Complementarity of Performance Pay and Task Allocation

Bryan Hong, Ivey Business School, Western University and Leonard Stern School of Business, New York University

Lorenz Kueng, Kellogg School of Management, Northwestern University

Mu-Jeung Yang, David Eccles School of Business, University of Utah

Abstract

Complementarity between performance pay and other organizational design elements has been argued to be one potential explanation for stark differences in the observed productivity gains from performance pay adoption. Using detailed data on internal organization for a nationally representative sample of firms, we empirically test for the existence of complementarity between performance pay incentives and decentralization of decision-making authority for tasks. To address endogeneity concerns, we exploit regional variation in income tax progressivity as an instrument for the adoption of performance pay. We find systematic evidence of complementarity between performance pay and decentralization of decision-making from principals to employees. However, adopting performance pay also leads to centralization of decision-making authority from non-managerial to managerial employees. The findings suggest that performance pay adoption leads to a concentration of decision-making control at the managerial employee level, as opposed to a general movement towards more decentralization throughout the organization.

1 Introduction

A fundamental concern in the design of every organization is the adoption of an appropriate incentive structure to motivate its members. The proper provision of performance-based incentives can increase the productivity of a firm's workforce, and lead to improved organizational performance (Lazear 2000). However, previous empirical studies have found considerable heterogeneity in the magnitude of productivity increases due to performance pay (Ichniowski and Shaw 2003). To explain these stark differences, scholars have increasingly begun to consider the complementarity between performance pay and different organizational design elements, as opposed to their isolated effects on firm performance (MacDuffie 1995, Ichniowski, et al. 1997, Black and Lynch 2001).

Complementarity between different organizational design elements has been highlighted as one important explanation for persistent performance differences across firms (Milgrom and Roberts 1995, Nadler and Tushman 1997). By adopting elements that are interdependent and mutually reinforce each other in their contributions to overall firm performance, superior performance is argued to be more easily sustained and more difficult to imitate by competitors (Porter 1996, Rivkin 2000). As a consequence, subsequent empirical work on complementarity has focused on identifying the specific organizational design elements adopted by firms that are complementary in nature (Novak and Stern 2008, Rawley and Simcoe 2010, Aral et al. 2012, Pierce 2012). However, prior empirical studies examining the complementarity of performance pay with other elements of organizational design thus far have produced mixed evidence (see Ennen and Richter 2010 for a review). Such efforts to provide generalizable quantitative tests have faced two significant challenges. First, the availability of large sample internal organization data has been limited. Second, observed correlations in the adoption of management practices may be explained by positive correlations of unobserved adoption costs unrelated to complementarity, making causal inferences difficult (Athey and Stern 1998, Cassiman and Veugelers 2006).

In this study, we test for the complementarity between performance pay and decentralization of decision-making for tasks within firms. Both practices have been studied extensively by scholars, but the potential complementarity between them has remained empirically untested. To address the empirical challenges of producing generalizable findings, we use unique establishment and firm-level panel data on management practices representing the population of businesses in the Canadian economy, which provides detailed measures of the allocation of decision authority for tasks to different members of the organizational hierarchy.

To mitigate concerns of correlated unobserved adoption costs explaining our findings, we address the issues raised by Arora (1996) and Athey and Stern (1998) by considering potentially exogenous factors predicting the adoption of performance pay. For our main empirical estimations, we consider two instrumental variable approaches based upon the tax progressivity of Canadian provinces. The basic intuition for using local tax progressivity as an instrument for performance pay adoption is that greater personal income tax progressivity increases the cost of providing high-powered incentives, and hence reduces the likelihood of adopting performance pay. For our first estimation approach, we use the tax progressivity of the province where the firm operates. For our second estimation, we consider the sample of firms in our data that operate multiple establishments across different provinces and use the tax progressivity of the province where the firm's headquarters is located as an instrument. This second approach allows us to test for the possibility of unobserved regional factors confounding our results by allowing for the inclusion of province fixed effects in our estimation. By including province fixed effects, our second estimation approach considers variation among establishments within each Canadian province for identification, using the tax progressivity of other Canadian provinces outside of the province where each establishment is located as the relevant source of exogenous variation.

In our results, we find that firms that adopt performance pay decentralize more tasks from principals, which we define as business owners and corporate headquarters, to employees within the establishment. The results provide evidence that performance pay and decentralization of decision-making are complements. In addition, we explore our main finding in greater detail by measuring decision-making control separately for managerial and non-managerial employees. We find that firms that adopt performance pay concentrate control at the management level, where decision-making is *decentralized* from headquarters and business owners to managerial employees at the establishment but *centralized* from non-managerial to managerial employees.

We investigate the mechanism driving concentration of control at the managerial level in three ways. First, we theoretically examine the conditions under which a model of "management by exception" with performance pay explains the empirical results. In the model, the managerial concentration of control is optimal when managers possess critical private information relative to non-managerial employees. The importance of this private information is defined by the profit effects of managerial decisions in two ways: 1) efficient decisions by managers are more beneficial to the firm than efficient decisions by non-managerial employees, and 2) self-interested decisions of managers can be very costly for the company, while self-interested decisions of non-managerial employees are less costly to the firm. As a result, the performance consequences of conflicts of interest are greater for managers than non-managerial employees. Therefore, the firm disproportionately gains from performance pay-induced efficient managerial decisions and allocates more decision authority for tasks to managers. Second, a task-level extension of our theory allows us to derive additional predictions on which types of tasks are more likely to be affected when performance pay is adopted. Consistent with our extended theory, we find that simpler, more routine tasks are more likely to be reallocated in response to performance pay adoption. Third, we derive a theory-based measure of misalignment of control and performance pay and empirically confirm the importance of misalignment for performance differences across firms.

Our study makes four main contributions. First, we develop a formal model to consider a more nuanced perspective of the interaction of performance pay and task allocation as opposed to a simple binary state of decentralization or centralization between two parties. Specifically, our model combines a three-layer version of "management by exception," similar to Garicano (2000), with decentralization along a continuum of tasks with optimal performance pay under moral hazard. The model clarifies the nature of our empirical exercise by showing the conditions under which complementarity may exist between task allocation and performance pay, and motivates our identification strategy by illustrating how exogenous differences in tax progressivity generate differences in performance pay adoption. While substantial literatures have examined the efficiency and performance implications of adopting performance pay (see Ichniowski and Shaw 2003 and Lazear and Oyer 2013 for reviews) and decentralization of decision-making (Chang and Harrington 2000, Baum and Wally 2003, Alonso et al. 2008), our model suggests in the spirit of complementarity theory that the mechanism determining their effectiveness may also be dependent on their joint adoption, and not only the effects of adopting each practice in isolation. Second, we contribute to the recent growing literature examining how differences in management practices may explain performance differences across firms. While previous studies have established a positive relationship between the overall quality of management practices and firm productivity (Bloom and Van Reenen 2007, Bloom et al. 2013b), we build upon these findings by considering how different management practices may interact. Here, we provide empirical evidence that misalignment between patterns of task allocation and performance pay negatively affects firm performance, consistent with the implications of our theoretical model. Third, by providing population-level findings, our empirical results are able to identify a general relationship of complementarity between decentralization and performance pay, where previous studies have provided mixed evidence by either identifying only specific costs (Frank and Obloj 2014, Larkin 2014) or benefits (Lo et al. 2016) of joint adoption in the specific context of sales forces, or relied only upon simulation models (Rivkin and Siggelkow 2003). Finally, we provide novel empirical evidence of the mechanisms determining the adoption of performance pay and task allocation that highlights the importance of managerial employees within hierarchies, not fully explained by current theories. Specifically, our findings suggest that managers play a unique and critical role in efficient organizational design when firms implement performance-based incentives.

The remainder of the paper is organized as follows. Section 2 develops the theoretical mechanism that illustrates the trade-offs that make decentralization and performance pay either complements or substitutes across different levels of the organizational hierarchy, and guides our empirical analysis. Section 3 describes our data and measures. Section 4 describes our instrumental variables strategy in greater detail and discusses our main empirical results. Section 5 examines the robustness of our findings, with concluding remarks in Section 6.

2 Theoretical considerations

To clarify the mechanism through which decentralization of decision-making and adoption of performance pay can be complements, we use a three-layer model of organizational hierarchy that considers principals, managerial employees, and non-managerial employees. Following prior studies examining management practices and decentralization (Bloom et al. 2012, Bloom et al. 2013a), we use a model of "management by exception," similar to Garicano (2000) and Garicano and Rossi-Hansberg (2012). Specifically, more decentralization allows a firm to economize on the business owner's or manager's time[1], thereby allowing them to focus only on complex and rare problems. We extend this basic framework in the context of a project decision-related moral hazard problem.

2.1 Economic environment

There are three players in our model, a principal P who can be considered the business owner, a managerial employee M and a non-managerial employee N. Firms face a unit measure of tasks or "problems" $z \in [0,1]$ with cumulative distribution $F(z)$ and density $f(z)$. As is standard, we assume that these are ordered by frequency and complexity so that lower values of z denote simple and very frequent tasks and high values of z very complex and rare problems. This is formalized by assuming

$$f(z) > 0, \qquad f'(z) < 0 \tag{1}$$

For any given problem or task z, players need to decide between two possible projects $d_i \in \{0,1\}$.

Task allocation across layers. We define "task allocation" as the allocation of inalienable decision rights for tasks to layers in the hierarchy.[2] Task allocation is captured by two decentralization cutoff points. Non-managerial employees are assigned tasks $z \in [0, z_N)$, and managerial employees decide which projects to choose on tasks $z \in [z_N, z_M)$. The principal P decides on projects in the remaining range $z \geq z_M$. In other words, non-managerial employees are assigned the least complex and most frequent and routine tasks, and principals decide on the least frequent and most complex tasks, with managers deciding the intermediate range of tasks. This division of labor across tasks reflects the idea of "management by exception." To make employees M and N understand how to decide to successfully complete tasks, P must incur training costs. These costs are greater the more complex the range of assigned problems is, and we

[1] The model applies to a firm's headquarters as well, but we omit this here for brevity of writing.

[2] In other words, we assume that the party with the decision right will ultimately also make the decision. This is in contrast to models with alienable decision rights, such as Aghion and Tirole (1997), where even if the principal retains the (formal) decision right to a task, she can ask advice from employees, who then effectively might exert "real decision authority" as the principal might "rubberstamp" the decision by employees.

denote the overall cost of solving problems in the range $[0, z]$ by $c_i \cdot z$, where $i \in \{P, M, N\}$ and $c_i > 0$. Similar to Bloom et al. (2013a), we assume that P knows all production tasks that M and N know so that knowledge overlaps. The principal P does not require a training cost, but each problem she solves takes $c_P \cdot h$ units of her time.

