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Abstract

A large literature, both theoretical and empirical, suggests that delegation of authority and incentives should have a positive relationship. Using data from a large cross section of British establishments, we show that the positive relationship between incentives and delegation that has been consistently documented in the empirical literature masks a stark difference between job types. We classify jobs into two categories: *complex* jobs include professional, technical and scientific occupations and *simple* jobs consist of all other occupations with a lower-level code in the Standard Occupational Classification (SOC) system. We find that for simple jobs, the relationship between delegation and incentives is positive as has been found in the previous literature, whereas for complex jobs it is negative. To explain this negative relationship for complex jobs, we develop a model where tasks have a risk-return tradeoff and where a single performance measure has to induce both task selection and effort. We find that if tasks vary sufficiently by risk and return and if effort is noisy to measure, then delegation and incentives have a negative relationship.

1 Introduction

A central question in organizations concerns the allocation of decision rights. That is, to what extent should workers be given the authority to select the tasks they perform on the job? Delegating authority to workers can be beneficial because workers often have better information about the tasks they perform than their employers. But workers' preferences over these tasks may differ from those of their employer,

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and this mismatch in preferences biases worker decisions. The resulting tradeoff between information and bias in decision making 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 choosing tasks and making other decisions, workers place less weight on their private benefits and more weight on the expected returns to their employer. Thus, authority and incentives are positively related.

This theoretical prediction has motivated an empirical literature to identify the sign of the relationship between authority and incentives. Some of the evidence is based on particular industries or types of jobs. Nagar (2002) finds that bank managers with more authority receive more incentive-based pay. Colombo and Delmastro (2004) analyze a sample of manufacturing plants and their parent companies in the Italian metalworking sector, finding that delegating authority to the plant manager is more likely when monetary incentives are introduced. Wulf (2007) uses compensation survey data on division managers and finds that corporate officers with broader authority (for example, presidents, vice presidents and Chief Financial Officers of a business unit, division, or function) are more likely than non-officers with less authority to have their pay tied to global performance measures such as firm sales growth. 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. Other evidence is based on broader cross sectional samples of workers spanning a variety of industries and job types. MacLeod and Parent (1999) find that workers with more "autonomy" are more likely to be paid commissions. Foss and Laursen (2005), using data on Danish firms, and DeVaro and Kurtulus (2010), using survey data on British establishments, find a positive relationship between delegation and incentives.

Consistent with the theoretical prediction, all of the preceding empirical studies have found a positive relationship between delegation and incentives.[2] However, striking counterexamples can be seen in certain jobs. Consider the following example involving cardiac surgeons. A crucial decision that a cardiology unit must make is when to perform a surgical procedure like a coronary angioplasty on a patient. For some patients, surgery may be a routine procedure with low risks. For other patients, surgery may yield very high returns but this comes with substantial risk. The unit must thus decide on a threshold level of risk-return above which surgeries are not performed. The unit has two alternatives for delegating authority. One is to review all of the patients that a surgeon sees and verify the patient's

[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 is a bivariate correlation appearing in Table 5 of Ortega (2009), based on cross sectional data from the EU-15 group.

risk-return characteristics before recommending surgery. Another is to leave the decision to operate with a surgeon. Noting that a common performance measure used for incentives in cardiac units is whether a patient survives surgery, consider what happens when a surgeon who can select a treatment plan has his pay tied more closely to his patients' mortality rates. Because this incentive scheme imposes risk on the surgeon, a risk-averse surgeon may choose not to operate on a high-risk patient even though surgery might help that patient. In fact, survey evidence suggests that in an overwhelming number of cases, incentives based on mortality rates lead surgeons to avoid risky but potentially beneficial surgeries.[3] Such behavior has negative implications both for the reputation of the cardiology unit and for public health.

The preceding example highlights a tradeoff that the cardiology unit faces when it strengthens incentives. Incentive pay can induce a surgeon to work harder but at the same time distorts the surgeon's decisions concerning how to treat patients. If effort is very noisy (as is the case with surgeons), the benefits from increased effort are outweighed by the costs of distortions in treatment plans. This in turn suggests that incentives must be muted when surgeons can select treatment plans for patients. We believe that this tradeoff between inducing effort and selecting tasks is not unique to cardiac surgeons and that it plays a role in many other high-level jobs. For example, tying academics' pay to the number of research papers published leads to academics pursuing safe research topics and publication strategies. Tying scientists' pay to the commercial success of a product leads scientists to be cautious when developing features of a product. Likewise, legal and financial advisors are likely to give conservative advice if their pay depends on final outcomes. Note that in all of these examples, effort is noisy to measure, which reduces the benefits of incentive pay.

These counterexamples to the standard theoretical prediction provide the motivation for this paper, which is to explore how the relationship between incentives and delegation varies across occupations. We classify jobs into two broad categories. *Complex* jobs are those for which task selection is valuable and for which effort is noisy to measure, as in the preceding examples. The jobs we include in this category are professional, and technical and scientific jobs, which are higher-level codes in the Standard Occupational Classification (SOC) system. *Simple* jobs, on the other hand, consist of clerical and secretarial occupations, craft and skilled manual occupations, personal service occupations, sales occupations, operative and assembly manual occupations, and routine unskilled manual occupations. We believe that in most cases task selection is less valuable and that effort is easier to measure for these jobs.[4]

[3] "Cardiologists Say Rankings Sway Choices on Surgery", *The New York Times*, January 11, 2005. Also see Leventis (1997) and Dranove, Kessler, McClellan, and Satterthwaite (2003) for empirical work on this topic.

[4] The following examples motivate our assumption that effort is more noisy to measure in the case of complex jobs. For the case of a windshield installer, which is classified as a simple job, it is

Using data from the 1998 British WERS – a nationally representative survey of British establishments that also contains survey information from up to 25 workers per establishment – we document a new empirical finding, namely that the positive relationship between incentives and delegation that has been reported in the empirical literature masks a stark difference between these two broad job types. We find that for simple jobs, the relationship between delegation and incentives is positive, as has been found in the previous literature, whereas for complex jobs it is negative, as in the example involving cardiac surgeons.

Documenting this new empirical result is the first contribution of the paper. The second contribution is to provide a potential theoretical explanation for the negative relationship between delegation and incentives for complex jobs. To do this, we develop a model with two features that are central to the example involving cardiac surgeons. The first is that a worker who is delegated authority can select the tasks on which he exerts effort, and these tasks have a positive risk-return tradeoff. Second, employers only have a single performance measure with which to induce both task selection and effort. These two features lead to a simple tradeoff. Stronger incentives on the performance measure, as is standard in many agency models, induce higher effort. But stronger incentives on the performance measure also lead the worker (when given authority to choose tasks) to inefficiently select a low risk-return task. Thus the employer must decide whether to induce effort or task selection. When tasks vary sufficiently in terms of their return and when output is a noisy measure of effort, then the employer prefers to induce task selection. And when tasks vary sufficiently by risk, this leads to a negative relationship between delegation and incentives. We think that this sufficient condition for the negative relationship between authority and incentives, i.e. high variation in task risk and returns and noise in measuring effort, is likely to hold in many jobs in the "complex" category.

Our work is related to some other theory papers that examine incentives for project selection. Jensen and Meckling (1976) consider a setting where projects vary by risk and return to study optimal capital structure. Their focus, however, is on excessive risk taking induced by debt contracts. 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) 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. Lambert (1986) and Core and Qian (2002) also study incentives for the selection of risky projects. Athey and Roberts (2001) show that in a setting with multiple agents, relative performance evaluation mitigates the adverse effects of risk that are

relatively easy to back out the effort of an installer by checking the windshield. For the case of a cardiac surgeon, on the other hand, it may be more difficult to back out the actions that a surgeon took at the end of a surgery.

