Market characteristics, intra-firm coordination, and the choice of human resource management systems: Theory and evidence

Takao Kato\textsuperscript{a,\ast}, Hideo Ow\textsuperscript{a}.

\textsuperscript{a} Department of Economics (Persson 222), Colgate University, 13 Oak Drive, Hamilton, NY 13346, USA
\textsuperscript{b} Institute of Social Science, University of Tokyo, Japan

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\textbf{A B S T R A C T}

This paper begins by constructing a team-theoretical model of organizational adaptation and coordination with three different task coordination modes: vertical control, horizontal coordination, and hybrid coordination. The model is then used to provide fresh insights on complementarities involving team work organization, communication channels, training and hiring, and other human resource management practices, and illustrate how such choice of practices is affected by the firm’s output market conditions. Our econometric analysis of new data from Japan which provide up-to-date information on the adoption of new team-based instruments for a horizontal coordination system (cross-functional problem solving project teams and Self-Managed Teams) yields results that are broadly consistent with the theory. First, new team-based instruments are more likely to be adopted by firms with well-established formal shop-floor-based communication channels (such as shopfloor committees), while they are much less likely to be adopted by firms with well-established information sharing institutions such as joint labor-management committees, which presumably enhance the efficiency of the vertical control system by minimizing labor-management communication errors. Finally, firms in more competitive markets and those with a higher concentration of sales among a small number of customers are more likely to adopt both types of team, whereas firms facing more erratic price movement tend not to adopt Self-Managed Teams.

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1. Introduction

Much of the literature on innovative HRMPs (Human Resource Management Practices) focuses on their effects on enterprise performance. It generally finds that HRM systems with complementary practices such as teams, joint labor-management committees, and incentive pay raise productivity or other firm performance measures.\textsuperscript{1}

\textsuperscript{\ast} Corresponding author. Tel.: +1 315 228 7562; fax: +1 315 228 7033.
E-mail addresses: \textsuperscript{\ast}tkato@colgate.edu (T. Kato), owan@iss.u-tokyo.ac.jp (H. Ow\textsuperscript{a}).


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However, relatively few attempts have been made to identify under what circumstances firms adopt these new practices and how they select a particular combination of HRMPs. Prior studies are largely empirical explorations of the determinants of the adoption of HRMPs, and different authors stress different possible determinants. For instance, Arthur (1992) views the firm’s selection of particular HRMPs as a part of its overall business strategy, and presents evidence from mininmills in the U.S. that a firm is more likely to choose HRMPs promoting employee commitment and involvement in concert with business strategies focusing on product and customer differentiation (as opposed to low cost strategies). Pil and MacDuffie (1996) use panel data of automobile assembly plants worldwide and show that employee involvement programs are more likely to be adopted in plants with other complementary personnel policies and practices such as hiring and training policies aimed at employee ability to learn new skills and teamwork. Another econometric case study of steel finishing lines by Ichniowski and Shaw (1995) demonstrates that innovative and productivity-enhancing HRMPs are more apt to be adopted by “young” plants with a relatively low cost of switching from the existing old system to the new system.

Finally, Osterman (1994) uses nationally representative samples of U.S. establishments encompassing diverse industries to study general patterns of the adoption and diffusion of innovative work practices. Among other things, the study reports evidence on a relationship between the adoption of HRMPs and exposure to global competition, which is closely related to one of the key findings of this paper.

Evidence on the incidence of new innovative work practices is even more limited outside of the U.S. Jirjahn (2002) applies a similar methodology used by Ichniowski and Shaw (1995) to his German establishment-level data and identifies a number of key determinants of the adoption of innovative HRMPs by German firms. One of Jirjahn’s key findings is that innovative HRMPs are more apt to be adopted by firms that rely on international markets for their products, yet less likely to be adopted by firms that consider domestic market share a primary goal. Brown et al. (2007) use Australian establishment-level data (Australian Workplace Industrial Relations Survey) and report evidence pointing to the importance of long-term employment relationships between the firm and workers as a significant complement to employee involvement programs. For cross-country comparative studies, Poutsma et al. (2003) use a survey of firms in ten EU members and stress the importance of country specific factors as determinants of the adoption and diffusion of participatory employment systems. Finally, on Japanese firms, Jones and Kato (1993) find that firms are more likely to adopt employee stock ownership plans when recent business performance is below average, the capital/labor ratio is relatively low, and employment growth is relatively fast. More recently Kato (2006), using firm-level data from Japan, shows that the employment system consisting of complementary HRMPs evolves significantly over time, pointing to the importance of a more dynamic view of HRMPs, which we will take up in this paper by examining why some Japanese firms add new forms of team-based HRMPs to the existing participatory employment system while others do not.

By reviewing the literature on the adoption of HRMPs, we are struck by the relative scarcity of coherent and testable theories on the firm’s choice of HRMPs. Milgrom and Roberts (1990) demonstrate how we can apply Topkis’s framework of monotone comparative statics to a study of complementarities among the firm’s choice of technology and practices, using a very important application to flexible production system vs. mass production system. Their approach, however, neglects the information-processing nature of the organization and the resultant need for coordination, which we believe are the key mechanism that explains many differences in HRMPs among firms. Information-processing models of organizational architecture based on team theory (Marschak and Radner, 1972) have been employed by Aoki (1986, 1990) and Carter (1995). Both works illustrate important tradeoffs among organizational modes: bounded rational control (prior planning) vs. imperfect horizontal coordination (ad hoc adaptation based on posterior information) in Aoki (1986, 1990) and among seven organizational forms (routine, marketing dominated, production dominated, marketing-led, production-led, centrally-managed, pooled information) which differ in the degrees of information aggregation and their information sharing schemes in Carter (1995). Their implications for the evolution of organizational architecture are rather limited, however, because the relative efficiency of each organizational mode depends on unknown parameters which are hard to observe or interpret: rate of learning-by-doing and interdependency among units in Aoki (1986, 1990) and organizational costs treated as black-box in Carter (1995).

We believe that the literature has been mostly silent on the potentially important interplay between modes of task coordination within the organization and its choice of bundling of HRMPs. Moreover, as contingency theory in organizational behavior (developed in the 1960s) stresses, a firm’s technological and output market conditions may play a crucial role in determining the firm’s choice of a specific mode of task coordination within the organization, and hence its selection of a specific HRM system (provided there is an important link between task coordination modes and HRM systems).  

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2 For other econometric case studies, see Boning et al. (2007) on the steel industry and Chi et al. (2007) on manufacturing firms near Minneapolis. For other cross-industry studies, see Blasi and Kruse (2006) and a recent NBER working paper which uses a representative sample of U.S. establishments including both manufacturing and non-manufacturing (Lynch, 2007).

3 The literature of contingency theory in organizational behavior attempted to make a connection between the varying technical and economic conditions outside an organization and the pattern of organization and administrative architecture that exhibit successful performance. Early works generally found that when the environment and task of the organization were certain and predictable then centralization and formalization were appropriate, but when they were uncertain and unpredictable then decentralization and lack of formalization were required. For example, Burns and Stalker (1961) concluded from their research on 20 English manufacturers that the more rapidly a firm’s technological and market environment was changing, the more flexible or “organic” its structure tended to be. Essentially similar conclusions were reached by Lawrence and Lorsch (1967) in their study of 12 large American firms. Subsequent studies on contingency theory, however, seem to have lost interest in the role of purely economic and market conditions in shaping
This paper begins by constructing a coherent team-theoretical model building on the work of Dessein and Santos (2006) and Aoki (1986, 1990). Aoki’s work focuses on comparing the efficiency of prior planning under vertical control to that of decentralized adaptation based on on-site information. The model structure of Dessein and Santos allows us to examine the basic tradeoffs between adaptation and coordination, which are inseparable in Aoki. By combining the elements of the two models, we can evaluate how a change in adaptation requirement affects the relative efficiency of the two organizational modes studied in Aoki.

More specifically, we derive three distinct modes of task coordination within the organization: vertical control, horizontal coordination, and hybrid coordination. The model is then used to generate implications about complementarities involving work organization, communication channels, training and hiring and other management practices, and illustrate how such choice of HRMPs is affected by the firm’s output market conditions.

Guided by our theoretical exploration, we analyze unique data from a new survey of Japanese firms that provides comprehensive data on evolving HRMPs in Japan in recent years.

Our probit estimates confirm two key insights from our theoretical explorations: (i) complementarity between team-based work organization and communication channels; and (ii) interplay between a firm’s output market characteristics and its choice of HRMPs. Specifically, the probit estimates suggest that: (i) firms with well-established formal shop-floor-based communication channels (such as Shop Floor Committees) are more likely to adopt new team-based instruments for information sharing and problem-solving (such as cross-functional problem solving project teams and self-directed teams), for Shop Floor Committees are complementary to Cross-Functional Teams and self-directed teams in horizontal coordination systems; and (ii) firms with well-established information sharing institutions such as Joint Labor-Management Committees (JLMCs) are less likely to adopt Cross-Functional Teams and self-directed teams, since JLMCs tend to enhance the efficiency of vertical control systems by minimizing labor-management communication errors, and hence reduce incentives to introduce new team-based instruments for horizontal coordination systems.

Concerning the interplay between product market competition and HRMPs, our probit estimates suggest that firms in more competitive markets and those with a higher concentration of sales among a small number of customers are more likely to adopt both types of teams while firms facing more erratic price movement tend not to adopt Self-Managed Teams.

In the next section, we present our theoretical exploration, followed by an empirical analysis of new Japanese data with a brief introduction to the new survey in Section 3. Concluding remarks are offered in Section 4.

2. Theoretical exploration

In this section, we present a team-theoretical model that will be used to explain a firm’s decision to introduce innovative HRMPs. We consider a firm with n employees and production that requires the combination of n tasks. The firm’s profit depends on how well it adapts to the organizational environment and how well tasks are coordinated with each other. We assume that the firm can employ one of the following two work systems to enhance its coordination capabilities: (1) decision rights are retained in the hands of the management to coordinate perfectly among tasks at the expense of adaptation (a vertical control system) or (2) tasks are bundled and delegated to teams to enhance the capability for adaptation and achieve perfect coordination within teams (a horizontal coordination system).

Task i requires taking primary action ai to adapt to a changing environment and complementary actions aj (for all j such that j i) to coordinate with other activities in the firm. There are two types of information that are relevant to the choice of optimal actions: η, the set of systematic environmental information, and θ (i.e., the local environmental information that is only observed by those working on task i. The former is the set of information that affects the optimal action in each task systematically including macro-economic conditions, the emergence of new technology, and changes in customer

the structure and management system of an organization. They primarily focused on the relationships between the process technology adopted within an organization and its structure (Woodward, 1965; Hickson et al., 1969; Gerwin, 1979; Reimann, 1980; Drazin and van de Ven, 1985). They all reported that as the production process of a work group becomes less routine, more uncertain, and/or more complex, its structure becomes more organic, with increased participation, autonomy, and informalization for group members. (The same cannot be said for most of the studies examining the structure and production process technology at the system [managerial] level. See Hickson et al., 1969) Since the choice of process technology is the dependent variable for the firm, it may be argued that a particular process technology may tend to develop in response to certain market, technological, or industry characteristics. The possibility that such environmental factors affect both the adoption of particular process technologies and organizational structures has long been ignored. It is surprising that few works in contingency theory literature attempt to answer the above question raised by Lawrence and Lorsch (1967) from a different perspective or using a large-scale dataset.