Project decisions and conflict of interest. Each player $i = P, M, N$ is assigned tasks and decides between two possible projects $d_i \in \{0,1\}$ for each task. If projects are successful, they are assumed to generate an output of $H = 1$ and $L = 0$ if they are unsuccessful. We assume that players only gain information on which project is efficient after tasks have been assigned to them. As a consequence, employees will have private information about which project is efficient. However, there is also an unobserved private gain to the agents associated with the inefficient project, which gives rise to a conflict of interest. To capture this, we denote employee $j \in M, N$ preferences as

$$U_j(w_j, d_j) = \ln(w_j) + (1 - d_j) \cdot g_j \quad (2)$$

where $g_j > 0$ captures an unobserved private gain that the agent derives from choosing the inefficient project.

For each player, project 1 (hereafter referred to as the "efficient project") is more likely to succeed than project 0 (hereafter referred to as the "inefficient project") $q_i^1 > q_i^0$. Note that different players i are allowed to have different success probabilities. Since tasks that are assigned to player $i = P, M, N$ are identical in terms of private gain g_j as well as in terms of success probabilities q_i^0, q_i^1, players will choose the same project for all tasks that are assigned to them. Given the task allocation, the expected outputs are therefore given by $[1 - F(z_M)] \cdot q_P^{d_P}$ for the principal, $[F(z_M) - F(z_N)] \cdot q_M^{d_M}$ for the manager, and $[F(z_N)] \cdot q_N^{d_N}$ for the non-managerial employee.

Timing. The timing of our model is as follows. At $t = 0$, P decides first whether to adopt performance pay and then determines the allocation of decision rights. At this stage, we assume that decision rights can still be reassigned, based on information about the complexity z. Information on which decision is efficient is not available. If performance pay is available, P will determine the optimal state-contingent wage payments, otherwise they will set a constant wage to meet the agent's outside option, which we denote as $w_i = U_R$. At $t = 1$, employees face the organizational choices made by P and information about which project is efficient is privately revealed. Note that we assume that once assigned in $t = 0$, task allocations at $t = 1$ are fixed. Consequently, players decide whether to choose the efficient project for all the tasks that are allocated to them. Production occurs and wage payments are made at the end of period 1.

2.2 Optimal performance pay contract

We now analyze how an organization would design performance pay contracts to minimize the costs of inducing employees to choose the efficient project. The optimal contracting problem, given decentralization decisions z_M, z_N for agent $j \in \{M, N\}$ is given by

$$\min_{\{w_j^H, w_j^L\}} q_j^1 \cdot w_j^H + \left(1 - q_j^1\right) \cdot w_j^L \tag{3}$$

$$(IC)\ E\left[U_j\left(w_j, d_j\right) \middle| d_j = 1\right] \geq E\left[U_j\left(w_j, d_j\right) \middle| d_j = 0\right]$$

$$(IR)\ E\left[U_j\left(w_j, d_j\right) \middle| d_j = 1\right] \geq U_R$$

In this context, we define a key parameter $k_j = q_j^1 - q_j^0$, which captures the increase of expected project success as a result of choosing the efficient rather than the inefficient project. Therefore k_j captures an incentive effect of performance pay, since performance pay induces employee j to make efficient decisions. The solution to the optimal contracting problem is given by state-contingent wages

$$w_j^H = \exp\left\{U_R + \frac{1 - q_j^0}{k_j} \cdot g_j\right\}, w_j^L = \exp\left\{U_R - \frac{q_j^0}{k_j} \cdot g_j\right\}$$

where exp{} denotes the exponential function. Expected compensation is given by

$$\overline{w}_j = q_j^1 \cdot w_j^H + \left(1 - q_j^1\right) \cdot w_j^L \tag{4}$$

2.3 Profits

Let $\alpha \in \{0,1\}$ denote an indicator function for the implementation of performance pay, i.e. if $\alpha = 1$, the firm has performance pay and zero otherwise. Then profits as a function of task allocation and performance pay can be written as

$$\begin{aligned}\Pi(z_M, z_N, \alpha) = {} & [1 - F(z_M)] \cdot (q_P^1 - c_P h) \\ & + [F(z_M) - F(z_N)] \cdot (q_M^0 + \alpha \cdot k_M) - c_M \cdot (z_M - z_N) - w_M - \alpha \cdot (\overline{w}_M - w_M) \\ & + F(z_N) \cdot (q_N^0 + \alpha \cdot k_N) - c_N \cdot z_N - w_N - \alpha \cdot (\overline{w}_N - w_N)\end{aligned} \tag{5}$$

The three separate lines in the profit equation capture profits associated with the three layers of principal, manager and non-managerial employee.[3]

We note that for each employee layer $j = M, N$, performance pay adoption α has two effects on performance. First, the benefit of performance pay adoption is more efficient decision-making, which is captured by the incentive effect terms $\alpha \cdot k_j$. Second, the costs of performance pay adoption are higher expected compensation costs, which are captured by the terms $\alpha \cdot \left(\overline{w}_j - w_j\right)$. Hence, firms will only adopt performance pay if the benefits from incentive effects outweigh the costs of higher expected compensation.

[3] To ensure that each layer will be allocated some decisions in equilibrium, we also impose the following regularity conditions:

$$q_N^0 > q_M^0 > q_P^0, c_N > c_M > 0$$

These regularity conditions ensure that each layer will have at least some decisions allocated to them, even without performance pay, as is empirically observed in the data.

2.4 Supermodularity

From this definition of profits, we now define supermodularity in our context, following Milgrom and Roberts (1995), who define two activities as being complementary if "doing (more of) any one of them increases the returns to doing (more of) the others." Specifically, we are interested in the supermodularity of performance pay adoption and managerial authority. Since managers decide tasks in the range $[z_N, z_M)$, the supermodularity of performance pay adoption and managerial authority involves these two cutoff points. Performance pay and managerial authority are supermodular if and only if

$$\frac{\partial[\Pi(z_M, z_N, \alpha = 1) - \Pi(z_M, z_N, \alpha = 0)]}{\partial z_M} = f(z_M) \cdot k_M > 0 \tag{6}$$

$$\frac{\partial[\Pi(z_M, z_N, \alpha = 1) - \Pi(z_M, z_N, \alpha = 0)]}{\partial z_N} = f(z_N) \cdot (k_N - k_M) < 0,$$

where profits from adopting performance pay ($\alpha = 1$ instead of $\alpha = 0$) increase if z_M increases and z_N decreases. Both the increase in z_M and the reduction in z_N allocate more decision authority to managers. Since by assumption (1) $f(z) > 0$ for all z, this supermodularity will hold if the following two conditions are met

$$k_M > 0\,, k_M > k_N \tag{7}$$

Hence, supermodularity of performance pay and managerial authority will be met if incentive effects of managers are positive and if managers have stronger incentive effects than non-managerial employees. The key to understanding why tasks might be centralized from non-managerial employees to managers can be described formally by the condition $k_M = q_M^1 - q_M^0 > k_N = q_N^1 - q_N^0$. Under this condition, managers possess more important private information than non-managerial employees. The importance of private information has two components: First, efficient decisions by managers are more likely to be successful than efficient decisions of non-managerial employees ($q_M^1 > q_N^1$). Second, inefficient or self-interested managerial decisions are likely to be more costly to the firm than self-interested decisions by non-managerial employees ($q_M^0 < q_N^0$). If instead non-managerial employees possessed private information that was more important relative to managers, then $k_M < k_N$ would apply and performance pay adoption would be complementary with more decentralization towards non-managerial employees.

2.5 Optimal Task Allocation

Here, we relate our definition of supermodularity to observed decentralization patterns in response to performance pay adoption. We assume that the firm decides to either adopt performance pay for all employees or not to adopt performance pay at all.[4] For the two problem complexity cutoff levels z_M, z_N

[4] Note that organizations could also decide to separately adopt performance pay for different layers, hence $\alpha_M \neq \alpha_N$ so that performance pay is adopted for one employee layer but not the other. In these cases, task allocation to layer

the first-order conditions of profits imply that

$$[q_M^0 - q_P^1 + c_P \cdot h + \alpha \cdot k_M] \cdot f(z_M) = c_M$$
$$[q_N^0 - q_M^0 + \alpha \cdot (k_N - k_M)] \cdot f(z_N) = c_N - c_M$$

where the left hand side captures the marginal benefits of increasing z_M, z_N and the right hand side the marginal cost of doing so. We define the function $\varphi(x) = f^{-1}\left(\frac{1}{x}\right)$, which is a monotonically increasing function, since $f(.)$ is monotonically decreasing as we defined in (1) and $\frac{1}{x}$ is monotonically decreasing in x.[5] The equilibrium cutoffs can be expressed as

$$z_M(\alpha) = \varphi_M\left(\frac{q_M^0 - q_P^1 + c_P \cdot h + \alpha \cdot k_M}{c_M}\right) \tag{8}$$
$$z_N(\alpha) = \varphi_N\left(\frac{q_N^0 - q_M^0 + \alpha \cdot (k_N - k_M)}{c_N - c_M}\right)$$

At this point, it is useful to explicitly state the testable implication of our model. In particular, for each cutoff z_M, z_N we can write the number of tasks associated with the two cutoffs as $\mu_M(\alpha) = \xi\left[1 - F\left(z_M(\alpha)\right)\right]$ and $\mu_N(\alpha) = \xi \cdot F\left(z_N(\alpha)\right)$, where ξ is the overall number of tasks in an organization, which we previously normalized to $\xi = 1$. As a result, the number of tasks for each layer are given by $\Sigma_P(\alpha) = \mu_M(\alpha)$ for the principal P, $\Sigma_N(\alpha) = \mu_N(\alpha)$ for the non-managerial employee N and $\Sigma_M(\alpha) = \xi - \Sigma_P(\alpha) - \Sigma_N(\alpha) = \xi \cdot \left[F\left(z_M(\alpha)\right) - F\left(z_N(\alpha)\right)\right]$ for the managerial employee M. The following proposition summarizes our main empirical specification relating exogenous differences in performance pay α to differences in the number of tasks allocated $\Sigma_i(\alpha)$ to each layer $i = P, M, N$.