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. Their framework is different because they do not have a positive risk-return tradeoff across projects. Our paper is also similar in spirit to Baker (1992) in that performance measures are limited in terms of inducing efficient outcomes. In his setting, however, the limitation arises from a divergence between the true benefit of the principal and the performance measure, whereas in our framework the limitation arises because the performance measure cannot disentangle effort from task selection. In both his paper and ours, noise associated with the performance measure and risk aversion of the agent make the problem worse. Recent papers by Manso (2011) and Ederer and Manso (2008) show how tolerating early failure in a dynamic setting encourages innovation. Once again, they do not consider a positive risk-return tradeoff across projects. Furthermore, they do not consider delegation of authority, nor do they conduct empirical tests.[5] In independently developed work, Lando (2004) constructs an example with a positive risk-return tradeoff across projects where delegation and incentives can be substitutes. His focus, however, is on the relative distortions between a principal and agent choosing projects when both cannot commit in advance to the projects they choose.

Our paper also relates 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. 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)). Raith (2008) is another paper outside of a delegation framework that studies incentives when an agent has better information (i.e. specific knowledge) than the principal. Finally, Van den Steen (2007) considers a setting where the principal and agent differ in their priors and focuses on a different notion of authority, based on the agent obeying orders. He finds that agents at the receiving end of authority (i.e. who are given orders by a principal) optimally have lower powered incentives.

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

2 Data and Empirical Analysis

In this section we provide empirical evidence concerning how the relationship between incentives and authority differs between complex and simple jobs. Our data are 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.[6] 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.[7] 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.[8]

A set of inverse probability sampling weights accompanies the 1998 WERS, and applying those "establishment weights" is necessary to ensure that the resulting statistics reflect a nationally representative sample of British workplaces. The sampling weights adjust for a number of factors influencing the probability of selection, including establishment size, major SIC group, and whether the establishment was included in the 1990 WIRS (the predecessor of the 1998 WERS). For details see pages 124-126 of Section 7.1 of the 1998 WERS technical appendix, Cully (1999). We use these weights throughout the analysis, referring to all results as "establishment weighted".

To distinguish complex from simple jobs, we rely on one-digit and two-digit Standard Occupational Classification (SOC) codes for each establishment's largest occupational group. There are nine one-digit codes, and we rely on these categoriza-

[6] Although a 2004 wave of the survey is available, for our purposes the 1998 wave is superior for two reasons. First, it contains more information on incentive pay within the establishment. Second, using the 1998 data means that our results are directly comparable to those in DeVaro and Kurtulus (2010) which used the same data set and the same measures of the key variables to examine the relationship between incentive pay and delegation, neglecting the distinction between complex and simple jobs.

[7] 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 the private and public sectors. If a case is sampled that does not meet these parameters, it is called "out of scope."

[8] Our measures of the 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 (2010).

tions to define jobs broadly as either complex or simple in the following definition:

Complex = 1 if the establishment's largest occupational group is "Professional occupations" or "Technical, scientific occupations" (= 0 if the establishment's largest occupational group is "Clerical and secretarial occupations" or "Craft and skilled manual occupations" or "Personal service occupations" or "Sales occupations" or "Operative and assembly manual occupations" or "Routine unskilled manual occupations").

Panel 1 of Appendix A displays the detailed two-digit and three-digit codes underlying the broad occupational group we refer to as "complex jobs". Panel 2 displays the one-digit codes underlying the group we define as "simple jobs". Although our categorization of jobs was the most reasonable two-group classification that occurred to us, we acknowledge that any binary cut of occupations into broad categories such as "complex" and "simple" is arbitrary, and it will be possible to identify certain jobs within those categories for which the classification is questionable.

A small number of observations (i.e. 14) have the establishment's largest occupational group reported as "Managers and senior administrative occupations". It seems rather unusual to us that this group would be the largest in any organization (i.e. in the typical case observed in practice and described by theoretical models, a manager would be supervising other workers). For this reason, and given that we are particularly interested in studying occupations that have not been examined in previous work, (namely non-managerial occupations to which two of our three measures of incentive pay pertain), we drop these 14 observations. In some sense, we believe that the positive relationship between incentive pay and delegation should hold for managers. We find that if we add managers to the analysis, our results weaken a bit, as we would expect.

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).[9]

A potential criticism of our first measure is that an establishment might be

[9] The survey asks what measures of performance are used for awarding incentive pay to non-managerial workers who are eligible for it (i.e. "1 = Individual performance / output", "2 = Group or team performance / output", "3 = Workplace-based measures", "4 = Organisation-based measures"). We classify the incentive pay measure as 0 if "individual performance / output" was not one of the reported performance criteria, so the measure equals 1 only when we can be certain 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 the incentive pay measure as 1, following DeVaro and Kurtulus (2010).

classified as using incentive pay even if very few workers (perhaps just a single worker) receive such pay. Our second and third measures are 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 *Complex* is defined with respect to the establishment's largest occupational group, which strengthens the compatibility between *Complex* 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 9).

Our third binary measure, capturing whether non-managerial workers at the establishment received individual performance-related pay in the last year, is defined as follows:[10]

Incentive Pay (n.m.) = 1 if at least some non-managerial workers received individual performance-related pay in the last year (= 0 otherwise).

As with our first two measures, we corrected the third measure to ensure that it pertains to individual-based performance-related schemes (see footnote 9).

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?"

Potential responses were "a lot", "some", "a little", and "none." Since our measures of incentive pay and *Complex* 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 (2010).[11] 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").

[10] In the raw data this measure appears as polychotomous with the following 7 categories: 1 = "None 0%", 2 = "Just a few 1-19%", 3 = "Some 20-39%", 4 = "Around half 40-59%", 5 = "Most 60-79%", 6 = "Almost all 80-99%", 7 = "All 100%".

[11] In DeVaro and Kurtulus (2010) the results were largely unaffected if worker responses were aggregated to the establishment level using the median rather than the modal response. In the present context our results are more sensitive to this alternative measure, and the coefficient of the key interaction term becomes statistically insignificant.

The control variables are defined in Appendix B 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, 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. Descriptive statistics for all variables in our analysis are displayed in Table 1.

The conventional wisdom from the previous theoretical literature is that delegation and incentive pay are positively related. In Prendergast (2002), two key elements drive the positive relationship: workers get private benefits from tasks, and firms can monitor worker effort. Without delegation, firms always monitor workers because it is a more effective instrument than output based pay to induce effort. On the other hand, when authority is delegated to a worker, inducing task selection is also important, and the only way to do this is through output based pay. This leads to the positive relationship between delegation and incentive pay. In Holmstrom and Milgrom (1991), private benefits once again play an important role. The other important feature in their framework is that some tasks are unproductive. Strengthening incentives on the productive task (i.e. output) then increases the opportunity cost of unproductive tasks, leading to a larger set of allowable tasks for the worker. A number of empirical studies have found support for this theoretical prediction of a positive relationship between delegation and incentive pay (e.g. DeVaro and Kurtulus (2010), Itoh, Kikutani, and Hayashida (2008), Wulf (2007), Foss and Laursen (2005), Colombo and Delmastro (2004), Nagar (2002), MacLeod and Parent (1999)).

We begin by estimating the standard relationship between incentive pay and authority, neglecting the distinction between complex and simple jobs. Consistent with previous empirical work, we also find a positive relationship between delegation and incentive pay. This positive 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 B. 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 0.066 (from 0.169 to 0.236) in the predicted probability that *Incentive Pay* = 1.

Column 2 of Table 2 includes the interaction *Delegation*$\times$*Complex* in the probit model and reveals the main empirical result of the paper. If the coefficient on this interaction were zero, then the relationship between delegation and incentive pay would not differ between the "complex" and "simple" jobs (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 0.053 (from 0.172 to 0.225) in the predicted probability that *Incentive Pay* = 1. However, this masks a pronounced difference between complex and simple jobs. For complex jobs, an increase in *Delegation* from 0 to 1 is associated, on average, with a decrease of 0.132 (from 0.238 to 0.106) in the predicted probability that *Incentive Pay* = 1. In contrast, for simple jobs, an increase in *Delegation* from 0 to 1 is associated, on average, with an increase of 0.094 (from 0.157 to 0.251) 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*. Finally, columns 5 and 6 of Table 2 are analogous to columns 1 and 2, respectively, but using our third measure of incentive pay, *Incentive Pay(n.m.)*, as the dependent variable. Again, the results are qualitatively the same in this case. In summary, across all three measures the empirical results suggest that the relationship between incentives and delegation is positive only for simple jobs and that it is negative for complex jobs. [12]

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 (2010)). To account for this tradeoff, we define the following risk measure from the management survey, following DeVaro and Kurtulus (2010):

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

Table 3 replicates Table 2, including *Risk* as a control variable in all models. Our main result concerning a negative relationship between incentives and authority holds even in the presence of *Risk* as a control. Furthermore, the *Risk* coefficient has the expected sign (negative) and is statistically significant, revealing a risk-incentives

[12] 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 "complex" 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.

tradeoff.

