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Author(s): Canice Prendergast
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The Tenuous Trade-off between Risk and Incentives

Canice Prendergast

University of Chicago and National Bureau of Economic Research

Empirical work testing for a negative trade-off between risk and incentives has not had much success: the data suggest a positive relationship between measures of uncertainty and incentives rather than the posited negative trade-off. I argue that the existing literature fails to account for an important effect of uncertainty on incentives through the allocation of responsibility to employees. When workers operate in certain settings, firms are content to assign tasks to workers and monitor their inputs. By contrast, when the situation is more uncertain, they delegate responsibility to workers but, to constrain their discretion, base compensation on observed output.

I. Introduction

Much of the empirical and theoretical work on agency issues concerns the trade-off of risk and incentives. From this perspective, the cost of offering a pay-for-performance contract to a (risk-averse) employee is that it imposes risk on his compensation, which causes higher wage costs. Consequently, when choosing higher performance pay, firms trade off the benefits of more effort against higher wage costs. The risk imposed on workers is increasing in the uncertainty of the environment so that the standard test of the trade-off is to show that incentive pay is lower in more uncertain environments. Unfortunately, empirical re-

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search has not shown a convincing relationship between pay for performance and observed measures of uncertainty. Indeed, as described below, for a range of occupations the data suggest that observed measures of uncertainty are *positively correlated* with incentive provision. The purpose of this paper is to understand why this is the case and to offer an alternative theory of how uncertainty affects incentive provision.

In agency models, the uncertainty of the environment typically has one effect: it adds observation error to performance measures. This leads to the negative relationship between uncertainty and incentives. This paper argues that there is another effect of uncertainty on incentive provision that may be more important, namely, the delegation of responsibility to employees. The paper focuses on the distinction between instances in which an employer tells his agent what to work on and situations in which the agent is given discretion over the activities that he spends time on. The results of the paper are based on two implications of this choice. First, delegation is more likely when there is greater uncertainty about what the agent should be doing. Second, output-based incentive pay is more likely to be observed in cases in which employees have considerable discretion: there is little need to base pay on output when inputs are monitored. So uncertain environments result in the delegation of responsibilities, which in turn generates incentive pay based on output. Thus uncertainty and incentives are positively correlated.

The idea is best described by the following example. A firm is involved in large-scale construction projects around the world and uses project managers to run those projects. Compare projects being carried out in Canada to those in, say, Armenia. The company has considerable experience in Canada and "knows the ropes" for doing business there. By contrast, the company is very much in the dark when doing projects in Armenia, both because the economic environment is so different from what it is accustomed to and because it has little experience there. If one were to make predictions about compensation using the standard trade-off between risk and incentives, one would expect to see more pay for performance for the project manager in Canada than in Armenia since the manager's performance can be measured more precisely in Canada. This is exactly the opposite of what happens: in fact, the Canadian manager is paid a salary (with a small bonus), whereas the Armenian manager's pay is tied to the profitability of the project. The reasoning is simple. The company believes that since it has a good idea of how business should be done in Canada, it takes control of most decision making and monitors the manager largely on the basis of his inputs. Headquarters feels that it can make effective decisions in Canada and therefore does not delegate much decision-making power to the manager. By contrast, headquarters has little ability to determine the profitability of the Armenian projects, since this depends on many pieces of information that it does not have. Because it believes itself to have such a poor handle on the business, it chooses an alternative strategy: it (largely) delegates decision making to the project manager. But it also offers him an output-based contract since this is the only way to monitor his performance. In effect, output-based pay is used because in uncertain environments, there are no other good measures by which to align incentives. Thus incentive pay and uncertainty are positively correlated, in contrast to the standard model of trading off risk and incentives. The modeling sections of the paper are largely devoted to outlining this effect, discussing its implications, and analyzing the robustness of its conclusions.

