optimal to let the business-unit managers communicate their type prior to the functional manager's standardization initiative.

Proof (1) Assume that the functional manager, when making a standardization initiative, recommends to the business-unit manager when to accommodate it. Since there are only two types of business-unit managers, this is equivalent to the functional manager making a three-type recommendation: never accommodate standardization (which is equivalent to the functional manager not initiating a standardization), always accommodate standardization, accommodate standardization if your type is Δ_L. Under such three type recommendation, the functional manager recommends "always accommodate" if and only if $k > k_{LH}$; he recommends "accommodate if type Δ_L" if $k_{LL} < k \leq k_{LH}$; and he recommends "never accommodate" if $k \leq k_{LL}$. Two incentive constraints need to be satisfied: the acceptance constraint of the Δ_H manager upon hearing the message "always accommodate", and the acceptance of the Δ_L manager upon hearing the message "accommodate if type Δ_L". Upon hearing the latter message, the Δ_L manager knows that $k_{LL} < k \leq k_{LH}$. Since s_f and s_{bu} are such that the communication constraint is violated, we know that a Δ_L manager would want to block standardization if he knows that $k \in (k_{LL}, k_{LH}]$ with probability bu, and $k \in (k_{LH}, k_{HH}]$ with probability $(1 - bu)$. He therefore certainly wants to block a standardization if he knows that $k \in (k_{LL}, k_{LH}]$ for sure.

(2) Assume that the above described three-type communication is feasible if the func-

tional manager talks first (that is, the business managers have no option to communicate prior to the standardization initiative of the functional manager). The only difference with the equilibrium that prevails when the business-unit managers communicate first, is that now for $k \in (k_{LH}, k_{HH}]$ standardization is implemented even if both business-unit managers are of type Δ_H. This is obviously welfare reducing. Hence, if a s_f and s_{bu} are such that the communication constraint of the business-unit managers is satisfied, then it is always optimal to let the business-unit managers communicate first. It is then without loss of generality to let the functional manager simply choose between initiating standardization and not initiating standardization and restrict any further communication from the functional manager to the business-unit manager. QED.

Lemma 4: *A Δ_L manager is willing to accommodate a standardization initiative for any s_f and s_{bu}, (with $s_f + s_{bu} > 1$, which always holds in equilibrium) such that the communication constraint (16) is satisfied.*
Proof. We can rewrite the acceptance constrain (AC) as:

$$K > \left[\frac{2s_{bu}s_f - (1 - s_{bu})(1 - s_f)}{(1 - s_f)s_f}\right] 2\Delta_L \tag{30}$$

The communication constraint under functional control is given by

$$\frac{(1 - s_f)(1 - s_{bu})}{s_f s_{bu}} \geq \frac{2\Delta_L}{\Delta_L + \Delta_H} \tag{CC}$$

and can be rewritten as

$$\frac{1 - s_{bu}}{s_f} 2\Delta_H \geq \frac{2s_{bu}s_f - (1 - s_f)(1 - s_{bu})}{(1 - s_f)s_f} 2\Delta_L.$$

Since $1 - s_{bu} < s_f$ and $K > 2\Delta_H$ by assumption, it follows that the LHS of the above expression is smaller than the LHS of (30).QED.

Proposition 6. *Under functional initiative with win-win synergies, decision making distortions as measured by $s_f/(1 - s_{bu})$ are strictly increasing in K and v, and decreasing in Δ_L. They do not depend on Δ_H. Moreover, $s_f/(1 - s_{bu}) > 1$.*
Proof. We can rewrite profits under functional initiative with win-win synergies, denoted as π^{fi}, as a function of ℓ and s_{bu} :

$$\pi^{fi} = \pi_i^{fi}(\ell) + \pi_e^{fi}(\ell, s_{bu})$$

where

$$\pi_e^{fi}(\ell, s_{bu}) = \left\{ s_{bu}(2 - s_{bu}) + \frac{(1 - s_{bu})}{\ell}(2 - \frac{(1 - s_{bu})}{\ell}) \right\} v$$

and

$$\frac{\partial \pi_i^{fi}(\ell)}{\partial \ell} = \frac{1}{2}\left[1 - \ell\right] \frac{\gamma^{fi}}{K} > 0$$