Proposition 1 (Test of supermodularity): Given regularity conditions, the change in number of tasks associated with the three managerial layers from the exogenous adoption of performance pay from α^0 to α^1 with $\alpha^1 \geq \alpha^0$ is given by

$$\frac{\Sigma_P(\alpha^1) - \Sigma_P(\alpha^1)}{(\alpha^1 - \alpha^0)} \approx -\xi \cdot f\left(z_M(\alpha^0)\right) \cdot \frac{\partial \varphi_M}{\partial \alpha}(\alpha^0) \cdot k_M < 0$$
$$\frac{\Sigma_M(\alpha^1) - \Sigma_M(\alpha^0)}{(\alpha^1 - \alpha^0)} \approx \xi \cdot [\, f\left(z_M(\alpha^0)\right) \cdot \frac{\partial \varphi_M}{\partial \alpha}(\alpha^0) \cdot k_M - \; f\left(z_N(\alpha^0)\right) \cdot \frac{\partial \varphi_N}{\partial \alpha}(\alpha^0) \cdot (k_N - k_M)] > 0$$

$j = M, N$ would increase if $k_j > 0$. We omit these cases here, since in the data most companies jointly adopt performance pay for all layers. However, we do explore the possible empirical importance of separate performance pay adoption by layer in the appendix.

[5] Since $f(x)$ is monotonically decreasing in x, its inverse $f^{-1}(x)$ will also be monotonically decreasing in x. As $x = 1/z$, we will have that $\varphi(z) = f^{-1}\left(\frac{1}{z}\right)$ is montonically decreasing in $\frac{1}{z}$ or monotonically increasing in z.

$$\frac{\Sigma_N(\alpha^1)-\Sigma_N(\alpha^0)}{(\alpha^1-\alpha^0)} \approx \xi \cdot f\big(z_N(\alpha^0)\big) \cdot \frac{\partial \varphi_N}{\partial\, \alpha}(\alpha^0) \cdot (k_N - k_M) < 0$$

In other words, under regularity conditions, performance pay adoption will lead to a concentration of decision-making at the managerial level if and only if supermodularity conditions (7) are met with $k_M > 0$, $k_M > k_N$.

Proof: We consider a first-order Taylor approximation around the point α_0 and exploit the fact that the following derivatives can be signed:

$$\frac{\partial \varphi_M}{\partial\, \alpha}(\alpha^0) = \frac{1}{f'\big(z_M(\alpha^0)\big)} \cdot \left(-\frac{c_M}{(q_M^0 - q_P^1 + c_P \cdot h + \alpha^0 \cdot k_M)^2}\right) > 0$$

since $f'(z) < 0$ as assumed in (1) and similarly,

$$\frac{\partial \varphi_N}{\partial\, \alpha}(\alpha^0) = \frac{1}{f'\big(z_N(\alpha^0)\big)} \cdot \left(-\frac{c_N - c_M}{\big(q_N^0 - q_M^0 + \alpha^0 \cdot (k_N - k_M)\big)^2}\right) > 0$$

Additionally, note that $f(z) > 0$ by equation (1). Given these regularity conditions, the stated concentration of tasks at the managerial level will only occur if supermodularity conditions (7) apply: $k_M > k_N > 0$.

Proposition 1 states that if performance pay and managerial authority are supermodular, one should observe an increased concentration of decision-making at the managerial level in response to exogenous performance pay adoption. Note in particular that centralization from non-managerial to managerial employees will be observed if managers have more important private information, or $k_M > k_N$, while if non-managerial employees have more important private information than managers, $k_M < k_N$ should lead to a further decentralization of decision-making towards non-managerial employees.

2.6 Effect of (progressive) taxation.

Until now, we assumed that differences in performance pay adoption $\alpha_1 - \alpha_0$ are given exogenously. In this section we show how differences in tax progressivity will imply differences in performance pay adoption $\alpha^1 - \alpha^0$ and therefore theoretically motivate the first stage of our instrumental variables strategy. We separate profits into two parts, which are both a function of performance pay adoption α:

$$\Pi(z_M(\alpha), z_N(\alpha), \alpha) = \Pi^A(\alpha) + \alpha \cdot (\overline{w}_M + \overline{w}_N) + (1-\alpha) \cdot 2\, U_R, \tag{9}$$

where alignment effects of performance pay and task allocation enter through the term $\Pi^A(\alpha)$, defined as

$$\begin{aligned}\Pi^A(\alpha) = {} & [1 - F(z_M(\alpha))] \cdot (q_P^1 - c_P h) \\ & + [F(z_M(\alpha)) - F(z_N(\alpha))] \cdot (q_M^0 + \alpha \cdot k_M) - c_M \cdot (z_M(\alpha) - z_N(\alpha)) \\ & + F(z_N(\alpha)) \cdot (q_N^0 + \alpha \cdot k_N) - c_N \cdot z_N(\alpha).\end{aligned}$$

The remaining terms in equation (9) capture the expected wage costs as a function of performance pay adoption. We introduce progressive taxation in its simplest form, as a linear-progressive tax, which applies a positive tax rate $\tau > 0$ for the high-output wage w_j^H and zero otherwise. In other words, taxation implies that the optimal wage contract (3) should be understood in terms of income, net of taxation. Linear-progressive taxation will make paying higher wages in the high-output state more expensive. Expected compensation costs as function of tax progressivity τ are given by

$$\bar{w}_j^\tau = \left(\frac{\tau}{1-\tau}\right) q_j^1 w_j^H + \bar{w}_j \quad (10)$$

Combining the effect of progressive taxation (10) with the decomposition of profits as given by (9) then leads to the theoretical motivation for our empirical specifications:

Proposition 2 (IV estimation first stage): Consider two firms with tax progressivity $\tau_1 < \tau_0$, all other things equal. The firm with lower tax progressivity is more likely to adopt performance pay, i.e. $\alpha^1 = \alpha(\tau_1) \geq \alpha^0 = \alpha(\tau_0)$.

Proof: Firms will only adopt performance pay ($\alpha = 1$) if the following condition holds

$$\Pi^A(1) - \Pi^A(0) \geq (\bar{w}_M^\tau - w_M) + (\bar{w}_N^\tau - w_N)$$

While the left-hand side is independent of tax progressivity, as taxes do not enter task allocation directly, the right-hand side is increasing in τ, as shown in (10). This condition therefore implies that performance pay adoption is monotonically decreasing in tax progressivity.

2.7 Extension: Task-level analysis

Our theoretical analysis thus far focuses on the overall fraction of total tasks over which every layer exerts authority, captured by the cutoff levels z_M, z_N. Here, we extend the analysis to explore the mechanism through which performance pay and decision-making are aligned. Specifically, we are interested in which types of tasks are realigned on average in response to performance pay adoption. Let a be an index of tasks, and f an index of firms. We assume that decision complexity z can be decomposed into two elements, according to $z_a(n_a) \cdot \epsilon_{a,f}$. First, the term $z_a(n_a)$, captures general "population level" problem complexity of the task a. For example, decisions about new product development in general are likely to be more complex problems than decisions about daily work planning. Tasks can be ordered by increasing problem complexity, for which we define the variable n_a, where higher numbers capture more complex tasks. We define $z_a(n_a) = \frac{1}{\psi(n_a)}$ with $\psi(.)$ being a monotonically decreasing function. Second, the term $\epsilon_{a,f}$ captures firm-specific unobservable and idiosyncratic factors that make successful decisions costly to make. For example, a corporate culture with low levels of destructive intra-organizational conflict might reduce the complexity of any given task. At the task level, we should observe that principals are allocated task a if

$$z_a(n_a) \cdot \epsilon_{a,f} \geq z_M(\alpha) \tag{11}$$

Proposition 3 (Test of extended model for task-level regressions): Let $P(a,f), M(a,f), N(a,f)$ be indicator functions that are one if P, M or N are deciding task a at firm f. Assuming that $\epsilon_{a,f}$ is normally distributed and utilizing linear approximations, the probability that P decides on task a at firm f is given by

$$P(P(a,f) = 1) = \Phi(\gamma_0 + \gamma_1 \cdot n_a + \gamma_2 \cdot \alpha + \gamma_3 \cdot n_a \times \alpha) \tag{12}$$

where $\Phi(.)$ is the cdf of the normal distribution. The implied predictions from our theory are that (i) $\gamma_1 > 0$: more complex tasks are on average more likely to be controlled by P, (ii) $\gamma_2 < 0$: performance pay adoption reduces the likelihood that P controls any task and (iii) $\gamma_3 > 0$: performance pay-induced realignment of tasks is weaker for more complex tasks.

Proof: We approximate the function $\psi(n_a)$ using $\psi(n_a) \approx \psi_0 + \psi_1 \cdot n_a$ and we approximate the cutoffs using $z_j(\alpha) \approx \phi_{j,0} + \phi_{j,1} \cdot n_a$. To be consistent with our theory, we require that the approximated linear functions meet the conditions: $\psi_1 < 0$, $\phi_{M,1} > 0$, $\phi_{N,1} < 0$.

The prediction regarding the interaction between task complexity and performance pay adoption ($\gamma_3 > 0$) is the key additional insight from our extended task-level analysis, capturing the idea that performance pay-induced realignment is attenuated for more complex tasks. In equation (11) this is the case as more complex tasks, such as product development, require deeper integration into firm-idiosyncratic factors $\epsilon_{a,f}$, such as the strategic decision-making process or an organization's collaborative culture, and are therefore less sensitive to performance pay adoption. Specifications similar to (12) can be written down for M and N and their interactions yield similar predictions: the interaction $n_a \times \alpha$ should be positive for non-managerial employees and negative for managers, capturing weaker realignment effects of tasks in response to performance pay adoption.

2.8 Performance implications of task misalignment

Here, we derive testable performance implications from our theory. We begin by noting that the profit function (5) can be rewritten as

$$\Pi(z_M, z_N, \alpha) = [(q_P^1 - c_P h) + \Pi_M^A(z_M, \alpha) + \Pi_N^A(z_N, \alpha)] - \alpha \cdot (\overline{w}_M + \overline{w}_N) - (1 - \alpha) \cdot 2\, U_R$$

As in equation (9), profits can be understood as consisting of two parts. The second part (after the rectangular brackets) captures the employee compensation costs as a function of adopting performance pay. Since this factor can easily be controlled for using observable compensation, we focus on the first part.

The first part (in rectangular brackets) captures the profit consequences of the (mis-) alignment of decisions and performance pay. We further decompose this part into two terms, which take the form

$$\Pi_j^A(z_j, \alpha) = \lambda_j(\alpha) \cdot F(z_j) - \tilde{c}_j \cdot z_j \tag{13}$$

with $j \in M, N$ and $\lambda_M(\alpha) = (q_M^0 - q_P^1 + c_P h + \alpha \cdot k_M)$, $\lambda_N(\alpha) = \left(q_N^0 - q_M^0 + \alpha \cdot (k_N - k_M)\right)$ as well as $\tilde{c}_M = c_M$and $\tilde{c}_N = c_N - c_M$. In other words, the profit term $\Pi_j^A(z_j, \alpha)$ can be interpreted as the profit impact of (mis-) aligning decision cutoff z_j and performance pay adoption α. Within this profit term, $F(z_j)$ is the measure of tasks below cutoff z_j, while $\lambda_j(\alpha)$ is the marginal benefit of allocating tasks below cutoff z_j, while $\tilde{c}_j$ is the marginal cost of doing so.