Aoki (1986, 1988) compares localized horizontal coordination with centralized hierarchical coordination and concludes that the latter is more efficient if information regarding emergent events is relatively more precisely monitored at the top level and concomitant centralized solutions are more swiftly implemented at the shop-floor level without distortion. In such situations where gradual and speedy reaction to on-site local information is more efficient, however, self-managed on-line teams will likely be chosen as effective coordination and decision making devices. Dessein and Santos (2006) also analyzes how organizations choose the level of adaptation to a changing environment when coordination among specialized tasks is a concern. One of their important findings is that the relationship between the need for task bundling (e.g., job enlargement or multi-tasking) and the quality of communication channels is not monotone. On the one hand, an improvement in the quality of communication makes it easier to coordinate specialized activities, reducing the need for task bundling. On the other hand, as coordination through communication improves, the organization will find it optimal to increase employee flexibility and become more adaptive, favoring more task bundling in order to reduce coordination failures. The latter effect tends to dominate the former when communication channels are poor and/or the interdependence among specialized activities is high. Dessein and Santos (2006) also shows that broad job assignment and investment in the quality of communication co-vary at the optimum under a reasonable assumption.
taste, while the latter is the one that is relevant only to the task where the information is observed. \( \theta^i \) is a random variable whose prior distribution is assumed to be known to all members of the firm. The set of systematic information \( \eta \) can be used to update the prior distribution of \( \theta^i \) to obtain a more accurate prescription for desirable actions. Let \( \bar{\theta}^i(\eta) = E(\theta^i | \eta) \) and \( \sigma^2(\eta) = \text{Var}(\theta^i | \eta) \) where the variance is common across \( i \). Assume \( 0 < \sigma^2 - \sigma^2(\eta) \leq \sigma^2(\phi) \) where \( \phi \) indicates the null set meaning that the decision maker has no systematic information. When \( \eta \subset \eta' \), \( \sigma^2(\eta) \geq \sigma^2(\eta') \). Adaptation calls for the use of local information and the primary action \( a^i \) should be set equal to \( \bar{\theta}^i \). On the other hand, to achieve perfect coordination between \( i \) and \( j \), action \( a^j \) should be set equal to the primary action \( a^i \). Let \( C^i \) be the adaptation and coordination losses for task \( i \). Then,

\[
C^i(a^1, a^2, \ldots, a^m) = \alpha(a^i - \bar{\theta}^i)^2 + \sum_{j \neq 1} \beta(a^i - a^j)^2
\]

where the parameters \( \alpha \) and \( \beta \) determine the importance of adaptation and coordination, respectively.

This separation of adaptation and coordination in the cost function may sound unrealistic because any decisions in complex transactions within the organization have both aspects of adaptation and coordination. For example, setting a price for a new product requires the marketing manager to take into account the customer demand that would change over time and the prices of similar products from competitors, but at the same time, coordinate with the production manager because the optimal price presumably depends on the timing of product launch, production plan, and cost-cutting efforts. Nonetheless, we believe that the cost function in (1.1) can be justified for the following two reasons. First, when you break down each activity into smaller steps, individual steps are often geared more to either adaptation or coordination. For example, a marketing manager will decide how much time and money to spend on marketing research that would generate valuable market demand information (adaptation). Then, he/she will develop several pricing plans for different production/promotion scenarios based on the market research (adaptation). Finally, he/she will consult with the production manager to check the feasibility of each pricing plan and determine which plan is best for the firm (coordination). Thus, the separation of adaptation and coordination in the cost function may not be as unrealistic as it might appear at first glance.

Second, the purpose of using this functional form is to examine the tradeoffs between adaptation and coordination and investigate how these tradeoffs change in response to market conditions. As Dessein and Santos (2006) also argue in their paper, such tradeoffs are prevalent. For example, since the late 1990s, Japanese automobile manufacturers have required suppliers of electrical control units (ECUs) to collaborate with other suppliers and accommodate many specification changes designed to improve functional performance at the car unit level in the course of the development of new models. As a result, many such suppliers experienced an increase in defect density at the time of system tests, as well as excessive workloads and delay to fix the defects during the late stage of development in the following years. This indicates that the push for adaptation often results in coordination problems. Additive and separable functional form is suitable for analyzing such tradeoffs. A similar modeling approach is found in labor economics where general and firm-specific human capital often enter the production function in a separable and additive form despite the view that most skills have both general and firm-specific components.

We assume that management obtains some systematic information through a variety of activities, including the use of consultants, market and technology research, and the analyses of its operations, but observes no local information directly. On the other hand, employees observe their local information relevant to their own tasks but have no direct access to systematic information. In the spirit of Aoki (1986, 2001), we consider two distinct modes of information processing systems: vertical control and horizontal coordination, as discussed earlier. Firms choose their information processing systems so as to minimize their total costs. Later, we will consider a hybrid mode of information processing.

### 2.1. Vertical control systems

When the systematic information possessed at the top is sufficient to infer the local information collected at the lower levels of organization relatively precisely, management will try to pre-specify both primary and complementary actions at \( a^i = \bar{\theta}^i = \bar{\theta}(\eta) \) to minimize coordination losses. Management’s instructions, however, are not necessarily understood correctly by their employees. There could be communication errors, distortion, or delay in implementation during which the environment may change. We assume that noise \( \psi^i \) is added to the management’s instruction for action \( a^i \), where \( \psi^i \)s are independent of each other and \( \theta^i \)s and have a common variance \( \sigma^2 \). In this work system, there is no teamwork and each worker is in charge of one task.

Furthermore, we assume that the workers receive very limited training that is only sufficient to do one task following the management’s instructions. The workers are not allowed to use their discretion because they do not have adequate knowledge of technology (i.e. cost function (1.1)) thus are not capable of figuring out how they can improve upon the

\footnote{This new situation encouraged many suppliers to search for better software development processes that work well with the “integral architecture;” a product design architecture that relies on coordinated efforts across parts suppliers to maximize functional performance of the final products. See Mizukami and Owan (2010) for an example of such efforts.}
instructions of management.\textsuperscript{6} If they fully understand the production technology, the workers would want to adjust the management’s instructions using the local information $\theta$ they perfectly observe even with the hierarchical coordination in the vertical control systems. Such an arrangement is what we call hybrid coordination and is discussed later.

Given the above assumption that the employees implement the management’s instructions like robots, the one assigned task $i$ takes $a_i^i = \bar{\theta}(\eta) + \epsilon_i$ and $a_j^i = \bar{\theta}(\eta) + \epsilon_j$ (for $j \neq i$).

The organization’s total cost is given by

$$
\sum_{i=1}^{n} E[C(a^{1}, a^{2}, \ldots, a^{n})|\eta] = \alpha \sum_{i=1}^{n} E[(a_i^i - \bar{\theta})^2 | \eta] + \beta \sum_{j \neq i} E[(a_i^j - a_i^i)^2 | \eta] = n\alpha(\sigma^2(\eta) + \sigma^2) + 2n(n - 1)\beta\sigma^2
$$

The vertical control system clearly fails to utilize the local information observed at the individual level. Horizontal coordination systems discussed next delegate the coordination role to the employees to have them directly respond to the local information $\theta$.

2.2. Horizontal coordination systems

When the management believes that adaptation at the lower levels of organization creates substantial economic value, they will let the employees choose their own actions. As is conventional with team-theoretical models, we assume that there is no conflict of interest between the management and the employees and the latter choose their actions to minimize the firm’s cost. Unlike the workers in the vertical control system who simply obey the management’s instructions, we assume that the workers in the horizontal coordination systems fully understand the production technology and act as rational agents. Hence, firms with such work systems have to incur higher costs of hiring and training, which will be discussed in detail later.

In this work system, each task is assigned to a group of employees. $t$ tasks can be assigned to a group of $t$ employees. Hence, $t = 1$ is simply a special case of team assignment where each task is assigned to an individual. We denote by $T(i)$ the group of employees to which task $i$ is assigned. To simplify our analysis, we restrict the team structure to be “symmetric,” meaning that all teams have the same number of members $t$. Therefore, $|T(i)| = t$ for all $i$. $\theta$ is tacit information meaning that employees can share the realization of the local information $\theta$ only by working closely together but cannot transmit the information to management within the time period in which planned decisions may be revised. We assume that employees in $T(i)$ can jointly observe $\theta$ prior to the actual implementation of actions, hence $a_i^j = a_i^\theta$ for $j \in T(i)$. Therefore, $t$ should not be interpreted just as the size of a team, rather it is the degree of task bundling and multitasking as modeled by Dessein and Santos (2006), as team members need to work together, share information, and constantly coordinate their activities within teams. The local information can also be communicated to other colleagues outside teams when the outsiders happen to have close interaction with the team members that facilitate the transfer of the tacit information. Following Dessein and Santos (2006), we model such communication in the following way: each team $T(i)$ sends a message concerning $\theta$ to all employees outside the team. With a probability $p$, an employee in charge of task $j \notin T(i)$ perfectly understands the message and takes the complementary action $a_i^\theta$ that is set precisely equal to the primary action $a_i^\theta$. With the probability of $1 - p$, the message concerning $\theta$ will be pure noise for the employee, and thus the choice of the relevant complementary action $a_i^\theta$ cannot be made contingent on it.

There are costs associated with team formation and information sharing, such as productive time diverted for information processing and communication, and resources spent for developing necessary team skills and other practices supporting team activities. Note that choosing the optimal action, taking into account the possibility of coordination failure, requires more highly trained employees than simply obeying the bosses’ instructions does. Hence, team activities require additional wage costs to hire more educated workers, or to provide additional training to help empowered workers to make decisions. Furthermore, firms develop communication channels such as cross-functional off-line teams, and invest in information and communication tools to raise $p$. Let $h(t, p, \tau)$ be the total cost of such expenditures for team formation, human capital investment and intra-firm horizontal communication per employee where the parameter $\tau$ denotes the firm’s capability of training its employees for better workplace communication and team activities. Such capability depends on the firm’s pre-existing conditions including the labor-management relationship, corporate culture, adoption of multi-skilling practices such as job rotation, quality of existing workforce. The firm optimally chooses $t$ and $p$ given pre-determined $\tau$. We assume $h(t, p, \tau)$ is increasing in $(t, p)$ and decreasing in $\tau$.

\textsuperscript{6} This assumption is reasonable for two reasons. First, the worker’s ability to identify and solve non-routine problems in the workplace is initially limited and can only be improved upon over time through learning by doing. Second, each employee lacks information concerning technologies used by others except for those directly related. Koike (1988) maintains that the provision of multiple skills through job rotation was indispensable for the worker’s ability to contribute to process improvement and solve non-routine problems at the local level because multi-skilling helps them understand the entire production process, and such comprehensive understanding of the production process is often crucial for non-routine problem solving.
The total adaptation and coordination cost (including that for team formation and human capital) is
\[
\sum_i C'(a^{i1}, a^{i2}, \ldots, a^{in}, T, p) = \sum_i \alpha (a^{i\theta} - \bar{\theta}^i)^2 + \sum_{i,j \in T(i)} \beta (a^{i\theta} - a^{j\theta})^2 + nh(t, p, \tau)
\]  

(1.3)

Note that the coordination losses within the same team \(T(i)\) do not appear in the expression because we expect the members of \(T(i)\) to perfectly coordinate among themselves. The average size of teams \(t\) and the precision of horizontal communication \(p\) are chosen by the management, but the actual actions are taken by the employees themselves.

The timing of the decision-making is as follows:

(1) Once the management chooses the horizontal coordination system, they determine the size of team \(t\) and the investment in communication quality \(p\).
(2) Local information \(\theta^i, i = 1, 2, \ldots, n\), is realized and observed by the employees of the group in charge of task \(i\).
(3) Workers communicate the local information, and with an independent probability \(p\), these communications are successful. Whether or not communications are successful is known by the receivers of the information only and the sender does not learn the outcome of the communication.
(4) For all \(i = 1, 2, \ldots, n\), the employees of the group in charge of task \(i\) choose actions \(a^{i\theta}, j = 1, 2, \ldots, n\), that would minimize the expected cost function (1.3), subject to their information constraints.

First, it is important to realize that the employees in charge of task \(i\) do not necessarily choose \(a^{i\theta} = \theta^i\), the action that adapts to the environment perfectly, because it raises the cost of coordination failure that takes place when communications with other employees fail. Note that the decision-makers for task \(i\) minimize \(\alpha (a^{i\theta} - \bar{\theta}^i)^2 + \sum_{j \notin T(i)} \beta (a^{i\theta} - a^{j\theta})^2\). It is easy to show that the optimal actions \(\{a^{i\theta}\}_{i,j}\) satisfy
\[
a^{i\theta} = \bar{\theta}(\phi) + \left[\frac{\alpha}{\alpha + \beta(n - t)(1 - p)}\right] (\theta^i - \bar{\theta}(\phi))
\]  

(1.4)

and
\[
a^{i\theta} = \begin{cases} 
    a^{i\theta} & \text{when task } j \text{ learns } \theta^i \\
    \bar{\theta}(\phi) & \text{when task } j \text{ does not learn } \theta^i 
\end{cases}
\]  

(1.5)

Hence, with the horizontal coordination system, the total cost is given by
\[
\sum_{i=1}^{n} E[C'(a^{i1}, a^{i2}, \ldots, a^{in}, T, p) | \phi] = n \frac{\alpha \beta(n - t)(1 - p)}{\alpha + \beta(n - t)(1 - p)} \sigma^2(\phi) + nh(t, p, \tau)
\]  

(1.6)

The management will choose \((t, p)\) to minimize this cost function. Let \(t^*\) and \(p^*\) be the optimal team size and the optimal investment in communication quality. In order to insure the uniqueness of the optimal organizational design, we make the following assumptions:

**Assumption 1.** The function \(\sum_{i=1}^{n} E[C'(a^{i1}, a^{i2}, \ldots, a^{in}, T, p) | \phi]\) is strictly quasi-convex in \((t, p)\).