It is also interesting to see how the incremental effects of delegation on incentive pay change when we control for risk in our analysis. To examine this question, we compare incremental effects of delegation on the variable *Incentive Pay* between Tables 2 and 3, restricting our attention to the subsample of tradeable goods and services (for which our definition of risk applies). For simple jobs, the incremental effects for delegation is 13.8 percent when risk is not controlled for (in the restricted version of Table 2) and 14.7 percent when risk is controlled for (in Table 3). Thus controlling for risk strengthens the positive relationship between delegation and incentive pay for simple jobs. This finding is consistent with Prendergast (2002) if we allow for risk aversion in his framework, because firms are more likely to delegate authority in uncertain settings where the value of a worker's private information is higher. This increases the risk premium paid to a worker which in turn leads to weaker incentive pay when the regression omits a control for risk.

For complex jobs, however, we see the opposite result. The incremental effect of delegation on *Incentive Pay* is -9.4 percent when risk is not controlled for (in the restricted version of Table 2) and -11.0 percent when risk is controlled for (in Table 3). Thus controlling for risk, makes the incremental effect of delegation even more negative for complex jobs, which is unexpected in light of Prendergast (2002). The key difference is that whereas the theory in Prendergast (2002) predicts a positive relationship between risk and delegation of authority, the empirical relationship is actually negative for complex jobs. One interpretation for this negative relationship is that in complex jobs a worker's private information might arise from specialized skills that he has acquired from doing his work rather than from knowing market conditions better. For example, authority is delegated to a cardiac surgeon based on his superior knowledge in evaluating patient characteristics rather than his knowledge of market conditions.

To get a feel for which jobs within the "complex" category might be driving our results, we replicated the analysis in Table 2, but dropping professionals from the analysis so that *Complex* includes only those in science and technology. The coefficients of *Delegation*$\times$*Complex* for our three incentive measures along with the t statistics in parentheses are as follows: -1.244 (2.15) for the variable *Incentive Pay*, -1.714 (3.15) for the variable *Incentive Pay(l.o.g.)*, and -1.976 (2.77) for the variable *Incentive Pay (n.m.)*. Thus, when we only consider science and technology in the complex category, our coefficients of interest are negative and statistically significant at conventional levels for all three incentive measures.

Next, we replicated the analysis in Table 2, but dropping the category Science and Technology from the analysis so that *Complex* includes only professionals. The coefficients of *Delegation*$\times$*Complex* for our three incentive measures along with the t statistics in parentheses are as follows: -0.916 (2.11) for the variable *Incentive Pay*, -0.440 (0.96) for the variable *Incentive Pay(l.o.g.)*, and -1.000 (2.06) for the variable *Incentive Pay (n.m.)*. Thus, when we only consider professionals in the complex category, our coefficients of interest are negative for all three incentive measures and statistically significant at conventional levels for two of them.

A potential concern is that the occupations that comprise the core of the analysis might be highly correlated with industry, which could have the following implication. Since our three basic empirical models omit interactions between the industry dummies and the delegation variable, it may be that the coefficient of *Delegation* $\times$ *Complex* in these models is only reflecting the effects of these omitted interactions. In exploring this possibility, we found that within the category of "*Complex*", it is true that there is a fair amount of overlap between the industry categories and the "largest occupational group" categories. To isolate which individual industry-delegation interactions (if any) might be driving our main result, we experimented with adding different configurations of these interactions as controls in our empirical models. For two of our three dependent variables (*Incentive Pay* and *Incentive Pay (n.m.)*) we found that our main result is robust to the inclusion of any such configuration. In the *Incentive Pay* model that includes all industry-delegation interactions, the coefficient of *Delegation* is 0.724 with a t-statistic of 2.25, and the coefficient of *Delegation* $\times$ *Complex* is -0.753 with a t-statistic of 1.66. Similarly, if the full set of interactions are included in the *Incentive Pay (n.m.)* model, the coefficient of *Delegation* is 0.390 with a t-statistic of 1.37, and the coefficient of *Delegation* $\times$ *Complex* is -1.156 with a t-statistic of 2.55.

For the model in which the dependent variable is *Incentive Pay(l.o.g.)* we found that our main result is sensitive to the inclusion of the interaction of delegation and the "Other Business Services" industry. This particular industry accounts for ten percent of sample and twenty percent of the subsample of "complex" jobs. In any configuration of industry-delegation controls that includes this particular interaction, the coefficient of *Delegation* $\times$ *Complex* becomes statistically insignificant, whereas in any configuration that omits this particular interaction our main result continues to hold. For example, in the model that includes all industry-delegation interactions except that for "other business services", the coefficient of *Delegation* is 0.735 with a t-statistic of 2.50, and the coefficient of *Delegation* $\times$ *Complex* is -0.846 with a t-statistic of 1.86. The fact that our main result is sensitive to industry-delegation controls (for the case of "other business services") for one of our three dependent variables suggests that industry, as well as occupation, may play an important role in moderating the relationship between delegation and incentive pay and that future theoretical work aimed at elucidating the role of industry would be valuable. The fact that industry matters is not surprising given that the nature of work is known to vary across industries, as demonstrated by Neal (1995) and others, and our basic argument is fundamentally about the nature of work, which is related both to occupation and to industries.

To summarize, our key empirical finding is that the positive relationship between incentives and delegation that has been reported in the empirical literature masks a stark difference between jobs. We find that for simple jobs, the relationship between delegation and incentives is positive, as has been found in the previous literature. For complex jobs, in contrast to the previous literature, we find that the relationship between delegation and incentive pay is negative.

As a final point before turning to the theory, given that DeVaro and Kurtulus (2010) found support for a positive relationship between risk and authority without distinguishing across occupations, it is interesting to consider this relationship while discriminating between complex and simple jobs. To do so, we estimated an ordered probit model in which the dependent variable was the four-valued authority measure. The independent variable, *Risk*, had a positive and significant coefficient. The incremental effect of *Risk* on the probability that the authority measure has the highest outcome was 0.096 in the model that omits the dummy variable for "complex versus simple jobs" and its interaction with *Risk*. In the model that includes these variables, the coefficient of *Risk* remained positive and significant ($t = 2.48$), and the coefficient of the interaction was negative with $t =$ -1.51. The incremental effect just mentioned became 0.102 in this model; when the incremental effect was decomposed into complex jobs and simple jobs, it became -0.047 for complex jobs and 0.140 for simple jobs.

3 Model

The objective of this section is to provide a theoretical explanation for the negative relationship between delegation and incentive pay when jobs are complex. In our model, we abstract from private benefits of workers (which is a key element in previous theoretical work), and instead focus on two key features that we believe are central to our example on cardiac surgeons: a positive risk-return tradeoff across tasks and the inability to contract separately on tasks. Later in this section, we adapt our framework and show how the existence of private benefits leads to a positive relationship between delegation and incentive pay, and compare our findings to Holmstrom and Milgrom (1991) and Prendergast (2002).

Our model consists of a principal (the employer) and an agent (the worker). The model has four main parts: a description of how the agent can influence output, the preferences of the principal and agent, contracting assumptions, and the timing of the game along with the information that the players have at various stages of the game.

First consider how an agent can influence output. There are two tasks: a low risk-return task, L, with a return normalized to 0 and a high risk-return task, H, where returns, given by R, are normally distributed. The mean of R is given by $\bar{R}(\xi) > 0$ where $\xi \geq 0$ is a parameter. The variance of R is given by $\alpha > 0$. Thus there is a positive risk-return tradeoff across task L and task H.