To understand possible profit losses from the misalignment of task allocation and performance pay adoption, let $\alpha^0 - \alpha^1$ be the difference in given performance pay choices, which are influenced by tax progressivity, with α^1 the current choice for performance pay adoption.[6] We focus on the performance effects of task allocation-performance pay misalignment, captured by $\Pi_j^A(z_j, \alpha)$. Denoting the measure of tasks $F_j = F(z_j), j = M, N$, a correct alignment is given by $\left(\alpha^1, z_j^1\right)_{j=M,N}$ or $\left(\alpha^1, F_j^1\right)_{j=M,N}$. In contrast, a misalignment of task allocation is denoted by $\left(\alpha^1, F_j^0\right)$, where although α^1 is given, $F_j^0 \neq F_j^1$, so task allocation and performance pay adoption are misaligned.

Proposition 4 (Misalignment analysis): Performance losses from the misalignment of task allocation and performance pay are given by

$$\Pi_j^A\left(z_j^0, \alpha^1\right) - \Pi_j^A\left(z_j^1, \alpha^1\right) \approx \frac{1}{2} \cdot \frac{\lambda_j(\alpha^1)}{f'\left(z_j^1\right)} \cdot \left(F_j^0 - F_j^1\right)^2 \tag{14}$$

with $f'(z) < 0$ as given by condition (1).

Proof: We use a second-order Taylor expansion of $\Pi_j^A(z_j, \alpha)$ around the optimal point α^1, z_j^1 (see Varian (1978)), combined with the implicit function theorem applied to $F_j = F(z_j)$, which gives $z_j^0 - z_j^1 \approx \frac{1}{f'\left(z_j^1\right)} \cdot \left(F_j^0 - F_j^1\right)$.

Equation (14) provides a theory-based misalignment measure between performance pay and task allocation. The term $\left(F_j^0 - F_j^1\right)^2$ is the squared deviation of the number of tasks from correctly aligned task allocations and is directly proportional to potential misalignment losses. We note that there are potentially two potential loss terms $\Pi_j^A\left(z_j^0, \alpha^1\right) - \Pi_j^A\left(z_j^1, \alpha^1\right), j = M, N$, corresponding to two cutoffs z_M, z_N. Hence, it is sufficient to look at two measures: $1 - F_M$, for the Principal, and F_N for the non-manager layer, since the measure for the managerial layer will be the residual $F_M - F_N$.

[6] Note that $\alpha^1 = 1$ denotes the adoption of performance pay, while $\alpha^1 = 0$ denotes the non-adoption of performance pay. In any case, we will assume that $\alpha^0 = 1 - \alpha^1$.

3 Data and Measurement

3.1 Data

The data for our study comes from the Workplace and Employee Survey (WES), developed and administered by Statistics Canada, and contains comprehensive information on firm management practices. The survey is a random stratified sample, representative of the population of businesses in the Canadian economy in each year. There are several advantages of this data compared to other existing microdata on management practices and firm internal organization. First, the WES data allows for direct measurement of task allocation not only between principals and agents, but also between different types of agents, such as managerial and non-managerial employees. Second, the WES data has much broader sectoral coverage compared to data used in industry-specific studies such as Ichniowski et al. (1997) or studies such as Bloom et al. (2014) based on the manufacturing sector, allowing for greater generalizability. Third, since the target population is the universe of Canadian businesses, the WES is not biased towards certain firm size classes, in contrast to the World Management Survey by Bloom and Van Reenen (2007). Finally, an important strength of the WES is that responding to the survey was mandatory under Canadian law, which resulted in regular response rates of approximately 90 percent, mitigating concerns of non-response bias in our analysis. The sample used for this study consists of a panel of approximately 5,800 for-profit business establishments, for the years 2003 and 2005.[7][8] Summary statistics are displayed in Table 1.

3.2 Measurement

Allocation of Decision Authority. The WES data contains detailed information regarding decision-making authority on 12 tasks across different layers of the organizational hierarchy, with survey questions similar to those used by Bresnahan et al. (2002) and Bloom et al. (2013a) measuring worker autonomy. The survey data we use asks "who normally makes decisions with respect to the following activities?". The 12 operating tasks in the survey range from "daily planning of individual work" to "product and service development." We consider the following five possible responses to the question of who makes decisions, which we call decision "layers": 1) non-managerial employees, 2) work supervisors, 3) senior managers, 4) individuals or groups outside the workplace (typically headquarters for multi-establishment firms), and 5) business owners.

Table 2 summarizes the patterns of task allocation across layers. We assign increasing integer values with increments of one to the layer of the hierarchy where decisions are made, where non-managerial employees have a value of 1, work supervisors have a value of 2, senior managers have a value of 3, and

[7] The data consists of 5,802 establishments in 2003 and 5,951 establishments in 2005.
[8] We note that our IV estimation, however, is a cross-sectional estimation approach.

both business owners and headquarters have a value of 4 since they represent principals. The sample means in Table 2 indicate how high, on average, in the levels of the hierarchy decisions are made and the number of layers involved. Decision-making for routine tasks like daily work planning is relatively more decentralized, while more complex tasks, such as product or service development, are typically decided at higher levels in the hierarchy.[9] The third column of Table 2 shows that, on average, slightly more than one layer is involved in decision-making for most tasks, suggesting that the survey's layer definitions are sufficiently distinct to provide variation for empirical analysis. Because of the distinction between business owners, headquarters, and senior management in the WES survey, we can identify principals as residual claimants of profit flows from the firm. Since most firms in the sample are single-establishment entities, the separation between professional senior managers and business owners is especially important for identifying principals. For multi-unit firms, decision-makers outside the establishment are typically the corporate headquarters, so we are able to identify the principal as the firm's headquarters in such cases. Agents are defined as any type of employee within the establishment, and include both managerial and non-managerial employees. We use three distinct measures of allocation of decision-making authority at the organizational level. $\text{PrincipalControl}_{it}$ counts the number of tasks that are carried out by the principal (business owners or headquarters), and corresponds to the theoretical variable $\Sigma_P(\alpha)$, and is thus a measure of *centralization* of decision authority. Similarly, the measures $\text{ManagerControl}_{it}$ and $\text{NonManagerControl}_{it}$ count the number of tasks allocated to agents, either to managerial employees ($\Sigma_M(\alpha)$ in our theory) or non-managerial employees ($\Sigma_N(\alpha)$ in the theory).

To analyze task-level variation within each establishment-year to test our extended model in section 2.7, we disaggregate the task level data within each establishment, and use the measures of PrincipalControl, ManagerControl, and NonManagerControl, but now as dummy variables equal to one if the individual task a within the establishment is allocated to each respective level of the organization. These measures correspond to the theory variables $P(a,f), M(a,f), N(a,f)$ in section 2.7.

Task complexity. To measure the complexity of tasks, we construct a variable at the individual task level based upon the logic developed by Garicano (2000) that proposes a clear relationship between task complexity and the level of the organizational hierarchy to which a task is assigned, where the least complex tasks are assigned to the lowest level of the hierarchy, while increasingly more complex tasks are assigned to progressively higher levels.[10] For the 12 tasks in our survey, we define each by an integer value from 1

[9] When comparing the differences between the first and second column of average decision layers, we note that this pattern becomes stronger if we exclude firms that have any involvement of business owners in decisions. By excluding those firms where business owners are involved in decision-making, we remove very small firms that are naturally centralized with business owners that are typically involved in all firm activities.

[10] Alternatively, we conducted a similar task-level analysis using the ordering of the questions in the survey itself, which was intended to capture a task ordering from operational to more strategic types of tasks (this was confirmed

to 12, based upon their ordering of average level of the organizational hierarchy to which the task is assigned in the Canadian population of businesses. Greater integer values imply higher average levels of the hierarchy that are assigned the task, and greater task complexity.[11] [12]

Performance Pay. The WES survey data offers a variety of information on performance-based compensation in firms. Specifically, it allows us to measure four different types of performance pay: 1) individual incentive pay, such as bonuses, commissions, and piece-rates, 2) group or team incentives, 3) firm profit sharing agreements, and 4) stock-based compensation. Given that standard principal-agent analysis characterizes very general forms of state-contingent compensation contracts to solve the moral hazard problem, we measure the presence of performance pay with an indicator equal to one if any form of performance pay is present. This measure corresponds to the performance pay adoption indicator $\alpha \in \{0,1\}$, which we defined in section 2.3.

Firm mortality. While conducting the WES, Statistics Canada followed up with all survey participants annually to verify instances where respondents went out of business, allowing us to exploit a reliable measure of organizational mortality. For our dependent variable, we use this data to construct a dummy variable equal to 1 if the organization experiences mortality by the time the WES is administered again, which captures the mortality event in the same year or following year after the survey is conducted.

4 Identification and Estimation

4.1 Instrumental variables strategy

Endogeneity concerns. As highlighted by Athey and Stern (1998), observing correlations in the adoption of different management practices provides insufficient evidence of their complementarity. Firms are likely to differ in their costs and benefits from adopting management practices, which may bias OLS estimates either upwards or downwards depending upon the source of heterogeneity. One source of possible unobserved heterogeneity includes variation in the skills of principals or employees across firms. For example, if very skilled employees allow firms to decentralize more tasks and at the same time lower the costs of adopting performance pay, then OLS estimates of the complementarity of decentralization and performance pay would be upward biased. On the other hand, highly efficient business owners or headquarters might be able to more effectively implement performance pay and at the same time might be

---

to us in writing by the designers of the WES survey). The results of this alternative approach were similar to our original approach.

[11] To ensure that our results are not purely a result of the linearity of our measure, we estimate piecewise linear approximations, with each linear piece consisting of an ordering of 4 tasks, as well as the Sheaf coefficient for ordinal independent variables which relaxes the assumption of equal spacing between tasks (Heise 1972). In both cases, we obtain similar results.

[12] The specific rank ordering of tasks is identical to the ordering in Table 2.

more productive in making decisions, so more tasks would be centralized. In this case, OLS estimates of complementarity would be downward biased.