**Assumption 2.** \(h(t, p, \tau)/(n - t)\) is submodular (or \(-h(t, p, \tau)/(n - t)\) is supermodular), namely the function has non-increasing differences for any pair of \((t, p, \tau)\).

Next, we state the proposition due to Dessein and Santos (2006):

**Proposition 1.** Suppose the horizontal coordination is adopted. Team size, \(t^*\), and the quality of communication channels, \(p^*\), are increasing in the parameters \(\alpha\), \(\sigma^2(\phi)\) and \(\tau\). (Proof in Section Appendix.)

The use of teamwork and communication channels will be more extensive as the importance of adaptation, the uncertainty of the business environment, and the firm’s capability of team building and supporting horizontal communication are greater. Note that Assumption 2 is critical in generating this monotonicity result.

As Dessein and Santos (2006) discuss, \(t^*\) and \(p^*\) are not necessarily monotonically increasing in \(\beta\), the degree of task interdependence or the cost of coordination failure, contrary to conventional wisdom. While an increase in \(\beta\) encourages the firm to raise \(t^*\) and \(p^*\) to hold down the coordination cost, it also induces the firm to take less adaptive primary actions (i.e. farther apart from \(\theta^i\)), which in turn reduces the need to coordinate among employees. Therefore, \(t^*\) and \(p^*\) are monotonically increasing in \(\beta\) only when \(\alpha\), the importance of adaptation, is sufficiently high.

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7 Since each employee has to send a signal to \((n - t)\) employees outside his/her team and evaluate the signals concerning \((n - t)\) tasks, \(h(t, p, \tau)/(n - t)\) can be interpreted as the opportunity cost for communicating with other employees to determine the optimal complementary actions per task. This submodularity assumption is reasonable because: (1) the greater the average team size, the higher the chance that an arbitrary outsider happens to have close interaction with someone in \(T(i)\) leading to a better communication quality; and (2) the higher the firm’s capability of training its employees for teamwork, the easier it will be to increase team size and communication quality.
The result that \( t^* \) and \( p^* \) are monotonically increasing in \( \sigma^2(\phi) \) is similar to a finding in Aoki (1990), which demonstrates that the optimal time to accumulate information processing capabilities (learning time) is increasing in prior uncertainty. Since both \( t^* \) and \( p^* \) in Dessein and Santos (2006) and learning time in Aoki (1990) improve information processing capabilities of the organizational form which relies on decentralized adaptation based on posterior information, the two results are essentially the same.

### 2.3. Choice of management system

Next, we examine which task coordination mode is most likely to excel. In this section, we conduct comparative statics analysis with respect to \( \alpha \) holding \( \beta \) constant. There are three reasons why we primarily present implications for the effect of a change in \( \alpha \) but not for a change in \( \beta \). First, the relative size of the total costs of the two coordination systems primarily depends on the relative magnitude of \( \alpha \) and \( \beta \) as will be suggested by the inequality (1.7), and therefore, an increase in \( \alpha \) and a decrease in \( \beta \) have a similar effect on a firm’s choice. We avoid duplication of essentially the same result by focusing only on the adaptation parameter \( \alpha \).

Second, it is much more difficult to measure empirically the level of \( \beta \), which basically embodies the interdependency and complexity of business transactions the firm engages in. As a result, we only test implications for a shift in \( \alpha \) in our empirical section. Third, although we cannot neglect a possible change in \( \beta \) in recent years, past studies have implied that the magnitude of a shift in \( \alpha \) is greater than that for \( \beta \). For example, recent changes in the business environment such as rapid technological changes, deregulation, and globalization are believed to raise the importance of firms’ adaptability to the new environment (D’Aveni, 1994; Hamel and Prahalad, 1996; Brown and Eisenhardt, 1998). However, the implications of recent changes for coordination requirements are rather mixed. On the one hand, it is perceived that global business development, or the “multinationalization” of many firms has made intra-firm cross-country/cross-product coordination more complex (Bartlett and Ghoshal, 1989). On the other hand, the standardization of processes through information technology is believed to have helped to simplify cross-functional coordination and encouraged outsourcing by standardizing cross-functional interfaces (Drucker, 1988; Sanchez and Mahoney, 1996; Hitt, 1999; Langlois, 2002).

In the analyses that follows, we let \( \alpha \in [\alpha, +\infty) \) where \( \alpha \) is chosen so that either vertical control or horizontal coordination (or their hybrid) is optimal. When \( \alpha \) is sufficiently small relative to \( \beta \), a bureaucratic organization where all activities are governed by routines and employees do not respond to posterior information will perform best.\(^8\) Since modern firms are under increasing pressure to respond to a changing business environment to remain competitive, we rule out such possibility to focus on relevant tradeoffs that are faced by most current firms.

The firm will choose the vertical control system (or, alternatively, the horizontal coordination system), if

\[
\sum_{i=1}^{n} E[C(a^{11}, a^{2i}, \ldots, a^{ni})|\eta] - \sum_{i=1}^{n} E[C(a^{11}, a^{2i}, \ldots, a^{ni}, T, p)|\phi]
\]

Or equivalently,

\[
\alpha(\sigma^2(\eta) + \sigma^2(\phi)) + 2\beta(n - 1)\sigma^2 < \frac{\alpha(n - t^*(1 - P^*))}{\alpha + (n - t^*)(1 - P^*)} \sigma^2(\phi) + h(t^*, p^*, \tau)
\]

(1.7)

**Fig. 1** illustrates the cost structures of the two systems with respect to the level of \( \alpha \). Specifically, they are the left-hand side and right-hand side of inequality (1.7) as a function of \( \alpha \). As can be easily seen, the cost under the vertical control system (left-hand side of (1.7)) is a linear function of \( \alpha \) while that under the horizontal coordination system (right-hand side of (1.7)) is concave in \( \alpha \).\(^9\) The reason for the concavity in the latter is that the adaptation and coordination losses do not rise in proportion with the increase in \( \alpha \) because both management and the employees adjust their decisions to reduce the adaptation losses. First, the management chooses higher degree of teamwork \( t \), and higher investment in communication quality \( p \) for greater \( \alpha \) as is shown in Proposition 1. Second, the primary actions the employees choose get closer to \((\theta^1, \ldots, \theta^p)\), the true state of the environment, to reduce adaptation losses as \( \alpha \) increases. Therefore, as Fig. 1 shows, the horizontal coordination becomes advantageous when \( \alpha \) exceeds a certain threshold. In theory, it is also possible that, for a sufficiently small \( \alpha \), the horizontal coordination system could become relatively more superior if \( h \) is sufficiently small and \( \sigma^2(\phi) \) is large enough. Fig. 1 illustrates this possibility. In reality, however, delegating strategically or operationally critical decisions to lower-level employees is very unlikely when adaptation is less critical (i.e. \( \alpha \) is small) because the horizontal coordination system typically requires substantial investment in employee training and is not worth doing unless the adaptation effort generates sufficient return. We believe that delegating decision rights to subordinates with little adaptation benefits but because vertical communication is too noisy is not a relevant case in the present-day business situations. Therefore, we set the lower bound \( q \) sufficiently large to rule out this case.

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\(^8\) To rule out bureaucratic organization, \( \alpha \) has to satisfy \( \alpha > \alpha(\beta) = 2(n - 1)\beta\sigma^2(\phi)/\sigma^2(\phi) - \sigma^2(\eta) - \sigma^2 \).

\(^9\) You can easily show that the cost function in the latter is concave using the results from Proposition 1, \( dt/d\alpha > 0 \) and \( dp/d\alpha > 0 \).
Assumption 3. \( \alpha \) satisfies \( \alpha > \inf_{t,p} \left\{ \alpha (\sigma^2(\eta) + \sigma^2_t) + 2\beta(n - 1)\sigma^2_t \right\} < \min_{t,p} \left\{ \min \left( \frac{\alpha(n - t)(1 - p)}{\alpha / \beta + (n - t)(1 - p)} + h(t, p, \tau) \right) \right\} \)

With this restriction to \( \alpha \), we can make the following simple prediction about the choice of coordination system:

Proposition 2. Holding the other parameters fixed, there exists \( \hat{\alpha} \) such that the horizontal coordination system functions better if and only if \( \alpha > \hat{\alpha} \) (Proof in Section Appendix).

With Propositions 1 and 2 combined together, we get the following implication: team organization is more likely to be adopted, and investment in horizontal communication channels to raise \( p \) is likely to be greater, as adaptation to a new environment becomes more important. This finding is our main theoretical contribution to the literature.

We summarize additional comparative statics results in Proposition 3.

Proposition 3. As systematic information becomes more important (i.e. \( \sigma^2(\phi) - \sigma^2(\eta) \) gets greater) and labor-management communication involves less noise (i.e. \( \sigma^2_t \) becomes smaller), the vertical control system becomes more desirable. On the other hand, as the pre-conditions that facilitate team formation and inter-team communication prevail (i.e. \( \tau \) rises), the horizontal coordination system is likely to be superior. (Proof is straightforward from (1.7) and thus omitted).

Proposition 3 may imply that as the technological and market changes become more disruptive, primary actions and responsibilities are less likely to be delegated to lower-level employees, because local information is less likely to be sufficient for the employees to engage in complex coordination activities in such occasions.

When \( \sigma^2(\eta) \) is large, so that information about the macroenvironment has relatively small value, the horizontal coordination system is adopted, and an increase in \( \sigma^2(\phi) \) leads to increases in \( t \) and \( p \) (Proposition 1). But, when \( \sigma^2(\eta) \) is small enough, an increase in \( \sigma^2(\phi) \) makes it more likely that the vertical control system is adopted (see (1.7)).

Results similar to Proposition 3 have already been shown in Aoki (1986). According to his paper (Proposition 1), the relative advantage of horizontal coordination (regardless of the imperfectness of coordination capability) is positively related to the degree of imprecision of management’s perception (the inverse of \( \sigma^2(\phi) - \sigma^2(\eta) \) in our model), the lag in hierarchical adaptation to emergent new events (similar to labor-management communication noise \( \sigma^2_t \) in our model), and the rate of learning of shops (similar to pre-conditions that facilitate team formation and inter-team communication \( \tau \) in our model).

2.4. Hybrid coordination system

Although hierarchical structures are often perceived to be incompatible with delegation or team organizations, an increasing number of firms seem to try to combine the empowerment approach with the traditional hierarchical structure.\(^{10}\)

We now consider hybrid organizations where employees adjust their actions according to local information, after receiving instructions from management. Let us call this information processing system “hybrid coordination”.

The timing of decision-making in this system is equivalent to that in the horizontal coordination system except that between step 1 and step 2, employees receive instructions from management: \( a^H = \hat{\theta}(\eta) + \nu^H \) and \( a^H = \hat{\theta}(\eta) + \nu^H \) (for \( j \neq i \)).

The total adaptation and coordination losses for such organizations can be obtained simply by replacing \( \sigma^2(\phi) \) with \( \sigma^2(\eta) \)

\(^{10}\) For example, Nonaka and Takeuchi (1995) argue that the “hypertext” organization, which has two layers, the hierarchical business layer and the project team layer, is an effective way to acquire, create, exploit, and accumulate new knowledge. According to them, this type of organization has been adopted by a number of large Japanese firms including Sharp and Kao Corporation.
in the cost function for horizontal coordination, and adding the expected cost of vertical communication errors $\sigma_v^2$ for the case when communication across teams fails. It is easy to show that the total cost function for this type is

$$\sum_{i=1}^{n} E[C(a^{1i}, a^{2i}, \ldots, a^{ni}, T, p, \eta)] = n \frac{\alpha(n - t^*)(1 - p^*)}{\alpha + (n - t^*)(1 - p^*)}\sigma_v^2(\eta) + \beta n(n - t^*)(1 - p^*)\sigma_v^2 + nh(t^*, p^*, \tau) \quad (1.8)$$

where $t^*$ and $p^*$ are chosen optimally to minimize the expression (1.8).

