Delegation and Incentives: a tradeoff between exploration and exploitation*

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Abstract

Standard agency theories predict a positive relationship between incentive pay and the degree to which workers have authority over how they do their jobs (e.g. which projects to select). With stronger incentives, when selecting projects, agents place relatively more weight on the monetary returns to a given project, and less weight on their own private benefit (i.e. utility) from the project. This paper, in contrast, suggests that when projects have a positive risk-return tradeoff and the agent is more risk averse than the principal, delegation of authority could imply weaker incentives. Weaker incentives reduce an agent's exposure to risk, leading to higher-return projects being selected. This creates a tension between inducing project selection (exploration) and inducing effort (exploitation). When exploration is more valuable to the principal than exploitation, delegation and incentives are negatively related. We empirically test these predictions using data from a large cross section of British establishments. Consistent with our theoretical predictions, we find the usual positive relationship between delegation and incentives in occupations that are predominantly exploitative, whereas for exploratory occupations we find a negative relationship.

1 Introduction

When deciding how much authority to grant workers over how they do their jobs, employers face a tradeoff. Workers often have superior information regarding the returns to various projects, so delegating workers the authority to choose projects

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has the potential to lead to more informed decisions. However, workers might also have exogenous private preferences over projects, which could bias decisions. This tradeoff between information and bias is at the center of several theoretical models (Holmstrom and Milgrom (1991), Jensen and Meckling (1992), Prendergast (2002), Itoh, Kikutani, and Hayashida (2008), Rantakari (2008)) and has the following implication. When workers are delegated authority, incentives must be stronger.[1] Stronger incentives ensure that, when selecting projects, workers place less weight on their private benefits and more weight on the expected return of a project.

The assumption that agents have exogenous private benefits over projects is reasonable in many settings. For example, corporate executives may benefit from the increased status that comes from empire building. Academics may benefit from designing a course that is closely related to their research interests. And managers can hire or promote employees whom they personally like. Furthermore, a number of recent empirical studies have found a positive relationship between delegation and incentives.[2] Wulf (2007) uses compensation survey data on division managers and find that corporate officers (for example, presidents, vice presidents and Chief Financial Officers of a business unit, division, or function) are more likely than other workers to have their pay tied to sales growth. MacLeod and Parent (1999) use survey data spanning a variety of industries and firms and find that workers with more "autonomy" are more likely to be paid commissions. DeVaro and Kurtulus (2009), using survey data on British establishments, and Foss and Laursen (2005), using data on Danish firms find a positive relationship between delegation and incentives. Nagar (2002) finds that bank managers with more authority receive more incentive-based pay. Finally, Itoh, Kikutani, and Hayashida (2008) use data on Japanese business groups and find that delegation of authority from a core firm to an affiliated firm is positively correlated with an accountability measure. Overall, there is a consensus in the literature, both theoretical and empirical, that delegation and incentives are positively related.

Implicit in the previous theoretical work, however, is an assumption that the degree of risk is similar across projects. Yet, in many delegation contexts, especially those involving innovation, the degree of risk can vary substantially across projects, with important implications. For example, scientists in pharmaceutical companies have to choose between risky projects that could yield blockbuster drugs and safer projects that yield drugs with lower expected revenues. Similarly, heart surgeons have to select between high-risk patients who are in need of risky surgery and low-risk patients who need only routine surgery. This paper examines the relationship between delegation and incentives when projects have a positive risk-return tradeoff (i.e. the higher-return projects are also riskier) and when workers are more risk-

[1] The strength of incentives in Holmstrom and Milgrom (1991) and Prendergast (2002) is measured by the slope of a linear, output-contingent compensation contract.

[2] The only prior evidence we are aware of suggesting a negative relationship between incentive pay and delegation is a bivariate correlation appearing in Table 5 of Ortega (2009), based on cross sectional data from the EU-15 group.

averse than principals.

When agents are risk-averse and projects are risky, delegation of authority biases a worker's decisions towards safer projects with lower expected returns. To correct this bias, the principal must weaken the worker's incentives, reducing the worker's exposure to risk and leading to the selection of higher-risk, higher-return projects. This suggests a tension between inducing project selection (which we refer to as "exploration") and inducing effort (which we refer to as "exploitation") (March (1991)). Inducing exploration requires weaker incentives, whereas exploitation requires stronger incentives. This tradeoff between exploration and exploitation leads to the main result of the paper. Delegation and incentive pay are negatively related if and only if the value of exploration to the principal is high relative to value of exploitation (i.e., when the variation in returns across projects is high, variation in risk across projects is low and effort is costly and hard to measure).

An important and attractive feature of our main result is that the key concept (namely exploration jobs versus exploitation jobs) that influences the relationship between delegation and incentives can be identified empirically using job titles. We test our empirical result using the 1998 WERS, a cross-sectional survey of British establishments that also contains survey information from up to 25 workers per establishment. We draw on both the employer survey and the worker survey to construct the key variables measuring incentive pay, delegation of authority, exploration jobs, and exploitation jobs. Our main empirical result, which is consistent with our theoretical model, is that delegation and incentive pay have a negative relationship for exploration jobs in which selecting high-return projects is more valuable to the employer than worker effort, whereas a positive relationship is found for exploitative jobs in which selecting high-return projects is less important to the employer than worker effort.

Our theoretical model is based on the principal-agent framework of Holmstrom and Milgrom (1991) and Prendergast (2002)[3], and features a continuum of projects that are ordered by their expected returns. The model has four main elements. First, after signing a contract, the agent is better informed than the principal about the attributes of projects. More precisely, the agent can order the projects based on expected returns, whereas the principal has to pay a fixed cost to learn the ordering. This information asymmetry creates a role for delegation. Second, the agent is risk averse, whereas the principal is risk neutral. This implies a divergence of interests when the degree of risk varies across projects. Third, incentives (which are measured by the slope of a linear contract) have two objectives: inducing effort, which is unobservable by the principal, and inducing project choice. Finally, the model is split into two cases: the "private benefits" case, which is similar to Holmstrom and

[3]An approach based on Holmstrom and Milgrom (1991) and Prendergast (2002) offers the advantage of tractability. In particular, focusing on linear contracts, a CARA utility function for agents, and a linear dependence of output on unobservable effort, project choice and a normally distributed error term implies a closed form solution for the agent's certainty equivalent. This greatly simplifies the analysis.

Milgrom (1991) and Prendergast (2002), and the "project risk" case, where projects are characterized by a positive relationship between risk and return. Splitting the model in this way allows us to contrast the relationship between delegation and incentives for both cases.

There are other papers that study conflicts between inducing project selection versus effort. Hirshleifer and Suh (1992) show how convexity in incentive schemes induces risky project selection but distorts effort. Hence, their focus is on the curvature of the contract rather than the level of incentives or delegation. Demski and Dye (1999) also consider a setting with a risk-return tradeoff, where contracts are designed not to influence a worker's project selection but rather to elicit a manager's private information about a project's attributes. Athey and Roberts (2001) show that in a setting with multiple agents, relative performance evaluation mitigates the adverse effects of risk that are borne by individual agents, as long as error terms are common or correlated across agents. However, this distorts project choice because the agent places negative weight on components of the project that show up in the performance measures of other agents. Recent papers by Manso (2009) and Ederer and Manso (2008) take a complementary approach to studying the tradeoff between exploration and exploitation. They consider a dynamic setting with risk-neutral agents and find that tolerating early failure provides incentives for exploration at the cost of exploitation. A key difference between their analysis and ours is in their approach to modeling exploration. In their framework, exploration involves learning the distribution of an activity, whereas in our setting, exploration involves choosing among projects characterized by varying degrees of risk. This gives us additional comparative static results with respect to project risk and returns. Furthermore, they do not consider delegation of authority [4].

Finally, our paper is related to a large literature investigating various aspects of delegation of authority. Aghion and Tirole (1997) show how delegation of authority provides incentives for an agent to exert effort (i.e. acquire information about projects). Bester and Krahmer (2008) also look at the incentive role of delegation, but in a setting in which projects are selected before the agent exerts effort and in which it is possible to contract on output. They find, in contrast to Aghion and Tirole (1997), that when higher effort must be induced, delegation is less likely. Though this could imply a negative relationship between delegation and the incentive level for an output-contingent contract, they do not emphasize this as a result. Meagher and Wait (2008) focus on delegation in an environment with delay costs. Other papers examine the tradeoff between information and bias to characterize the settings in which delegation is optimal (Dessein (2002), Alonso and Matouschek (2008), Marino and Matsusaka (2005)). Whereas our paper uses a moral hazard framework, an alternative approach studies delegation in an adverse selection setting (Mookherjee (2006)). Another paper, outside of a delegation framework, that

[4] Other papers that study incentives for innovation outside of a delegation context are Nagaoka and Owan (2008) and Hellmann and Thiele (2008).

studies incentives when an agent has better information (i.e. specific knowledge) than the principal is Raith (2008).

2 Model

We construct a principal-agent model that builds on Holmstrom and Milgrom (1991) and Prendergast (2002). There is a continuum of projects, $[0, \bar{x}]$, and let x denote one such project. Output for any one of these projects is given by $y = a + \xi x + \epsilon$, where a denotes effort, ϵ is normally distributed with mean 0 and variance σ^2, and $\xi > 0$ is a parameter measuring the variation in expected returns across projects. Thus, projects are ordered in terms of their expected return, with the project $\bar{x}$ having the highest expected return. The critical assumption in this paper is that projects vary by risk as well as by expected return. This feature is modeled by allowing the variance of ϵ to depend on the project chosen. In particular, $\sigma^2(x) = \sigma_0^2 + \alpha x$, where $\alpha \geq 0$ is a parameter measuring the extent to which projects vary by risk. When $\alpha > 0$ there is a positive risk-return tradeoff: higher-return projects are also riskier.

After the contract is signed, agents privately observe their effort, a, and the ordering of projects.[5] The principal can never observe a but can observe the ordering of x at a cost of C. Note that output is separable in effort, productivity and noise. This allows us to clearly isolate tradeoffs in the model.

The principal is risk neutral. The agent's utility function is of the constant absolute risk aversion (CARA) form and is given by

$$U(w, a, x) = -e^{-\eta(w - \frac{ca^2}{2} + \beta B(x))}$$

where η is the coefficient of absolute risk aversion, w denotes wages, $B(x)$ is a strictly concave, twice continuously differentiable private benefit function for the agent, β measures the relative importance of private benefits in an agent's utility function, and $\frac{ca^2}{2}$ is the agent's effort cost function, with $c > 0$.

As in Holmstrom and Milgrom (1991) and Prendergast (2002), we restrict our attention to contracts that are linear in output for tractability and to allow for a clear interpretation of the strength of incentives based on the slope of the contract. Thus, we assume $w = t + sy$, where t is a fixed transfer from the principal to the agent, and s is the slope of the contract, with $s \leq 1$. Incentives are said to be stronger when s is higher. Because of the CARA-Normal framework, we can write the agent's certainty equivalent, denoted by CE, as follows:

$$CE = t + sa + s\xi x - \frac{ca^2}{2} - \frac{\eta s^2(\sigma_0^2 + \alpha x)}{2} + \beta B(x)$$

[5] Since agents observe the attributes of a project after the contract has been signed, the revelation principle cannot be applied here.

The timing is as follows. The principal offers a contract to the agent that specifies t and s and whether authority is delegated to the agent or not. If the principal retains authority we assume that he can commit to a project choice. The agent then decides whether to participate. If he does participate, he learns the ordering of projects at no cost whereas the principal has the option to learn the ordering by paying the fixed cost C. Projects are then selected by the party that has authority and the agent exerts unobservable effort. Finally, output is realized and wages paid.

To illustrate how incentives vary with authority, we consider the following two optimization problems. The first considers a setting in which the principal chooses a project. This is called the "no delegation" problem, and the subscript used for variables in this problem is n. In the second problem, the principal delegates authority to an agent to choose the project, x. The subscript used for variables in this problem is d.

No Delegation

In the "no delegation" problem the principal incurs a cost of C to differentiate the projects based on their risk-return attributes.