Output, given by y, consists of two additively separable components. The first component is the return on tasks described above, and the second component is the output from effort, which is given by $a + \epsilon_a$, where a is the agent's effort and ϵ_a is a normally distributed variable with mean 0 and variance $\sigma_a^2 > 0$. The parameter σ_a^2 is the noise with which output measures effort. Thus

$$y = \begin{cases} a + \epsilon_a & \text{if task } L \text{ is selected} \\ a + \epsilon_a + R & \text{if task } H \text{ is selected} \end{cases}$$

We also impose the following restrictions on the function $\bar{R}$.

Assumption 1. *The function $\bar{R}$ satisfies the following properties.*

1. *$\bar{R}$ is continuous and strictly increasing in ξ.*
2. *There exists some ξ so that $\bar{R}(\xi) = \dfrac{1}{2c(1+\eta c\sigma_a^2)}$.*
3. *The function $\bar{R}(\xi)$ is bounded above by $\dfrac{1}{2c}$.*

The first part of Assumption 1 says that expected returns across tasks get larger as the parameter ξ increases. The second part of Assumption 1 says that for ξ sufficiently high, returns on task H exceed the maximum possible (second best) surplus from effort. This part ensures that the principal prefers to induce task H when ξ is sufficiently large. The third part of Assumption 1 says that returns on task H do not exceed the efficient (first best) surplus that can be generated from effort. This part ensures that there is some conflict of interest between the principal and agent over task selection.

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

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

where $\eta > 0$ is the coefficient of absolute risk aversion, w denotes wages and $\frac{ca^2}{2}$ is the agent's effort cost function, with $c > 0$.

Next consider contracts. We assume that contracts can only be written on output, y. That is, the individual components of y (effort and tasks) cannot be contracted on. As in Holmstrom and Milgrom (1991) and Prendergast (2002), we restrict our attention to linear contracts, both for tractability and to allow for a clear interpretation of the strength of incentives based on the contract slope.[13] 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

[13]Our empirical work focuses on non-managerial worker groups. The assumption of linear contracts is more reasonable for such workers than for executives, whose incentive compensation plans are comprised more heavily of nonlinear components (e.g. stock options).

higher. Because of the CARA-Normal framework, we can write the agent's certainty equivalent, denoted by CE, as follows:

$$CE = \begin{cases} t + sa - \dfrac{ca^2}{2} - \dfrac{\eta s^2 \sigma_a^2}{2} & \text{if task } L \text{ is selected} \\ t + sa + s\bar{R}(\xi) - \dfrac{ca^2}{2} - \dfrac{\eta s^2 (\sigma_a^2 + \alpha)}{2} & \text{if task } H \text{ is selected} \end{cases}$$

Finally, the timing and information structure are 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 selecting either task L or H. The agent then decides whether to participate. If he does participate, he can distinguish task L from task H at no cost. The principal, however, has to pay an information cost $C > 0$ to distinguish between tasks. We assume that the principal can select tasks only if he pays the cost C.[14] Tasks are then selected by the party that has authority, and the agent exerts 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 tasks. 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 select tasks. The subscript used for variables in this problem is d.

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

The principal's problem is

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

subject to the incentive compatibility condition associated with effort

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

and subject to the agent's participation constraint

$$CE \geq w_0 \tag{IR_n}$$

where w_0 is the agent's reservation wage.

In the delegation problem, the agent decides the task, and the optimization problem is

[14] This assumption says that the principal cannot select a task randomly when he does not bear the cost C. One way to interpret this assumption is that the cost C does not merely provide information about tasks but also gives the principal access to those tasks. An alternative way to ensure that the principal never chooses tasks when he is not informed is to assume a third task with extremely low payoffs to the principal.

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

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 task selection

$$x_d \in \quad argmax \quad CE \tag{IC_{xd}}$$

and the agent's participation constraint

$$CE \geq w_0 \tag{IR_d}$$

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. Second, the delegation problem has an additional incentive compatibility condition with respect to task selection. That is, the principal must induce both effort and task selection when he delegates authority to an agent.

Henceforth, let s_n^* and x_n^* denote the optimal levels of incentives and task choice for the no-delegation problem, and let s_d^* and x_d^* denote the optimal levels of incentives and task 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^*). Also note that since the individual rationality constraint and the incentive compatibility constraint with respect to effort are common to both the "delegation" and "no delegation" problems, we sometimes drop the subscripts, n and d, and refer to these constraints as (IR) and (IC_a).

To see how a conflict of interest with respect to tasks arises in the delegation problem, substitute the agent's individual rationality constraint into the principal's expected profit function. Then, given an incentive level s, the principal prefers task H if and only if $\bar{R}(\xi) - \frac{\eta s^2 \alpha}{2} \geq 0$, whereas the agent prefers task H if and only if $s\bar{R}(\xi) - \frac{\eta s^2 \alpha}{2} \geq 0$. Because $s \leq 1$, the agent places less weight than the principal on task returns relative to risk and is thus likely to pick task L even though the principal prefers task H. To correct this conflict, incentives must be reduced.[15] This creates a tension between inducing effort and higher return tasks when the agent is delegated authority.

[15] When $s > 0$ the agent finds task H at least as good as task L if and only if $\bar{R}(\xi) - \frac{\eta s \alpha}{2} \geq 0$. Notice that $\bar{R}(\xi) - \frac{\eta s \alpha}{2}$ is decreasing in s.

Before solving for the optimal contract, it is useful to define a cutoff level of risk, α_d, associated with task H, where $\alpha_d \equiv \frac{2\bar{R}(\xi)}{\eta}\frac{(1+\eta c\sigma_a^2)}{(1-2\bar{R}(\xi))}$. Above this cutoff level, a conflict of interests arises between the principal who wants to induce task H and an agent who prefers to select task L instead.

A job is characterized by the vector, $(\xi, \alpha, \sigma_a^2)$. Given the cutoff α_d, we define a complex job in the following way.

Definition 1. *A job is complex if* $\xi \geq \bar{R}^{-1}(\frac{1}{2c(1+\eta c\sigma_a^2)})$ *and* $\alpha > \alpha_d$.

The definition says that a job is complex if tasks vary sufficiently in terms of their expected return (ξ is sufficiently large), if output is a very noisy measure of effort (σ_a^2 is sufficiently large) and if the variation in risk across tasks given by α is strictly above a critical threshold α_d so that preferences between the principal and agent diverge with respect to task selection.[16] As we mentioned at the start of our model, our main focus is to understand how delegation and incentive pay can have a negative relationship for these complex jobs.

To solve the model, start by defining $s_L = \frac{1}{1+\eta c\sigma_a^2}$ and $s_H = \frac{1}{1+\eta c(\sigma_a^2+\alpha)}$. Note that s_L corresponds to the principal's optimal solution in the "no delegation" problem if the task is fixed at L. Likewise s_H corresponds to the principal's optimal solution in the "no delegation" problem if the task is fixed at H.

We now state the two main propositions of the paper. The proofs of the propositions are in Appendix C. The first proposition compares incentive levels across the "no delegation" and "delegation" problems. The second proposition states conditions under which authority is delegated to an agent. We say that the relationship between delegation and incentives is negative if $s_d^* < s_n^*$.