Note that adaptation and coordination losses are smaller in the hybrid coordination system than in the vertical control system because local information is utilized in the former. However, the rationality required for employees in this hybrid coordination system is higher than that required for those in the vertical control system. In the latter, employees only need to execute what is prescribed by management. In the former, in contrast, employees have to predict what complementary actions their colleagues might choose and solve the cost minimization problem as discussed in Eq. (1.8). Therefore, only firms with capable employees and complementary practices can implement the hybrid coordination system. In other words, $h(t, p, \tau)$ is likely to be substantial and thus the vertical control system may still be optimal.

In contrast, we can show that the hybrid coordination system always dominates the horizontal coordination system as long as $\sigma_v^2$ is not too high. More precisely, the hybrid coordination system is superior to the horizontal coordination system as long as the vertical control system is at least as good as bureaucratic organization where no posterior information is used. Furthermore, since employees can always ignore the instructions from management when they are too noisy (hybrid and horizontal coordination systems become virtually equivalent in this case), the hybrid coordination system should always be as good as the (pure) horizontal coordination. Therefore, the comparison we should make may be between the vertical control system and the hybrid coordination system.

Nonetheless, we do not present such analysis here for the following two reasons. First, Propositions 1–3 still hold even after replacing the original horizontal coordination system with the hybrid coordination system but the presentation of such comparison becomes more cumbersome without adding much new insight. The important point is that the firm faces a similar tradeoff between prior planning and ad hoc adaptation based on posterior information as was discussed in Aoki (1990). Second, in our setup, the labor-management communication noise $\sigma_v^2$ is exogenously given unlike the endogenous precision of horizontal communication $p$. If the amounts of investment in both vertical and horizontal communication are a firm’s choice and the resources for them are limited, the firm is likely to invest in either one because they are Edgeworth substitutes in the cost function for the hybrid coordination system. In such a model, only extreme organizational modes (i.e., vertical control and horizontal coordination) will appear in equilibrium. Bearing this possibility in mind, results from the comparison between the vertical control and original horizontal coordination would still be suitable for understanding the basic tradeoff we recognize in this section.

3. Evolving HRMPs in Japan: an application

3.1. Institutions and hypotheses

Following the burst of the financial market bubble at the end of the 1980s, Japan experienced a decade-long economic stagnation, during which time Japanese firms experimented with new forms of innovative work practices. We apply the theory developed above to such evolving HRMPs in Japan. We begin with providing institutional information on key HRMPs in Japan, including both long-established HRMPs and newer forms.

Established at the top level (corporate and/or establishment level), and involving both management and union representatives, Joint Labor-Management Committees (JLMCs) serve as a mechanism for information sharing at the top level on a large variety of issues, ranging from basic business policies to working conditions. JLMCs were one of the many labor-management institutions proposed at the beginning of the 1950s by the Japan Productivity Center. After a decade of tumultuous industrial relations between 1945 and 1955, Japanese unions and management, with endorsement from the Japanese government, began to implement a number of well-known human resource management techniques, including JLMCs.\(^{11}\)

Through JLMCs, top management and full-time union officials (in the absence of unions, the majority of employee representatives are elected by employees) engage in extensive and frequent two-way information sharing (Kato and Morishima, 2002). The quality of information shared with labor representatives is typically high, in part due to the high information processing capacity of union leaders (some of whom hold bachelor’s degrees in business and economics and sometimes even graduate degrees), and trust developed over time between top management and labor representatives. Some information shared by top management with labor representatives via JLMCs appears to be insider information material (Kato, 2003).\(^{12}\)

\(^{11}\) According to the Survey of Labor-Management Communication by the Ministry of Health, Labor, and Welfare conducted in 2004, more than 60% of firms use JLMCs for information sharing for basic management decisions such as business strategies and production and sales plans.

\(^{12}\) Information sharing via JLMCs is not unidirectional. Regular JLMC meetings are held typically once a month, and unions begin preparation for the next JLMC meeting almost immediately upon completion of the current meeting. Full-time union officials visit various shopfloors and talk to general membership to find out what they are concerned about and what they want to know from management. Based on this time-consuming field work, labor representatives to JLMCs write up detailed lists of questions which are then given to top management seven to ten days prior to meetings. Management
Aside from JLMCs and formal trade unions, many Japanese corporations also use shop-floor committees (SFCs) in which supervisors and employees meet regularly (almost once a month) and discuss shop-floor issues, mostly those related to working conditions of a local nature, such as air-conditioning, smoking/non-smoking environments, bathrooms, paid vacations, and cafeteria menus. SFCs provide frontline workers with valuable opportunities to learn how to share information with their coworkers and supervisors and engage in collective problem solving on issues that are mostly limited to what concerns them the most: workplace conditions. Though the diffusion of SFCs lagged behind JLMCs, by the end of 1980s (the end of the Japanese financial bubble), SFCs became a key element of the Japanese employment system (Kato and Morishima, 2002).

As mentioned above, during the recession following the bubble, Japanese firms started introducing newer forms of innovative work practices. Particularly noteworthy are: (i) cross-functional project teams (hereafter called Cross-Functional Teams), in which members from diverse functional groups across department lines engage in activities to reduce costs and improve quality, services, and delivery performance under specific targets and action plans; (ii) self-managed on-line teams (hereafter called Self-Managed Teams), in which members in the workplace are given autonomy to decide on work processes and task coordination in order to share operational know-how and information, and respond to market changes quickly; (iii) pay for performance (PFP), through which the wage or salary of an individual is linked to his/her own output or some other performance measure under a pre-determined rule; and (iv) profit-sharing plans (PSPs), through which the total amount of bonuses is linked to a measure of firm performance, such as profit, sales, production, or value-added.

Our theory outlined in the previous section guides us in developing empirically testable hypotheses on the adoption of such newer forms of innovative HRM systems. Specifically, on the one hand, we interpret the employment of Self-Managed Teams as the adoption of the horizontal coordination system with $t > 1$, and the use of Cross-Functional Teams as positive investment in communication channels $p$ in our theory. On the other hand, we interpret the existence of SFCs as high $r$, the parameter of organizational capability for team activities for the following reasons. First, SFCs can be viewed as an excellent training ground for frontline workers before taking on Cross-Functional Teams, which involve many more people with diverse backgrounds from different departments, and tackling issues that are more challenging and wider in scope. Second, SFCs are considered as best a co-determination mechanism for issues of limited scope in which managers try to resolve some workplace condition issues jointly with workers, or at least in consultation with workers. Self-Managed Teams, in principle, represent the full delegation of authority to workers, and allow for workers to make autonomous decisions, not only on workplace condition issues, but also on vital production issues. As such, SFCs prepare frontline workers well for Self-Managed Teams with a fuller authority delegation.

The existence of JLMCs can be viewed as low $\sigma^2$, labor-management communication noise. The relative efficiency of hierarchical structures depends on whether they can implement centralized solutions swiftly without distortion. Knowing management decisions well, employees or teams will more likely take actions without delay or misunderstanding.

We are now ready to state our empirically testable hypotheses. First, interpreting the existence of SFCs as high $r$, the parameter of organizational capability for team activities as we explained above, Propositions 1 and 3 in the previous section imply:

**Hypothesis I.** Firms with SFCs are more likely to use new team-based instruments for information sharing and problem-solving (such as Cross-Functional Teams and Self-Managed Teams).

Second, with the existence of JLMCs interpreted as low $\sigma^2$, labor-management communication noise, Proposition 3 leads to:

**Hypothesis II.** Firms with JLMCs are less likely to use Cross-Functional Teams and Self-Managed Teams.

Another key insight from our theoretical section is the potentially crucial role that output market conditions play in shaping the nature of HRM systems. According to Propositions 1 and 2, firms are more likely to adopt team organization and invest in communication quality when adaptation to the environment becomes more crucial for them. We first argue that speedy adaptation creates more value when the competition is more intense (i.e. when a slow response to environmental changes could result in a rapid fall in sales). Therefore, we expect that Cross-Functional Teams and Self-Managed Teams are more prevalent in such firms facing greater output market competition, ceteris paribus. Thus,
Hypothesis III. Firms facing greater output market competition are more likely to use Cross-Functional Teams and Self-Managed Teams.

We also maintain that responding in a timely manner to the information the frontline employees obtain from customers is more crucial for business success when sales are concentrated among a small number of customers. Reliance on a few customers typically arises in long-term buyer–supplier relationships built on commitment to a high level of service quality, which requires flexibility and adaptation to changing customers’ needs. Therefore, by applying Propositions 1 and 2 to a situation where \( \alpha \) increases, Cross-Functional Teams and Self-Managed Teams are more prevalent in such firms making highly concentrated sales to a limited number of customers.

Hypothesis IV. Firms with a higher concentration of sales among a small number of customers are more likely to use Cross-Functional Teams and Self-Managed Teams.

Proposition 3 in the theory section suggests that in burgeoning markets with high technological uncertainty or cyclical markets with large price fluctuations (i.e. high \( \sigma^{2}(\phi) \)), firms are less likely to adopt the horizontal coordination system (and hence Cross-Functional Teams and Self-Managed Teams). The implication from the model is that teams which react to on-site information in an ad hoc manner cannot implement systematically planned solutions. Individuals coordinate well when decentralized attempts to share local information succeed but fail to coordinate when ad hoc communication does not work. As a result, the adaptation capability of the horizontal communication system is impaired from the need to reduce coordination losses when the uncertainty in prior information is high. In other words, in disruptive environments, the advantage of quickly utilizing on-the-spot information will be more than offset by the cost of choosing suboptimal solutions in an imperfectly coordinated manner.

There is one more reason why the horizontal communication is less likely to work in disruptive or cyclical environments. Team instruments require stable membership and the commitment of management so that members can learn their tasks, new skills, and how to work together. This stability is at risk when demand fluctuates widely and management finds it difficult to commit to maintaining teams. As a result, a more hierarchical control system may be chosen and team instruments for the horizontal coordination system are less likely to be adopted. Thus,

Hypothesis V. Firms with greater output price fluctuations are less likely to use Cross-Functional Teams or Self-Managed Teams.

3.2. Data

Japan’s Ministry of Economy, Trade and Industry (METI) has been conducting the Information and Communication Technology Workplace Survey (ICTWPS) annually since 2001, which provides data on IT investment and IT-related activities from about half of 9,500 randomly selected enterprises that use computers in their businesses. As a supplement to the ICTWPS, METI allowed a team of researchers, including us and our colleagues at the Tokyo Institute of Technology, to conduct a new survey of Japanese firms, the HRMOS (HRM and Organization Survey of Japanese Firms), in November 2005. The sample universe included all firms that responded at least once to the ICTWPS since 2001, and were in seven key industries — general machinery, electrical machinery, information and communication electronics equipment, transportation equipment, precision instruments and machinery, retail, and financial. Of all firms that have responded to the ICTWPS at least once since 2001, 3,017 were in those seven industries.

We sent questionnaires to each of those 3,017 firms in November 2005, asking the director of management planning and the director of human resource management to fill out separate sections. We received usable responses from 365 firms (a response rate of 12.1%). Among those, there were 192 firms in manufacturing and 173 firms in non-manufacturing industries, and 80 firms are listed on Japan’s stock exchanges. Our response rate is neither particularly high nor low for a mail-in survey of Japanese firms.

To study the representativeness of our sample, let us compare the distribution of our sample firms (respondents to the HRMOS) by industry with that of respondents to the 2005 ICTWPS that are in the seven industries, assuming that the distribution of the latter is similar to our sample universe (respondents to ICTWPS 2001–2005 that are in the seven industries). The industrial make-up of our sample is largely comparable to that of the population except that our sample includes relatively more firms in general machinery and fewer firms in financial service. In addition, we find that the average firm in our sample is smaller than the average firm in the population (1103 workers as opposed to 1659 workers).