The principal's problem is

$$\underset{a_n, x_n \in [0, \bar{x}], s_n \in [0,1]}{Max} \quad \mathbb{E}[y - w] - C$$

subject to the incentive compatibility condition associated with effort

$$a_n = \frac{s_n}{c} \tag{IC_{an}}$$

and the agent's participation constraint

$$t_n + s_n a_n + s_n \xi x_n - \frac{c a_n^2}{2} - \frac{\eta s_n^2 (\sigma_0^2 + \alpha x_n)}{2} + \beta B(x_n) \geq w_0 \tag{IR_n}$$

where w_0 is the agent's reservation wage.

Delegation

In the delegation problem, the agent chooses the project, and the optimization problem is

$$\underset{a_d, x_d \in [0, \bar{x}], s_d \in [0,1]}{Max} \quad \mathbb{E}[y - w]$$

subject to the incentive compatibility condition associated with effort

$$a_d = \frac{s_d}{c} \tag{IC_{ad}}$$

the incentive compatibility condition with respect to project selection

$$x_d \in \ argmax \ \ t_d + s_d a_d + s_d \xi x_d - \frac{c a_d^2}{2} - \frac{\eta s_d^2(\sigma_0^2 + \alpha x_d)}{2} + \beta B(x_d) \qquad (IC_{xd})$$

and the agent's participation constraint

$$t_d + s_d a_d + s_d \xi x_d - \frac{c a_d^2}{2} - \frac{\eta s_d^2(\sigma_0^2 + \alpha x_d)}{2} + \beta B(x_d) \geq w_0 \qquad (IR_d)$$

There are two features that distinguish the no-delegation problem from the delegation one. First, the fixed cost, C, appears only in the no-delegation problem. As C increases, the principal delegates more. Second, the delegation problem has an additional incentive compatibility condition with respect to project selection. Henceforth, let s_n^* and x_n^* denote the optimal levels of incentives and project choice for the no-delegation problem, and let s_d^* and x_d^* denote the optimal levels of incentives and project choice for the delegation problem. The objective of the following analysis is to compare the optimal level of incentives across both of these problems (i.e. to compare s_n^* with s_d^*).

To see the effects of introducing a risk-return tradeoff, we divide the model into two cases. In the first case, $\alpha = 0$ and $\beta > 0$. This case is similar to Holmstrom and Milgrom (1991) and Prendergast (2002). In the second case, we set $\beta = 0$ and focus only on the risk-return tradeoff, with $\alpha > 0$. For both cases, we compute $s_d^* - s_n^*$ and then examine how this difference changes as a function of parameters.[6]

2.1 Private Benefits ($\beta > 0$ and $\alpha = 0$)

In this section the focus is only on private benefits, with $\beta > 0$ and $\alpha = 0$. To see the conflict of interests between the principal and agent with respect to project selection, substitute the agent's individual rationality constraint into the principal's expected profit function. Then the principal's optimal project choice maximizes $\xi x + \beta B(x)$, whereas an agent's optimal project choice maximizes $s\xi x + \beta B(x)$. Given that $s \leq 1$, the agent places less weight than the principal on project returns. The following proposition illustrates how the principal can resolve this conflict of interests with respect to project choice:

Proposition 1. *$s_d^* \geq s_n^*$, and the inequality is strict if the optimal project choice in the delegation problem is interior.*

The proofs of all results are in the appendix. The key intuition underlying Proposition 1 is that there is no tension between inducing effort and inducing project

[6]Mainly for tractability, we do not combine the private-benefits and project-risk cases into a single integrated model. In particular, the risk premium term from the individual rationality constraint is not concave in project choice and the level of incentives. However, in the model that includes both private benefits and project risk, the tension between inducing exploration and exploitation continues to hold provided the variation in risk across projects is sufficiently large.

selection in a setting with exogenous private benefits. To see this more clearly, suppose $s_d^* < s_n^*$. Then by increasing s_d to s_n^*, the principal can induce a higher (and more profitable) level of effort. Furthermore, this increase also aligns interests in terms of project selection. Because effort and projects are separable in the principal's objective function, this implies strictly higher profits.

Though the preceding result is similar in spirit to Holmstrom and Milgrom (1991) and Prendergast (2002) there are important differences. Holmstrom and Milgrom (1991) do not have project selection in their model. Their emphasis is on the set of allowable tasks across which an agent can allocate time. Strengthening incentives on output increases the opportunity cost of unproductive tasks for the agent, leading to a larger set of allowable tasks and, thus, a positive relationship between delegation and incentives. Prendergast (2002) is closer to our paper, the key difference being that in his framework, the only role of incentives is to induce project selection, because effort can be observed perfectly by paying a cost. In contrast, in our paper incentives play two roles, inducing effort and project selection, and the tension between these two roles drives the main results in the next section.

2.2 Project Risk ($\beta = 0$ and $\alpha > 0$)

In many delegation settings, particularly those involving innovation, project risk plays an important role. In this section, we study the relationship between delegation and incentives when projects vary by risk. To contrast the results in this section with those of the earlier "private benefits" literature, we abstract from exogenous private benefits that agents derive from projects (i.e. we set $\beta = 0$). Once again, as in the private benefits case, it is useful to see how a conflict of interests arises in this setting. The principal's optimal project choice maximizes $\xi x - \dfrac{\eta s^2 \alpha x}{2}$, whereas the agent's optimal project choice maximizes $s\xi x - \dfrac{\eta s^2 \alpha x}{2}$. Because $s \leq 1$, the agent places less weight than the principal on project returns relative to risk. But the key difference in the project risk case is that to correct this distortion, incentives have to be reduced. Thus, there is a tension between inducing project selection and inducing effort.

To solve the model, start by defining $s_0 = \dfrac{1}{1 + \eta c \sigma_0^2}$ and $\bar{s}(\alpha) = \dfrac{1}{1 + \eta c(\sigma_0^2 + \alpha \bar{x})}$. Note that s_0 corresponds to the principal's optimal solution in the "no delegation" problem if the project is fixed at $x = 0$. Likewise, $\bar{s}(\alpha)$ corresponds to the principal's optimal solution in the "no delegation" problem if the project is fixed at $x = \bar{x}$. Lemma 1 suggests that in the "no delegation" problem, at the optimum, the principal chooses either the lowest risk-return project (i.e. $x = 0$) along with the slope s_0 or the highest risk-return project (i.e. $x = \bar{x}$) along with the slope $\bar{s}(\alpha)$.

Lemma 1. *Consider the "no delegation" problem. The optimal solution sets either*

$x_n^* = 0$ *and* $s_n^* = s_0$ *or* $x_n^* = \bar{x}$ *and* $s_n^* = \bar{s}(\alpha)$.

Lemma 1 simplifies the solution to the "no delegation" problem. Because the risk-return tradeoff is linear, the lemma says that only corner solutions are possible. This result also extends to the delegation problem, as will be shown later. Based on March (1991), we refer to $(x = x_0)$ as exploitation. In this case the principal focuses on effort and not project selection. Similarly, we refer to $(x = \bar{x})$ as exploration. Here the principal emphasizes project selection over effort.

We next characterize the values from exploitation and exploration. Let $V_{exploit} = \frac{1}{2c(1+\eta c\sigma_0^2)}$ denote the value from exploitation. Note that this value is higher when effort is less costly to an agent, when effort is more easily measurable, and when an agent is less risk averse. The value from exploration, on the other hand, depends on two terms, the variation in project returns and the variation in project risk. Let $V_{return} = \xi\bar{x}$ denote the value from high-return projects. The value from exploration then depends on V_{return} and the variation in project risk, α. A higher V_{return} increases the value from exploration, whereas a higher α reduces the value from exploration. Lemma 2 characterizes the solution to the "no delegation" problem, using the preceding definitions.

Lemma 2. *Consider the "no delegation" problem. Let* $\alpha_n = \frac{2\xi}{\eta}\frac{(1+\eta c\sigma_0^2)^2}{(1-2c\xi\bar{x}(1+\eta c\sigma_0^2))}$. *When* $V_{return} < V_{exploit}$, *the optimal solution sets* $x_n^* = 0$ *and* $s_n^* = s_0$ *if and only if* $\alpha \geq \alpha_n$. *When* $V_{return} \geq V_{exploit}$ *the optimal solution sets* $x_n^* = \bar{x}$ *and* $s_n^* = \bar{s}(\alpha)$.

Lemma 2 says that the choice between exploration and exploitation depends on their respective values. When the variation in returns is high and when the variation in risk is low, the principal should choose exploration over exploitation.

Now consider the delegation problem. The problem here is that the principal and the agent have a conflict of interests because of their different risk preferences. In particular, an agent may choose the safer project when the principal wants him instead to choose the higher-return one. Furthermore, because of the tension between inducing effort and project selection, inducing project selection is costly for the principal. We make the following assumption to ensure that there are some incentive conflicts between the principal and agent.

Assumption 1. $\xi\bar{x} < \frac{1}{2c}$.

Assumption 1 says that for conflicts of interest to exist, returns should not vary too much across projects. Lemma 3 establishes that the "no delegation" solution is not incentive compatible for a certain range of α.

Lemma 3. *Let* $\alpha_d = \frac{2\xi}{\eta}\frac{(1+\eta c\sigma_0^2)}{(1-2\xi c\bar{x})}$. *When* $V_{return} < V_{exploit}$, *the "no delegation" solution is incentive compatible if and only if* $\alpha \in (0, \alpha_d]$ *or* $\alpha \geq \alpha_n$. *Also* $\alpha_d < \alpha_n$. *When* $V_{return} \geq V_{exploit}$ *the "no delegation" solution is incentive compatible if and only if* $\alpha \in (0, \alpha_d]$.

To understand the implications of Lemma 3 for the analysis, first consider the case in which $V_{return} < V_{exploit}$. In this case the "no delegation" solution is implementable in the intervals $\alpha \in (0, \alpha_d]$ or $\alpha \geq \alpha_n$ with $\alpha_d < \alpha_n$. Thus, in these intervals delegation strictly dominates no-delegation, and there is no point in comparing incentives between the two problems. The interesting range here is the interval (α_d, α_n). Similarly, when $V_{return} \geq V_{exploit}$ the interesting range of α to consider is $\alpha > \alpha_d$. Propositions 2 and 3 compare s_n and s_d in these relevant intervals.

Proposition 2. *Suppose* $V_{return} \geq V_{exploit}$. *Then for all* $\alpha > \alpha_d$ *the optimal solution sets* $x_d^* = \bar{x}$ *and* $s_d^* = \frac{2\xi}{\eta\alpha} < s_n^* = \bar{s}(\alpha)$.

Proposition 2 considers a setting in which the value from high-return projects exceeds the value from exploration. In this case the principal always prefers the high risk-return project. When $\alpha \leq \alpha_d$, the agent's interests are aligned with those of the principal. However, when $\alpha > \alpha_d$, the agent's preferences diverge, and he prefers the low risk-return project. To induce the agent to select the high risk-return project, incentives have to be weakened, leading to a negative relationship. It is useful to note that as α gets sufficiently large, both s_d^* and s_n^* approach 0, but the negative relationship still holds. Figure 1 shows the relationship between delegation and incentives when $V_{return} \geq V_{exploit}$.

Proposition 3. *Suppose* $V_{return} < V_{exploit}$. *Then there exists* $\hat{\alpha} \in (\alpha_d, \alpha_n)$ *such that for all* $\alpha \in (\alpha_d, \hat{\alpha})$ *the optimal solution sets* $s_d^* < s_n^*$ *and for all* $\alpha \in (\hat{\alpha}, \alpha_n)$ *the optimal solution sets* $s_d^* > s_n^*$.

The key factor that drives Proposition 3 is the tension between inducing project selection and inducing effort. As in Proposition 2, the agent's preferences diverge at α_d, with the agent preferring the low risk-return project and the principal preferring the high risk-return project. For levels of α immediately above α_d, the principal finds it useful to induce the high-return project by weakening incentives. But as α increases, at some point the principal finds inducing projects very costly and switches to inducing effort instead. This implies a positive relationship between delegation and incentives. Proposition 3 seems surprising at first, because although project risk plays a role in generating a negative relationship between delegation and incentives, increasing the variation in risk implies a positive relationship. Underlying this result, however, is a simple tradeoff between exploration and exploitation. Figure 2 shows the relationship between delegation and incentives when $V_{return} < V_{exploit}$.