Proposition 1. *Consider a complex job. Then*

$$x_n^* = x_d^* = H$$

and

$$s_d^* = \frac{2\bar{R}(\xi)}{\eta\alpha} < s_H = s_n^*$$

Proposition 1 says that the relationship between delegation and incentive pay is negative for complex jobs. The intuition for the result is as follows. Because the return across tasks, $\bar{R}(\xi)$ exceeds the expected profit from inducing task L, the

[16] An alternative way to think of complexity is that α is strongly positively correlated to ξ and σ_a^2. To see this, suppose $\alpha = k_1\xi + k_2\sigma_a^2$. Then when ξ and σ_a^2 are large enough and when k_1 and k_2 sufficiently large and positive, then a job is complex

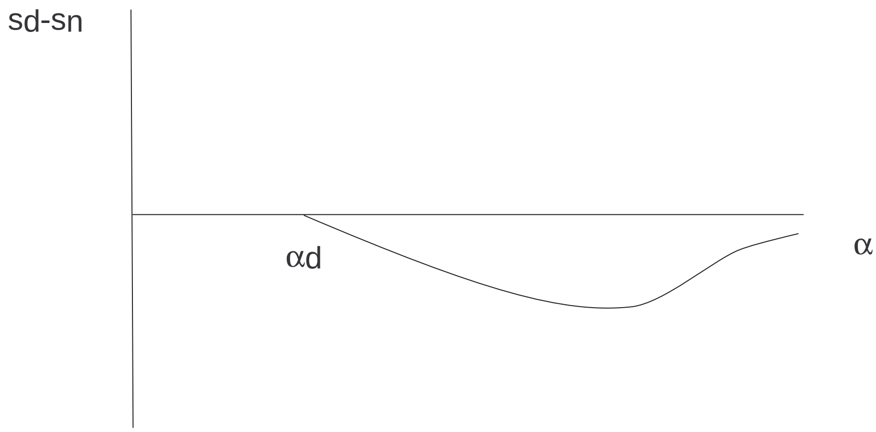

Figure 1: *Negative relationship between delegation and incentives for complex jobs.*

principal always prefers to induce task H. When $\alpha \leq \alpha_d$, there is no conflict of interests and the agent selects task H when the incentive level is s_H. However, when $\alpha > \alpha_d$, the agent's preferences diverge and the agent prefers task L. To get the risk averse agent to select task H, incentives have to be weakened, leading to a negative relationship between delegation and incentives. 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 for complex jobs.

We now provide a brief discussion (without a formal proof) about the relationship between delegation and incentive pay for jobs that are not complex.[17] There are two remaining cases to consider. In Case 1, $\alpha \leq \alpha_d$. For this case, the difference in the risk premium across tasks is low, so there is no conflict of interests with respect to task selection and $s_d^* = s_n^*$. In Case 2, $\xi < \bar{R}^{-1}(\frac{1}{2c(1+\eta c\sigma_a^2)})$ and $\alpha > \alpha_d$. For this case, there is a non-monotonicity in the relationship between delegation and incentive pay. For levels of α just above α_d the relationship is negative. For intermediate levels of α, the relationship switches to positive. This is because though the principal prefers task H in the no-delegation problem, inducing this task in the delegation problem distorts effort too much. Thus the principal induces task L instead when he delegates authority. Finally, for α very large, preferences are once again aligned between the principal and agent (they both prefer task L) and incentive levels are the same across both the delegation and no-delegation problems.

Proposition 1 characterizes the tasks selected and the incentive levels across

[17] In a previous working paper version we have formal proofs for all of these claims (DeVaro and Prasad (2011)).

both the delegation and no-delegation problems. It does not tell us when authority is delegated to an agent. The next proposition describes conditions under which authority is delegated to an agent for the case of complex jobs. Define $\bar{C}(\xi, \alpha, \sigma_a^2)$ as the critical level of the information cost above which authority is delegated to an agent for a job. A lower $\bar{C}$ indicates that the principal is more likely to delegate authority, and when $\bar{C} = 0$, the principal always delegates authority to the agent.

Proposition 2. *Consider complex jobs. Then*

1. $\bar{C}(\xi, \alpha, \sigma_a^2) = (s_H - s_d^*)(\frac{1}{c} - \frac{s_H + s_d^*}{2} - \frac{\eta(\sigma_a^2 + \alpha)(s_H + s_d^*)}{2}) > 0.$

2. $\bar{C}(\xi', \alpha, \sigma_a^2) < \bar{C}(\xi, \alpha, \sigma_a^2)$ *whenever* $\xi' > \xi$.

3. $\bar{C}(\xi, \alpha, \sigma_a^{2\prime}) < \bar{C}(\xi, \alpha, \sigma_a^2)$ *whenever* $\sigma_a^{2\prime} > \sigma_a^2$.

The first part of Proposition 2 characterizes the critical level of information cost above which authority is delegated. The last two parts say that for complex jobs, the principal is more likely to delegate authority when the expected return on task H is high and when effort is noisier to measure.[18] When the expected return on task H is high the interests of the principal and agent are more closely aligned (i.e both place more weight on task returns relative to risk). Thus, incentives do not have to be weakened as much to get the agent to choose task H. This in turn leads to lower distortions in effort in the delegation problem, which makes delegation more likely. Next, consider what happens when effort gets noisier to measure. In this case, inducing effort is more costly because of the risk premium that has to be paid to the agent. This reduces incentives across both problems (in the limit, as the noise gets very large, incentives go to 0). Once again, distortions in effort in the delegation problem are not large relative to the no-delegation problem, and the principal is more likely to delegate authority.

Combining Propositions 1 and 2, we can examine the relationship between delegation and incentives as we change three key parameters: C, ξ, and σ_a^2. First consider the information cost C. Because C is a fixed cost which does not affect optimal incentive levels in either problem, delegation is more likely as C increases.

[18]The relationship between $\bar{C}$ and α is non-monotonic. $\bar{C}$ weakly increases in α till a certain threshold level of α beyond which it strictly decreases in α. The intuition for the result is that for low levels of α, the principal's and the agent's interests are more closely aligned (i.e both place less weight on task risk relative to returns). Thus incentives do not have to be weakened as much to induce the agent to select the higher return task. This leads to lower distortions in effort for the delegation problem, which makes delegation more likely. As α gets sufficiently high, there are conflicts of interest between the principal and agent. But because the high return task is very risky, the levels of s_d^* and s_n^* are very low, and thus distortions in effort for the delegation problem are small. Once again the principal is more likely to delegate.

From Proposition 1, we know that delegation and incentives must have a negative relationship. Next, consider the parameter ξ. Start with a value of ξ where the principal prefers not to delegate, and consider an increase in ξ. From Proposition 2 we know that delegation is more likely. Furthermore, because s_H does not vary with ξ, and because $s_d^* < s_H$, we know that incentives must be lower if authority is delegated. A similar argument can be applied to the parameter σ_a^2.

It is useful at this stage to compare our model with Prendergast (2002). As mentioned earlier, we abstract from private benefits, which is a central feature in his paper. We modify our model to study private benefits in the subsection that follows. A second critical difference which drives the positive relationship in his paper is that the principal can monitor the agent's effort. This provides the principal with an effective instrument to target only effort. Thus when authority is not delegated to an agent, the principal always monitors effort. On the other hand, when authority is delegated to the agent, the principal offers an output based contract, so that the agent focuses more on task returns rather than his private benefits (which Prendergast assumes are small). This is how the positive relationship between delegation and incentive pay arises in his framework. In an extension, Prendergast (2002) does consider a case where the performance measure upon which the agent is rewarded is not aligned with output that the principal cares about. He also assumes that this misalignment between the performance measure and output can be correlated with noise with which output measures effort (which resembles our definition of complex jobs). But even for this case, because of the ability of firms to monitor workers, delegation and incentive pay are positively related.

To summarize, there are three channels through which the negative relationship between delegation and incentive pay in Table 2 can arise for complex jobs. First, it could be that complex jobs vary in terms of the information cost $\bar{C}$ (with all other parameters held fixed). In this case delegation is more likely for jobs where the information cost is high, and this leads to the negative relationship between delegation and incentive pay. Second, it could be that complex jobs vary in terms of the noise with which output is a measure of effort, σ_a^2 (with all other parameters held fixed). Delegation is more likely as σ_a^2 is higher (because distortions in effort are smaller) and incentive pay is lower because of the higher risk premium that has to be paid to the agent, again leading to a negative relationship. Finally, it could be that complex jobs vary in terms of the expected return across tasks, ξ (with all other parameters held fixed). Delegation is more likely as ξ is higher (because there is less of a conflict of interests with respect to task selection) and incentive pay is lowered to get the agent to choose task H. This again leads to a negative relationship between delegation and incentive pay.

3.1 Private Benefits

The main objective of our model was to find sufficient conditions for delegation and incentives to have a negative relationship. Our result is different from other models in the literature (e.g., Holmstrom and Milgrom (1991) and Prendergast (2002)) that have yielded a positive relationship between these variables when an agent has private benefits across tasks. In this subsection, we abstract from the risk-return tradeoff across tasks and instead focus on agents having private benefits, which allows us to compare our results with previous theoretical work. Our key contribution in this section is to show that the positive relationship between delegation and incentives still holds even if firms cannot monitor workers (as in Prendergast (2002)) and even if there are no unproductive tasks (as in Holmstrom and Milgrom (1991)).