Tax progressivity instrument. To address endogeneity issues, we exploit regional variation of income tax progressivity across Canadian provinces as an instrument for the adoption of performance pay. We are guided in our choice of the instrumental variable by Proposition 2 (IV estimation first stage). As shown earlier, when tax progressivity is greater, marginal increases in income are more heavily taxed relative to low tax progressivity regimes, which reduces the likelihood of performance pay adoption. Within Canada, provincial variation in income taxes is greater than in many comparable countries, with Canadians on average paying a large share of their total income taxes to their provincial governments (Murphy et al. 2013).

Construction of the instrumental variable. To construct our instrument, we use information on income tax progression of Canadian provinces collected from the annual publication *Finances of the Nation* by the Canadian Tax Foundation, which provides income tax data by province. Our measure of tax progressivity is residual income progression, a standard measure used in the public finance literature to measure tax progressivity (Jakobsson 1976, Musgrave and Musgrave 1989). Our measure is defined as

$$\rho = \frac{1-MTR}{1-ATR},$$

where *MTR* is the marginal income tax rate applicable for the average income level and ATR the average income tax rate at the average income level for each province. In this measure, $\rho = 1$ corresponds to a flat tax system, while $\rho < 1$ implies that the tax system exhibits progressivity. Consequently, higher values of ρ imply less progressivity and imply a higher incentive to adopt performance pay.

We adjust this measure of tax progression in two ways. First, we smooth annual fluctuations in provincial tax progressivity, by taking the 10-year historical average of the tax progressivity measure. Second, for firms that operate in multiple provinces, we use the tax progressivity of the province where the firm's headquarters is located as our relevant measure. In our data, we find that the adoption of management practices is typically implemented firm-wide irrespective of the location of the firm's establishments, suggesting that adoption decisions made at headquarters are likely to be implemented throughout the entire firm. [13] [14]

[13] The fact that management practices in general and performance pay in particular do not vary much across region for multi-establishment, multi-regional firms suggests that other internal frictions such as equity concerns and social norms might prevent firms from writing optimal contracts given the local tax schedules.

[14] As an additional piece of analysis to validate our approach, we also conducted regression analyses after assigning tax progressions based on actual establishment locations. When tax progression variables based on actual location and on headquarters location are included together to predict performance pay, only headquarter-based tax progression measures are highly significant, while tax progression based on actual establishment location is not statistically significant.

Exploiting multi-province firms. For the second part of our instrumental variables strategy, we consider the subsample of firms in our data that operate in multiple provinces, using the tax progressivity of the province where the firm's headquarters is located as our instrumental variable. This allows for the additional inclusion of province fixed effects as controls along with our tax progressivity instrument, and effectively compares establishments which are part of different multi-province firms within the same province as the relevant identifying variation. Establishments with headquarters located in regions with high tax progressivity are predicted to be less likely to adopt performance pay than establishments in the same province that have headquarters in regions with low tax progressivity. By including province fixed effects, this second estimation approach uses the tax progressivity of other Canadian provinces outside of the province where each establishment is located as the relevant source of exogenous variation, and addresses concerns of potential unobserved heterogeneity across provinces that may explain our results.[15]

4.2 Task Allocation Specifications

As discussed earlier, the potentially endogenous variable of interest is the adoption of performance pay. Our measure is denoted by $\text{PerformancePay}_{i,t}$, for establishment *i* in year *t*, capturing the existence of any form of performance pay and corresponds to the theoretical variable $\alpha \in \{0,1\}$. Our main specifications are guided by our theoretical analysis in section 2. In particular, Proposition 2 (IV estimation first stage) leads us to the following first stage for the instrumental variables regression:

$$\text{PerformancePay}_{i,t} = \beta_\rho \cdot \rho_{i,t} + \text{Controls}_{i,t} + \varepsilon_{1,i,t},$$

where $\rho_{i,t}$ is our tax progressivity measure. Since higher values of $\rho_{i,t}$ capture less progressive income taxes, one would expect that $\beta_\rho > 0$, implying that lower progressivity increases the likelihood of adopting performance pay. The exogenous variation from the first stage is then used according to Proposition 1 (Test of supermodularity) to obtain the following second stage instrumental variable (IV) coefficient estimates

$$\text{PrincipalControl}_{i,t} = \beta_{PP} \cdot \text{PerformancePay}_{i,t_{i,t}} + \text{Controls}_{i,t} + \varepsilon_{2,i,t}$$

where $\text{PrincipalControl}_{i,t}$ measures the number of tasks decided by the principal and corresponds to the theorical object $\Sigma_p(\alpha)$ and β_{PP} represents the causal relationship between the adoption of performance pay and the degree of decentralization of decision authority at the establishment level. In particular, $\beta_{PP} > 0$ implies that adoption of performance pay increases decision control by the principal. In this case,

[15] We note that the F-test statistic of the excluded tax progressivity instrument is 34.40 for our full sample analysis and 17.08 for our analysis on the sample of multi-province firms, mitigating concerns that weak instruments may confound estimation (Stock et al. 2002, Semadeni et al. 2014).

decentralization and performance pay would be substitutes. On the other hand, if $\beta_{PP} < 0$, adoption of performance pay leads to less control by the principal and more delegation of decisions to employees, implying that decentralization and performance pay would be complements. We repeat this analysis using ManagerControl and NonManagerControl as dependent variables at the establishment level to examine how tasks are allocated among agents when performance pay is adopted, corresponding to variables $\Sigma_M(\alpha), \Sigma_N(\alpha)$ in Proposition 1.

A number of control variables are also included in our analysis. We include industry fixed effects at the four digit NAICS code level and year fixed effects to control for industry differences and economy-wide shocks or trends. We control for firm size, measured by the logged total number of employees, and establishment age. We also include separate dummy variable controls for establishments that are part of a multi-establishment enterprise, export their goods or services abroad, have an organized union, or are foreign-owned, which we define as having over 50 percent of the organization's assets owned by a foreign interest.

For our specification at the task level, we follow the theoretical arguments summarized in Proposition 3 (Test of extended model for task-level regressions) and use the same instrumental variable approach and include the same controls, but use dummy dependent variables that correspond to the theoretical variables $P(a, f), M(a, f), N(a, f)$ as described above. As outlined in Proposition 3, we are interested in exploring how task complexity may lead to differences in the effects of performance pay adoption, so we include an interaction term for our task complexity measure and performance pay adoption. To address potential endogeneity issues, we use the interaction between our tax progressivity instrument and task complexity measure as an additional instrumental variable.

4.3 Performance Specification

To supplement our test for joint adoption of performance pay and task allocation, we also consider whether misalignment affects firm performance. Specifically, we consider how joint adoption influences the probability of firm mortality, which is closely linked to firm productivity (Jovanovic 1982, Hopenhayn 1992, Melitz 2003, Foster, Haltiwanger, and Syverson 2008). Our approach is based on our theory-based misalignment measures we derived in section 2.8 and is similar in spirit to the approach by Nickerson and Silverman (2003). We run first stage IV regressions for each of our three primary task allocation measures on performance pay adoption and the same control variables as our task allocation specifications. Then, we calculate the squared deviation between the observed task allocation F^0 and the predicted task allocation F^1 from the first stage regression for our PrincipalControl, and NonManagerControl variables and calculate the terms $\left(F_j^0 - F_j^1\right)^2, j = M, N$ as given by Proposition 4 (Misalignment analysis). These variables measure the misalignment between task allocation predicted by performance pay and the actual task allocation at the firm as described by our theoretical analysis, with the lowest possible value being zero (no misalignment of task allocation and performance pay). Greater task misalignment is predicted to increase the likelihood of firm mortality, which would predict a positive and statistically significant coefficient for our second stage performance regression. To examine the performance implications of misalignment, we conduct our analysis in two parts for estimation. In the first part, we examine misalignment of tasks allocated to principals, to test whether the misalignment of performance pay and decentralization from principals to employees predicts firm mortality, to test for complementarity of performance pay and decentralization. For the second part of our analysis, we explore the implications of "relative" misalignment, to test whether misalignment at different levels of the hierarchy may differentially impact performance outcomes. Here, we include both PrincipalControl and NonManagerControl misalignment in the same specification, which map directly to the two measures $1 - F_M$ and F_N in section 2.8. To test for the effects of relative misalignment, we compare the coefficients for PrincipalControl and NonManagerControl misalignment. For our control variables, we include the same controls as our task allocation specifications, and add establishment age squared, the average wage of employees within the establishment, the cumulative number of new product and process innovations at the establishment during the panel period, and a Herfindahl index for each 4 digit NAICS code to control for the intensity of firm competition.

4.3 Results

Baseline results for our coefficients of interest are presented in Table 3. Columns 1 through 3 provide OLS estimates of our measures of decision control and the adoption of performance pay. On average, adopting performance pay is associated with principals controlling two fewer tasks and managerial agents carrying out roughly one more task, while non-managerial agents' control has no statistically significant relationship with performance pay. However, as noted earlier, the OLS results do not provide reliable evidence of complementarity, since unobserved factors may bias the coefficient estimates. Columns 4 through 6 report instrumental variable (IV) estimates.[16] In Column 4, the coefficient estimate for our performance pay measure is negative and significant, providing evidence for the presence of complementarity between performance pay and the decentralization of decisions from principals to agents. In response to the adoption of performance pay, firms systematically reallocate decision authority away from principals down to lower levels in the organizational hierarchy.

[16] We also note that the coefficient estimates for the IV estimates are generally larger in magnitude than the OLS estimates, implying that the correlation between decentralization and performance pay in the OLS error term is negative, and that unobservable factors may confound simple correlation tests for the adoption of performance pay and decentralization.

In Columns 5 and 6, the coefficient for performance pay is positive and significant for managers, but negative and significant for non-managerial employees. Taken together, the results from Columns 4 through 6 suggest that while adoption of performance pay does lead to principals decentralizing decision-making to agents at lower levels in the hierarchy, tasks are also centralized away from non-managerial employees to managers, resulting in the concentration of decision-making at the management level. Our results run counter to several commonly proposed mechanisms of performance pay and decentralization. First, since performance pay enables more efficient decision-making at all levels of the organization, the adoption of performance pay might have induced a general movement toward decentralization across all layers of the hierarchy. In this context, proponents of worker empowerment as discussed by Ichniowski and Shaw (2003) can be understood in terms of our model as corresponding to the theoretical condition $0 < k_M < k_N$, which as discussed in section 2.4, captures the idea that non-managerial employees have more important private information than managers. But as discussed in section 2.5, the condition $0 < k_M < k_N$ would imply that the performance pay coefficient for NonManagerControl is positive. Second, a popular view among management practitioners is that middle management is an inefficient bureaucratic layer (Hamel 2011). This view can be understood in terms of our model as the case of $0 = k_M < k_N$, so there is no significant gain from more efficient managerial decisions induced by performance pay. From this perspective, one might have predicted that firms reallocate tasks from managerial to non-managerial employees. If true, the coefficient for ManagerControl would have been negative, and the coefficient on NonManagerControl positive.