with $\gamma^{fi} = E(\Delta_L)^2$. The acceptance constraint AC

$$\left[\frac{2s_{bu}}{1 - s_f} - \frac{1 - s_f}{s_{bu}}\right] < \frac{K}{2\Delta_L}$$

can be rewritten as

$$\left[\frac{2(1 - \ell s_f)}{1 - s_f} - \ell\right] < \frac{K}{2\Delta_L}$$

Note that if AC is binding, then it must be that $\ell < 1$. If the acceptance constraint is non-binding, then we find the following first order conditions

$$\frac{1}{2}\left[1 - \ell\right] \frac{\gamma^{fi}}{K} - 2s_f^2 \ell v = 0 \quad (31)$$

$$2\left[(1 - s_f) - s_f \ell^2\right] v = 0, \quad (32)$$

which are equivalent to the first order conditions (14) and (15), with $\gamma = \gamma^{fi} = E(\Delta_L)^2$. It follows again that $0 < \ell < 1$ and $1/\ell, s_f$ and s_{bu} are increasing in v, K, but decreasing in γ. If the acceptance constraint is binding, then abusing notation, we can rewrite profits as a function of ℓ :

$$\pi^{fi} \equiv \pi^{fi}(\ell, s_f(\ell)) = \pi_i^{fi}(\ell) + \pi_e^{fi}(\ell, s_f(\ell))$$

where

$$s_f(\ell) = \frac{\ell + \frac{K}{2\Delta_L} - 2}{\frac{K}{2\Delta_L} - \ell}$$

and

$$\pi_e^{fi}(\ell, s_f(\ell)) = \left\{(1 - s_f^2(\ell)\ell^2) + s_f(\ell)(2 - s_f(\ell))\right\} v$$

This yields the following first order condition with respect to ℓ

$$\frac{d\pi^{fi}(s_f(\ell), \ell)}{d\ell} = \frac{1}{2}\left[1 - \ell\right] \frac{\gamma}{K} - 2s_f^2 \ell v + 2v\left[(1 - s_f(\ell)) - s_f(\ell)\ell^2\right] \frac{2\left(\frac{K}{2\Delta_L} - 1\right)}{(\frac{K}{2\Delta_L} - \ell)^2} = 0$$

It follows that ℓ is decreasing in v, and thus also $s_f(\ell)$ is decreasing in v. Moreover, since it must be that $\ell + \frac{K}{2\Delta_L} - 2 > 0$, we have that

$$\frac{2\left(\frac{K}{2\Delta_L} - 1\right)}{(\frac{K}{2\Delta_L} - \ell)^2}$$

is decreasing in $\frac{K}{2\Delta_L}$. It follows that ℓ is also decreasing in K and increasing in Δ_L. The impact on $s_f(\ell)$ is ambiguous. QED.

Proposition 7 *Let s_f^c and s_{bu}^c be the optimal incentives under functional control with (Δ_L) communication and s_f^{fi} and s_{bu}^{fi} be the optimal incentives under functional initiative with Δ_L cooperation, then $s_f^{fi}/(1 - s_{bu}^{fi}) > s_f^c/(1 - s_{bu}^c)$.*

Proof: Assume first that the business-unit manager's incentive constraint is binding in both cases (communication constraint under functional control and acceptance constraint under functional initiative). The decision-making distortion ℓ^c under functional control then must satisfy the following first order condition:

$$\frac{d\pi(\ell, s_f^c(\ell))}{d\ell} = \frac{1}{2}[1-\ell]\frac{\gamma}{K} - 2(s_f^c(\ell))^2\ell v + 2v\left[(1 - s_f^c(\ell)) - s_f^c(\ell)\ell^2\right]\frac{1}{\ell^2}\frac{2}{\frac{\Delta_H}{\Delta_L} - 1} = 0 \quad (33)$$

Note that since $s_f^c(\ell)$ is increasing in ℓ, we have that

$$\frac{d\pi(\ell, s_f^c(\ell))}{d\ell^2} < 0$$

Similarly, the decision-making distortion ℓ^{fi} under functional initiative must satisfy

$$\frac{d\pi^{fi}(\ell, s_f^{fi}(\ell))}{d\ell} = \frac{1}{2}[1-\ell]\frac{\gamma}{K} - 2(s_f^{fi}(\ell))^2\ell v + 2v\left[(1 - s_f^{fi}(\ell)) - s_f^{fi}(\ell)\ell^2\right]\frac{2\left(\frac{K}{2\Delta_L} - 1\right)}{(\frac{K}{2\Delta_L} - \ell)^2} = 0$$