To incorporate private benefits, we make two changes to our model. First, we assume that $\alpha = 0$ so that tasks do not vary by risk. Second, we assume that the agent has private benefits across tasks. The private benefit from task L to the agent is given by $B_L > 0$, and the private benefit from task H to the agent is given by $B_H > 0$. The following proposition says that when agents have private benefits, delegation and incentives must be positively related.

Proposition 3. *In the case where agents have private benefits, $s_d^* \geq s_n^*$.*

To see why a conflict of interests arises between the principal and agent with respect to task selection, substitute the agent's individual rationality constraint into the principal's expected profit function. Then, given an incentive level s, the principal prefers task H if and only if $\bar{R}(\xi) + B_H \geq B_L$, whereas the agent prefers task H if and only if $s\bar{R}(\xi) + B_H \geq B_L$. Because $s \leq 1$, the agent places less weight than the principal on task returns relative to his private benefits and is thus likely to choose task L even though the principal prefers task H. But in contrast to the previous case where tasks have a positive risk-return tradeoff, incentives must be increased for this conflict to be reduced. This is how private benefits from tasks lead to a positive relationship between delegation and incentives. In fact, as we show in the proof of Proposition 3, when $\frac{B_L - B_H}{\bar{R}(\xi)}$ is strictly greater than but sufficiently close to $\frac{1}{1+\eta c \sigma_a^2}$, the inequality in Proposition 3 is strict.

4 Conclusion

In this paper we document a new empirical finding on the relationship between delegation and incentives. Using data from a large cross section of British establishments, we show that the positive relationship between incentives and delegation that has been consistently documented in the empirical literature masks a stark difference between job types; for simple jobs the relationship is positive, whereas for complex jobs it is negative. We also construct a theoretical model offering a potential explanation for the negative relationship between delegation and incentive pay for complex jobs. In our model there is one performance measure which performs multiple functions: inducing task selection when authority is delegated and inducing effort. Inducing task selection requires weaker incentives, whereas inducing effort requires stronger incentives. We find that when returns on tasks vary a lot, and when effort is noisy to measure, delegation and incentives are negatively related. We believe that both of these features characterize a number of occupations involving complex jobs.

Our empirical and theoretical 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. While we see the new stylized fact we present as striking, particularly given the breadth of the sample on which it is based, we caution that it is based on an empirical distinction between complex jobs and simple jobs that is (necessarily) arbitrary. The result should therefore be subjected to further scrutiny in future work using other datasets. In particular, narrowing the focus to particular occupations might offer opportunities for sharper distinctions between complex jobs and simple jobs and would also eliminate some of the unobservables that may be inadequately controlled for in our analysis. As noted earlier, the previous literature contains some evidence from studies based on particular occupations, e.g. Nagar (2002) and Wulf (2007). Both of those studies consider managers, as opposed to our analysis which focuses on non-managers (two of our three incentive measures are for non-managers), so we see our study and theirs as complementary. It is interesting to note that their studies of managers find a positive relationship between incentives and delegation. Although we do think of management as a complex job, we think there may be other factors at play that drive the positive relationship. In particular, there is a hierarchical aspect to management that could play an important role in the relationship between delegation and incentive pay (see Rosen (1982)). In fact, Wulf (2007) uses hierarchy itself as indirect measure of authority. Private benefits from empire building (Avery, Chevalier, and Schaefer (1998)) and from taking decisions to benefit a division (Rajan, Servaes, and Zingales (2000)) could also be driving the positive relationship. We believe a promising direction for future work would be to investigate the role of private benefits versus risk-return tradeoffs across individual occupations to see which effect dominates.

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) may not hold 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 complex jobs and others to simple jobs. This allocation of workers to jobs could be expected to reduce the incentive tradeoff between task selection and effort, though it would result in a higher wage bill. We leave this topic to future research.

Appendix A

Panel 1: Two-digit and three-digit SOC codes for Complex Jobs

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: One-digit SOC codes for Simple Jobs

CODE	DESCRIPTION
4	ADMINISTRATIVE AND SECRETARIAL OCCUPATIONS
5	SKILLED TRADES OCCUPATIONS
6	PERSONAL SERVICE OCCUPATIONS
7	SALES AND CUSTOMER SERVICE OCCUPATIONS
8	PROCESS PLANT AND MACHINE OPERATIVES
9	ELEMENTARY OCCUPATIONS

Appendix B

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

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 it belongs; 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
Complex	0.176	0.016
Incentive Pay	0.141	0.016
Incentive Pay(l.o.g.)	0.082	0.012
Incentive Pay(n.m.)	0.108	0.014
Delegation	0.294	0.021
Risk	0.206	0.022
Largest Occupational Group:		
Professional Occupations	0.125	0.014
Technical and Scientific Occupations	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
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*, *Complex*, 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		***Incentive Pay(l.o.g.)***		***Incentive Pay(n.m.)***	
	(1)	(2)	(3)	(4)	(5)	(6)
Independent Variables:						
Delegation	0.285*	0.406**	0.529***	0.601***	0.212	0.367 **
	(0.160)	(0.169)	(0.192)	(0.203)	(0.179)	(0.183)
Delegation x Complex		-1.057***		-0.882**		-1.250***
		(0.351)		(0.431)		(0.395)
Complex		0.357		0.187		0.219
		(0.273)		(0.294)		(0.303)
Industry Controls						
Manufacturing	-0.918***	-0.914***	-0.666*	-0.667*	-0.344	-0.381
	(0.308)	(0.300)	(0.392)	(0.391)	(0.353)	(0.343)
Electricity, Gas and Water	-0.872***	-0.870***	-0.705*	-0.709**	-0.090	-0.052
	(0.313)	(0.300)	(0.363)	(0.358)	(0.364)	(0.325)
Construction	-0.812**	-0.827**	-0.911***	-0.926***	-0.579*	-0.625**
	(0.373)	(0.368)	(0.318)	(0.319)	(0.297)	(0.288)
Hotels and Restaurants	-0.631*	-0.632*	-1.909***	-1.920***	-0.826***	-0.845***
	(0.356)	(0.361)	(0.348)	(0.346)	(0.308)	(0.307)
Transport and Communication	-1.115***	-1.101***	-1.436***	-1.422***	-0.619*	-0.633*
	(0.288)	(0.288)	(0.346)	(0.348)	(0.350)	(0.348)
Financial Services	0.348	0.417	0.593*	0.636*	0.893***	0.959***
	(0.314)	(0.310)	(0.339)	(0.342)	(0.333)	(0.321)
Other Business Services	-0.373	-0.393	-0.576**	-0.558*	0.296	0.298
	(0.280)	(0.296)	(0.291)	(0.304)	(0.302)	(0.310)
Public Administration	-0.695*	-0.734*	-0.789*	-0.818**	0.617**	0.603**
	(0.411)	(0.410)	(0.407)	(0.403)	(0.252)	(0.273)
Education	-1.624***	-1.786***	-3.072***	-3.129***		
	(0.578)	(0.530)	(0.453)	(0.444)		
Health	-1.719***	-1.755***	-2.885***	-2.842***		
	(0.282)	(0.280)	(0.416)	(0.404)		
Other Community Services	-1.078***	-1.076***	-1.118***	-1.113***	-0.164	-0.152
	(0.314)	(0.314)	(0.381)	(0.381)	(0.285)	(0.289)
Constant	-0.900*	-0.721	-1.116**	-1.152**	-2.020***	-2.041***
	(0.469)	(0.475)	(0.501)	(0.517)	(0.362)	(0.386)
Incremental Effect						

of *Delegation*						
Overall (All Jobs)	0.066	0.053	0.083	0.077	0.041	0.034
Complex Jobs		-0.132		-0.036		-0.117
Simple Jobs		0.094		0.095		0.072
Sample Size	1719	1719	1719	1719	1639	1639

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*.

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

TABLE 3: Probit Results Adding Risk as a Control.