Columns 1 through 3 of Table 4 display the results from the second part of our instrumental variables strategy, where we repeat our analysis on the sample of establishments that are part of multi-province firms and include province fixed effects. The results are consistent with our full sample IV estimates, and we again find evidence that performance pay leads to decentralization of decision-making authority from principals to agents, and centralization from non-managerial to managerial employees. The consistency of results also suggests that unobserved heterogeneity across provinces is unlikely to explain our findings.

Regression results at the individual task level, where we test for the interactions between performance pay adoption and task complexity, are shown in Table 5. Columns 1 through 3 show baseline coefficients for performance pay that are again similar to our findings at the establishment level in Tables 3 and 4. However, the interaction terms for performance pay and task complexity are statistically significant and positive for principals, negative for managers, and positive for non-managerial employees, consistent with the theoretical prediction from Proposition 3 that the effects of performance pay on task reallocation are attenuated by increasing task complexity.

Performance specification results are displayed in Table 6. As shown in Columns 1 and 2, the coefficient for PrincipalControl misalignment is positive and statistically significant, consistent with complementarity between decentralization and performance pay, where greater misalignment increases the likelihood of firm mortality. In Column 2, we also include the misalignment of NonManagerControl, to examine relative misalignment across different levels of the hierarchy. Both misalignment of PrincipalControl and NonManagerControl, which map to $(1 - F_M)$ and F_N in our theoretical model, are statistically significant and positively predict firm mortality. However, when we formally test the hypothesis that both coefficients are equal, we cannot reject the null (Chi-squared=0.89, p-value 34.7%). Taken together, the results suggest that while the magnitude of misalignment explains performance outcomes in our setting, misalignments at different levels of the hierarchy do not have substantially different effects on performance outcomes.

Overall, our findings suggest that the largest gains from implementation of performance pay occur through more efficient decision making of managers and that managerial activities are likely to play a more critical role in determining firm performance outcomes than activities at other levels of the organizational hierarchy. The results are also supportive of the hypothesis proposed by Atalay et al. (2013) that the nature of firms is intimately connected to their role in "mediating managerial supervision and control." We also note that our findings suggest a more nuanced relationship than originally proposed by Rivkin and Siggelkow (2003). In their agent-based simulation model, they find that joint adoption of centralization and the provision of performance pay result in better firm performance. However, their test of decentralization is modeled as a simple binary organizational design feature between two parties, without the distinctions between principals, managers, and non-managerial employees.

More broadly, we note that our findings offer a novel perspective on the importance of managers within the firm. While the significance of managers in determining firm outcomes is a well-established notion (Barnard 1938, Penrose 1959, Finkelstein and Hambrick 1996), explanations for enabling or constraining forces that may affect the importance of managers have focused on individual factors in isolation, such as limits on managerial authority (Hambrick and Finkelstein 1987). By contrast, relatively little work has explored how the interaction between different organizational practices enables the effects of managers. We show both theoretically and empirically how managers may matter more for firm outcomes as the complementarity of performance pay and managerial authority reinforces the importance of managers as decision-makers.

5 Validity and robustness

5.1 Examination of Athey-Stern conditions

Our main econometric specification follows Proposition 6 in Athey and Stern (1998), which allows for "reduced-form tests exploiting exclusion restrictions," and lists the conditions under which such tests based on exclusion restrictions are a valid test of complementarity. While not all of these conditions are directly testable, we examine whether evidence exists that the conditions are likely to be met in our setting, supporting the validity of our test of complementarity.

Condition 1: Firms optimize. Evidence for this condition is based upon the first stage of the instrumental variables estimation in Appendix Table A19, where we show that firms respond to differences in tax progressivity as predicted by our theory in Proposition 2.

Condition 2: Variables are ordered in such a way that profits remain supermodular even after adding several system and practice-specific noise terms; and Condition 3: There are no system-specific error terms, or the model is not a "Random-Systems Model." To explore whether our results may be affected after adding practice-specific noise terms or system-specific error terms, we consider whether our results are robust to variation in organization size (measured by total number of employees), organization age, or across industries (measured by 2 digit NAICS codes), where variation in noise and error terms may arguably be correlated with any of these three variables. Variation in size and age is considered by breaking our sample into quintiles for each variable. Since we already provide evidence of optimizing behavior of firms, we focus our analysis on testing for joint adoption. In general, while we might expect to lose statistical power due to fewer observations in our data within each subsample, we would expect to at least observe qualitatively similar results as in our original test for joint adoption of performance pay and decentralization. As the results in Appendix Tables A20-A25 show, in general we find at least qualitatively similar results as our original findings, and in many cases quantitatively similar results.

Condition 4: An exclusion restriction applies to the instrument being used. Here, we include a number of additional possible confounding variables as controls and examine mechanisms that may invalidate the exclusion restriction of our instrumental variable. Appendix Tables A5-A11 as well as Figures A12-A17 and accompanying discussion examine this issue further.

Condition 5: There are no interactions of practices outside the production function. While not directly testable, we explore this condition by considering possible dependent variables that may not necessarily have a direct effect on productivity, or at least are relatively distant from the production function compared to other organizational outcome variables. Specifically, we estimate the same specification as our firm mortality regressions, but now with the Gini coefficient of wages (measuring wage inequality within the establishment) as a dependent variable, as well as the logged number of employee grievances filed.[17] As the results in Appendix Table A26 show, our measures of misalignment between performance pay and task allocation do not predict changes in these organizational outcome variables at standard levels of statistical significance.

[17] Both variables are calculated using data from the WES survey.

5.2 Potential alternative explanations

Here, we consider several additional alternative explanations for our results.

Loss of control. An alternative mechanism that might explain some of our results is the idea of "loss of control" in the spirit of Aghion and Tirole (1997): delegation might carry the risk that employees make uninformed decisions in situations in which principals would have made a more informed decision. To investigate this potential explanation, we define "coordination tasks" that include setting staffing levels, product/service development, and production technology choice, and "implementation tasks" that include purchase of supplies, equipment maintenance, customer relations, follow-up of results, and quality control.[18] If "loss of control" issues are more likely to occur for coordination than implementation tasks, principals might be less likely to decentralize coordination tasks, even if performance pay is adopted. Consequently, decentralization from principals to employees should be systematically weaker for coordination tasks relative to implementation tasks. Results for the two types of tasks are shown in Table 7. While the point estimates for Columns 1 and 4 in Table 7 seem consistent with this view, we cannot reject the hypothesis that effects for coordination and implementation tasks are equal.[19]

Variation in the level of performance pay across hierarchical levels. One possible explanation for the concentration of tasks at the managerial level is that managers receive greater performance pay than non-managerial employees. If performance pay differences lead to significant total wage differences between managers and non-managerial employees, then variation in compensation across organizational layers would be a valid proxy for differences in performance pay strength. We therefore construct a measure of wage inequality within the establishment by calculating the Gini coefficient of wages, which we compute using a separate section of the WES survey that asks respondents to report the number of employees within specified wage brackets. Prior studies of wage inequality within firms have found that variation of wages is largely driven by differences across hierarchical levels, as opposed to within the same level in the hierarchy (Prendergast 1999, Gibbs and Hendricks 2004). We then test whether our findings of managerial concentration of authority are robust to controlling for the Gini coefficient of wages to capture differences in performance pay strength between managers and non-managerial employees. As shown in Columns 1-3 of Table 8, our results remain robust to the inclusion of this control.

Risk. In response to empirical studies that find a positive correlation between risk and performance pay, theoretical models such as Prendergast (2002) have argued that risk can drive both decentralization and performance pay. Therefore, a potential confounding variable potentially biasing our results could be risk.

[18] To make the magnitudes of the coefficient estimates comparable, our dependent variable measure for each set of tasks is divided by the respective total count of tasks (3 for coordination, 5 for implementation).
[19] Principal control: Chi-squared=1.56, p-value .21; Manager control: Chi-squared=10.6, p-value=.001; Non-manager control: Chi-squared=4.38, p-value=.04

To address this concern, we include the standard deviation of operating margin at the establishment level as an explicit measure of risk. As shown in Columns 4-6 of Table 8, including this additional control for risk does not affect our results.

Distance to corporate headquarters. A possible alternative explanation for the results in our multi-province sample test is that establishments that are geographically further away from corporate headquarters are more likely to be decentralized, and also more likely to be given performance pay.[20] To address this, we repeat our baseline multi-province firm analysis and include an additional control for the distance between an establishment and its headquarters province, calculated by driving distance.[21] We cannot observe the precise locations of establishments in our data, economic activity within Canadian provinces is highly concentrated in each province's major urban areas (Brown and Rispoli 2014), so we are able to reasonably approximate the center of economic activity within each province by identifying a population-weighted midpoint between each province's three most populated cities. As Columns 7-9 of Table 8 show, we obtain similar results with the inclusion of this control.

6 Conclusion

Our results provide empirical evidence consistent with the existence of complementarity between performance pay and decentralization of decision-making. While performance pay adoption does lead to decentralization of decision-making from principals to agents, we find that, among agents, the adoption of performance pay also leads to centralization of authority from non-managerial to managerial employees. The results suggest that understanding the interaction of different organizational practices can enhance our understanding of the role of management within organizations. While we have provided generalizable results at the level of a national economy, future work should examine how the nature of specific contexts might affect our results (Cassiman and Veugelers 2006). This research would not only complement the task allocation patterns we find in this study, but contribute to extending current theories about how the internal organization of firms can lead to sustainable competitive advantage. Also, our estimates of the average degree of complementarity between performance pay and decentralization are potentially useful to calibrate quantitative models of endogenous productivity and management practices. One example of such models are agent-based models, such as Rivkin (2000). Overall, our findings suggest that identifying and understanding the mechanisms driving complementarity between management practices in greater detail is a fruitful area for future research.

[20] In the literature examining franchising, Kalnins and Lafontaine (2004) find that more geographically distant establishments are more likely to be franchised, where franchising can be viewed as a combination of decentralization and performance pay adoption.
[21] We also find similar results when using straight line distance.

References

Aghion, P., Tirole, J. 1997. Formal and real authority in organizations. *Journal of political economy*, 105(1), 1-29.

Alonso, R., Dessein, W., Matouschek, N. 2008. When does coordination require centralization?. *American Economic Review*, **98**(1), 145-179.