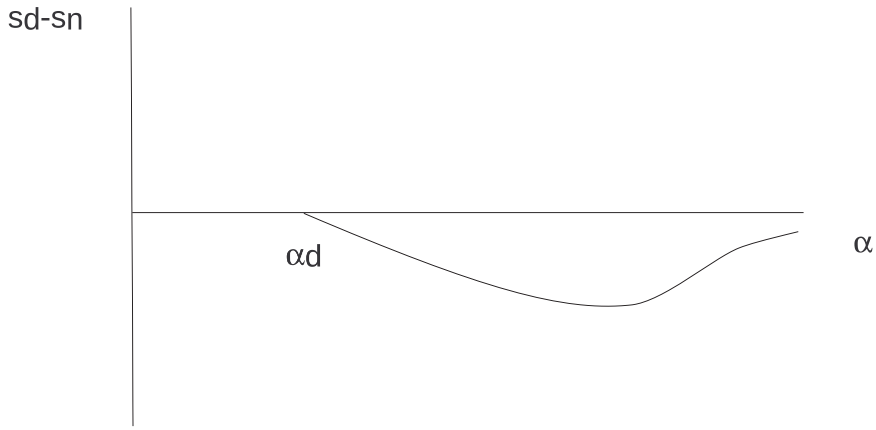

Figure 1: *Relationship between delegation and incentives when* $V_{return} \geq V_{exploit}$

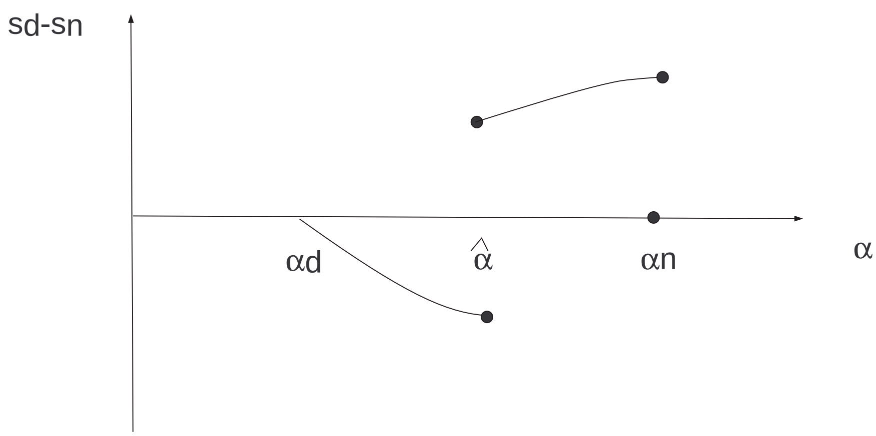

Figure 2: *Relationship between delegation and incentives when* $V_{return} < V_{exploit}$

Combining Propositions 2 and 3, we see that delegation and incentives have a negative relationship if and only if the principal values exploration more than exploitation, i.e. when projects vary substantially in their returns relative to risk and when effort is less valuable. Figures 1 and 2 clearly illustrate this. In Figure 1, V_{return} is high relative to $V_{exploit}$, implying a negative relationship. In Figure 2, where V_{return} is low relative to $V_{exploit}$, delegation and incentives are negatively related if and only if projects do not vary much by risk.

These results generate the main testable implication of the model: delegation and incentive pay should have a negative relationship for exploratory jobs and the standard positive relationship for exploitative jobs.

3 Data and Empirical Analysis

In this section we empirically test the main implication of our theoretical model. Our sample is drawn from both the management and worker questionnaires in the 1998 British Workplace Employee Relations Survey (WERS), jointly sponsored by the Department of Trade and Industry, ACAS, the Economic and Social Research Council, and the Policy Studies Institute.[7] Distributed via the UK Data Archive, the WERS data are a nationally representative stratified random sample covering British workplaces with at least ten employees, except for those in the following 1992 Standard Industrial Classification (SIC) divisions: agriculture, hunting, and forestry; fishing; mining and quarrying; private households with employed persons; and extra-territorial organizations. Some of the 3192 workplaces targeted were found to be out of scope, and the final sample size of 2191 implies a net response rate of 80.4% (Cully, Woodland, O'Reilly, and Dix (1999)) after excluding the out-of-scope cases.[8] Data were collected between October 1997 and June 1998 via face-to-face interviews. The respondent in the management questionnaire was usually the most senior manager at the workplace with responsibility for employment relations.[9]

The management survey contains information on each establishment's largest occupational group, based on one-digit and two-digit Standard Occupational Classification (SOC) codes. There are nine one-digit codes, and we rely on these broad

[7]Although a 2004 wave of the survey is available, for our purposes the 1998 wave is superior given that it contains more information on incentive pay within the establishment. A further advantage of using the 1998 data is that our results are comparable to DeVaro and Kurtulus (2009) which used the same data set to examine the relationship between incentive pay and delegation, neglecting the distinction between exploration jobs versus exploitation jobs.

[8]The "scope" is workplaces with 10 or more employees located in Great Britain (England, Scotland and Wales) and engaged in activities within Sections D (Manufacturing) to O (Other Community, Social and Personal Services) of the 1992 Standard Industrial Classification. The survey covers both private and public sectors. If a case is sampled that does not meet these parameters, it is called "out of scope."

[9]Our measures of two key variables (i.e. incentive pay and delegation) as well as controls for firm characteristics and the degree of risk in the production environment are defined as in DeVaro and Kurtulus (2009), which uses the same data set.

categorizations to define jobs as either predominantly "exploration" or predominantly "exploitation". We begin by dropping from the sample the 14 establishments for which the largest occupational group is "managers and administrators."[10] We assign two of the remaining eight one-digit occupations as "exploration" in the following definition:

Exploration = 1 if the establishment's largest occupational group is "Professional occupations" or "Associate professional and technical occupations" (= 0 if the establishment's largest occupational group is "Clerical and secretarial occupations" or "Craft and related occupations" or "Personal and protective service occupations" or "Sales occupations" or "Plant and machine operatives" or "Other occupations in agriculture, forestry and fishing")

In the interests of conservatism, we rely only on the broad, one-digit codes in defining jobs that are predominantly "exploration", to avoid making arbitrary judgements about many detailed occupations. Panel 1 of Appendix B displays the detailed two-digit and three-digit codes underlying the occupations we define as exploration jobs.[11] Panel 2 displays the two-digit codes underlying the occupations we define as exploitation jobs.

The relevant theoretical notion of the strength of incentive pay is the slope of an output-based compensation contract. Such a continuous measure of incentive pay is unavailable in the WERS, so we rely on three categorical measures, defined from the management survey. The first is:

Incentive Pay = 1 if any employees at the workplace received payments or dividends from individual performance-related schemes (= 0 otherwise)[12]

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[10] Our sense is that in most management jobs the exploitation component is greater than the exploration component. However, since both components are present in management, to be conservative we drop these observations from our sample. The results we report are slightly stronger if these occupations are defined as "exploitation" jobs.

[11] Inspection of the detailed two-digit codes led us to identify three occupations that we believe do not have strong exploration components (i.e. "Health Associate Professionals", "Social Welfare Associate Professionals", and "Associate Professional and Technical Occupations"). To avoid *ad hoc* deletions, we retain these occupations in our definition of exploration jobs, though we note that in (unreported) sensitivity analyses that drop these observations, our results are slightly strengthened.

[12] The actual wording of the survey question permits group-based as well as individual-based schemes. However, when non-managerial workers are eligible for incentive pay, the survey asks what measures of performance are used for awarding such pay (i.e. "1 = Individual performance / output", "2 = Group or team performance / output", "3 = Workplace-based measures", "4 = Organisation-based measures"). The majority of establishments responding to this question reports using individual-based schemes. Since the theory pertains to individual-based schemes, we classify the incentive pay measure as 0 if "individual performance / output" was not one of the performance criteria listed as the basis for incentive pay. This creates a measure equaling 1 only when we can be certain (given that non-managerial workers are eligible for incentive pay) that individual-based performance measures are used. If performance pay is used at the establishment but no non-managerial occupations are eligible for it, we have no information on what performance measures are used. This occurs in fewer than 15 percent of cases, and in such cases we classify

One potential criticism of our first measure is that an establishment might be classified as using incentive pay even if very few workers (perhaps just a single worker) receive such pay. Our second and third measures are considerably less susceptible to this problem. Our second measure is defined as follows, where the suffix "l.o.g." denotes "largest occupational group":

Incentive Pay(l.o.g.) = 1 if any employees in the establishment's largest occupational group received payments or dividends from individual performance-related schemes (= 0 otherwise)

One advantage of using *Incentive Pay(l.o.g.)* as the dependent variable is that *Exploration* is defined with respect to the establishment's largest occupational group, which strengthens the compatibility between *Exploration* and the dependent variable. As was true of our first measure of incentive pay, the actual survey question underlying the second measure permits group-based as well as individual-based incentive schemes, so we corrected the second measure so that it indicates when individual-based performance-related pay schemes are used (see footnote 12).

Our third measure, capturing the proportion of non-managerial workers at the establishment that received individual performance-related pay in the last year, is defined as follows:

Incentive Pay% = 1 if "None 0% "

= 2 if "Just a few 1-19% "

= 3 if "Some 20-39% "

= 4 if "Around half 40-59% "

= 5 if "Most 60-79% "

= 6 if "Almost all 80-99% "

= 7 if "All 100% "

As with our first two measures, we corrected the third measure to ensure that it pertains to individual-based performance-related schemes (see footnote 12).

Our measure of delegation is derived from the worker survey. A random sample of up to 25 employees per establishment was surveyed and asked the following question: "In general, how much influence do you have about the range of tasks you do in your job?"

the incentive pay measure as 1, following DeVaro and Kurtulus (2009). Given that the majority of establishments report basing incentive pay (at least in part) on individual performance measures, the likelihood of misclassifying these relatively few ambiguous cases is small.

Potential responses were “a lot”, “some”, “a little”, and “none.” Since our measures of incentive pay and *Exploration* are establishment-wide measures, within each establishment we aggregate the individual worker responses to the delegation question by taking the modal worker response, as in DeVaro and Kurtulus (2009). The logic is that the most frequently occurring worker response to the delegation question within an establishment reflects the degree of delegation faced by the typical worker in the workplace. Thus, our delegation measure is defined as follows:

Delegation = 1 if the modal worker in the establishment responds “a lot”; (= 0 if the modal worker's response is “none”, “a little”, or “some”)

The control variables are defined in Appendix C and include establishment size, main activity of the establishment, industry, whether the firm has a single establishment or multiple establishments, ownership (private versus public, franchise versus non-franchise, publicly traded versus non-publicly traded), single-product or multiple-product, fraction of part-time workers, temporary workers, fixed-term workers under one year, fixed-term workers over one year, number of recognized unions, fraction of the establishment that is unionized, and whether the establishment has been operation for more than five years. Some of the variables in our analysis contain missing values, and we estimate all of our models using listwise deletion. The main source of missing information is *Delegation*, since only 1782 of the 2191 establishments reported any worker responses to the survey question underlying this variable. Models that control for risk in the production environment also have smaller sample sizes, since the underlying survey question was asked only in the trading sector. As noted earlier, we also drop from the sample the 14 establishments reporting that their largest occupational group is “managers and administrators”. Descriptive statistics for all variables in our analysis are displayed in Table 1. We use establishment weights in that table and throughout our analysis.