Note that

$$\frac{1}{\ell^2}\frac{2}{\frac{\Delta_H}{\Delta_L} - 1} > \frac{2\left(\frac{K}{2\Delta_L} - 1\right)}{(\frac{K}{2\Delta_L} - \ell)^2}$$

Indeed, this inequality will be satisfied whenever

$$(\frac{K}{2\Delta_L} - \ell)^2 > \left(\frac{\ell K}{2\Delta_L} - \ell\right)(\frac{\ell 2\Delta_H}{2\Delta_L} - \ell)$$

which is always verified whenever $\ell < 1$. Let ℓ^{fi} be a solution to the first order condition under functional initiative. Note further that since $\frac{K}{2\Delta_L} > \frac{\ell\Delta_H}{\Delta_L}$, we have that $s_f^c(\ell) < s_f^{fi}(\ell)$

for a given ℓ. It thus follows that

$$\frac{d\pi(s_f^c(\ell^{fi}),\ell^{fi})}{d\ell} = \frac{1}{2}\left[1-\ell^{fi}\right]\frac{\gamma}{K} - 2(s_f^c(\ell^{fi}))^2\ell^{fi}v + 2v\left[(1-s_f^c(\ell^{fi})) - (s_f^c(\ell^{fi}))(\ell^{fi})^2\right]\frac{1}{(\ell^{fi})^2}\frac{2}{\frac{\Delta_H}{\Delta_L}-1} > 0 \tag{34}$$

from which it must be that

$$\ell^c(\gamma) > \ell^{fi}(\gamma) \tag{35}$$

Since $\ell^P(\gamma)$ is increasing in γ, and $\gamma^{fi} < \gamma^c$, we have that

$$\ell^c(\gamma^c) > \ell^{fi}(\gamma^c) > \ell^{fi}(\gamma^{fi}) \tag{36}$$

Secondly, assume that the incentive constraint is non-binding under both functional control and functional initiative. Denoting by $\tilde{\ell}^c$ and $\tilde{\ell}^{fi}$ the optimized values of ℓ if one ignores incentive constraints, then from an inspection of the first order conditions, it follows directly that

$$\tilde{\ell}^c > \tilde{\ell}^{fi}$$

Next, assume that only the incentive constraint is binding under functional control, then since $\ell^c > \tilde{\ell}^c$, this follows directly from $\tilde{\ell}^c > \tilde{\ell}^{fi}$.

Finally, assume that only under functional initiative, the incentive constraint is binding, that is $\ell = \ell^{fi} > \tilde{\ell}^{fi}$ under functional initiative and $\ell = \tilde{\ell}^c = \ell^c$ under functional control with communication. Since $\gamma^{fi} = 2\Delta_L^2 < \gamma^{nc} = 2\bar{\Delta}^2$, and $\tilde{\ell}^c(\gamma)$ and $\ell^c(\gamma)$ are increasing in γ, it follows that

$$\ell^c = \tilde{\ell}^c(\gamma^c) = \ell^c(\gamma^c) > \ell^c(\gamma^{fi}) \geq \tilde{\ell}^c(\gamma^{fi}) \tag{37}$$

Note further that, since the first order conditions are identical except for the value of γ, we have $\tilde{\ell}^c(\gamma^{fi}) = \tilde{\ell}^{fi}(\gamma^{fi}) = \tilde{\ell}^{fi}$ and $\tilde{s}_f^c(\gamma^{fi}) = \tilde{s}_f^{fi}(\gamma^{fi}) = \tilde{s}_f^{fi}$, where $\tilde{\ell}^c$, $\tilde{\ell}^{fi}, \tilde{s}_f^c$ and $\tilde{s}_f^{fi}$ refer to variables which are optimized ignoring any communication or acceptance constraint. However, we know $\tilde{\ell}^{fi}$ and $\tilde{s}_f^{fi}$ violated the acceptance constraint under functional initiative. From lemma 4, $\tilde{\ell}^c(\gamma^{fi}) = \tilde{\ell}^{fi}$ and $\tilde{s}_f^c(\gamma^{fi}) = \tilde{s}_f^{fi}$ then also must violate the communication constraint under functional control. But if $\tilde{\ell}^c(\gamma^{fi}) = \tilde{\ell}^{fi}(\gamma^{fi})$ and $\tilde{s}_f^c(\gamma^{fi}) = \tilde{s}_f^{fi}(\gamma^{fi})$ violate both the communication and the acceptance constraint, then inequality (35) holds, that is $\ell^c(\gamma^{fi}) > \ell^{fi}(\gamma^{fi})$, where ℓ^c and ℓ^{fi} refer to variables which are optimized subject to respectively the communication and acceptance constraint. From (37), it then follows that