Aral, S., Brynjolfsson, E., Wu, L. 2012. Three-way complementarities: Performance pay, human resource analytics, and information technology. *Management Science*, 58(5), 913-931.

Arora, A. 1996. Testing for complementarities in reduced form regressions: a note. *Economics letters* **(50)**1 51-55.

Atalay, E., A. Hortascu, C. Syverson. 2013. Vertical integration and input flows. *American Economic Review* **104**(4) 1120-1148.

Athey, S., S. Stern. 1998. An empirical framework for testing theories about complementarity in organization design. Working Paper No. 6600, the National Bureau of Economic Research, Cambridge, MA.

Barnard, C. 1938. *The functions of the executive*. Harvard University Press, Cambridge.

Baum, R., Wally, S. 2003. Strategic decision speed and firm performance. *Strategic Management Journal*, **24**(11), 1107-1129.

Black, S. E., Lynch, L. M. 2001. How to compete: the impact of workplace practices and information technology on productivity. *Review of Economics and Statistics*, 83(3), 434-445.

Bloom, N., Brynjolfsson, E., Foster, L., Jarmin, R., Patnaik, M., Eksten, I.S., Van Reenen, J. 2014. IT and Management in America. Discussion Paper No. DP9886, Centre for Economic Policy Research, London, U.K.

Bloom, N., Garicano L., Sadun, R., Van Reenen, J. 2013a. The distinct effects of information technology and communication technology on firm organization. *Management Science* **60**(12) 2859-2885.

Bloom, N., Sadun, R., Van Reenen, J. 2012. The organization of firms across countries. *Quarterly Journal of Economics* **127**(4) 1663-1705.

Bloom, N., Sadun, R., Van Reenen, J. 2013b. Management as technology? Mimeo, Stanford University, Stanford, California.

Bloom, N., Van Reenen, J. 2007. Measuring and explaining management practices across firms and countries. *Quarterly Journal of Economics* **122**(4) 1351-1408.

Bresnahan, T., E. Brynjolfsson, L. Hitt. 2002. Information technology, workplace organization and the demand for skilled labor: firm-level evidence. *Quarterly Journal of Economics* **117**(1) 339-376.

Brown, W. M., Rispoli, L. 2014. Metropolitan Gross Domestic Product: Experimental Estimates, 2001 to 2009.

Carley, K. M., Z. Lin. 1997. A theoretical study of organizational performance under information distortion. *Management Sci*. **43** 976–997.

Cohen, M. D., March, J. G. and Olsen, J. P. (1972). 'A

Cassiman, B., Veugelers, R. 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*, **52**(1), 68-82.

Chang, M. H., Harrington Jr, J. E. 2003. Multimarket competition, consumer search, and the organizational structure of multiunit firms. *Management Science*, **49**(4), 541-552.

Ennen, E., Richter, A. 2010. The whole is more than the sum of its parts—or is it? A review of the empirical literature on complementarities in organizations. *Journal of Management*, 36(1), 207-233.

Hambrick, D. C., Finkelstein, S. 1987. Managerial discretion: A bridge between polar views of

organizational outcomes. *Research in organizational behavior*.
Finkelstein, S., Hambrick, D. C. 1996. *Strategic leadership: Top executives and their effects on organizations*. West Publishing Company.
Foster, L., Haltiwanger, J., Syverson, C. 2008. Reallocation, firm turnover, and efficiency: Selection on productivity or profitability? *The American Economic Review*, 98(1), 394-425.
Frank, D. H., Obloj, T. 2014. Firm-specific human capital, organizational incentives, and agency costs: Evidence from retail banking. *Strategic Management Journal*, 35(9), 1279-1301.
Garicano, L. 2000. Hierarchies and the organization of knowledge in production. *Journal of Political Economy*, **108**(5).
Garicano, L., Rossi-Hansberg, E. 2012. Organizing growth. *Journal of Economic Theory* **147**(2) 623-656.
Gibbs, M., Hendricks, W. 2004. Do formal salary systems really matter?. *ILR Review*, 58(1), 71-93.
Grossman, G., O. Hart. 1983. An analysis of the principal-agent problem. *Econometrica* **50**(1) 7-45.
Hamel, G. 2011. First, let’s fire all the managers. *Harvard Business Review*, **89**(12), 48-60.
Heise, D. R. 1972. Employing nominal variables, induced variables, and block variables in path analyses. *Sociological Methods & Research*, 1(2), 147-173.
Hopenhayn, H. 1992. Entry, Exit and Firm Dynamics in the Long Run. *Econometrica* **60**(5), 1127-50
Ichniowski, C., Shaw, K. 2003. Beyond incentive pay: Insiders' estimates of the value of complementary human resource management practices. *The Journal of Economic Perspectives*, 17(1), 155-180.
Ichniowski, C., K. Shaw, G. Prennushi. 1997. The effects of human resource management practices on productivity: a study of steel finishing lines. *American Economic Review* **87**(3) 291-313.
Jakobsson, U. 1976. On the measurement of the degree of progression. *Journal of Public Economics* **5**(1) 161-172.
Jovanovic, B. 1982. Selection and the Evolution of Industry. *Econometrica*, 649-670.
Kalnins, A., Lafontaine, F. 2004. Multi-unit ownership in franchising: evidence from the fast-food industry in Texas. *RAND Journal of Economics*, 747-761.
Larkin, I. 2014. The cost of high-powered incentives: Employee gaming in enterprise software sales. *Journal of Labor Economics*, 32(2), 199-227.
Lazear, E. 2000. Performance pay and productivity. *American Economic Review* **90**(5) 1346-1361.
Lazear, P., Oyer P. 2013. Personnel Economics. *Handbook of Organizational Economics*. Princeton University Press.
Levinthal, D. A. 1997. Adaptation on rugged landscapes. *Management Sci*. **43** 934–950.
Lo, D., Dessein, W., Ghosh, M., Lafontaine, F. 2016. Price delegation and performance pay: Evidence from industrial sales forces. *The Journal of Law, Economics, and Organization*, *32*(3), 508-544.
MacDuffie, J. P. 1995. Human resource bundles and manufacturing performance: Organizational logic and flexible production systems in the world auto industry. *Industrial & Labor Relations Review*, 48(2), 197-221.
Melitz, M. J. 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), 1695-1725.
Milgrom, P., J. Roberts. 1995. Complementarities and fit strategy, structure, and organizational change in manufacturing. *Journal of Accounting and Economics* **19**(2) 179-208.
Murphy, R., J. Clemens, N. Veldhuis. 2013. The economic costs of increased marginal tax rates in Canada. *Studies in Budget and Tax Policy.* Fraser Institute, B.C., Canada.
Musgrave, R., P. Musgrave. 1989. *Public finance in theory and practice*. McGraw-Hill, New York.
Nadler, D. A., M. L. Tushman. 1997. *Competing by Design*. Oxford University Press, New York.

Nickerson, J. A., & Silverman, B. S. 2003. Why firms want to organize efficiently and what keeps them from doing so: Inappropriate governance, performance, and adaptation in a deregulated industry. *Administrative Science Quarterly*, 48(3), 433-465.

Novak, S., Stern, S. 2008. How does outsourcing affect performance dynamics? Evidence from the automobile industry. *Management Science*, 54(12), 1963-1979.

Penrose, E. T. 1959. *The theory of the growth ofthe firm*. New York: Sharpe.

Pierce, L. 2012. Organizational structure and the limits of knowledge sharing: Incentive conflict and agency in car leasing. *Management Science*, 58(6), 1106-1121.

Porter, M. 1996. What is strategy?. *Harvard Business Review*.

Prendergast, C. 1999. The provision of incentives in firms. *Journal of economic literature*, 37(1), 7-63.

Prendergast, C. 2002. The tenuous trade-off between risk and incentives. *Journal of Political Economy* 22(2) 34-56.

Rawley, E., Simcoe, T. S. 2010. Diversification, diseconomies of scope, and vertical contracting: Evidence from the taxicab industry. *Management Science*, 56(9), 1534-1550.

Rivkin, J. 2000. Imitation of complex strategies. *Management Science* **46**(6) 824-844.

Rivkin, J. W., Siggelkow, N. 2003. Balancing search and stability: Interdependencies among elements of organizational design. *Management Science*, 49(3), 290-311.

Van Den Steen, E. 2010. Disagreement and the allocation of control. *Journal of Law, Economics and Organization* **26**(2) 385-426.

Semadeni, M., Withers, M. C., & Trevis Certo, S. 2014. The perils of endogeneity and instrumental variables in strategy research: Understanding through simulations. *Strategic Management Journal*, **35**(7), 1070-1079.

Siggelkow, N. and Porter, M. (2008). Contextuality within Activity Systems and Sustainability of Competitive Advantage, *Academy of Management Perspectives*

Stock, J. H., Wright, J. H., Yogo, M. 2002. A survey of weak instruments and weak identification in generalized method of moments. *Journal of Business & Economic Statistics*, **20**(4).

Table 1. Descriptive statistics

	Variable	Mean	σ
1.	PrincipalControl	6.00	4.96
2.	ManagerControl	2.65	3.99
3.	NonManagerControl	0.77	1.87
4.	PerformancePay	0.30	0.46
5.	Firm size (total employees), logged	2.05	0.98
6.	Establishment age (in years)	14.02	12.61
7.	Multi-unit enterprise	0.04	0.20
8.	Foreign-owned	0.03	0.18
9.	Exporter	0.16	0.37
10.	Unionized	0.11	0.31
11.	Residual Income Progression	0.89	0.04
	N = 11,753		

Note: All descriptive statistics use survey sampling weights to be representative of the Canadian economy.

Table 2. Summary statistics of average decision layer for each task

		Average Layer		
	Task/Activity	All Layers	Excluding Bus. Owners	Avg. No. of Layers
1.	Daily work planning	2.98	2.15	1.05
2.	Weekly work planning	3.05	2.25	1.06
3.	Purchase of supplies	3.06	2.29	1.07
4.	Equipment maintenance	3.14	2.41	1.05
5.	Customer relations	3.20	2.47	1.16
6.	Follow-up of results	3.27	2.46	1.08
7.	Quality control	3.28	2.56	1.15
8.	Training	3.32	2.66	1.11
9.	Filling Vacancies	3.53	2.76	1.03
10.	Setting staffing levels	3.57	2.81	1.03
11.	Product or Service Development	3.62	2.92	1.06
12.	Production technology choice	3.62	2.94	1.02
	N = 11,753			

Note: All descriptive statistics use survey sampling weights to be representative of the Canadian economy.