Next, it is plausible that firms with more innovative HRMPs are more likely to respond to our survey. To shed some light on the extent of such a response bias, we compare the proportion of firms with innovative HRMPs calculated from our survey to what has been calculated from the three earlier and larger surveys. First, regarding pay for performance (PFP) and

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15 For instance, in June of 1991, the Rengo Sogo Seikatsu Kaisatsu Kenkyu Jo (Rengo Research Institute of General Life Development) mailed questionnaires on labor conditions and employee participation/ involvement to 6,800 firms (including both public and private firms in Japan) and received usable responses from 689 firms (a response rate of 10%). In June of 1989, the Japan Productivity Center mailed questionnaires on HRMPs to 1,030 firms and received usable responses from 203 firms (a response rate of 19.7%). Kato and Morishima (2003) HRM Survey of Japanese Firms in 2001, which is perhaps the closest to our survey in terms of the content of the questionnaire, had a response rate of 17%. 

profit sharing plans (PSPs), there is a comparable yet larger governmental survey of Japanese firms called the General Survey of Employment Conditions (Shūro Jōken Sōgō Chōsha), which was conducted by the Ministry of Health, Labor and Welfare in 2004. The proportions of firms with PSP and PSPs in our sample are 48.1% and 45.4% respectively, and the comparable figures from the General Survey of Employment Conditions turn out to be reasonably similar (50.5% and 53.6% respectively).

Unfortunately, for employee involvement programs, there is no comparable, larger governmental survey. The only governmental survey that provides somewhat similar information is the Survey of Labor–Management Communications (Rōshi Komyunikeishon Chōsa, SLMC), conducted by the Ministry of Health, Labor and Welfare. The SLMC reports that in 2004, 37.3% of establishments had JLMCs; and 49.8% had SFCs. According to our survey, 55.4% of firms had JLMCs and 38% had SFCs in that same year. A simple comparison of the incidence of JLMCs and SFCs between our survey and the SLMC appears to suggest an overrepresentation of firms with JLMCs and under-representation of firms with SFCs in our sample. However, there is an important difference between the two surveys which may account for the discrepancy in the incidence of JLMCs and SFCs between the two surveys. The SLMC is a survey of establishments while ours is a survey of firms. Being a survey of establishments rather than firms, the SLMC naturally yields a lower incidence of JLMCs and a higher incidence of SFCs. Thus, some firms have JLMCs only at the headquarter level while their establishments have only SFCs, hence, the proportion of establishments with JLMCs is naturally lower than that of firms with JLMCs. On the contrary, SFCs are more prevalent among larger firms than among smaller firms according to the SLMC. Larger firms are more likely to have more establishments. The proportion of establishments with SFCs tends to exceed that of firms with SFCs.¹⁶

As explained in the introduction, our survey, HRMOS, is the first survey in Japan which provides comprehensive data on the use of new forms of innovative work practices by Japanese firms, such as Cross-Functional Teams and Self-Managed Teams, as well as more traditional forms such as JLMCs and SFCs. In addition, the HRMOS asks Japanese firms about their use of management practices with growing popularity, such as: (i) benchmarking, or a formal system of learning about practices in other successful firms, used to help clarify where ones’ company stands, relative to others, in the practices that matter most in ones’ area of business and (ii) management by objective (MBO), through which objectives are clarified, goals are set, and achievements for individual employees are assessed in a way that facilitates the coordination of employees’ activities to attain the firm’s strategic goals.

Finally, the HRMOS also provides data on various firm characteristics, such as age of the firm, number of employees, whether the firm is listed in one of Japan’s stock exchanges, industry classification, and education and training of labor force.

In order to explore possible complementarities among HRMPs, we first look at how the incidence of a practice differs depending on the presence of other practices. Table 1 summarizes such conditional incidence rates (percentage of firms with a certain practice, conditional on the presence of another practice). First, 74% of firms with Self-Managed Teams also have Cross-Functional Teams while the unconditional incidence rate of Cross-Functional Teams is 54%. Likewise, the incidence rate of Self-Managed Teams conditional on the presence of Cross-Functional Teams is 11 percentage-points higher than the unconditional incidence rate. The difference between the conditional and unconditional incidence rates is statistically significant at the 1% level for both Cross-Functional Teams and Self-Managed Teams. This is consistent with Hypotheses I–V.

Second, shop-floor committees seem to complement team activities. Firms with SFCs are more likely to have Cross-Functional Teams and Self-Managed Teams (14 and 8 percentage-points more likely than the average firm respectively), which is consistent with Hypothesis I. The null hypothesis that either team organizations are introduced independently from

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¹⁶ To demonstrate this, consider two firms: one large and one small. The large firm has two establishments and each establishment has an SFC, whereas the small firm has only one establishment and has no SFC. The survey of firms will yield 50% for the proportion of firms with SFC whereas the survey of establishments will yield 66.7% for the proportion of establishments with SFC.
SFCs is rejected at the 1% significance level. As we have argued earlier, SFCs play an important role both as a communication channel and a pre-condition that nurtures team skills and participatory corporate culture.

Third, profit sharing plans (PSPs) and pay for performance (PFP) tend to co-exist in the same organizations. 70% of firms with PSPs have PFP; likewise 70% of those with PFP have PSPs, whereas the unconditional incidence rates are a little over 50% for both pay schemes. Although our theoretical exploration does not offer any direct guidance on a firm’s decision to introduce contingent pay schemes, the literature on incentive contracts generally predicts that the incidence of performance-based pay should be associated with decentralized decision-making (see Prendergast, 2002; MacLeod and Parent, 1999, for example). Hence, the relatively high correlation between PSPs and PFP may simply reflect the fact that decentralized organizations tend to have either or both contingent pay schemes.

Another finding in Table 1 that is consistent with this view is an indication of complementarity between SFCs and PFP. The incidence rate of PFP conditional on the presence of SFCs is 8 percentage-points higher than its unconditional incidence rate. Since the SFC is one form of worker empowerment, and could be a training ground for team activities with greater autonomy, offering pay for performance (PFP) to motivate workers to make better decisions may make sense. Another explanation is that, since PFP is known to cause potentially negative effects, including increased financial risk, less cooperative behavior, multitasking agency problems, ratchet effects, etc., it may be equally important to encourage cooperation, share expectations, and provide safeguards through employee organizations such as SFCs.

Fourth, firms with benchmarking are more likely to adopt many other HRMPs. To the extent that firms with benchmarking tend to copy HRMPs in successful firms with less regard to contextual differences, environmental factors may not explain management’s decision to adopt new HRMPs in firms with benchmarking as much as in other firms (which will be explored further in our probit analysis).

Our Survey also confirms our prior expectation that, compared to Cross-Functional Teams, Self-Managed Teams, PFP, and PSPs, JLMCs and SFCs are indeed older and more well-established practices. Nearly 80% of JLMCs and over 60% of SFCs were introduced before 1985. In contrast, the majority of Cross-Functional Teams, Self-Managed Teams, PFP, and PSPs were introduced after 1985, and many of them were actually in existence for less than 5 years.

When deliberating on the introduction of team organization and performance-based pay schemes in the 2000s, Japanese firms were unlikely to be considering the introduction of JLMCs and SFCs at the same time. As such, the incidence of JLMCs and SFCs can be considered exogenous determinants of the incidence of team and contingent pay. Also keep in mind that once JLMCs and SFCs are instituted, they are rarely abolished later (Kato, 2003).

3.3. Probit analysis: exploring the determinants of HRMP incidence

To investigate with more precision the empirical hypotheses and the suggestive findings from the previous section, we further specify Probit models. Let NEWHRM, be a binary variable that assumes the value of 1 if Firm i has NEWHRM, zero otherwise. As we discussed before, for NEWHRM, we consider two newer forms of HRMP: (i) Cross-Functional Teams and (ii) Self-Managed Teams.17 We begin with the following benchmark probit model: \( \Pr(NEWHRM_i = 1) = F(JLMC_i, SFC_i, MARKET_i, FIRMi, industry dummy) \), where \( JLMC_i = 1 \) if Firm i has JLMC, 0 otherwise; \( SFC_i = 1 \) if Firm i has SFC, 0 otherwise; \( MARKET_i = a \) vector of variables capturing output market conditions for Firm i; and \( FIRMi = a \) vector of variables capturing firm characteristics.

The sign and statistical significance of the estimated coefficients on JLMC, and SFC, inform us of the validity of Hypotheses 1 and II. For MARKET, the data will enable us to use three variables: (i) Overseas Sales Ratio; (ii) Customer Concentration (concentration of sales among major customers); and (iii) Extent of Price Changes (magnitude of price changes by competitors for major products). The Overseas Sales Ratio is designed to capture the firm’s exposure to stiff global competition, which may play a vital role in the adoption of certain HRM practices as Hypothesis III states (Osterman, 1994 and Lynch, 2007 use similar variables and find them to be significant determinants of the adoption of HRM policies).18

Since a non-trivial number of firms failed to provide data on Customer Concentration and Extent of Price Changes, we begin with considering only Overseas Sales Ratio in order to maintain the largest possible sample size, and then introduce the remaining two market condition measures. Reassuringly, our key results turn out to be insensitive to the inclusion of those two additional market condition measures and the subsequent loss of observations (except for our results on these two additional market condition variables themselves, of course).

For controls, our data allow for the use of firm age, number of employees as a firm size measure, whether or not the firm is a listed firm in one of the Japan’s stock exchanges, and industry dummy variables (see Table 2 for the definitions of

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17 In addition to Cross-Functional Teams and Self-Managed Teams, an earlier version of our paper also considered PSPs and PFP for NEWHRM relying on the previous literature that predicts the relationship between pay schemes and empowerment practices. However, the probit estimates of (1) with PSPs and PFP for NEWHRM turned out to be almost always insignificant, except for a positive association of PFP with SFCs, hardly showing any systematic evidence for or against the prediction. Since the analysis of pay schemes is not our focus in this paper, the results are not reported here to save space. These as well as other unreported results are available upon request from Takao Kato.

18 Though the literature on HRM adoption, such as Osterman (1994) and Lynch (2007) tends to equate selling product in the global market to facing tough global competition, an alternative interpretation is possible. Selling product globally might mean that a product has a dominant brand position, and/or stronger protection by patents and copyrights. We will discuss this alternative interpretation more explicitly below.
Table 2
List of independent variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
<th>Values/units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed</td>
<td>The firm is listed in one of the three stock exchanges in Tokyo, Osaka, or Nagoya</td>
<td>1 or 0</td>
</tr>
<tr>
<td>Number of employees</td>
<td>Number of regular employees on a non-consolidated basis</td>
<td>In thousands</td>
</tr>
<tr>
<td>Overseas sales ratio</td>
<td>Level of overseas sales ratio rated on a 5-point scale: 1 for 0%, 2 for more than 0% but less than 10%, 3 for 10% or more and less than 30%, 4 for 30% or more and less than 50%, and 5 for 50% or more</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>Customer concentration</td>
<td>Share of sales to five major customers in total sales rated on a 5-point scale: 1 for less than 10%, 2 for 10% or more and less than 30%, 3 for 30% or more and less than 50%, 4 for 50% or more and less than 80%, and 5 for 80% or more</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>Extent of price changes</td>
<td>Typical changes of market price or prices set by major competitors for the firm's core products or services rated on a 5-point scale: 1 for within 3%, 2 for within 5%, 3 for within 10%, 4 for within 20%, 5 for more than 20%</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>College graduates</td>
<td>Share of employees with college or postgraduate degrees in total regular workforce</td>
<td>%</td>
</tr>
<tr>
<td>Training for new hires</td>
<td>Number of days spent in formal training for new hires</td>
<td>Days</td>
</tr>
<tr>
<td>Layers of organization</td>
<td>Number of layers of organization from parent to front-line workers in the firm’s core business</td>
<td>Positive integers</td>
</tr>
<tr>
<td>M-form organization</td>
<td>The firm is organized not by functions but by production lines, customer types, or regions</td>
<td>1 or 0</td>
</tr>
<tr>
<td>Autonomy of Cross-Functional Teams</td>
<td>Degrees to which cross-functional offline teams receive directions from middle managers in deciding work processes, rated on a 5-point scale: 1 for rarely, 2 for very occasionally, 3 for sometimes, 4 for often, and 5 for always</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>Autonomy of Self-Managed Teams</td>
<td>Degree to which self-managed online teams receive directions from middle managers in deciding work processes rated on a 5-point scale: 1 for rarely, 2 for very occasionally, 3 for sometimes, 4 for often, and 5 for always</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>Decision making speed</td>
<td>Average length of time the firm normally takes to make five types of decisions rated on a 5-point scale: 1 for less than 1 week, 2 for 1 week or longer and less than 1 month, 3 for 1 month or longer and less than 3 months, 4 for 3 months or longer and less than 6 months, and 5 for 6 months or longer</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>Decision making level</td>
<td>Average level of people with real authority over 7 types of decision rated on a 5-point scale: 1 for president, 2 for executive, division manager or plant manager, 3 for general manager or foreman, 4 for section chief, group manager, or line manager, and 5 for line worker</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>Differentiation strategy</td>
<td>Degree to which the firm sees its strategy classified as a differentiation strategy rated on a 5-point scale: 1 for strongly disagree, 2 for disagree, 3 for somewhat agree, 4 for agree, 5 for strongly agree</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>Cost leadership strategy</td>
<td>Degree to which the firm sees its strategy classified as a cost leadership strategy rated on a 5-point scale: 1 for strongly disagree, 2 for disagree, 3 for somewhat agree, 4 for agree, 5 for strongly agree</td>
<td>1,2,3,4,5</td>
</tr>
</tbody>
</table>

Some prior studies report significant roles that trade unions play in the adoption of innovative HRMPs (see, for instance, Jirjahn, 2002, and Brown et al., 2007). Unfortunately, our data provide no information on unions and it is impossible to control for unions directly in our study. Nonetheless, firm size (measured by number of employees) has been reported highly correlated with unionization in Japan (see Hara and Kawaguchi, 2008, for instance), and hence we hope our inability to control for unionization can be alleviated to some extent by the use of firm size.