$$\ell^c = \ell^c(\gamma^c) > \ell^c(\gamma^{fi}) > \ell^{fi}(\gamma^{fi}) = \ell^{fi}$$

In other words, we always have $\ell^c > \ell^{fi}$. QED

Proposition 8 *If, under functional initiative, business-unit managers always cooperate, integration through functional control is weakly preferred.*

Proof: The optimization problem under "informal" functional control, that is functional initiative where business managers always cooperate, is identical to the optimization problem under "formal" functional control, except for an additional acceptance constraint given by

$$\frac{1-s_f}{2}\left(\frac{K}{2}+\frac{k_{LH}}{2}\right) > s_{bu}\Delta_H \tag{38}$$

which indicates that a Δ_H manager must be willing to accommodate a standardization initiative knowing that the functional manager initiates standardization whenever $k > k_{LH}$.[29]. Let s_f^* and s_{bu}^* be the solution to the maximization problem under functional control. Then if given s_f^* and s_{bu}^*, a business-unit manager of type Δ_H is willing to cooperate with any standardization proposed by the functional manager, then the optimal output shares s_f and s_{bu} are identical to s_f^* and s_{bu}^*. Functional control and functional initiative are then equivalent. In contrast, if s_f^* and s_{bu}^* violate (38), then given that it is optimal to induce both Δ_H and Δ_L managers to cooperate, functional initiative is strictly dominated by functional control. QED.

Proposition 9: *If under functional initiative business-unit managers always cooperate, integration through functional control is strictly preferred whenever* $K \leq 2\Delta_H + \Delta_H - \Delta_L$.

Proof: To prove proposition 9, we now show that s_f^* and s_{bu}^* violate (38) whenever $K \leq 2\Delta_H + (\Delta_H - \Delta_L)/2$. Substituting k_{LH} and s_{bu}^* and s_f^*, we can rewrite (38) as

$$\frac{1}{2}\left(\frac{K}{2}+\frac{s_f^*}{1-s_{bu}^*}\frac{\Delta_L+\Delta_H}{2}\right) > \frac{s_{bu}^*}{1-s_f^*}\Delta_H \tag{39}$$

By Proposition 3, $(1-s_{bu}^*)/s_f^* \leq 1$ and hence $s_{bu}^*/(1-s_f^*) \geq 1$. Consequently a necessary condition for (38) to be satisfied is that

$$\frac{1}{2}\left(\frac{K}{2}+\frac{\Delta_L+\Delta_H}{2}\right) > \Delta_H \tag{40}$$

which is always violated whenever $K \leq 2\Delta_H + (\Delta_H - \Delta_L)$. QED.

Revenue sharing among business-unit managers. We now substantiate the claim, made informally in the text, that when incentives are sufficiently unimportant, it is never

[29] The functional manager use this cut-off rule both in a pooling equilibrium and in a separating equilibrium where the other manager is a Δ_L type. If this acceptance constraint is satisfied, then a Δ_H manager will also be willing to cooperate when the other business unit manager is revealed to be a Δ_H type, and the functional manager initiates a standardization effort whenever $k > k_{HH}$.