Table 3. Decentralization and performance pay

	(1)	(2)	(3)	(4)	(5)	(6)
		OLS			IV	
Dependent variable: Control by	Principal	Manager	Non-Manager	Principal	Manager	Non-Manager
PerformancePay	-1.962***	1.315***	0.077	-6.454***	6.129***	-1.884**
	(0.168)	(0.131)	(0.062)	(1.150)	(1.039)	(0.752)
Firm size	-1.598***	1.162***	-0.142*	-0.974***	0.493***	0.131
(logged total employees)	(0.101)	(0.081)	(0.078)	(0.198)	(0.126)	(0.133)
Establishment age	0.008	0.004	0.006**	0.001	0.011*	0.003
	(0.005)	(0.006)	(0.003)	(0.004)	(0.006)	(0.003)
Multi-unit enterprise	0.127	-0.345	-0.382***	0.977***	-1.256***	-0.011
	(0.174)	(0.334)	(0.106)	(0.247)	(0.418)	(0.181)
Exporter	0.344	-0.415	0.042	0.376	-0.450	0.056
	(0.249)	(0.238)	(0.119)	(0.267)	(0.294)	(0.148)
Unionized	-1.374***	0.003	0.099	-1.562***	0.204	0.017
	(0.400)	(0.172)	(0.214)	(0.457)	(0.256)	(0.202)
Foreign-owned	-1.964***	1.721***	0.081	-1.446***	1.166***	0.307
	(0.398)	(0.431)	(0.154)	(0.416)	(0.294)	(0.242)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Observations	11,753	11,753	11,753	11,753	11,753	11,753
Adj R-squared	0.31	0.26	0.12	-	-	-

Standard errors in parentheses, clustered by province-year. Instrumental variable results use a limited information maximum likelihood IV estimator. All regressions use sampling weights. *** p<0.01, ** p<0.05, * p<0.1

Table 4. Decentralization and performance pay – Multi-province firms only

	(1)	(2)	(3)	(4)	(5)	(6)
		OLS			IV	
Dependent variable: Control by	Principal	Manager	Non-Manager	Principal	Manager	Non-Manager
PerformancePay	-2.451**	3.949***	0.361***	-7.945***	6.906***	-1.744**
	(1.019)	(0.721)	(0.107)	(2.047)	(1.968)	(0.841)
Firm size	-0.307	0.383	-0.061	-0.017	0.227	0.050
(logged total employees)	(0.268)	(0.229)	(0.067)	(0.206)	(0.249)	(0.093)
Establishment age	0.003	0.008	-0.004	0.001	0.009	-0.005
	(0.010)	(0.012)	(0.004)	(0.009)	(0.009)	(0.004)
Exporter	-0.025	-0.950	-0.253	0.567	-1.269	-0.026
	(0.275)	(0.893)	(0.148)	(0.533)	(0.838)	(0.153)
Unionized	0.948*	-1.149	-0.025	0.541	-0.930	-0.180
	(0.532)	(1.117)	(0.280)	(0.528)	(1.049)	(0.258)
Foreign-owned	-0.070	0.407	0.187	-0.372	0.570	0.071
	(0.546)	(0.680)	(0.234)	(0.596)	(0.531)	(0.299)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Province fixed effects	Y	Y	Y	Y	Y	Y
Observations	1,544	1,544	1,544	1,544	1,544	1,544
Adj R-squared	0.56	0.49	0.41	0.31	0.44	0.09

Standard errors in parentheses, clustered by province-year. The multi-unit enterprise control is omitted since the entire sample consists of multi-unit firms. Instrumental variable results use a limited information maximum likelihood IV estimator. All regressions use sampling weights. *** p<0.01, ** p<0.05, * p<0.1

Table 5. Task level regressions

	(1)	(2)	(3)
Dependent variable: Dummy for control by	Principal	Manager	Non-Manager
	IV	IV	IV
PerformancePay	-0.437***	0.703***	-0.218***
	(0.101)	(0.111)	(0.083)
Task complexity	0.017***	0.000	-0.011***
	(0.001)	(0.002)	(0.001)
PerformancePay X Task complexity	0.012***	-0.024***	0.009**
	(0.004)	(0.008)	(0.004)
Firm size	-0.062***	0.054***	0.011
(logged total employees)	(0.016)	(0.011)	(0.012)
Establishment age	-0.000	0.001**	0.000*
	(0.000)	(0.000)	(0.000)
Multi-unit enterprise	0.002	-0.101***	-0.001
	(0.026)	(0.037)	(0.018)
Exporter	0.035*	-0.028	0.005
	(0.020)	(0.024)	(0.006)
Unionized	-0.167***	0.023	0.001
	(0.038)	(0.020)	(0.015)
Foreign-owned	-0.188***	0.108***	0.026
	(0.038)	(0.029)	(0.019)
Year fixed effects	Y	Y	Y
Industry fixed effects	Y	Y	Y
Observations	141,036	141,036	141,036

Standard errors in parentheses, clustered by province-year. Instrumental variable results use a limited information maximum likelihood IV estimator. All regressions use sampling weights. *** p<0.01, ** p<0.05, * p<0.1

Table 6. Firm Mortality

Dependent variable: Firm mortality	(1) Probit	(2) Probit
PrincipalControl misalignment	0.004**	0.003**
	(0.001)	(0.002)
NonManagerControl misalignment		0.003***
		(0.001)
Firm size	-0.070***	-0.067***
(logged total employees)	(0.019)	(0.021)
Establishment age	-0.025**	-0.024**
	(0.011)	(0.011)
Establishment age, squared	0.000	0.000
	(0.000)	(0.000)
Multi-unit enterprise	0.153**	0.162***
	(0.065)	(0.061)
Herfindahl Index	-0.002***	-0.002***
	(0.000)	(0.000)
Foreign-owned	0.112*	0.112*
	(0.067)	(0.067)
Exporter	-0.144	-0.143
	(0.257)	(0.262)
Unionized	-0.115	-0.124*
	(0.074)	(0.067)
Number of new product innovations	-0.044	-0.045
	(0.055)	(0.055)
Number of new process innovations	-0.205***	-0.205***
	(0.003)	(0.001)
Average wage	-0.003	-0.003
	(0.003)	(0.003)
Year fixed effects	Y	Y
Industry fixed effects	Y	Y
Observations	10,225	10,225
Log likelihood	-193,256	-193,118
Pseudo R-squared	0.22	0.22

Standard errors in parentheses, clustered by province-year. All regressions use sampling weights. *** p<0.01, ** p<0.05, * p<0.1

Table 7. Coordination tasks vs. implementation tasks

	(1)	(2)	(3)	(4)	(5)	(6)
	Coordination			Implementation		
Dependent variable: Control by	Principal	Manager	Non-Manager	Principal	Manager	Non-Manager
	IV	IV	IV	IV	IV	IV
PerformancePay	-0.513***	0.302***	-0.060*	-0.582***	0.569***	-0.154**
	(0.090)	(0.074)	(0.036)	(0.119)	(0.098)	(0.070)
Firm size	-0.050***	0.041***	-0.004	-0.080***	0.032***	0.012
(logged total employees)	(0.018)	(0.012)	(0.009)	(0.019)	(0.010)	(0.012)
Establishment age	-0.0003	0.001**	0.000	0.0004	0.0008	0.0002
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
Multi-unit enterprise	0.052***	-0.071*	-0.004	0.107***	-0.110***	-0.011
	(0.017)	(0.041)	(0.010)	(0.029)	(0.034)	(0.012)
Exporter	0.027	-0.024**	0.004	0.038	-0.037	-0.001
	(0.022)	(0.011)	(0.010)	(0.028)	(0.032)	(0.012)
Unionized	-0.174***	0.046**	0.012	-0.111***	0.009	0.001
	(0.040)	(0.022)	(0.018)	(0.037)	(0.027)	(0.018)
Foreign-owned	-0.127***	0.138***	0.009	-0.110***	0.063***	0.031
	(0.046)	(0.039)	(0.009)	(0.036)	(0.020)	(0.033)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Observations	11,753	11,753	11,753	11,753	11,753	11,753

Standard errors in parentheses, clustered by province-year. Instrumental variable results use a limited information maximum likelihood IV estimator. All regressions use sampling weights. *** p<0.01, ** p<0.05, * p<0.1

Table 8. Additional robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Wage inequality			Risk			Distance to HQ		
Dependent variable: Control by	Principal	Manager	Non-Manager	Principal	Manager	Non-Manager	Principal	Manager	Non-Manager
	IV	IV	IV	IV	IV	IV	IV	IV	IV
PerformancePay	-5.979***	6.211***	-1.993**	-6.481***	5.645***	-1.915***	-11.780***	10.351***	-2.275*
	(1.384)	(1.092)	(0.788)	(1.057)	(0.974)	(0.726)	(3.303)	(2.526)	(1.222)
Gini coefficient of wages	-0.405	-0.858	0.716*						
	(1.016)	(0.835)	(0.372)						
Std. dev of operating margin				0.450	0.452	-0.505***			
				(0.707)	(0.292)	(0.174)			
Distance to headquarters							0.485**	-0.436*	0.067
							(0.239)	(0.241)	(0.060)
Firm size	-1.038***	0.546***	0.091	-0.914***	0.581***	0.097	0.088	0.133	0.064
(logged total employees)	(0.193)	(0.103)	(0.117)	(0.202)	(0.128)	(0.137)	(0.237)	(0.282)	(0.109)
Establishment age	0.002	0.012**	0.002	0.005	0.009	0.003	-0.003	0.012	-0.005
	(0.004)	(0.006)	(0.003)	(0.006)	(0.006)	(0.003)	(0.014)	(0.010)	(0.004)
Multi-unit enterprise	0.894***	-1.292***	0.031	0.958***	-1.192***	0.034	-1.056**	-0.097	-0.160
	(0.280)	(0.436)	(0.195)	(0.229)	(0.372)	(0.184)	(0.495)	(0.576)	(0.281)
Exporter	0.426	-0.451	0.053	0.632**	-0.509	0.068	1.023	-1.679*	0.037
	(0.281)	(0.297)	(0.153)	(0.273)	(0.313)	(0.168)	(0.812)	(1.006)	(0.199)
Unionized	-1.559***	0.164	0.029	-1.562***	0.083	0.008	0.339	-0.748	-0.209
	(0.443)	(0.274)	(0.201)	(0.473)	(0.247)	(0.213)	(0.606)	(1.132)	(0.278)
Foreign-owned	-1.506***	1.151***	0.334	-1.435***	1.245***	0.322	-0.451	0.641	0.060
	(0.423)	(0.305)	(0.248)	(0.400)	(0.305)	(0.238)	(0.711)	(0.555)	(0.323)
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	11,670	11,670	11,670	10,488	10,488	10,488	1,544	1,544	1,544