We begin by estimating the standard relationship between incentive pay and authority, neglecting the distinction between exploration and exploitation jobs. The conventional wisdom from the previous literature is that delegation and incentive pay are positively related, and a number of empirical studies have documented this relationship (e.g. DeVaro and Kurtulus (2009), Itoh, Kikutani, and Hayashida (2008), Wulf (2007), Foss and Laursen (2005), Colombo and Delmastro (2004), Nagar (2002), MacLeod and Parent (1999)). This relationship is corroborated in column 1 of Table 2, which reports results from a probit model in which *Incentive Pay* is the dependent variable and *Delegation* is the key independent variable, including the controls defined in Appendix C. The coefficient of *Delegation* is positive and statistically significant. As seen at the bottom of column 1, an increase in *Delegation* from 0 to 1 is associated, on average, with an increase of 0.073 (from 0.170 to 0.243) in the predicted probability that *Incentive Pay* = 1.[13]

[13]In Tables 2-5 we report coefficient estimates rather than marginal and incremental effects. This is in part because marginal and incremental effects are cumbersome to compute for every covariate

We now turn to our theoretical model's main prediction: the relationship between incentive pay and delegation should be positive only when exploitation is the dominant feature of the job, and it should be negative when exploration is the dominant feature. This prediction is strongly supported in column 2 of Table 2, which includes the interaction *Delegation*×*Exploration* in the aforementioned probit model. If the coefficient on this interaction were zero, then the relationship between delegation and incentive pay would not differ between the "exploration" and "exploitation" groups (and would be positive as in the previous literature and our specification in column 1). Instead, this parameter is negative and estimated with high precision. As seen at the bottom of column 2, an increase in *Delegation* from 0 to 1 is associated, on average, with an increase of 0.059 (from 0.173 to 0.232) in the predicted probability that *Incentive Pay* = 1. However, this masks a pronounced difference between exploration and exploitation jobs. For exploration jobs, an increase in *Delegation* from 0 to 1 is associated, on average, with a decrease of 0.125 (from 0.233 to 0.107) in the predicted probability that *Incentive Pay* = 1. In contrast, for exploitation jobs, an increase in *Delegation* from 0 to 1 is associated, on average, with an increase of 0.099 (from 0.160 to 0.259) in the predicted probability that *Incentive Pay* = 1.

Columns 3 and 4 of Table 2 are analogous to columns 1 and 2, respectively, though using our second measure of incentive pay, *Incentive Pay(l.o.g.)*, as the dependent variable. The results are qualitatively the same in this case, based on the average incremental effects of *Delegation*. Table 3 displays ordered probit results, using our third measure of incentive pay, *Incentive Pay%*, as the dependent variable. Since the dependent variable has seven categories, we report seven average incremental effects at the bottom of Table 3. Again, the results are qualitatively the same in this case. In summary, across all three measures of incentive pay, our model's main testable implication is strongly supported by the data.[14]

A potential omitted variable in our three incentive pay models is the degree of risk in the production environment. A well-known prediction from agency theory is that the relationship between these two variables should be negative (Holmstrom (1979); Shavell (1979)). Recent work suggests that identifying this risk-incentives tradeoff empirically requires controlling for delegation in models of incentive pay (Prendergast (2002); DeVaro and Kurtulus (2009)). As a robustness check, to account for this tradeoff, we define the following risk measure from the management

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in probit and ordered probit models in STATA when the models include interactions. However, at the bottom of each specification in Tables 2-5 (and also in the text, in some cases) we report the average incremental effect of *Delegation*, which is the effect of interest in this paper. Throughout the paper, incremental effects are computed for every observation in the sample and then averaged across those observations.

[14]In unreported sensitivity analyses, we investigated the possibility that our results are being driven by a particular narrowly-defined occupational group. To explore this possibility, for every two-digit occupation in our "exploration" group, we replicated all analyses for the subsample that dropped that two-digit occupation. Across all of these tests, our qualitative results were identical and the quantitative results were similar.

survey, following DeVaro and Kurtulus (2009):

Risk = 1 if the current state of the market for the main product or service of the establishment is described as "turbulent" (= 0 otherwise)

Tables 4 and 5 replicate tables 2 and 3, respectively, including *Risk* as a control variable in all models. Our main result is robust to the inclusion of *Risk* as a control. Furthermore, the *Risk* coefficient has the expected sign (negative) and is statistically significant, revealing a risk-incentives tradeoff.

4 Conclusion

This paper studies the relationship between delegation and incentives when risk-averse agents must exert effort and select projects that have a risk-return tradeoff. Whereas the previous literature in this area (both theoretical and empirical) finds that delegation and incentives are positively related, this paper predicts a negative relationship in settings where exploration is important.

When projects vary by risk and an agent is more risk averse than the principal, then weaker incentives encourage risk taking, whereas stronger incentives encourage effort. A tradeoff between these two features determines the relationship between delegation and incentives. When the benefits from exploration exceed those of exploitation, delegation and incentives have a negative relationship, whereas when the benefits from exploitation are greater than those from exploration, delegation and incentives have a positive relationship.

Our theoretical predictions are strongly supported by empirical analysis. We find a positive relationship between delegation and incentives, consistent with the empirical literature. However, we show that this relationship obscures sharply different relationships for exploration jobs versus exploitation jobs. In particular, consistent with our theoretical prediction, we find a strong positive relationship between authority and incentives for exploitation jobs but a strong negative relationship for exploitation jobs. These empirical results, along with our theoretical explanation for them, are new to the literature. Our theoretical and empirical analysis shows that the relationship between an employer's decisions about incentive pay and delegation is more nuanced than has been appreciated in the previous literature.

We conclude with two points. First, in addition to contributing to the academic literature, our main result has important managerial implications in that we show why the conventional wisdom (i.e. delegation of authority should go hand in hand with incentive pay) is wrong for a certain important class of jobs. The lesson for managers is not just that the optimal incentive pay and delegation decisions depend crucially on job characteristics. The analysis goes further in illuminating which job characteristics matter and why, and our theoretical result is supported by empirical evidence from a large cross section of employers. Second, we note that our theoretical framework is tractable and could be extended in a number of interesting directions. One particularly fruitful direction might be to allow for endogenous job assignments in a setting with multiple agents as opposed to just one. Some workers would be assigned to exploratory jobs and others to exploitative jobs. This allocation of workers to jobs could be expected to reduce the incentive tradeoff between exploration and exploitation, though it would result in a higher wage bill. We leave this topic to future research.

Appendix A

Proofs

Proof of Proposition 1: Note that in both the no-delegation and delegation problem, the individual rationality constraint must bind at the optimum. Otherwise the transfer can always be reduced without altering incentive constraints, leading to an increase in profits.

After substituting (IR_n) and (IC_{an}) into the principal's objective function, the "no delegation" problem can be written as

$$\underset{s_n, x_n}{Max}\ \pi_s(s_n) + \pi_x(x_n) = \frac{s_n}{c} - \frac{s_n^2}{2c} - \frac{\eta s_n^2 \sigma_0^2}{2} + \xi x_n + \beta B(x_n) - w_0 - C$$

where $\pi_s(s_n) = \frac{s_n}{c} - \frac{s_n^2}{2c} - \frac{\eta s_n^2 \sigma_0^2}{2}$.

Likewise, after substituting (IR_d) and (IC_{ad}) into the principal's objective function, the delegation problem can be written as

$$\underset{s_d, x_d}{Max}\ \pi_s(s_d) + \pi_x(x_d) = \frac{s_d}{c} - \frac{s_d^2}{2c} - \frac{\eta s_d^2 \sigma_0^2}{2} + \xi x_d + \beta B(x_d) - w_0$$

subject to (IC_{xd}) where $\pi_s(s_d) = \frac{s_d}{c} - \frac{s_d^2}{2c} - \frac{\eta s_d^2 \sigma_0^2}{2}$.

Now suppose to the contrary that $s_d^* < s_n^*$. Consider an alternative incentive level, $s_d' = s_n^*$, along with an incentive compatible project choice, x_d'. Since $\pi_s(.)$ is strictly concave in s_d, and since s_n^* maximizes $\pi_s(.)$, it follows that $\pi_s(s_d') > \pi_s(s_d^*)$.

The following claim is needed to verify that s_d' does not decrease profits with respect to project choice.

Claim: Let $x \in \ argmax\ \ s\xi x + \beta B(x)$. Then x is weakly increasing in s.

Proof The first order necessary conditions for an optimum must satisfy

$$s\xi + \beta B'(x) = \bar{\mu} - \mu_0$$

where $\bar{\mu}$ is the multiplier associated with the constraint $x \leq \bar{x}$ and μ_0 is the multiplier associated with the constraint $x \geq 0$. If the solution is interior, then at the optimum we have $\frac{dx}{ds} = -\frac{\xi}{\beta B''(x)} > 0$ as $B(x)$ is strictly concave. If the solution is at the corner, then the optimal solution, x, is weakly increasing in s since $s\xi + \beta B'(x)$ is strictly increasing in s.■

Since $s_d^* < s_d'$, the preceding claim implies $x_d^* \leq x_d'$. Also, since $s_d' \leq 1$, it follows from the preceding claim that $x_d' \leq x_n^*$. Combining the inequalities, we have

$$x_d^* \leq x_d' \leq x_n^* \tag{1}$$

Since $\pi_x(.)$ is concave, and since x_n^* is the solution to the principal's problem without the incentive constraint for project selection, from (1) we have $\pi_x(x_d') \geq \pi_x(x_d^*)$. This contradicts the optimality of s_d^* and x_d^*. Thus, $s_d^* \geq s_n^*$.

Now suppose x_d^* is an interior solution. Once again, substituting (IR_d) and (IC_{ad}) into the principal's objective function, the first order necessary conditions imply that the optimal solution s_d^* satisfies

$$\frac{1}{c} - \frac{s_d^*}{c} - \eta s_d \sigma_0^2 = \lambda \xi \tag{2}$$

where λ is the multiplier associated with the constraint (IC_{xd}). Rearranging (2), we get

$$s_d^* = \frac{1 - \lambda \xi c}{1 + c\eta\sigma_0^2} \tag{3}$$

Similarly, the first order necessary conditions imply that the optimal solution, x_d^*, satisfies

$$\xi + \beta B'(x_d^*) = \lambda \beta B''(x_d^*)$$

Rearranging the above equation, we get

$$\frac{\xi + B'(x_d^*)}{B''(x_d^*)} = \lambda \tag{4}$$

Since B is a strictly concave function, and since $s_d^* \xi + B'(x_d^*) = 0$ from (IC_{xd}), it follows from (4) that $\lambda < 0$.

From (3) we have $s_d^* > s_n^*$.■

Proof of Lemma 1: Suppose to the contrary that $x_n^* \in (0, \bar{x})$. Since the principal's objective function is linear in x, it must be that

$$0 = \xi \bar{x} - \frac{\eta s_n^{*2} \alpha \bar{x}}{2} = \xi x_n^* - \frac{\eta s_n^{*2} \alpha x_n^*}{2}$$

Also, since $s_0 \neq \bar{s}$, it must be that either $s_n^* \neq s_0$ or $s_n^* \neq \bar{s}$ or both. Suppose $s_n^* \neq s_0$. Then the principal can choose $x_n = 0$ and the incentive level s_0 and strictly increase his profits. A similar reasoning holds if $s_n^* \neq \bar{s}$. This contradicts the optimality of an interior project choice.■

Proof of Lemma 2: Substitute (IR_n) and (IC_{an}) into the principal's objective function. Then the principal's expected profit from choosing $x_n = 0$ and $s_n = s_0$ is

$$\frac{s_0}{c} - \frac{s_0^2}{2c} - \frac{\eta s_0^2 \sigma_0^2}{2} - w_0 \tag{5}$$

Substituting s_0 in (5), the principal's expected profit can be rewritten as

$$\frac{1}{2c(1+\eta c\sigma_0^2)} - w_0$$

Similarly, the principal's expected profit from choosing $x_n = \bar{x}$ and $s_n = \bar{s}(\alpha)$ is given by

$$\xi\bar{x} + \frac{1}{2c(1+\eta c(\sigma_0^2 + \alpha\bar{x}))} - w_0$$

Thus $x_n = 0$ and $s_n = s_0$ is optimal if and only if

$$\frac{1}{2c(1+\eta c\sigma_0^2)} - w_0 \geq \xi\bar{x} + \frac{1}{2c(1+\eta c(\sigma_0^2 + \alpha\bar{x}))} - w_0 \tag{6}$$

Multiplying both sides of (6) by $2c(1+\eta c\sigma_0^2)$, we have $x_n = 0$ and $s_n = s_0$ is optimal if and only if

$$1 \geq 2c\xi\bar{x}(1+\eta c\sigma_0^2) + \frac{(1+\eta c\sigma_0^2)}{(1+\eta c(\sigma_0^2 + \alpha\bar{x}))} \tag{7}$$

If $\xi\bar{x} \geq \frac{1}{2c(1+\eta c\sigma_0^2)}$, the inequality in (7) does not hold and the optimal solution is $x_n = \bar{x}$ and $s_n = \bar{s}$.