optimal to give business-unit managers a share in each other's revenues ("cross-sharing"). In particular, let business-unit manager i receive a share αs_{bu} in revenues R_i and a share $(1-\alpha)s_{bu}$ in the revenues R_j of business unit j.[30] So far, we have assumed that $\alpha = 1$, in which case equilibrium effort is given by vs_{bu}. Positive cross-shares, that is setting $\alpha < 1$, reduces business unit effort from $e_{iL} = s_{bu}v$ to $e_{iL} = \alpha s_{bu}v$. Note that unlike a reduction in s_{bu} or s_f, this dilution of effort incentives through revenue-sharing between business-unit managers does not improve decision-making by the functional manager: k_{LL}, k_{LH} and k_{HH} are independent of α. It is therefore straightforward to show that allocating positive cross-shares ($\alpha < 1$) cannot be optimal if business-unit managers only cooperate if $(\Delta_i, \Delta_j) = (\Delta_L, \Delta_L)$ or if business-unit manager always cooperate.[31]

The next proposition shows that for v small, it is also never optimal to give business-unit managers a share in each other's profits in order to induce them to block standardization initiative if and only if $(\Delta_i, \Delta_j) = (\Delta_H, \Delta_H)$. In particular, such a structure is then always dominated by functional control.

Proposition A.3.2.: *Assume v small. If under functional initiative, business-unit managers receive a positive share $(1-\alpha)s_{bu}$ in each other's profits such that they cooperate unless business units face high adaptation costs, then functional control is strictly preferred.*

Proof: For v sufficiently small, we can ignore the communication constraint under functional control, and from the envelope theorem

$$\begin{aligned}\frac{d\pi^c(v, s_f^c, s_{bu}^c)}{dv} &= \frac{\partial \pi^c(v, s_f^c, s_{bu}^c)}{\partial v} \\ &= s_{bu}^c\left[2 - s_{bu}^c\right] + s_f^c(2 - s_f^c)\end{aligned}$$

where s_f^c and s_{bu}^c are given by the first order conditions (14) and (15). Since $\lim_{v\to 0} s_{bu}^c = \lim_{v\to 0} s_f^c = 1/2$,

$$\lim_{v\to 0} \frac{d\pi^c}{dv} = 1.5$$

Note further that $\lim_{v\to 0} \pi^c = \pi^{fb}$, where π^{fb} are first best profits.

Consider now functional initiative where α is chosen such that business-unit managers only cooperate when $(\Delta_i, \Delta_j) = (\Delta_L, \Delta_L)$ or $(\Delta_i, \Delta_j) = (\Delta_L, \Delta_H)$. In order for business-unit managers to block synergies only when $(\Delta_i, \Delta_j) = (\Delta_L, \Delta_H)$, it will be necessary to set $\alpha < 1$. Indeed, business-unit managers will cooperate with win-lose standardization, that

[30] As before, we let s_f and $1 - s_{bu}$ be the share of the functional manager respectively in the costs C_i and revenues R_i of business unit i. As we have done throughout the paper, we only consider organizations where both business unit managers are treated symmetrically.

[31] In addition to the dilution of incentives, one can verify that setting $\alpha < 1$ makes the communication constraint more difficult to be satisfied.

is$(\Delta_i, \Delta_j) = (\Delta_L, \Delta_H)$, if and only if

$$\frac{1-s_f}{2}\left(\frac{K+k_{LH}}{2}\right) > s_{bu}\left[\alpha\Delta_H + (1-\alpha)\Delta_L\right], \tag{41}$$

and they will block standardization when $(\Delta_i, \Delta_j) = (\Delta_H, \Delta_H)$ if and only if

$$\frac{1-s_f}{2}\left(\frac{K+k_{HH}}{2}\right) < s_{bu}\Delta_H \tag{42}$$

Since $k_{LH} < k_{HH}$, it follows that both inequalities can be satisfied simultaneously only if $\alpha < 1$. If α, s_{bu} and s_f satisfy the constraints (41) and (42), the profit function is given by

$$\begin{aligned} \pi^{\alpha fi} \quad \equiv \quad & \max_{s_{bu}, s_f, \alpha} \pi = \frac{(1-p)^2}{K}\int_{k_{LL}}^{K}(k-2\Delta_L)\,dk + \frac{2\,(1-p)\,p}{K}\int_{k_{LH}}^{K}(k-\Delta_L-\Delta_H)dk \\ & +\alpha s_{bu}(2-\alpha s_{bu})v + s_f(2-s_f)v \end{aligned}$$