After estimating the benchmark model, we augment the model with two additional sets of variables. First, Proposition 3 suggests that the scope, nature and quantity of human capital accumulated by a firm’s labor force may play an important role in the firm’s choice of HRM system. Unfortunately, the scope, nature and quantity of human capital are difficult to quantify and we are left with two rather ordinary variables, College Graduates (percent of labor force with college or postgraduate degrees) and Training for New Hires (days spent in formal training for new hires). Second, our theoretical exploration points to possible interplay between the choice of HRMPs and benchmarking/MBO (e.g., complementarity of PFP and MBO as discussed in the previous section). Thus we consider Benchmarking (=1 if the firm uses benchmarking, 0 otherwise) and MBO (=1 if the firm uses MBO, 0 otherwise).

We are somewhat less confident in our results from these additional specifications as compared to those from the benchmark model, for human capital formation and management practices such as benchmarking and MBO are more likely to be endogenous than JLMCs and SFCs, and the results from these augmented specifications ought to be interpreted with caution.20

The first two columns of Table 3 present the probit estimates of Eq. (1), our benchmark model with Cross-Functional Teams as the dependent variable. The first column is a parsimonious specification in which only the overseas sales ratio is used for MARKET, whereas the second includes two additional variables for MARKET (and hence has a smaller sample

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19 We also considered average age of employees and average tenure of employees as additional controls, and found little change in the results.

20 Unfortunately, no reliable instrument is available in our dataset.
size). The third column summarizes the probit estimates of Eq. (1) augmented by human capital formation variables, and the fourth presents the probit estimates of Eq. (1) augmented by management strategy variables.

We find the following three results consistently for all specifications. First, the estimated coefficients on SFCs are positive and significant at the 1% level, confirming Hypothesis I. In other words, we find evidence that formal shop-floor-based communication channels facilitate the introduction of team-based instruments for information sharing and problem-solving.

Second, the estimated coefficients on the Overseas Sales Ratio are positive and significant at the 5% level, confirming that firms exposed to stiff global competition are more likely to adopt cross-functional off-line teams (Hypothesis III). Since we control for industries, this is not merely a reflection of inter-industry differences in export ratio and diffusion of teams. The result is robust to the inclusion of two additional variables for MARKET in the benchmark model as well as to the use of two augmented specifications (one with human capital and the other with management strategies).

Third, the estimated coefficients on Customer Concentration are positive and significant at the 5% level. Firms with a higher concentration of sales among their top five customers are more likely to have cross-functional off-line teams, supporting Hypothesis IV.

Regarding the relationship between JLMCs and Cross-Functional Teams, the estimated coefficients on JLMCs are mostly of the expected sign, yet are not statistically significant even at the 10% level, and thus fail to support Hypothesis II. The data are also inconsistent with Hypothesis V, which predicts a negative correlation between Range of Price Changes and Cross-Functional Teams. One possible explanation for these two results might be a widespread adoption of the hybrid mode of coordination, where Cross-Functional Teams are used to improve hierarchical decision making, which will be discussed later.

Similarly, the estimated coefficients on the human capital variables are of expected sign, yet are not statistically significant even at the 10% level. As we argued earlier, we suspect that the lack of significance may be due to imprecise measure of the scope, nature and quantity of human capital accumulated by a firm’s labor force. Finally, we also find no statistically significant association between management practices (benchmarking/MBO) and the use of Cross-Functional Teams.

Table 4 reports the probit estimates with Self-Managed Team as the dependent variable. The most robust results on the incidence of the Self-Managed Team are the statistically significant estimated coefficients on JLMCs and SFCs. For all specifications, the estimated coefficients on JLMCs are negative and statistically significant at the 5% level, confirming Hypothesis II that JLMCs favor the vertical control system by reducing labor-management communication errors, and hence make firms less likely to adopt Self-Managed Teams.21 Likewise, consistent with Hypothesis I that Self-Managed Teams and SFCs are complements and facilitate horizontal coordination, the estimated coefficients on SFCs are positive and statistically significant (the significance level varies from 1% to 10%).

Regarding the MARKET variables, we find that the estimated coefficients on Range of Price Changes are negative and significant at the 5% level for two out of the three specifications. As we discussed earlier, price volatility reflects the variance

21 It is well known that unions in the U.S. like very specific job descriptions since specific job descriptions facilitate wage negotiations. As such, unions in the U.S. often oppose to self-managed teams which are frequently accompanied by broader job descriptions. If Japanese JLMCs play a similar role as unions in the U.S., it will not be surprising that we observe fewer incidents of self-managed teams in firms with well established JLMCs than in other firms. This interpretation is, however, not quite plausible in the Japanese context especially among large firms where wages are not job-based and job descriptions are not explicit, instead only vaguely understood, and workers are multi-skilled and are expected to be flexible in job assignment in exchange for job security (see Carmichael and MacLeod, 1993 for the rationale of multiskilling practices in Japanese firms). And most importantly there is no evidence that Japanese JLMCs oppose to any of these management practices (see, for instance, Kato, 2003 for institutional information on Japanese JLMCs).

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JLMCs</td>
<td>-0.145 (0.161)</td>
<td>-0.068 (0.178)</td>
<td>0.049 (0.196)</td>
<td>-0.024 (0.181)</td>
</tr>
<tr>
<td>SFCs</td>
<td>0.569*** (0.156)</td>
<td>0.612*** (0.171)</td>
<td>0.623*** (0.191)</td>
<td>0.632*** (0.178)</td>
</tr>
<tr>
<td>Overseas sales ratio</td>
<td>0.164*** (0.081)</td>
<td>0.188*** (0.087)</td>
<td>0.199*** (0.096)</td>
<td>0.181*** (0.089)</td>
</tr>
<tr>
<td>Customer concentration</td>
<td>0.137*** (0.058)</td>
<td>0.184*** (0.064)</td>
<td>0.145** (0.060)</td>
<td></td>
</tr>
<tr>
<td>Range of price changes</td>
<td>-0.088 (0.085)</td>
<td>0.027 (0.095)</td>
<td>-0.118 (0.087)</td>
<td></td>
</tr>
<tr>
<td>College graduates</td>
<td>0.005 (0.004)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training for new hires</td>
<td>0.000 (0.004)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benchmarking</td>
<td></td>
<td></td>
<td></td>
<td>-0.099 (0.091)</td>
</tr>
<tr>
<td>MBO</td>
<td></td>
<td></td>
<td></td>
<td>0.062 (0.082)</td>
</tr>
<tr>
<td>Listed</td>
<td>-0.028 (0.187)</td>
<td>-0.027 (0.205)</td>
<td>-0.070 (0.248)</td>
<td>-0.026 (0.206)</td>
</tr>
<tr>
<td>Number of employees</td>
<td>0.002 (0.020)</td>
<td>-0.002 (0.021)</td>
<td>0.027 (0.032)</td>
<td>0.000 (0.023)</td>
</tr>
<tr>
<td>Firm age</td>
<td>0.005 (0.006)</td>
<td>0.008 (0.006)</td>
<td>0.006 (0.007)</td>
<td>0.009 (0.006)</td>
</tr>
<tr>
<td>Industry Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Prob &gt; x²</td>
<td>0.0006</td>
<td>0.0039</td>
<td>0.0026</td>
<td>0.0078</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.0758</td>
<td>0.0932</td>
<td>0.1163</td>
<td>0.0991</td>
</tr>
<tr>
<td># of Observations</td>
<td>332</td>
<td>284</td>
<td>234</td>
<td>279</td>
</tr>
</tbody>
</table>

Note: Robust standard errors are in parentheses.

* * * Significance levels of 5%.

** ** Significance levels of 1%.
of the market environment, which will be better monitored by the management than by lower-level managers or employees. The negative coefficients on Range of Price Changes are therefore congruent with Hypothesis V: vertical control dominates horizontal coordination when systematic information is sufficiently important.

The coefficients on Overseas Sales Ratio and Customer Concentration are of expected sign (positive) yet insignificant for all specifications except for specification (3) where the coefficient of Overseas Sales Ratio is significant only at the 10% level, failing to lend strong support to Hypotheses III and IV.

Our human capital variables appear to do slightly better here than in the case of Cross-Functional Teams. Thus, the estimated coefficient on Training for New Hires is positive and significant at the 10% level, pointing to complementarity between training and Self-Managed Teams. The management practice variables (benchmarking/MBO) are again found to be not significantly associated with the incidence of Self-Managed Teams.

Table 5 summarizes main results from our Probit model estimation. Although the coefficients on all key independent variables in the table are of expected sign, the significance of each coefficient differs between the two models of different dependent variables, Cross-Functional Teams and Self-Managed Teams. The first model generally supports Hypotheses I, III and IV while the second model provides evidence for Hypotheses I, II and V. To see if the above results change when we account for the possibility of joint-determination of Cross-Functional Teams and Self-Managed Teams, we estimated a bivariate probit model. Reassuringly, our results change little.

3.4. Cluster analysis: identifying systems of HRMPs

Lastly, to further explore a key theme of our theoretical exploration, that complementary elements of an HRM system are introduced together to maximize the benefits of each system, we conducted a cluster analysis to identify the most common

Table 4

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JLMCs</td>
<td>−0.404** (0.170)</td>
<td>−0.395** (0.189)</td>
<td>−0.484** (0.212)</td>
<td>−0.401** (0.193)</td>
</tr>
<tr>
<td>SFCs</td>
<td>0.373** (0.162)</td>
<td>0.452** (0.173)</td>
<td>0.326* (0.196)</td>
<td>0.402** (0.182)</td>
</tr>
<tr>
<td>Overseas sales ratio</td>
<td>0.092 (0.076)</td>
<td>0.070 (0.080)</td>
<td>0.153* (0.090)</td>
<td>0.088 (0.083)</td>
</tr>
<tr>
<td>Customer concentration</td>
<td>0.016 (0.061)</td>
<td>0.045 (0.066)</td>
<td>0.019 (0.064)</td>
<td>0.019 (0.064)</td>
</tr>
<tr>
<td>Range of price changes</td>
<td>−0.183** (0.086)</td>
<td>−0.090 (0.098)</td>
<td>−0.178** (0.089)</td>
<td>−0.178** (0.089)</td>
</tr>
<tr>
<td>College graduates</td>
<td>0.006 (0.004)</td>
<td>0.006 (0.003)</td>
<td>0.006 (0.003)</td>
<td>0.006 (0.003)</td>
</tr>
<tr>
<td>Training for new hires</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benchmarking</td>
<td>−0.300 (0.092)</td>
<td>−0.077 (0.089)</td>
<td>−0.307 (0.220)</td>
<td>−0.307 (0.220)</td>
</tr>
<tr>
<td>Listed</td>
<td>−0.392** (0.207)</td>
<td>−0.337 (0.216)</td>
<td>−0.378 (0.264)</td>
<td>−0.378 (0.264)</td>
</tr>
<tr>
<td>Number of employees</td>
<td>0.041** (0.020)</td>
<td>0.030 (0.021)</td>
<td>0.020 (0.037)</td>
<td>0.020 (0.037)</td>
</tr>
<tr>
<td>Firm Age</td>
<td>−0.004 (0.006)</td>
<td>−0.002 (0.006)</td>
<td>−0.005 (0.007)</td>
<td>−0.005 (0.007)</td>
</tr>
<tr>
<td>Industry dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Prob &gt; F</td>
<td>0.0015</td>
<td>0.0083</td>
<td>0.1458</td>
<td>0.0253</td>
</tr>
<tr>
<td>Pseudo R²</td>
<td>0.081</td>
<td>0.0825</td>
<td>0.0851</td>
<td>0.0847</td>
</tr>
<tr>
<td># of Observations</td>
<td>327</td>
<td>280</td>
<td>224</td>
<td>275</td>
</tr>
</tbody>
</table>

Note: Robust standard errors are in parentheses.
   * Significance levels of 10%.
   ** Significance levels of 5%.
   *** Significance levels of 1%.