Now suppose $\xi\bar{x} < \frac{1}{2c(1+\eta c\sigma_0^2)}$. Then rearranging terms in (6) we have $x_n = 0$ and $s_n = s_0$ is optimal if and only if

$$\alpha \geq \frac{2\xi}{\eta}\frac{(1+\eta c\sigma_0^2)^2}{(1-2c\xi\bar{x}(1+\eta c\sigma_0^2))} = \alpha_n$$

■

Proof of Lemma 3: Consider the case in which $\xi\bar{x} \geq \frac{1}{2c(1+\eta c\sigma_0^2)}$. In this case the optimal solution for the "no delegation" case is $x_n = \bar{x}$ and $s_n = \bar{s}(\alpha)$. Given the incentive level $\bar{s}(\alpha)$, an agent chooses $\bar{x}$ if and only if

$$\bar{s}(\alpha)\xi\bar{x} - \frac{\eta\bar{s}(\alpha)^2\alpha\bar{x}}{2} \geq 0$$

Rearranging, we get

$$\xi\bar{x} \geq \frac{\eta\bar{s}(\alpha)\alpha\bar{x}}{2} \tag{8}$$

Substituting $\bar{s}(\alpha)$ and rearranging (8), we get

$$\alpha \leq \frac{2\xi}{\eta}\frac{(1+\eta c\sigma_0^2)}{(1-2\xi c\bar{x})} = \alpha_d$$

Similar reasoning holds for the case in which $\xi\bar{x} < \dfrac{1}{2c(1+\eta c\sigma_0^2)}$. Clearly $\alpha_d < \alpha_n$.■

Proof of Proposition 2: Consider the delegation problem, and let $\alpha > \alpha_d$. First, note that $x_d^* \in \{0, \bar{x}\}$. If not, both the agent and principal are indifferent between project 0 and project $\bar{x}$ (because the agent's certainty equivalent and the principal's expected profit are both linear in projects, given an incentive level). As in Lemma 1, the principal can choose either s_0 and the project 0 or $\bar{s}(\alpha)$ and the project $\bar{x}$. Both options are feasible and yield a strictly higher profit, leading to a contradiction.

Suppose the principal implements $\bar{x}$. To satisfy (IC_{xd}), it must be the case that

$$s_d\xi\bar{x} - \frac{\eta s_d^2\alpha\bar{x}}{2} \geq 0$$

which reduces to

$$s_d \leq \frac{2\xi}{\eta\alpha} \tag{9}$$

Substituting (IR_d) and (IC_{ad}), the principal's problem when he implements $\bar{x}$ is

$$\underset{s_d}{Max}\ \frac{s_d}{c} - \frac{s_d^2}{2c} - \frac{\eta s_d^2(\sigma_0^2 + \alpha\bar{x})}{2} + \xi\bar{x} - w_0$$

subject to (9). The first order necessary conditions imply

$$\frac{1}{c} - \frac{s_d}{c} - \eta s_d(\sigma_0^2 + \alpha\bar{x}) = \mu \tag{10}$$

where μ is the non-negative multiplier associated with (9). As $\alpha > \alpha_d$, it follows from Lemma 3 that $\frac{2\xi}{\eta\alpha} < \bar{s}(\alpha)$. Also, note that the principal's profit after substituting (IR_d) and (IC_{ad}) is strictly concave in s_d and that the left-hand side of (10) is equal to 0 when $s_d = \bar{s}(\alpha)$. Thus, for any s_d satisfying (9), the left-hand side of (10) is strictly positive. From the complementary slackness conditions, (9) always binds.

Thus, the principal's expected profit if he implements $\bar{x}$ is

$$\xi\bar{x} + \frac{2\xi}{\eta\alpha c} - \frac{2\xi^2(1+\eta c\sigma_0^2)}{\eta^2\alpha^2 c} - \frac{2\xi^2\bar{x}}{\eta\alpha} - w_0 \tag{11}$$

and the principal's expected profit if he implements project 0 is

$$\frac{1}{2c(1+\eta c\sigma_0^2)} - w_0 \tag{12}$$

At the optimum, the principal implements $\bar{x}$ if and only if

$$\xi\bar{x} + \frac{2\xi}{\eta\alpha c} - \frac{2\xi^2(1+\eta c\sigma_0^2)}{\eta^2\alpha^2 c} - \frac{2\xi^2\bar{x}}{\eta\alpha} \geq \frac{1}{2c(1+\eta c\sigma_0^2)} \tag{13}$$

Simplifying (13), we get

$$\frac{1}{\alpha}(2 - 2c\xi\bar{x} - \frac{2\xi(1+\eta c\sigma_0^2)}{\eta\alpha}) \geq \frac{\eta(1-2c\xi\bar{x}(1+\eta c\sigma_0^2))}{2\xi(1+\eta c\sigma_0^2)} \tag{14}$$

Define $f(\alpha) = \frac{1}{\alpha}(2-2c\xi\bar{x}-\frac{2\xi(1+\eta c\sigma_0^2)}{\eta\alpha})$. There are three properties of the function f worth noting. First, $\lim_{\alpha\to 0} f(\alpha) = -\infty$. Second $f(\alpha_d) = \frac{\eta(1-2c\xi\bar{x})}{2\xi(1+\eta c\sigma_0^2)} > 0$. Third, there is a unique value of α denoted by $\alpha' = \frac{\xi(1+\eta c\sigma_0^2)}{\eta(1-c\xi\bar{x})}$, where the function f takes the value 0. These properties imply that $f(\alpha) > 0 \geq \frac{\eta(1-2c\xi\bar{x}(1+\eta c\sigma_0^2))}{2\xi(1+\eta c\sigma_0^2)}$ for all $\alpha > \alpha_d$. It follows that the principal always implements $\bar{x}$ at the optimum. Thus $s_d^* = \frac{2\xi}{\eta\alpha} < \bar{s}(\alpha) = s_n^*$.■

Proof of Proposition 3: Consider the delegation problem and let $\alpha \in (\alpha_d, \alpha_n)$. From the proof of proposition 2, we know that at the optimum the principal either implements project 0 with an incentive level s_0 or project $\bar{x}$ with an incentive level $s_d = \frac{2\xi}{\eta\alpha}$.

We also know from the proof of Proposition 2 that the principal implements $\bar{x}$ if and only if

$$\frac{1}{\alpha}(2 - 2c\xi\bar{x} - \frac{2\xi(1+\eta c\sigma_0^2)}{\eta\alpha}) \geq \frac{\eta(1 - 2c\xi\bar{x}(1+\eta c\sigma_0^2))}{2\xi(1+\eta c\sigma_0^2)} \tag{15}$$

Let $\hat{\alpha}$ be the value of α for which (15) holds with equality. Again, define $f(\alpha) = \frac{1}{\alpha}(2 - 2c\xi\bar{x} - \frac{2\xi(1+\eta c\sigma_0^2)}{\eta\alpha})$. Because $\frac{2\xi}{\eta\alpha_d} = \bar{s}(\alpha_d)$, and since $\alpha_d < \alpha_n$, from lemma 3 it must be that $f(\alpha_d)$ is strictly greater than the right-hand side of (15). Also, since $\frac{2\xi}{\eta\alpha_n} < \bar{s}(\alpha_n)$, it follows that $f(\alpha_n)$ is strictly less than the right-hand side of (15). Because f is continuous, there exists $\hat{\alpha} \in (\alpha_d, \alpha_n)$ from the intermediate value theorem. Finally, $f'(\alpha) = \frac{2}{\alpha^2}(\frac{2\xi(1+\eta c\sigma_0^2)}{\alpha\eta} - (1 - c\xi\bar{x}))$. Note that $f'(\alpha_d) = \frac{-2c\xi\bar{x}}{\alpha_d^2} < 0$ and that $f'(\alpha) < 0$ for all $\alpha \geq \alpha_d$. Thus, $\hat{\alpha}$ is unique. ■

Appendix B

Panel 1: Two-digit and three-digit SOC codes for Exploration Occupations

CODE	DESCRIPTION
20	NATURAL SCIENTISTS
200	Chemists
201	Biological scientists & biochemists
202	Physicists, geologists & meteorologists
209	Other natural scientists nes
21	ENGINEERS AND TECHNOLOGISTS
210	Civil, structural, municipal, mining & quarry engineers
211	Mechanical engineers
212	Electrical engineers
213	Electronic engineers
214	Software engineers
215	Chemical engineers
216	Design & development engineers
217	Process & production engineers
218	Planning & quality control engineers
219	Other engineers & technologists nes
22	HEALTH PROFESSIONALS
220	Medical practitioners
221	Pharmacists/pharmacologists
222	Ophthalmic opticians
223	Dental practitioners
224	Veterinarians
23	TEACHING PROFESSIONALS
230	University & polytechnic teaching professionals
231	Higher & further education teaching professionals
232	Education officers, school inspectors
233	Secondary (& middle school deemed secondary) education teaching professionals
234	Primary (& middle school deemed primary) & nursery education teaching professionals
235	Special education teaching professionals
239	Other teaching professionals nes
24	LEGAL PROFESSIONALS
240	Judges & officers of the court
241	Barristers & advocates
242	Solicitors
25	BUSINESS AND FINANCIAL PROFESSIONALS
250	Chartered & certified accountants

CODE	DESCRIPTION
251	Management accountants
252	Actuaries, economists & statisticians
253	Management consultants, business analysts
26	ARCHITECTS, TOWN PLANNERS AND SURVEYORS
260	Architects
261	Town planners
262	Building, land, mining & general practice surveyors
27	LIBRARIANS AND RELATED PROFESSIONALS
270	Librarians
271	Archivists & curators
29	PROFESSIONAL OCCUPATIONS NEC
290	Psychologists
291	Other social & behavioural scientists
292	Clergy
293	Social workers, probation officers
30	SCIENTIFIC TECHNICIANS
300	Laboratory technicians
301	Engineering technicians
302	Electrical/electronic technicians
303	Architectural & town planning technicians
304	Building & civil engineering technicians
309	Other scientific technicians nes
31	DRAUGHTS PERSONS, QUANTITY AND OTHER SURVEYORS
310	Draughts persons
311	Building inspectors
312	Quantity surveyors
313	Marine, insurance & other surveyors
32	COMPUTER ANALYSTS/PROGRAMMERS
320	Computer analyst/programmers
33	SHIP AND AIRCRAFT OFFICERS, AIR TRAFFIC PLANNERS AND CONTROLLERS
330	Air traffic planners & controllers
331	Aircraft flight deck officers
332	Ship & hovercraft officers
34	HEALTH ASSOCIATE PROFESSIONALS
340	Nurses
341	Midwives
342	Medical radiographers
343	Physiotherapists
344	Chiropodists
345	Dispensing opticians

CODE	DESCRIPTION
346	Medical technicians, dental auxiliaries
347	Occupational & speech therapists, psychotherapists, therapists nes
348	Environmental health officers
349	Other health associate professionals nes
35	LEGAL ASSOCIATE PROFESSIONALS
350	Legal service & related occupations
360	Estimators, valuers
36	BUSINESS AND FINANCIAL ASSOCIATE PROFESSIONALS
361	Underwriters, claims assessors, brokers, investment analysts
362	Taxation experts
363	Personnel & industrial relations officers
364	Organisation & methods & work study officers
37	SOCIAL WELFARE ASSOCIATE PROFESSIONALS
370	Matrons, houseparents
371	Welfare, community & youth workers
38	LITERARY, ARTISTIC AND SPORTS PROFESSIONALS
380	Authors, writers, journalists
381	Artists, commercial artists, graphic designers
382	Industrial designers
383	Clothing designers
384	Actors, entertainers, stage managers, producers & directors
385	Musicians
386	Photographers, camera, sound & video operators
387	Professional athletes, sports officials
39	ASSOCIATE PROFESSIONAL AND TECHNICAL OCCUPATIONS
390	Information officers
391	Vocational & industrial trainers
392	Careers advisers & vocational guidance specialists
393	Driving instructors (excluding HGV)
394	Inspectors of factories, utilities & trading standards
395	Other statutory & similar inspectors nes
396	Occupational hygienists & safety officers (health & safety)
399	Other associate professional & technical occupations nes