It is easy to see that $\pi^{\alpha fi}$ is continuous in v. Note first that whenever $K > 2\Delta_H$, then

$$\lim_{v\to 0}\pi^{\alpha fi} < \pi^{fb} = \lim_{v\to 0}\pi^c$$

and by continuity, functional control is strictly preferred for v small. Assume therefore $K = 2\Delta_H$, then

$$\lim_{v\to 0}\pi^{\alpha fi}(\alpha, s_{bu}, s_f) = \lim_{v\to 0}\pi^c = \lim_{v\to 0}\pi^{fb}$$

Indeed, by setting $\ell \equiv (1-s_{bu})/s_f = 1$, decision-making by the functional manager is first best, and we can always find an α so that the constraints (41) and (42) are verified. For v small, functional control is then strictly preferred over functional initiative if and only if

$$\lim_{v\to 0}\frac{d\pi^{\alpha fi}(\alpha^*, s_{bu}^*, s_f^*)}{dv} < \lim_{v\to 0}\frac{d\pi^c}{dv} = 2$$

Since we must have that $\lim_{v\to 0}\ell^* = 1$, it follows that $\hat{\alpha} = \lim_{v\to 0}\alpha$ will be given by the highest value of α such that (41) holds given $\ell^* = 1$:

$$\frac{1}{2}\left(\frac{K}{2} + \frac{\Delta_H+\Delta_L}{2}\right) - \left[\hat{\alpha}\Delta_H + (1-\hat{\alpha})\Delta_L\right] = 0$$

which for $K = 2\Delta_H$, simplifies to $\hat{\alpha} = 3/4$. As noted in the main text, if $\ell < 1$, then for (41) to hold given $K = 2\Delta_H$, it must be that $\alpha < 3/4$.

Given that $\lim_{v\to 0}\ell = 1$, for v small the communication constraint will not be binding, and s_f, ℓ and α will be given by the following Kuhn-Tucker conditions:

$$\frac{1}{2}\left[1-\ell\right]\frac{\gamma}{K} - 2s_f^2\ell v + \lambda\left[\frac{\partial AC}{\partial \ell}\right] = 0 \tag{43}$$

$$2\left[(1-s_f) - s_f\alpha^2\ell^2 - \ell\alpha(1-\alpha)\right]v + \lambda\left[\frac{\partial AC}{\partial s_f}\right] = 0 \tag{44}$$

$$2(1-s_f\ell)(1-\alpha(1-s_f\ell))v + \lambda\left[\frac{\partial AC}{\partial \alpha}\right] = 0, \tag{45}$$

where

$$AC \equiv \frac{1-s_f}{2}\left(\frac{2\Delta_H + \ell(\Delta_L+\Delta_H)}{2}\right) - (1-s_f\ell)\left[\alpha\Delta_H + (1-\alpha)\Delta_L\right], \tag{46}$$

and λ is the Langrange multiplier. The constraint $AC \geq 0$ is equivalent to (41). Applying the envelope theorem, we have that

$$\begin{aligned}\frac{d\pi^{\alpha fi}(\alpha, s_f, \ell, \lambda)}{dv} &= \frac{\partial\pi^{\alpha fi}(\alpha, s_f, \ell, \lambda)}{\partial v}\\ &= \alpha(1-s_f\ell)\left[2-\alpha(1-s_f\ell))\right] + s_f(2-s_f)\end{aligned}$$

Since $\lim_{v\to 0}\ell = 1$, and $\lim_{v\to 0}\alpha = \hat{\alpha} < 1$, then

$$\begin{aligned}\lim_{v\to 0}\frac{d\pi^{\alpha fi}}{dv} &= \hat{\alpha}(1-s_f)\left[2-\hat{\alpha}(1-s_f)\right] + s_f(2-s_f)\\ &< (1-s_f)\left[2-(1-s_f)\right] + s_f(2-s_f)\\ &\leq \frac{1}{2}\left[2-\frac{1}{2}\right] + \frac{1}{2}(2-\frac{1}{2}) = \lim_{v\to 0}\frac{d\pi^c}{dv}.\end{aligned}$$

where the last step uses the fact that $\lim_{v\to 0} s_{bu}^c = \lim_{v\to 0} s_f^c = 1/2$. QED

Proposition 10: *There exists a $\tilde{v}$ such that functional control is preferred over functional initiative whenever $0 < v < \tilde{v}$. If $K \leq 2\Delta_H + \Delta_H - \Delta_L$, this preference is always strict.*