Table 5
Summary of probit estimation results.

<table>
<thead>
<tr>
<th>Key independent variables</th>
<th>Interpretation</th>
<th>Dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cross-Functional Teams</td>
</tr>
<tr>
<td></td>
<td>Prediction</td>
<td>Estimated</td>
</tr>
<tr>
<td>SFCs</td>
<td>High r. organizational capability for team activities (Hypothesis I)</td>
<td>+</td>
</tr>
<tr>
<td>JLMCs</td>
<td>Low σ, labor-management communication noise (Hypothesis II)</td>
<td>–</td>
</tr>
<tr>
<td>Overseas sales ratio</td>
<td>α: greater output market competition</td>
<td>+</td>
</tr>
<tr>
<td>Customer concentration</td>
<td>α: importance of local information in a long-term buyer–supplier relationship</td>
<td>+</td>
</tr>
<tr>
<td>Extent of price changes</td>
<td>σ(φ): uncertainty and importance of systematic information</td>
<td>–</td>
</tr>
<tr>
<td>College graduates</td>
<td>ρ: human capital</td>
<td>+</td>
</tr>
<tr>
<td>Training for new hires</td>
<td>ρ: human capital</td>
<td>+</td>
</tr>
</tbody>
</table>

Notes: *, **, *** in the “estimated” row indicates the significance at the 10%, 5%, 1% in the baseline model.
combinations of HRMPs. Using Ward’s method, we sorted firms into four groups with distinct sets of work organization and pay schemes.\footnote{Ward’s method attempts to minimize the sum of squares of any two (hypothetical) clusters that can be formed at each step of a tree clustering algorithm. In general, this method is regarded as very efficient.} In the clustering algorithm, distances are based only on the proportions of employees (measured by five-point scale) in four newer HRMPs: cross-functional off-line teams, self-directed online teams, pay-for-performance, and profit sharing plans. Namely, the characteristics of firm \(i\) takes the vector \((x_{\text{PFP}}^{i}, x_{\text{SMOT}}^{i}, x_{\text{PFP}}^{i}, x_{\text{PSP}}^{i})\) where \(x_{k}^{i}\) \((k = \text{Cross-Functional Team, Self-Managed Team, PFP, PSP})\) can take any integer between 0 and 4. Each variable has 0 for “not adopted,” 1 for “less than 25% of employees participate,” 2 for “25% or more but less than 50% of employees participate,” 3 for “50% or more but less than 75% of employees participate,” or 4 for “75% or more employees participate.”

Table 6 shows the results. System 1 is the traditional HRM and work system and does not employ any of the team organizations or new pay schemes to a great extent (each variable is either 0 or 1 for most firms). System 2 uses contingent pay schemes considerably, but without introducing team organizations to a great extent. System 3 widely adopts cross-functional off-line teams, but not self-directed on-line teams to any great extent. Finally, System 4 adopts both types of team and also uses profit sharing plans and/or pay for performance. To relate the results with our theoretical model, we interpret System 1 and System 2 as vertical control systems, System 3 as a hybrid coordination system, and System 4 as a horizontal coordination system.

Note that the proportion of firms with joint labor-management committee is highest for System 3 (73\%). This result is consistent with our interpretation that system 3 is a hybrid coordination system. If management maintains a substantial level of formal authority in many decisions but employs teams to improve information acquisition and adaptation capability, the firm will introduce off-line teams which do not require substantial changes in production procedure and training programs. In such organizations, JLMCs are an essential mechanism that management uses to convey their mission, strategy, and long-term plans to their employees, who are somewhat empowered to adjust their implementation in order to adapt to changing environments.

Another noteworthy finding is that the proportion of firms with shop-floor committees is highest for System 4 (53\%). As our theory suggests, the horizontal coordination system should have a flat structure with the least layers in the organization, and provide teams with the most autonomy. Such organizations, with highly self-directed teams, may not necessarily require JLMCs since management has to commit to the empowerment strategy. Rather, the horizontal coordination system will require close and frequent communication among work units, which may necessitate formal structures such as SFCs.

Following Arthur (1992), Ichniowski and Shaw (1995), and Jirjahn (2002), we estimated a multinomial logit model to discern the possible determinants of each system. Table 7 reports the results. The estimated coefficients on SFCs for System 4 are positive and statistically significant at the 5\% level in model 1 without controlling for relative business strategy (strategy differentiation strategy – cost leadership strategy), and still positive and statistically significant at the 10\% level in model 2 with relative business strategy controlled for, confirming one of the key findings from the previous section. Though somewhat less precisely estimated, the estimated coefficients on JLMCs for System 4 are negative, which is again consistent with one of the key findings from the previous section. Finally, the estimated coefficient on Strategy for System 4 is positive, which is broadly consistent with Arthur (1992) and Osterman (1994).

4. Concluding remarks

This paper has explored theoretically and empirically a potentially important yet oft-neglected interplay between task coordination within an organization and the structure of the organization and HRMP bundling. In so doing, we have also provided fresh insights on linkages between a firm’s output market characteristics and its choice of HRMP system, for a firm’s market conditions affect how the firm coordinates various tasks within the organization. Furthermore, such output market conditions also influence the firm’s decision about its hiring and training policy, as well as its market strategy. In sum, we have explored complementarity among strategies, human capital, and organizational choices as suggested by Bresnahan et al. (2002).

Our model, which was built on works by Dessein and Santos (2006) and Aoki (1986), has two important implications: (1) as the value of adaptation vs. coordination increases, a firm is more likely to rely on horizontal coordination rather than vertical control, and utilize teams and invest in horizontal communication channels; (2) as the market environment becomes more disruptive, the firm is more likely to adopt a vertical control system, and hence develop labor-management communication channels. A rise in the value of coordination may or may not induce more usage of teams and horizontal coordination.

Guided by our theoretical exploration, we have conducted an empirical analysis of new data from Japan, which provide for the first time information on newer forms of organizational innovation, such as self-managed online teams and cross-functional off-line teams, in addition to data on longer-established practices, including joint labor-management committees and shopfloor committees.

One novel finding is that new team-based instruments are more likely to be adopted by firms with well-established formal shop-floor-based communication channels (such as shop-floor committees), while they are less apt to be adopted by firms with well-established information sharing institutions such as joint labor-management committees. This finding
### Table 6
Systems of HRM practices.

<table>
<thead>
<tr>
<th>Clusters</th>
<th>System 1</th>
<th>System 2</th>
<th>System 3</th>
<th>System 4</th>
</tr>
</thead>
<tbody>
<tr>
<td># of Observations</td>
<td>149</td>
<td>106</td>
<td>38</td>
<td>66</td>
</tr>
<tr>
<td>Variables used in the cluster analysis</td>
<td>Participation in Cross-Functional Teams (5-pt scale bet. 0 and 4)</td>
<td>Participation in Self-Managed Teams (5-pt scale bet. 0 and 4)</td>
<td>Participation in PSPs (5-pt scale bet. 0 and 4)</td>
<td>Participation in PFP (5-pt scale bet. 0 and 4)</td>
</tr>
<tr>
<td></td>
<td>0.49 (0.63)</td>
<td>0.49 (0.65)</td>
<td>3.24 (0.85)</td>
<td>1.94 (1.63)</td>
</tr>
<tr>
<td></td>
<td>Participation in Self-Managed Teams (5-pt scale bet. 0 and 4)</td>
<td>Participation in Self-Managed Teams (5-pt scale bet. 0 and 4)</td>
<td>Participation in Cross-Functional Teams (5-pt scale bet. 0 and 4)</td>
<td>Participation in PFP (5-pt scale bet. 0 and 4)</td>
</tr>
<tr>
<td></td>
<td>0.21 (0.48)</td>
<td>0.20 (0.47)</td>
<td>0.13 (0.34)</td>
<td>3.09 (1.20)</td>
</tr>
<tr>
<td></td>
<td>Participation in PSPs (5-pt scale bet. 0 and 4)</td>
<td>Participation in PSPs (5-pt scale bet. 0 and 4)</td>
<td>Participation in Cross-Functional Teams (5-pt scale bet. 0 and 4)</td>
<td>Participation in PFP (5-pt scale bet. 0 and 4)</td>
</tr>
<tr>
<td></td>
<td>0.20 (0.58)</td>
<td>3.86 (0.38)</td>
<td>1.13 (1.66)</td>
<td>2.44 (1.86)</td>
</tr>
<tr>
<td></td>
<td>Participation in PFP (5-pt scale bet. 0 and 4)</td>
<td>Participation in PFP (5-pt scale bet. 0 and 4)</td>
<td>Participation in Self-Managed Teams (5-pt scale bet. 0 and 4)</td>
<td>Participation in Cross-Functional Teams (5-pt scale bet. 0 and 4)</td>
</tr>
<tr>
<td></td>
<td>0.96 (1.53)</td>
<td>2.78 (1.79)</td>
<td>0.84 (1.39)</td>
<td>2.62 (1.79)</td>
</tr>
<tr>
<td>Other variables averaged within each system</td>
<td>Listed</td>
<td>Listed</td>
<td>Listed</td>
<td>Listed</td>
</tr>
<tr>
<td>Number of employees</td>
<td>728.6 (1550.5)</td>
<td>967.24 (1795.77)</td>
<td>1459.84 (4580.54)</td>
<td>1211.08 (4584.51)</td>
</tr>
<tr>
<td>JLMCs</td>
<td>0.56 (0.50)</td>
<td>0.64 (0.48)</td>
<td>0.73 (0.45)</td>
<td>0.55 (0.50)</td>
</tr>
<tr>
<td>SFCs</td>
<td>0.36 (0.38)</td>
<td>0.39 (0.49)</td>
<td>0.39 (0.50)</td>
<td>0.53 (0.50)</td>
</tr>
<tr>
<td>Layers of organization</td>
<td>6.43 (1.35)</td>
<td>6.33 (1.58)</td>
<td>6.37 (2.08)</td>
<td>6.11 (1.69)</td>
</tr>
<tr>
<td>M-form organization (yes: 1, no: 0)</td>
<td>0.36 (0.48)</td>
<td>0.33 (0.47)</td>
<td>0.32 (0.47)</td>
<td>0.44 (0.50)</td>
</tr>
<tr>
<td>Decision making speed (1: fast--5: slow)</td>
<td>2.57 (0.70)</td>
<td>2.50 (0.73)</td>
<td>2.65 (0.73)</td>
<td>2.35 (0.58)</td>
</tr>
<tr>
<td>Decision making level (1: low--5: high)</td>
<td>2.55 (0.55)</td>
<td>2.58 (0.52)</td>
<td>2.54 (0.50)</td>
<td>2.55 (0.62)</td>
</tr>
<tr>
<td>Differentiation strategy (1: absolutely not, 7)</td>
<td>3.20 (1.06)</td>
<td>3.46 (0.52)</td>
<td>3.03 (1.08)</td>
<td>3.61 (0.82)</td>
</tr>
<tr>
<td>Cost leadership strategy (1: absolutely)</td>
<td>3.01 (0.91)</td>
<td>3.17 (0.89)</td>
<td>3.49 (0.93)</td>
<td>3.61 (0.82)</td>
</tr>
<tr>
<td>Days of formal training for new</td>
<td>20.3 (27.7)</td>
<td>19.26 (26.82)</td>
<td>16.44 (25.28)</td>
<td>26.20 (29.63)</td>
</tr>
</tbody>
</table>
Table 7  
Determinants of systems: multinomial logit estimates.