Panel 2: Two-digit SOC codes for Exploitation Occupations

CODE	DESCRIPTION
40	ADMINISTRATIVE/CLERICAL OFFICERS AND ASSISTANTS IN CIVIL SERVICE AND LOCAL GOVERNMENT
41	NUMERICAL CLERKS AND CASHIERS
42	FILING AND RECORDS CLERKS
43	CLERKS (NOT OTHERWISE SPECIFIED)
44	STORES AND DESPATCH CLERKS, STOREKEEPERS
45	SECRETARIES, PERSONAL ASSISTANTS, TYPISTS, WORD PROCESSOR OPERATORS
46	RECEPTIONISTS, TELEPHONISTS AND RELATED OCCUPATIONS
49	CLERICAL AND SECRETARIAL OCCUPATIONS NES
50	CONSTRUCTION TRADES
51	METAL MACHINING, FITTING AND INSTRUMENT MAKING TRADES
52	ELECTRICAL/ELECTRONIC TRADES
53	METAL FORMING, WELDING AND RELATED TRADES
54	VEHICLE TRADES
55	TEXTILES, GARMENTS AND RELATED TRADES
56	PRINTING AND RELATED TRADES
57	WOODWORKING TRADES
58	FOOD PREPARATION TRADES
59	OTHER CRAFT AND RELATED OCCUPATIONS
60	NCOS AND OTHER RANKS, ARMED FORCES
61	SECURITY AND PROTECTIVE SERVICE OCCUPATIONS
62	CATERING OCCUPATIONS
63	TRAVEL ATTENDANTS AND RELATED OCCUPATIONS
64	HEALTH AND RELATED OCCUPATIONS
65	CHILDCARE AND RELATED OCCUPATIONS
66	HAIRDRESSERS, BEAUTICIANS AND RELATED OCCUPATIONS
67	DOMESTIC STAFF AND RELATED OCCUPATIONS
69	PERSONAL AND PROTECTIVE SERVICE OCCUPATIONS NES
70	BUYERS, BROKERS AND RELATED AGENTS
71	SALES REPRESENTATIVES
72	SALES ASSISTANTS AND CHECKOUT OPERATORS
73	MOBILE, MARKET AND DOOR-TO-DOOR SALESPERSONS AND AGENTS
79	SALES OCCUPATIONS NEC
80	FOOD, DRINK AND TOBACCO PROCESS OPERATIVES
81	TEXTILES AND TANNERY PROCESS OPERATIVES
82	CHEMICALS, PAPER, PLASTICS AND RELATED PROCESS OPERATIVES
83	METAL MAKING AND TREATING PROCESS OPERATIVES
84	METAL WORKING PROCESS OPERATIVES
85	ASSEMBLERS/ LINEWORKERS

CODE	DESCRIPTION
86	OTHER ROUTINE PROCESS OPERATIVES
87	ROAD TRANSPORT OPERATIVES
88	OTHER TRANSPORT AND MACHINERY OPERATIVES
89	PLANT AND MACHINE OPERATIVES NES
90	OTHER OCCUPATIONS IN AGRICULTURE, FORESTRY AND FISHING
91	OTHER OCCUPATIONS IN MINING AND MANUFACTURING
92	OTHER OCCUPATIONS IN CONSTRUCTION
93	OTHER OCCUPATIONS IN TRANSPORT
94	OTHER OCCUPATIONS COMMUNICATIONS
95	OTHER OCCUPATIONS IN SALES AND SERVICES
99	OTHER OCCUPATIONS NES

Appendix C

FIRM CHARACTERISTICS USED AS CONTROL VARIABLES:

Single-Establishment Firm = 1 if the establishment is either a single independent establishment not belonging to another body, or the sole UK establishment of a foreign organization
= 0 if the establishment is one of a number of different establishments within a larger organization

Establishment Size = total number of full time, part time, and temporary workers at the establishment (measured in thousands)

Fraction of Part Time Workers = number of part time workers at the establishment as a fraction of establishment size

Temporary Workers = 1 if there are temporary agency employees working at the establishment at the time of the survey
= 0 otherwise

Fixed Term Workers Under One Year = 1 if there are employees who are working on a temporary basis or have fixed-term contracts for less than one year
= 0 otherwise

Fixed Term Workers Over One Year = 1 if there are employees who have fixed term contracts for one year or more
= 0 otherwise

Number of Recognized Unions = Total number of recognized unions at the workplace

100% Workers Unionized = 1 if 100% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure)
= 0 otherwise

80-99% Workers Unionized = 1 if 80-99% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure)
= 0 otherwise

60-79% Workers Unionized = 1 if 60-79% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure)

= 0 otherwise

40-59% Workers Unionized = 1 if 40-59% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure)
= 0 otherwise

20-39% Workers Unionized = 1 if 20-39% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure)
= 0 otherwise

1-19% Workers Unionized = 1 if 1-19% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure)
= 0 otherwise

0% Workers Unionized = 1 if 0% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure)
= 0 otherwise

Main Activity of Establishment = 1 if the main activity of the establishment is to produce goods or services for consumers = 0 for any of the following other possibilities: supplier of goods or services to other companies; supplier of goods or services to other parts of the organization to which we belong; do not produce goods or provide services for sale in the open market; an administrative office only

Single Product = 1 if the establishment is concentrated on one product or service
= 0 if it is concentrated on several different products or services

Private Sector Franchise = 1 if the establishment is a private sector company and a franchise
= 0 otherwise

Private Sector Non-franchise = 1 if the establishment is a private sector company but not a franchise
= 0 otherwise

Private Sector Publicly-Traded Franchise = 1 if the establishment is a publicly-traded private sector unit and a franchise
= 0 otherwise

Private Sector Publicly-Traded Non-franchise = 1 if the establishment is a publicly-traded private sector unit but not a franchise
= 0 otherwise

Operation Over Five Years = 1 if the workplace has been operating at its present address for 5 years or more
= 0 otherwise

Industry Controls: (Manufacturing; Electricity, Gas, and Water; Construction; Wholesale and Retail; Hotels and Restaurants; Transport and Communication; Financial Services; Other Business Services; Public Administration; Education; Health; Other Community Services)

TABLE 1: Descriptive Statistics

	Mean	Standard Error
Exploration	0.176	0.016
Incentive Pay	0.141	0.016
Incentive Pay(l.o.g.)	0.082	0.012
Incentive Pay%:		
=1 None 0%	0.298	
=2 Just a few 1-19%	0.054	
=3 Some 20-39%	0.028	
=4 Around half 40-59%	0.019	
=5 Most 60-79%	0.012	
=6 Almost all 80-99%	0.018	
=7 All 100%	0.571	
Delegation	0.078	0.016
Risk	0.206	0.022
Largest Occupational Group:		
Professional Occupations	0.125	0.014
Associate Professional and Technical Operations	0.051	0.010
Clerical and Secretarial Occupations	0.168	0.017
Craft and Skilled Service Occupations	0.118	0.016
Personal and Protective Service Occupations	0.203	0.018
Sales Occupations	0.140	0.017
Plant and Machine Operatives	0.096	0.013
Other Occupations	0.099	0.013
Industry:		
Manufacturing	0.129	0.017
Electricity, Gas and Water	0.002	0.000
Construction	0.039	0.008
Wholesale and Retail	0.196	0.019
Hotels and Restaurants	0.066	0.011
Transport and Communication	0.044	0.009
Financial Services	0.031	0.006
Other Business Services	0.104	0.014
Public Administration	0.049	0.009
Education	0.142	0.016
Health	0.147	0.016
Other Community Services	0.050	0.009
Firm Characteristics:		
Single-Establishment Firm	0.326	0.022
Fixed Term Workers Over One Year	0.170	0.016
Fixed Term Workers Under One Year	0.253	0.018
Operation Over Five Years	0.898	0.013

Main Activity of Establishment	0.537	0.023
Temporary Workers	0.190	0.016
Establishment Size	0.060	0.003
Fraction of Part Time Workers	0.328	0.014
Number of Recognized Unions	0.886	0.055
100% Workers Unionized	0.298	0.020
80-99% Workers Unionized	0.054	0.008
60-79% Workers Unionized	0.028	0.006
40-59% Workers Unionized	0.019	0.006
20-39% Workers Unionized	0.012	0.005
1-19% Workers Unionized	0.018	0.006
0% Workers Unionized	0.571	0.022
Private Sector Publicly-Traded Non-franchise	0.009	0.003
Private Sector Publicly-Traded Franchise	0.273	0.019
Private Sector Non-franchise	0.024	0.008
Private Sector Franchise	0.430	0.023
Sample Size = 1766		

Note: Tabulations are for the 1766 establishments for which data on *Incentive Pay*, *Exploration*, and *Delegation* are non-missing, excluding those observations for which the largest occupational group is Managers and Administrators. However, some of the above statistics are based on smaller sample sizes due to missing values in individual variables. *Establishment Size* is measured in thousands. All statistics are establishment weighted.

TABLE 2: Probit Results: Dependent Variable = *Incentive Pay*

	Dependent Variable			
	Incentive Pay		*Incentive Pay(l.o.g.)*	
Independent Variables:				
Delegation	0.320**	0.438***	0.531***	0.608***
	(0.157)	(0.166)	(0.188)	(0.198)
Delegation x Exploration		-1.078***		-0.926**
		0.348		(0.423)
Exploration		0.331		0.220
		(0.254)		(0.271)
Industry Controls				
Manufacturing	-0.850***	-0.841***	-0.582	-0.578
	(0.306)	(0.298)	(0.361)	(0.359)
Electricity, Gas and Water	-0.936***	-0.942***	-0.776**	-0.789**
	(0.345)	(0.337)	(0.373)	(0.368)
Construction	-0.825**	-0.836**	-0.830***	-0.842***
	(0.369)	(0.364)	(0.322)	(0.323)
Hotels and Restaurants	-0.680**	-0.680**	-1.934***	-1.945***
	(0.328)	(0.333)	(0.360)	(0.357)
Transport and Communication	-1.229***	-1.198***	-1.360***	-1.337***
	(0.313)	(0.305)	(0.338)	(0.341)
Financial Services	0.456	0.534	0.532	0.587*
	(0.332)	(0.327)	(0.335)	(0.336)
Other Business Services	-0.415	-0.425	-0.586**	-0.575*
	(0.279)	(0.297)	(0.291)	(0.302)
Public Administration	-0.782**	-0.805**	-0.754*	-0.785**
	(0.352)	(0.355)	(0.386)	(0.385)
Education	-1.926***	-2.055***	-2.998***	-3.065***
	(0.441)	(0.444)	(0.446)	(0.440)
Health	-1.799***	-1.820***	-2.845***	-2.806***
	(0.268)	(0.275)	(0.394)	(0.384)
Other Community Services	-1.171***	-1.156***	-1.069***	-1.067***
	(0.303)	(0.305)	(0.363)	(0.365)
Firm Controls				
Single-Establishment Firm	-0.103	-0.099	-0.132	-0.142

	(0.201)	(0.199)	(0.237)	(0.236)
Fixed Term Workers Over One Year	0.101	0.137	0.266	
	(0.190)	(0.189)	(0.214)	(0.210)
Fixed Term Workers Under One Year	0.057	0.111	0.285*	0.328*
	(0.141)	(0.142)	(0.173)	(0.177)
Operation Over Five Years	0.362**	0.344**	0.438**	0.424**
	(0.173)	(0.167)	(0.218)	(0.206)
Main Activity of Establishment	0.084	0.053	0.221	0.198
	(0.158)	(0.157)	(0.192)	(0.191)
Temporary Workers	0.186	0.151	0.447***	0.418***
	(0.148)	(0.147)	(0.160)	(0.159)
Establishment Size	0.118	0.108	-0.006	-0.014
	(0.090)	(0.088)	(0.124)	(0.125)
Fraction of Part Time Workers	-0.579*	-0.509	-0.629	-0.584
	(0.336)	(0.322)	(0.424)	(0.427)
Number of Recognized Unions	0.151***	0.148***	0.010	0.011
	(0.047)	(0.047)	(0.078)	(0.079)
100% Workers Unionized	-0.285	-0.303	0.159	0.143
	(0.262)	(0.261)	(0.321)	(0.321)
80-99% Workers Unionized	0.105	0.141	0.389	0.406
	(0.247)	(0.248)	(0.316)	(0.311)
60-79% Workers Unionized	-0.496**	-0.501**	-0.257	-0.265
	(0.230)	(0.236)	(0.289)	(0.290)
40-59% Workers Unionized	-0.300	-0.318	-0.703	-0.711
	(0.331)	(0.327)	(0.454)	(0.448)
20-39% Workers Unionized	0.230	0.205	0.203	0.158
	(0.422)	(0.414)	(0.394)	(0.392)
1-19% Workers Unionized	0.855	0.755	-1.002	-1.034**
	(0.680)	(0.647)	(0.553)	(0.546)
Constant	-0.676	-0.721	-1.330**	-1.366**

	(0.473)	(0.475)	(0.541)	(0.547)
Incremental Effect of *Delegation*				
Overall (All Jobs)	0.073	0.059	0.082	0.076
Exploration Jobs		-0.125		-0.041
Exploitation Jobs		0.099		0.095
Sample Size	1712	1712	1712	1712

Note 1: Results are probit coefficients, with robust standard errors in parentheses below each estimate. Statistical significance at the 10%, 5%, and 1% levels, respectively, is denoted by *, **, and ***, using two-tailed tests. Reference group for industry dummies is *Wholesale* and *Retail*. Reference group for % unionized dummies is 0% *Workers Unionized*.