Proof: Given proposition 8, proposition 9 and proposition A.3.2, we only need to show that functional control is preferred over functional initiative with win-win synergies whenever $0 < v < \tilde{v}$. Under functional initiative with win-win synergies, standardization is only implemented if both $\Delta_1 = \Delta_2 = \Delta_L$. Given that $k > \Delta_H + \Delta_L$ with probability $K - (\Delta_H + \Delta_L) > 0$, functional initiative with win-win synergies yields profits π^{fi} which are strictly smaller than first-best profits π^{FB}. In contrast, under functional control, $\lim_{v\to 0}\pi^c = \pi^{FB}$. Indeed, $\lim_{v\to 0} s_f^c = s_{bu}^c = 1/2$ in which case $k_{ij} = k_{fb}$ and the communication constraint is always satisfied. Since profits under functional control are continuous in v, it follows that there exists a $\tilde{v} > 0$ such that for $v < \tilde{v}$, functional control strictly dominates functional initiative with win-win synergies. QED.

Proposition 11: *(i) An increase in v may result in a shift from Functional Control with communication (standardization contingent on k, Δ_1 and Δ_2) to Functional Initiative (with standardization only if $\Delta_1 = \Delta_2 = \Delta_L$, win-win synergies), but never the other way around (ii) An increase in v may result in a shift from Functional Control with communication (standardization contingent on k, Δ_1 and Δ_2) to Functional Control without communication (standardization contingent only on cost savings k) but never the other way around.*

Proof: Part (ii) follows immediately from Proposition 1. We now prove (i). Applying envelope theorem, we have that

$$\begin{aligned}\frac{d\pi^{fi}(v, s_f^{fi}, s_{bu}^{fi}, \lambda^{fi})}{dv} &= \frac{\partial \pi^{fi}(v, s_f^{fi}, s_{bu}^{fi}, \lambda^{fi})}{\partial v} \\ &= s_{bu}^{fi}\left[2 - s_{bu}^{fi}\right] + s_f^{fi}(2 - s_f^{fi})\end{aligned}$$

where (s_f^{fi}, s_{bu}^{fi}) are the optimal shares under functional initiative with communication and $\lambda^{fi} \geq 0$ is strictly positive if and only if the acceptance constraint is binding. Similarly, we have that

$$\frac{d\pi^c(v, s_f^c, s_{bu}^c, \lambda^c)}{dv} = s_{bu}^c\left[2 - s_{bu}^c\right] + s_f^c(2 - s_f^c)$$

where (s_f^c, s_{bu}^c) are the optimal shares under functional control with communication and $\lambda^c \geq 0$ is strictly positive if and only if the communication constraint is binding. Assume now that

$$s_{bu}^{fi}\left[2 - s_{bu}^{fi}\right] + s_f^{fi}(2 - s_f^{fi}) \leq s_{bu}^c\left[2 - s_{bu}^c\right] + s_f^c(2 - s_f^c)$$

then

$$\pi_e^{fi}(s_{bu}^{fi}, s_f^{fi}) \leq \pi_e^{fi}(s_{bu}^c, s_f^c)$$

and since $(1 - s_{bu}^{fi})/s_f^{fi} < (1 - s_{bu}^c)/s_f^c$, also

$$\pi_i^{fi}(s_{bu}^{fi}, s_f^{fi}) < \pi_i^{fi}(s_{bu}^c, s_f^c)$$

Moreover, if (s_{bu}^c, s_f^c) satisfy the communication constraint under functional control, then they also satisfy the acceptance constraint under functional initiative. Hence, $\pi^{fi}(s_{bu}^{fi}, s_f^{fi}) < \pi^{fi}(s_{bu}^c, s_f^c)$, which is impossible given that (s_{bu}^{fi}, s_f^{fi}) are the optimal shares under functional initiative. It follows that we must have that

$$s_{bu}^{fi}\left[2 - s_{bu}^{fi}\right] + s_f^{fi}(2 - s_f^{fi}) > s_{bu}^c\left[2 - s_{bu}^c\right] + s_f^c(2 - s_f^c)$$

and thus $d\pi^{fi}/dv > d\pi^c/dv$.QED.