	Dependent Variable					
	Incentive Pay		*Incentive Pay(l.o.g.)*		*Incentive Pay(n.m.)*	
	(1)	(2)	(3)	(4)	(5)	(6)
Independent Variables:						
Delegation	0.565***	0.685***	0.734***	0.803***	0.419**	0.575 ***
	(0.191)	(0.200)	(0.209)	(0.224)	(0.206)	(0.205)
Delegation x Complex		-1.253**		-0.894		-1.357***
		(0.535)		(0.552)		(0.483)
Complex		0.466		0.209		0.270
		(0.393)		(0.368)		(0.373)
Risk	-0.367	-0.416*	-0.713***	- 0.733***	-0.422	-0.443*
	(0.238)	(0.226)	(0.246)	(0.248)	(0.273)	(0.244)
Industry Controls						
Manufacturing	-1.002***	-0.996***	-0.675*	-0.684*	-0.428	-0.479
	(0.316)	(0.307)	(0.387)	(0.386)	(0.363)	(0.356)
Electricity, Gas and Water	-1.341***	-1.268***	-1.030**	-0.993**	-0.391	-0.287
	(0.424)	(0.404)	(0.471)	(0.465)	(0.407)	(0.383)
Construction	-0.889**	-0.893**	-0.707**	-0.720**	-0.622*	-0.674*
	(0.432)	(0.423)	(0.353)	(0.352)	(0.363)	(0.349)
Hotels and Restaurants	-0.801**	-0.812**	-2.077***	-2.101***	-1.023***	-1.066***
	(0.356)	(0.368)	(0.357)	(0.358)	(0.337)	(0.340)
Transport and Communication	-1.283***	-1.261***	-1.443***	-1.423***	-0.699*	-0.721*
	(0.326)	(0.325)	(0.401)	(0.402)	(0.385)	(0.385)
Financial Services	0.358	0.456	0.702**	0.753**	0.937***	1.028***
	(0.336)	(0.324)	(0.348)	(0.352)	(0.357)	(0.340)
Other Business Services	-0.706**	-0.760**	-0.581*	-0.597*	-0.035	-0.069
	(0.291)	(0.327)	(0.338)	(0.361)	(0.301)	(0.321)
Public Administration	-2.018***	-2.056***	-1.180***	-1.211**	-0.240	-0.214
	(0.494)	(0.503)	(0.447)	(0.444)	(0.318)	(0.333)
Education	-2.725***	-2.979***	-2.540***	-2.610***		
	(0.443)	(0.505)	(0.410)	(0.434)		
Health	-2.137***	-2.216***	-2.485***	-2.479***		
	(0.355)	(0.395)	(0.364)	(0.375)		
Other Community Services	-1.171***	-1.149***	-0.803**	-0.794**	-0.035	0.006
	(0.360)	(0.362)	(0.358)	(0.358)	(0.332)	(0.334)
Constant	-0.688	-0.737	-1.744***	-1.758***	-2.019***	-2.014***

	(0.571)	(0.583)	(0.560)	(0.543)	(0.445)	(0.447)
Incremental Effect of *Delegation*						
Overall (All Jobs)	0.123	0.114	0.110	0.108	0.077	0.073
Complex Jobs		-0.110		-0.011		-0.100
Simple Jobs		0.147		0.122		0.108
Sample Size	1242	1242	1242	1242	1193	1193

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*.

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

Appendix C

Proofs

Proof of Proposition 1: Consider the "no delegation" problem. Notice that s_L maximizes the principal's expected profit when task L is chosen, and s_H maximizes the principal's expected profit when task H is chosen. Thus the principal's expected profit from choosing task L is

$$\frac{s_L}{c} - \frac{s_L^2}{2c} - \frac{\eta s_L^2 \sigma_a^2}{2} - w_0 - C. \tag{1}$$

Substituting s_L in (1), the principal's expected profit can be rewritten as

$$\frac{1}{2c(1+\eta c\sigma_a^2)} - w_0 - C.$$

Similarly, the principal's expected profit from choosing task H is given by

$$\bar{R}(\xi) + \frac{s_H}{c} - \frac{s_H^2}{2c} - \frac{\eta s_H^2(\sigma_a^2+\alpha)}{2} - w_0 - C, \tag{2}$$

which can be rewritten as

$$\bar{R}(\xi) + \frac{1}{2c(1+\eta c(\sigma_a^2+\alpha))} - w_0 - C.$$

We assume that if the principal is indifferent between task L and task H, he always chooses task L. Thus task H is optimal if and only if

$$\bar{R}(\xi) + \frac{1}{2c(1+\eta c(\sigma_a^2+\alpha))} > \frac{1}{2c(1+\eta c\sigma_a^2)}. \tag{3}$$

When $\bar{R}(\xi) \geq \dfrac{1}{2c(1+\eta c\sigma_a^2)}$, the inequality in (3) holds. Thus $x_n^* = H$, and $s_n^* = s_H$.

Next, consider the delegation problem. First, notice that the "no delegation" solution with the incentive-task pair (s_H, H) is implementable in the "delegation" problem if and only if it satisfies (IC_{xd}), which is given by the condition

$$s_H\bar{R}(\xi) - \frac{\eta s_H^2\alpha}{2} \geq 0.$$

Substituting s_H and rearranging, we get

$$\alpha(1-2\bar{R}(\xi)c) \leq \frac{2\xi}{\eta}(1+\eta c\sigma_a^2)$$

.

We can rearrange the expression above to get

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

.

Thus, when $\alpha \leq \alpha_d$, we must have $x_d^* = H$ and $s_d^* = s_H$.

Next suppose $\alpha > \alpha_d$. We compare two cases, one where the principal implements task H and the other where the principal implements task L.

Suppose the principal implements task H. Then, the principal's problem after substituting (IR_d) and (IC_{ad}) into the expected profit function is

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

subject to (IC_{xd}) which can be written as

$$s_d \leq \frac{2\bar{R}(\xi)}{\eta\alpha} \tag{4}$$

The first order necessary conditions imply

$$\frac{1}{c} - \frac{s_d}{c} - \eta s_d(\sigma_a^2+\alpha) = \mu \tag{5}$$

where μ is the non-negative multiplier associated with (4).

Since $\alpha > \alpha_d$, it follows that $\frac{2\bar{R}(\xi)}{\eta\alpha} < s_H$. 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 (5) is equal to 0 when $s_d = s_H$. Thus, for any s_d satisfying (4), the left-hand side of (5) is strictly positive. From the complementary slackness condition, (4) always binds.

Thus, the principal's expected profit if he implements H is

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

Next, suppose the principal implements task L. Then (IC_{xd}) can be written as $s_d \geq \frac{2\bar{R}(\xi)}{\eta\alpha}$. Since $s_H > \frac{2\bar{R}(\xi)}{\eta\alpha}$ when $\alpha > \alpha_d$, and since $s_L > s_H$, it follows that the incentive level s_L and task L always satisfy (IC_{xd}). Since s_L maximizes the principal's expected profit subject to (IR_d) and (IC_{ad}) when x is fixed at L, it follows that the principal always chooses s_L when he implements the task L. Thus the principal's expected profit if he implements task L is

$$\frac{1}{2c(1+\eta c\sigma_a^2)} - w_0. \tag{7}$$

At the optimum, the principal implements H if and only if

$$\bar{R}(\xi) + \frac{2\bar{R}(\xi)}{\eta\alpha c} - \frac{2\bar{R}(\xi)^2(1+\eta c\sigma_a^2)}{\eta^2\alpha^2 c} - \frac{2\bar{R}(\xi)^2}{\eta\alpha} > \frac{1}{2c(1+\eta c\sigma_a^2)}. \tag{8}$$

Since $\bar{R}(\xi) \geq \frac{1}{2c(1+\eta c\sigma_a^2)}$, the inequality in (8) holds when

$$\frac{2\bar{R}(\xi)}{\eta\alpha c}(1 - \frac{\bar{R}(\xi)(1+\eta c\sigma_a^2)}{\eta\alpha} - \bar{R}(\xi)c) > 0,$$

which can be written as

$$1 - \frac{\bar{R}(\xi)(1+\eta c\sigma_a^2)}{\eta\alpha} - \bar{R}(\xi)c > 0.$$

When $\alpha > \alpha_d$, the condition above always holds. Thus the principal always implements H at the optimum in the delegation problem. Thus for $\alpha > \alpha_d$ it follows that $s_d^* = \frac{2\bar{R}(\xi)}{\eta\alpha} < s_H = s_n^*$.■

Proof of Proposition 2: The principal prefers to delegate authority if and only if

$$\bar{R}(\xi) + \frac{s_H}{c} - \frac{s_H^2}{2c} - \frac{\eta s_H^2(\sigma_a^2+\alpha)}{2} - w_0 - C \leq \bar{R}(\xi) + \frac{s_d^*}{c} - \frac{{s_d^*}^2}{2c} - \frac{\eta {s_d^*}^2(\sigma_a^2+\alpha)}{2} - w_0.$$

Thus

$$\bar{C} = (s_H - s_d^*)(\frac{1}{c} - \frac{s_H + s_d^*}{2c} - \frac{\eta(\sigma_a^2+\alpha)(s_H+s_d^*)}{2}). \tag{9}$$

Since $s_d^* < s_H$ from Proposition 1, it follows that $\bar{C} > 0$.