Note 2: The overall incremental effect of *Delegation* (for all jobs) is the average value over all sample observations of the predicted values of $Prob(\textit{Incentive Pay(l.o.g.)} = 1 \mid \textit{Delegation} = 1) - Prob(\textit{Incentive Pay(l.o.g.)} = 1 \mid \textit{Delegation} = 0)$ evaluating *Exploration* at its observed value for each observation. The incremental effect of *Delegation* for "Exploration" jobs is the average value over all sample observations of the predicted values of $Prob(\textit{Incentive Pay(l.o.g)} = 1 \mid \textit{Exploration} = 1 \text{ and } \textit{Delegation} = 1) - Prob(\textit{Incentive Pay(l.o.g)} = 1 \mid \textit{Exploration} = 1 \text{ and } \textit{Delegation} = 0)$. The incremental effect of *Delegation* for "Exploitation" is the average value over all sample observations of $Prob(\textit{Incentive Pay(l.o.g)} = 1 \mid \textit{Exploration} = 0 \text{ and } \textit{Delegation} = 1) - Prob(\textit{Incentive Pay(l.o.g)} = 1 \mid \textit{Exploration} = 0 \text{ and } \textit{Delegation} = 0)$.

TABLE 3: Ordered Probit Results: Dep. Var. = *Incentive Pay%*

	Dependent Variable: Incentive Pay%	
Independent Variables:		
Delegation	0.258	0.395**
	(0.167)	(0.178)
Delegation x Exploration		-1.255***
		(0.400)
Exploration		0.400*
		(0.235)
Industry Controls		
Manufacturing	-0.745**	-0.727**
	(0.296)	(0.288)
Electricity, Gas and Water	-0.880***	-0.893***
	(0.338)	(0.326)
Construction	-0.987***	-0.985***
	(0.297)	(0.292)
Hotels and Restaurants	-1.214***	-1.230***
	(0.290)	(0.288)
Transport and Communication	-1.234***	-1.189***
	(0.380)	(0.372)
Financial Services	0.629**	0.727**
	(0.318)	(0.315)
Other Business Services	-0.285	-0.293
	(0.274))	(0.286)
Public Administration	-0.530	-0.551
	(0.375)	(0.380)
Education	-1.665***	-1.838***
	(0.424)	(0.420)
Health	-2.118***	-2.176***
	(0.380)	(0.382)
Other Community Services	-0.831***	-0.809***
	(0.314)	(0.316)
Firm Controls		
Single-Establishment Firm	-0.020	-0.021
	(0.186)	(0.183)
Fixed Term Workers Over One Year	0.080	0.136

	(0.195)	(0.188)
Fixed Term Workers Under One Year	0.273*	0.341**
	(0.160)	(0.164)
Operation Over Five Years	0.217	0.206
	(0.190)	(0.180)
Main Activity of Establishment	0.000	-0.035
	(0.160)	(0.159)
Temporary Workers	0.118	0.080
	(0.155)	(0.153)
Establishment Size	0.007	-0.004
	(0.091)	(0.093)
Fraction of Part Time Workers	-0.566	-0.468
	(0.353)	(0.340)
Number of Recognized Unions	0.122**	0.121**
	(0.055)	(0.055)
100% Workers Unionized	0.033	0.019
	(0.238)	(0.237)
80-99% Workers Unionized	0.270	0.311
	(0.331)	(0.333)
60-79% Workers Unionized	-0.322	-0.323
	(0.255)	(0.258)
40-59% Workers Unionized	-0.269	-0.281
	(0.391)	(0.384)
20-39% Workers Unionized	0.463	0.446
	(0.514)	(0.506)
1-19% Workers Unionized	0.876	0.762
	(0.634)	(0.604)
Cutoff 1	1.083**	1.178**
	(0.457)	(0.464)
Cutoff 2	1.240***	1.336***
	(0.463)	(0.473)
Cutoff 3	1.324***	1.421***
	(0.485)	(0.495)
Cutoff 4	1.447***	1.544***
	(0.479)	(0.489)

Cutoff 5	1.500***	1.598***
	(0.480)	(0.490)
Cutoff 6	1.786***	1.886***
	(0.488)	(0.499)
Incremental Effect of *Delegation*		
Overall (All Jobs)		
=1 (None 0%)	-0.050	-0.040
=2 (Just a few 1-19%)	0.006	0.004
=3 (Some 20-39%)	0.003	0.002
=4 (Around half 40-59%)	0.004	0.003
=5 (Most 60-79%)	0.002	0.001
=6 (Almost all 80-99%)	0.009	0.007
=7 (All 100%)	0.025	0.023
Exploration Jobs		
=1 (None 0%)		0.137
=2 (Just a few 1-19%)		-0.018
=3 (Some 20-39%)		-0.009
=4 (Around half 40-59%)		-0.013
=5 (Most 60-79%)		-0.005
=6 (Almost all 80-99%)		-0.026
=7 (All 100%)		-0.065
Exploitation Jobs		
=1 (None 0%)		-0.075
=2 (Just a few 1-19%)		0.009
=3 (Some 20-39%)		0.005
=4 (Around half 40-59%)		0.007
=5 (Most 60-79%)		0.003
=6 (Almost all 80-99%)		0.014
=7 (All 100%)		0.038
Sample Size	1632	1632

Note 1: Results are ordered probit coefficients, with robust standard errors in parentheses below

each estimate. Statistical significance at the 10%, 5%, and 1% levels, respectively, is denoted by *, **, and ***, using two-tailed tests. Reference group for industry dummies is *Wholesale* and *Retail*. Reference group for % unionized dummies is 0% *Workers Unionized*.

Note 2: The overall incremental effect of *Delegation* (for all jobs) is the average value over all sample observations of the predicted values of $Prob(Incentive\ Pay\% = j \mid Delegation = 1) - Prob(Incentive\ Pay\% = j \mid Delegation = 0)$, for j = 1, 2, ..., 7, evaluating *Exploration* at its observed value for each observation. The incremental effect of *Delegation* for "Exploration" jobs is the average value over all sample observations of the predicted values of $Prob(Incentive\ Pay\% = j \mid Exploration = 1 \text{ and } Delegation = 1) - Prob(Incentive\ Pay\% = j \mid Exploration = 1 \text{ and } Delegation = 0)$, for j = 1, 2, ..., 7. The incremental effect of *Delegation* for "Exploitation" is the average value over all sample observations of $Prob(Incentive\ Pay\% = j \mid Exploration = 0 \text{ and } Delegation = 1) - Prob(Incentive\ Pay\% = j \mid Exploration = 0 \text{ and } Delegation = 0), for j = 1, 2, ..., 7$.

TABLE 4: Probit Results: Dependent Variable = *Incentive Pay(l.o.g.)*

	Dependent Variable			
	Incentive Pay		***Incentive Pay(l.o.g.)***	
Independent Variables:				
Delegation	0.589***	0.727***	0.729***	0.800***
	(0.191)	(0.195)	(0.204)	(0.218)
Delegation x Exploration		-1.409***		-0.917*
		(0.527)		(0.542)
Exploration		0.528		0.189
		(0.400)		(0.370)
Industry Controls				
Manufacturing	-0.857***	-0.835***	-0.562	-0.566
	(0.319)	(0.307)	(0.358)	(0.357)
Electricity, Gas and Water	-1.384***	-1.305***	-0.996**	-0.954**
	(0.455)	(0.443)	(0.477)	(0.473)
Construction	-0.838**	-0.835**	-0.639*	-0.648*
	(0.423)	(0.410)	(0.362)	(0.360)
Hotels and Restaurants	-0.861***	-0.874***	-2.102***	-2.123***
	(0.330)	(0.340)	(0.364)	(0.363)
Transport and Communication	-1.108***	-1.077***	-1.240***	-1.214***
	(0.307)	(0.303)	(0.385)	(0.384)
Financial Services	0.550	0.689	0.661*	0.725**
	(0.372)	(0.360)	(0.354)	(0.357)
Other Business Services	-0.704**	-0.768**	-0.586*	-0.593
	(0.290)	(0.330)	(0.338)	(0.363)
Public Administration	-1.965***	-2.001***	-1.109	-1.144**
	(0.497)	(0.501)	(0.451)	(0.448)
Education	-3.031***	-3.353***	-2.473**	-2.532***
	(0.522)	(0.587)	(0.401)	(0.427)
Health	-2.176***	-2.266***	-2.473**	-2.461***
	(0.361)	(0.404)	(0.369)	(0.376)
Other Community Services	-1.106***	-1.070***	-0.730***	-0.718**
	(0.366)	(0.367)	(0.367)	(0.368)
Firm Controls				
Single-Establishment Firm	0.018	0.021	-0.216	-0.216

	(0.210)	(0.207)	(0.260)	(0.259)
Fixed Term Workers Over One Year	0.301	0.408	0.275	0.361
	(0.266)	(0.270)	(0.305)	(0.296)
Fixed Term Workers Under One Year	0.055	0.136	0.078	0.138
	(0.173)	(0.172)	(0.192)	(0.197)
Operation Over Five Years	0.513**	0.474**	0.639**	0.612**
	(0.231)	(0.227)	(0.300)	(0.287)
Main Activity of Establishment	0.278	0.234	0.347	0.312
	(0.211)	(0.212)	(0.242)	(0.240)
Temporary Workers	0.149	0.094	0.455**	0.424**
	(0.179)	(0.179)	(0.182)	(0.183)
Establishment Size	0.188	0.188	0.124	0.124
	(0.136)	(0.131)	(0.107)	(0.106)
Fraction of Part Time Workers	-0.618	-0.505	-0.514	-0.468
	(0.403)	(0.384)	(0.445)	(0.443)
Number of Recognized Unions	0.176***	0.163**	0.045	0.042
	(0.068)	(0.069)	(0.105)	(0.105)
100% Workers Unionized	-0.428	-0.462	0.016	0.000
	(0.293)	(0.295)	(0.325)	(0.322)
80-99% Workers Unionized	-0.145	-0.108	-0.146	-0.128
	(0.252)	(0.263)	(0.305)	(0.311)
60-79% Workers Unionized	-0.697***	-0.709***	-0.477	-0.491
	(0.266)	(0.273)	(0.318)	(0.320)
40-59% Workers Unionized	-0.462	-0.471	-0.709	-0.717
	(0.378)	(0.374)	(0.483)	(0.480)
20-39% Workers Unionized	0.446	0.509	-0.285	-0.263
	(0.549)	(0.529)	(0.419)	(0.449)
1-19% Workers Unionized	-1.364**	-1.396***		
	(0.550)	0.536		
Risk	0.427*	0.488	-0.732***	-0.756
	(0.241)	(0.229)	(0.245)	(0.542)

Constant	-0.630 (0.623)	-0.663 (0.634)	-1.893*** (0.639)	-1.898*** (0.623)
Incremental Effect of *Delegation*				
Overall (All Jobs)	0.126	0.116	0.111	0.108
Exploration Jobs		-0.129		-0.014
Exploitation Jobs		0.153		0.123
Sample Size	1214	1214	1214	1214

Note 1: This table is the same as Table 2 except that it includes the variable *Risk* as a control. Results are probit coefficients, with robust standard errors in parentheses below each estimate. Statistical significance at the 10%, 5%, and 1% levels, respectively, is denoted by *, **, and ***, using two-tailed tests. Reference group for industry dummies is *Wholesale* and *Retail*. Reference group for % unionized dummies is 0% *Workers Unionized*.