<table>
<thead>
<tr>
<th>System 1 is the base outcome</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Robust SE</td>
</tr>
<tr>
<td>System 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JLMCs</td>
<td>0.069</td>
<td>0.333</td>
</tr>
<tr>
<td>SFCs</td>
<td>−0.197</td>
<td>0.322</td>
</tr>
<tr>
<td>Listed</td>
<td>0.152</td>
<td>0.447</td>
</tr>
<tr>
<td>In (number of employees)</td>
<td>−0.010</td>
<td>0.148</td>
</tr>
<tr>
<td>Firm age</td>
<td>0.019</td>
<td>0.013</td>
</tr>
<tr>
<td>Share of managers (%)</td>
<td>0.040</td>
<td>0.023</td>
</tr>
<tr>
<td>Average age of employees</td>
<td>−0.016</td>
<td>0.042</td>
</tr>
<tr>
<td>Average tenure of employees</td>
<td>−0.062</td>
<td>0.040</td>
</tr>
<tr>
<td>Strategy</td>
<td>0.240</td>
<td>0.145</td>
</tr>
<tr>
<td>System 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JLMCs</td>
<td>0.250</td>
<td>0.509</td>
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<tr>
<td>SFCs</td>
<td>−0.161</td>
<td>0.452</td>
</tr>
<tr>
<td>Listed</td>
<td>0.082</td>
<td>0.628</td>
</tr>
<tr>
<td>In (number of employees)</td>
<td>−0.125</td>
<td>0.256</td>
</tr>
<tr>
<td>Firm age</td>
<td>0.010</td>
<td>0.019</td>
</tr>
<tr>
<td>Share of managers (%)</td>
<td>0.056</td>
<td>0.033</td>
</tr>
<tr>
<td>Average age of employees</td>
<td>−0.016</td>
<td>0.061</td>
</tr>
<tr>
<td>Average tenure of employees</td>
<td>0.032</td>
<td>0.051</td>
</tr>
<tr>
<td>Strategy</td>
<td>−0.401</td>
<td>0.235</td>
</tr>
<tr>
<td>System 4</td>
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<td></td>
</tr>
<tr>
<td>JLMCs</td>
<td>−0.166</td>
<td>0.410</td>
</tr>
<tr>
<td>SFCs</td>
<td>0.820</td>
<td>0.393</td>
</tr>
<tr>
<td>Listed</td>
<td>−0.154</td>
<td>0.538</td>
</tr>
<tr>
<td>In (number of employees)</td>
<td>−0.295</td>
<td>0.196</td>
</tr>
<tr>
<td>Firm age</td>
<td>0.009</td>
<td>0.015</td>
</tr>
<tr>
<td>Share of managers (%)</td>
<td>0.027</td>
<td>0.027</td>
</tr>
<tr>
<td>Average age of employees</td>
<td>−0.039</td>
<td>0.053</td>
</tr>
<tr>
<td>Average tenure of employees</td>
<td>−0.060</td>
<td>0.051</td>
</tr>
<tr>
<td>Strategy</td>
<td>0.270</td>
<td>0.173</td>
</tr>
<tr>
<td>Number of observations</td>
<td>290</td>
<td></td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>−347.44</td>
<td></td>
</tr>
</tbody>
</table>

Strategy = differentiation strategy – cost leadership strategy.

1 Significance level of 10%
2 Significance level of 5%

is consistent with the view that: (1) firms where activities or decisions are coordinated differently tend to adopt different types of work organization; and (2) communication channels such as labor-management committees and shop-floor committees play an important role in intra-firm coordination. The finding largely supports path-dependency in the evolution of organizational architecture.

We have also confirmed empirical patterns that are consistent with the implications from our theory about the relationships between market structure/environment and the adoption of team organizations. Specifically, firms in more competitive markets and those having a higher concentration in sales among a small number of customers in long-term buyer–supplier relationships are more likely to adopt both types of teams, while firms facing more erratic price movement tend not to adopt self-managed online teams.

Finally, some of our findings can be meaningfully compared to prior studies (although different data and methodologies used by prior studies make strict comparisons rather difficult). First, our finding of a positive and significant association between exposure to global competition and innovative work practices is consistent with some prior studies based on data from other countries, such as Osterman (1994) on U.S. establishments, and Jirjahn (2002) on German establishments. Second, some prior studies report a significant linkage between the incidence of innovative HRMPs and firm age (notably Ichniowski and Shaw, 1995). We failed to find such linkage. The lack of a significant linkage of the incidence of newer forms of HRMPs to firm age is, however, not too surprising in the Japanese context, in which most firms had already adopted a participatory work system some time ago, and what we are studying is in essence whether these already “participatory” Japanese firms add newer forms of HRMPs. The “birth effects” (Ichniowski and Shaw, 1995) are probably less relevant to our study. Third, prior evidence on the relationship between firm size (measured by number of employees) and the adoption of innovative HRMPs tends to be inconclusive. For instance, Osterman (1994) and Jirjahn (2002) report mixed evidence whereas Brown et al. (2007) find more consistently positive associations between firm size and employee involvement schemes. Though the estimated coefficients on firm size in our study are mostly positive, as in Brown et al. (2007), they are imprecisely estimated, and hence no definitive conclusion can be drawn.
Appendix A.

A.1. Proof of Proposition 1

Let
\[ \Pi(t, p|\alpha, \sigma^2(\phi), \tau) = -\sum_{i=1}^{n} E[C(a_i^1, a_i^2, \ldots, a_i^m, T, p)|\phi] = -n(\alpha \beta(n - t)(1 - p)/(\alpha + \beta(n - t)(1 - p))\sigma^2(\phi) - \nu(t, p, \tau). \]

Then, \((\partial^2 \Pi(t, p|\alpha, \sigma^2(\phi), \tau))/(\partial t \partial z) \geq 0\) and \((\partial^2 \Pi(t, p|\alpha, \sigma^2(\phi), \tau))/(\partial t \partial z) \geq 0\) for any \(z \in (\alpha, \sigma^2(\phi), \tau)\). Hence, if \((\partial^2 \Pi(t, p|\alpha, \sigma^2(\phi), \tau))/(\partial t \partial z) \geq 0\), the result is immediate from the comparative statics analysis of supermodular functions. The last inequality, however, does not hold in general. In order to apply the theory of supermodular optimization to this case, we define \(\pi(t, \hat{p}) = \max_{\hat{p}} \Pi(t, p)\). Let \(p^*(t) = \arg \max_{\hat{p}} \Pi(t, p)\), the optimal communication quality given the degree of task bundling in teams \(t\). From Assumption 1, \(p^*(t)\) is uniquely determined and the highest optimal value of \(\hat{p}\) is always equal to \(p^*(t)\). Therefore, the theory of supermodular optimization, in order to obtain the monotone comparative statics result, it suffices to show that

\[ \frac{\partial \pi(\hat{t}, \hat{p})}{\partial \hat{p}} - \frac{\partial \pi(t, \hat{p})}{\partial \hat{p}} \geq 0 \quad (A1.1) \]

for any \(\hat{t} > t \in T\), namely \(t\) and \(\hat{p}\) have non-decreasing differences with \(\pi\).

First, we need to show \(p^*(\hat{t}) > p^*(t)\). Given Assumption 2, the supermodularity of \(-h(t, p, \tau)/(n - t)\),

\[ 0 = \frac{\partial \Pi}{\partial \hat{p}}(t, p^*(t)) = n(n - t) \left[ \frac{\alpha^2 \beta}{(\alpha + \beta(n - t)(1 - p^*(t)))^2} \sigma^2(\phi) - \frac{h_p(\hat{t}, p^*(t), \tau)}{n - \hat{t}} \right] \]

< \(n(n - t) \left[ \frac{\alpha^2 \beta}{(\alpha + \beta(n - t)(1 - p^*(t)))^2} \sigma^2(\phi) - \frac{h_p(t, p^*(t), \tau)}{n - t} \right] \]

\[ = n \left( \frac{n - \hat{t}}{n - t} \right) \left[ \frac{\alpha^2 \beta(n - \hat{t})}{(\alpha + \beta(n - t)(1 - p^*(t)))^2} \sigma^2(\phi) - \frac{h_p(\hat{t}, p^*(t), \tau)}{n - \hat{t}} \right] \]

< \(n \left( \frac{n - \hat{t}}{n - t} \right) \left[ \frac{\alpha^2 \beta(n - t)}{(\alpha + \beta(n - t)(1 - p^*(t)))^2} \sigma^2(\phi) - \frac{h_p(t, p^*(t), \tau)}{n - t} \right] \]

\(= \left( \frac{n - \hat{t}}{n - t} \right) \frac{\partial \Pi}{\partial \hat{p}}(\hat{t}, p^*(\hat{t})).\)

and \((\partial \Pi/\partial \hat{p})(\hat{t}, p^*(\hat{t})) > 0\). By Assumption 1, the strict quasi-concavity of \(\Pi(t, p)\), \(p^*(\hat{t}) > p^*(t)\).

We prove the inequality \((A1.1)\) in the following three cases:

1. When \(p^*(\hat{t}) > p^*(t) > \hat{p}, \partial \pi(\hat{t}, \hat{p})/(\partial \hat{p}) - \partial \pi(t, \hat{p})/(\partial \hat{p}) - \partial \pi(\hat{t}, \hat{p})/(\partial \hat{p}) = \Pi(\hat{t}, p^*(\hat{t})) - \Pi(t, p^*(t)) = 0\);
2. When \(p^*(\hat{t}) > \hat{p} > p^*(t), \partial \pi(\hat{t}, \hat{p})/(\partial \hat{p}) - \partial \pi(\hat{t}, \hat{p})/(\partial \hat{p}) = \partial \pi(\hat{t}, \hat{p})/(\partial \hat{p}) = -\partial \Pi(t, \hat{p})/(\partial \hat{p}) > 0\) by Assumption 2;
3. When \(\hat{p} > p^*(\hat{t}) > p^*(t), \partial \pi(\hat{t}, \hat{p})/(\partial \hat{p}) - \partial \pi(t, \hat{p})/(\partial \hat{p}) = \partial \pi(\hat{t}, \hat{p})/(\partial \hat{p}) = \Pi(\hat{t}, \hat{p}) - \Pi(t, \hat{p}) = n(\alpha^2 \beta(n - \hat{t})/(\alpha + \beta(n - t)(1 - \hat{p}))^2 \sigma^2(\phi) - n(\alpha^2 \beta(n - t)/(\alpha + \beta(n - t)(1 - \hat{p}))^2 \sigma^2(\phi) - nh_p(\hat{t}, \hat{p}, \tau) + nh_p(t, \hat{p}, \tau) \]

\[\]
\[ \begin{align*}
&> -\frac{n}{\alpha + \beta(n-\ell)(1-\bar{\beta})} \sigma^2(\phi) + \frac{n(n-\ell)}{n} \left( h_p(\ell, \bar{\beta}, \tau) \right) - \frac{n-\ell}{n} \frac{h_p(\ell, \bar{\beta}, \tau)}{n} \\
&= \frac{\hat{\ell} - \ell}{n-\ell} \left[ \frac{\alpha^2 \beta(n-\ell)}{(\alpha + \beta(n-\ell)(1-\bar{\beta}))^2} \sigma^2(\phi) - h_p(\ell, \bar{\beta}, \tau) \right] \\
&= \frac{\hat{\ell} - \ell}{n-\ell} \Pi_p(\ell, \bar{\beta}) > 0
\end{align*} \]

The last inequality is from $\hat{\beta} > p^*(\ell)$. This concludes the proof. □

A.2. Proof of Proposition 2

The right-hand side of the inequality (1.7), the adaptation and coordination losses for the horizontal coordination system, approaches to $\min_{\ell} \beta(n-\ell)(1-p)\sigma^2(\hat{\beta}) + h_p(\ell, \bar{\beta}, \tau)$ as $\alpha$ increases to the infinity. Since the left-hand side of the inequality is an increasing linear function of $\alpha$, the latter always eventually exceeds the former. Let $\hat{\alpha}$ be the greatest intersection of the cost functions of the two systems. If the cost (adaptation and coordination losses) of the horizontal coordination system is always smaller than that of the vertical control system, let $\hat{\alpha} = \varphi$. This concludes the proof. □

References


M.E. Sharpe, Armonk, NY.


Takao Kato is W.S. Schupf Professor of Economics and Far Eastern Studies, Colgate University; Research Fellow, IZA Bonn; and a Research Associate in the Center on Japanese Economy and Business at Columbia Business School, the Tokyo Center for Economic Research, and the Center for Corporate Performance at Aarhus School of Business (ASB).

Hideo Owam is a Professor in the Institute of Social Science, the University of Tokyo, Japan.