To see how $\bar{C}$ varies with parameters, first consider the parameter ξ and let $\xi' > \xi$. Let $s_d^*(\xi)$ denote optimal incentive levels as a function of ξ for the "delegation" problem. Since $\frac{2\bar{R}(\xi)}{\eta\alpha}$ is strictly increasing in ξ, it follows from Proposition 1 that $s_d^*(\xi') > s_d^*(\xi)$. Thus from (9) we have $\bar{C}(\xi) > \bar{C}(\xi') = 0$.

Next, consider the parameter σ_a^2 and let $\sigma_a^{2\prime} > \sigma_a^2$. Notice that we can rewrite (9) as

$$(\frac{s_H - s_d^*}{2c})(1 - s_d^*(1 + \eta c(\sigma_a^2 + \alpha))), \tag{10}$$

which is strictly decreasing in σ_a^2.

Thus $\bar{C}(\xi, \alpha, \sigma_a^{2\prime}) < \bar{C}(\xi, \alpha, \sigma_a^2)$. ■

Proof of Proposition 3: Consider the "no delegation" problem. Regardless of the task that the principal chooses, he will always set $s' = \dfrac{1}{1 + \eta c \sigma_a^2}$ at the optimum. If he chooses task L his expected profit is

$$\frac{s'}{c} - \frac{s'^2}{2c} - \frac{\eta s'^2 \sigma_a^2}{2} + B_L - w_0 - C. \tag{11}$$

and if he chooses task H, his expected profit is

$$\frac{s'}{c} - \frac{s'^2}{2c} - \frac{\eta s'^2 \sigma_a^2}{2} + \bar{R}(\xi) + B_H - w_0 - C. \tag{12}$$

The principal prefers task H over task L if and only if

$$\bar{R}(\xi) + B_H \geq B_L \tag{13}$$

Now, consider the "delegation" problem. Suppose $\bar{R}(\xi) + B_H < B_L$ so that the principal's optimal solution in the "no delegation" problem is (s', L). Given s', the agent picks task L over task H, because $s'\bar{R}(\xi) + B_H < B_L$. Thus the "no delegation" solution is implementable when authority is delegated.

Suppose, on the other hand that $\bar{R}(\xi) + B_H \geq B_L$. The "no delegation" solution (s', H) is implementable when authority is delegated, if and only if

$$s'\bar{R}(\xi) + B_H \geq B_L \tag{14}$$

If $\bar{R}(\xi) + B_H \geq B_L$ and $s'\bar{R}(\xi) + B_H < B_L$, then the principal has two choices. First suppose he implements task H. Then, the principal's problem after substituting (IR_d) and (IC_{ad}) into the expected profit function is

$$\underset{s_d}{Max} \frac{s_d}{c} - \frac{s_d^2}{2c} - \frac{\eta s_d^2 \sigma_a^2}{2} + \bar{R}(\xi) + B_H - w_0$$

subject to (IC_{xd}) which can be written as

$$s_d \bar{R}(\xi) + B_H \geq B_L \tag{16}$$

The first order necessary conditions imply

$$\frac{1}{c} - \frac{s_d}{c} - \eta s_d \sigma_a^2 = -\mu \bar{R}(\xi) \tag{17}$$

where μ is the non-negative multiplier associated with (16). At the optimum, it must be the case that $\mu > 0$. If not, then $s_d = s'$ and because (14) does not hold, the incentive constraint in (16) is violated, leading to a contradiction. Thus $s_d = \dfrac{B_L - B_H}{\bar{R}(\xi)} > s'$ and the principal's expected profit is given by

$$\frac{B_L - B_H}{\bar{R}(\xi)c} - \frac{1}{2c}(\frac{B_L - B_H}{\bar{R}(\xi)})^2 - \frac{\eta\sigma_a^2}{2}(\frac{B_L - B_H}{\bar{R}(\xi)})^2 + \bar{R}(\xi) + B_H - w_0 \tag{18}$$

Next, suppose the principal implements task L. Then (IC_{xd}) can be written as $s_d\bar{R}(\xi) + B_H \leq B_L$. Notice that s' satisfies this constraint. Since s' maximizes the principal's expected profit subject to (IR_d) and (IC_{ad}) when x is fixed at L, it follows that the principal always chooses s' when he implements the task L. So the principal's expected profit if he implements task L is

$$\frac{1}{2c(1 + \eta c\sigma_a^2)} + B_L - w_0. \tag{19}$$

Thus it follows that $s_d^* \geq s' = s_n^*$. In fact, when $\dfrac{B_L - B_H}{\bar{R}(\xi)}$ is sufficiently close to s' the principal will strictly prefer to induce task H when he delegates authority leading to $s_d^* > s' = s_n^*$. ■

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.

AVERY, C., J. CHEVALIER, AND S. SCHAEFER (1998): "Why do managers undertake acquisitions? An analysis of internal and external rewards for acquisitiveness," *Journal of Law, Economics and Organization*, 14, 24–43.

BAKER, G. (1992): "Incentive Contracts and Performance Measurement," *Journal of Political Economy*, 100, 598–614.

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.

CORE, J., AND J. QIAN (2002): "Project Selection, Production, Uncertainty, and Incentives," *Mimeo, University of Pennsylvania*.

CULLY, M. (1999): *1998 Workplace Employee Relations Survey: User Guide*chap. Section 7: Weighting the Cross Section and Panel Samples.

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 (2010): "An Empirical Analysis of Risk, Incentives, and the Delegation of Worker Authority," *Industrial and Labor Relations Review*, 64(4).

DEVARO, J., AND S. PRASAD (2011): "Delegation and Incentives: a tradeoff between Exploration and Exploitation (with Jed DeVaro)," *Working Paper*.

Dranove, D., D. Kessler, M. McClellan, and M. Satterthwaite (2003): "Is More Information Better? The Effects of Report Cards on Health Care Providers," *Journal of Political Economy*, 111(3), 555–588.

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 (1976): "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure," *Journal of Financial economics*, 3(4), 305–360.

——— (1992): *Contract Economics*chap. Specific and General Knowledge, and Organizational Structure. Blackwell, Oxford.

Lambert, R. A. (1986): "Executive Effort and the Selection of Risky Projects," *Rand Journal of Economics*, 17(1), 77–88.

Lando, H. (2004): "Are Delegation and Incentives Complementary Instruments?," *Working Paper*.

Leventis, A. (1997): "Cardiac Surgeons Under Scrutiny: A Testable Patient-Selection Model," *CEPS Working Paper*, pp. 1–25.

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. (2011): "Motivating Innovation," *Journal of Finance*, 66(5), 1823–1860.

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.

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.

Neal, D. (1995): "Industry-Specific Human Capital: Evidence from Displaced Workers," *Journal of Labor Economics*, 13(4), 653–677.

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.

Rajan, R., H. Servaes, and L. Zingales (2000): "The Cost of Diversity: The Diversification Discount and Inefficient Investment," *Journal of Finance*, 55, 35–80.

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

Rosen, S. (1982): "Authority, Control and the Distribution of Earnings," *Bell Journal of Economics*, 13, 311–323.

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

Van den Steen, E. J. (2007): "The Cost of Incentives under Disagreement Can an Employee be too Motivated?," *Working Paper*, pp. 1–27.

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