Note 2: The overall incremental effect of *Delegation* (for all jobs) is the average value over all sample observations of the predicted values of $Prob(\textit{Incentive Pay(l.o.g.)} = 1 \mid \textit{Delegation} = 1) - Prob(\textit{Incentive Pay(l.o.g.)} = 1 \mid \textit{Delegation} = 0)$ evaluating *Exploration* at its observed value for each observation. The incremental effect of *Delegation* for "Exploration" jobs is the average value over all sample observations of the predicted values of $Prob(\textit{Incentive Pay(l.o.g)} = 1 \mid \textit{Exploration} = 1 \text{ and } \textit{Delegation} = 1) - Prob(\textit{Incentive Pay(l.o.g)} = 1 \mid \textit{Exploration} = 1 \text{ and } \textit{Delegation} = 0)$. The incremental effect of *Delegation* for "Exploitation" is the average value over all sample observations of $Prob(\textit{Incentive Pay(l.o.g)} = 1 \mid \textit{Exploration} = 0 \text{ and } \textit{Delegation} = 1) - Prob(\textit{Incentive Pay(l.o.g)} = 1 \mid \textit{Exploration} = 0 \text{ and } \textit{Delegation} = 0)$.

TABLE 5: Ordered Probit Results: Dep. Var. = *Incentive Pay%*

	Dependent Variable: Incentive Pay%	
Independent Variables:		
Delegation	0.460**	0.622***
	(0.193)	(0.198)
Delegation x Exploration		-1.601***
		(0.539)
Exploration		0.614*
		(0.352)
Industry Controls		
Manufacturing	-0.785**	-0.753**
	(0.310)	(0.296)
Electricity, Gas and Water	-1.023**	-0.916**
	(0.454)	(0.420)
Construction	-0.948**	-0.918***
	(0.371)	(0.353)
Hotels and Restaurants	-1.444***	-1.488***
	(0.312)	(0.315)
Transport and Communication	-0.973***	-0.928***
	(0.295)	(0.289)
Financial Services	0.704**	0.865**
	(0.347)	(0.338)
Other Business Services	-0.584**	-0.671**
	(0.289)	(0.320)
Public Administration	-1.314***	-1.351
	(0.406)	(0.410)
Education	-2.457***	-2.817***
	(0.447)	(0.515)
Health	-1.993***	-2.102***
	(0.389)	(0.424)
Other Community Services	-0.559	-0.505
	(0.350)	(0.347)
Firm Controls		
Single-Establishment Firm	0.097	0.093
	(0.184)	(0.183)
Fixed Term Workers Over One Year	0.151	0.289

	(0.259)	(0.252)
Fixed Term Workers Under One Year	0.277	0.375**
	(0.185)	(0.189)
Operation Over Five Years	0.290	0.251
	(0.234)	(0.227)
Main Activity of Establishment	0.085	0.027
	(0.214)	(0.214)
Temporary Workers	0.130	0.072
	(0.186)	(0.186)
Establishment Size	0.099	0.100
	(0.097)	(0.095)
Fraction of Part Time Workers	-0.497	-0.355
	(0.402)	(0.376)
Number of Recognized Unions	0.167**	0.155*
	(0.078)	(0.078)
100% Workers Unionized	-0.062	-0.085
	(0.254)	(0.253)
80-99% Workers Unionized	-0.254	-0.225
	(0.269)	(0.288)
60-79% Workers Unionized	-0.483*	-0.492*
	(0.282)	(0.288)
40-59% Workers Unionized	-0.351	-0.361
	(0.427)	(0.421)
20-39% Workers Unionized	0.820	0.896
	(0.623)	(0.582)
1-19% Workers Unionized	-1.435**	-1.481***
	0.579	0.573
Risk	-0.482**	-0.571***
	(0.241)	(0.212)
Cutoff 1	1.197**	1.294**
	(0.522)	(0.520)
Cutoff 2	1.323**	1.421***
	(0.522)	(0.524)
Cutoff 3	1.429***	1.527***
	(0.552)	(0.554)

Cutoff 4	1.586***	1.685***
	(0.546)	(0.547)
Cutoff 5	1.653***	1.753***
	(0.545)	(0.547)
Cutoff 6	1.984***	2.087***
	(0.554)	(0.556)
Incremental Effect of *Delegation*		
Overall (All Jobs)		
=1 (None 0%)	-0.084	-0.080
=2 (Just a few 1-19%)	0.007	0.006
=3 (Some 20-39%)	0.006	0.005
=4 (Around half 40-59%)	0.009	0.008
=5 (Most 60-79%)	0.004	0.003
=6 (Almost all 80-99%)	0.017	0.015
=7 (All 100%)	0.042	0.043
Exploration Jobs		
=1 (None 0%)		-0.015
=2 (Just a few 1-19%)		-0.014
=3 (Some 20-39%)		-0.012
=4 (Around half 40-59%)		-0.017
=5 (Most 60-79%)		-0.007
=6 (Almost all 80-99%)		-0.030
=7 (All 100%)		-0.074
Exploitation Jobs		
=1 (None 0%)		0.111
=2 (Just a few 1-19%)		0.009
=3 (Some 20-39%)		0.008
=4 (Around half 40-59%)		0.011
=5 (Most 60-79%)		0.005
=6 (Almost all 80-99%)		0.021
=7 (All 100%)		0.056

Sample Size	1187	1187

Note 1: This table is the same as Table 3 except that it includes the variable *Risk* as a control. Results are ordered probit coefficients, with robust standard errors in parentheses below each estimate. Statistical significance at the 10%, 5%, and 1% levels, respectively, is denoted by *, **, and ***, using two-tailed tests. Reference group for industry dummies is *Wholesale* and *Retail*. Reference group for % unionized dummies is 0% *Workers Unionized*.

Note 2: The overall incremental effect of *Delegation* (for all jobs) is the average value over all sample observations of the predicted values of $Prob(\textit{Incentive Pay\%} = j \mid \textit{Delegation} = 1) - Prob(\textit{Incentive Pay\%} = j \mid \textit{Delegation} = 0)$, for j = 1, 2, ..., 7, evaluating *Exploration* at its observed value for each observation. The incremental effect of *Delegation* for "Exploration" jobs is the average value over all sample observations of the predicted values of $Prob(\textit{Incentive Pay\%} = j \mid \textit{Exploration} = 1$ and $\textit{Delegation} = 1) - Prob(\textit{Incentive Pay\%} = j \mid \textit{Exploration} = 1$ and $\textit{Delegation} = 0)$, for j = 1, 2, ..., 7. The incremental effect of *Delegation* for "Exploitation" is the average value over all sample observations of $Prob(\textit{Incentive Pay\%} = j \mid \textit{Exploration} = 0$ and $\textit{Delegation} = 1) - Prob(\textit{Incentive Pay\%} = j \mid \textit{Exploration} = 0$ and $\textit{Delegation} = 0), forj = 1, 2, ..., 7.$

References

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

Alonso, R., and N. Matouschek (2008): "Optimal Delegation," *Review of Economic Studies*, 75(1), 259–293.

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

Bester, H., and D. Krahmer (2008): "Delegation and Incentives," *Rand Journal of Economics*, 39(3), 664–682.

Colombo, M., and M. Delmastro (2004): "Delegation of Authority in Business Organization: An Empirical Test," *Journal of Industrial Economics*, 52(1), 53–80.

Cully, M., S. Woodland, A. O'Reilly, and G. Dix (1999): *Britain at Work: As Depicted by the 1998 Workplace Employee Relations Survey*. Routledge, London.

Demski, J., and R. Dye (1999): "Risk, Return, and Moral Hazard," *Journal of Accounting Research*, 37(1), 27–55.

Dessein, W. (2002): "Authority and Communication in Organizations," *Review of Economic Studies*, 69, 811–838.

DeVaro, J., and F. Kurtulus (2009): "An Empirical Analysis of Risk, Incentives, and the Delegation of Worker Authority," *Industrial and Labor Relations Review (forthcoming)*.

Ederer, F., and G. Manso (2008): "Is Pay-for-Performance Detrimental to Innovation?," *Working Paper*.

Foss, N., and K. Laursen (2005): "Performance Pay, Delegation, and Multitasking under Uncertainty and Innovativeness: An Empirical Investigation," *Journal of Economic Behavior and Organization*, 58(2), 246–276.

Hellmann, T., and V. Thiele (2008): "Incentives and Innovation: A Multitasking Approach," *Working Paper*.

Hirshleifer, D., and Y. Suh (1992): "Risk, Managerial Effort and Project Choice," *Journal of Financial Intermediation*, 2, 308–345.

Holmstrom, B. (1979): "Moral Hazard and Observability," *Bell Journal of Economics*, 10, 74–91.

HOLMSTROM, B., AND P. MILGROM (1991): "Multitask Principal-Agent Analysis: Incentive Contracts, Job Ownership and Asset Design," *Journal of Law, Economics and Organization*, 7, 24–52.

ITOH, H., T. KIKUTANI, AND O. HAYASHIDA (2008): "Complementarities among authority, accountability, and monitoring: Evidence from Japanese business groups," *Journal of The Japanese and International Economies*, 22(2), 207–228.

JENSEN, M., AND W. MECKLING (1992): *Contract Economics*chap. Specific and General Knowledge, and Organizational Structure. Blackwell, Oxford.

MACLEOD, B., AND D. PARENT (1999): *Research in Labor Economics (S. Polacheck, Eds.)*chap. Job Characteristics and the Form of Compensation. JAI, Stamford, Conn.

MANSO, G. (2009): "Motivating Innovation," *Working Paper*.

MARCH, J. (1991): "Exploration and Exploitation in Organizational Learning," *Organization Science*, 2(1), 71–87.

MARINO, A., AND J. MATSUSAKA (2005): "Decision Processes, Agency Problems, and Information: An Economic Analysis of Capital Budgeting Procedures," *The Review of Financial Studies*, 18(1), 301–325.

MEAGHER, K., AND A. WAIT (2008): "Who Decides about Change and Restructuring in Organizations?," *Working Paper*.

MOOKHERJEE, D. (2006): "Decentralization, Hierarchies and Incentives: A Mechanism Design Perspective," *Journal of Economic Literature*, 44(2), 367–390.

NAGAOKA, S., AND H. OWAN (2008): "Intrinsic and Extrinsic Motivation for Inventors," *Working Paper*.

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

ORTEGA, J. (2009): "Employee Discretion and Performance Pay," *The Accounting Review*, 84(2), 589–612.

PRENDERGAST, C. (2002): "The Tenuous Trade-off between Risk and Incentives," *Journal of Political Economy*, 110(5), 1071–1102.

RAITH, M. (2008): "Specific Knowledge and Performance Measurement," *Rand Journal of Economics*, 39(4), 1059–1079.

RANTAKARI, H. (2008): "Uncertainty, Delegation and Incentives," *Working Paper*.

Shavell, S. (1979): "Risk Sharing and Incentives in the Principal and Agent Relationship," *Bell Journal of Economics*, 10(1), 55–73.

Wulf, J. (2007): "Authority, Risk, and Performance Incentives: Evidence from Division Manager Positions Inside Firms," *Journal of Industrial Economics*, 55(1), 169–196.