I begin in Section II by describing the existing empirical evidence on the trade-off of risk and incentives. Evidence on the trade-off comes from three areas: (i) executives, (ii) sharecroppers, and (iii) franchisees. First, the evidence on executive compensation about whether risk and incentives are substitutes is mixed. Some studies find evidence in favor of the negative trade-off, others find evidence of a positive relationship, and some find no relationship. Second, the evidence on agricultural sharecropping clearly points to a *positive* relationship between measures of risk and the fraction of output received by sharecroppers. Third, firms often decide whether to franchise their retail outlets or to retain them as company-owned. For franchisees, strong output-based contracts are the norm, whereas in company-owned stores, pay for performance is more muted. Contrary to the trade-off of risk and incentives, again there is a clear *positive* relationship between measures of risk and the decision to franchise: thus pay for performance is more common in risky settings.[1]

Most work in agency theory assumes that the tasks carried out by employees are fixed and then considers the optimal output-based contracts given that restriction. At one extreme of this spectrum, workers are residual claimants on output, whereas at the other they are offered few incentives without output-based pay. But realistically, when output-based pay disappears, firms do not simply resign themselves to workers' exerting little effort. Instead, they find other means of monitoring, namely by assigning the agent to carry out certain tasks and by direct

[1] Beyond these systematic studies, the theory also seems a little strained at a more anecdotal level in that the theory suggests that pay for performance would be more likely to be observed in stable industries and time periods in which there is little extraneous risk on workers. While I know of no recent systematic work on the cross-industry nature of pay for performance, it appears that incentive pay is used mostly in volatile industries, such as the use of options in high-tech industries and bonuses in the financial sector. Lazear (2000) also makes this point. If the trade-off of risk and incentives is the primary force determining pay for performance, these are hardly the candidates that would be predicted to be most likely to use such risky instruments.

observation of the agent's inputs. This in itself is not a problem for the existing theory unless the marginal cost of using this combination of directed actions and input monitoring depends on the uncertainty in the environment. But I argue that there is a natural relationship between the effectiveness of directed action and uncertainty. In particular, in stable scenarios, a principal has a good idea of what the agent should be doing, so that by observing efforts, he can be pretty sure that private and social benefits are aligned. However, in less certain environments, the principal may be able to monitor inputs (e.g., whether the agent is keeping busy) but is likely to have less idea about what the agent should be spending his time on. In the absence of an effective mechanism for revealing this information, the principal is likely to respond by offering a pay-for-performance contract. In other words, input monitoring will be used in stable settings, but less so in more uncertain environments, where workers will be offered more discretion but will have their actions constrained by tying pay to performance.

The reason for this result is simply that the expected marginal return to using output-based contracts to align socially and privately optimal actions is greater in uncertain situations than in stable ones, so that incentive pay is positively related to uncertainty. Obvious though this point may be, it remains unobserved in the literature, which has typically assumed that the marginal return to actions is independent of the underlying riskiness of the environment. I argue that this assumption is not plausible in many settings, and introducing a relationship between uncertainty and the marginal return to agent actions explains why we see more pay for performance in rapidly changing industries such as the high-tech sector,[2] whereas in more stable settings, input-based contracts will be the norm.

The basic insight of the model is described in Section III, where the optimal trade-off between input monitoring and output monitoring is shown to depend on the underlying uncertainty of the environment. Section IV considers further applications and extensions of the model. First, I argue that in contrast to the implications of the existing literature, this paper suggests that pay-for-performance contracts are more likely to be found in complex than in straightforward jobs. The reason for this is that it is more difficult to monitor in complex positions, since the optimal action is hard to pinpoint, compared to jobs in which there is little doubt over the right course of action. Hence complexity and incentive pay go hand-in-hand. Second, I consider a series of modeling extensions in which I show that the insights of the model are robust to such extensions as allowing communication between the principal and

[2] One needs to be a little careful here to distinguish these firms from start-ups, which may offer options and stocks rather than high salaries for reasons of liquidity constraints.

agent and to cases in which partial delegation of responsibilities may be optimally used. Finally, I argue that the basic results are also likely to hold with other forms of uncertainty.

In Section V, I show that one critical assumption generates the positive trade-off between uncertainty and incentives: the availability of good measures of output. It is well known that when output measures are unreliable, the desirability of output-based contracting falls because of multitasking concerns. This *in itself* is not a problem for the theory; what does matter is how multitasking concerns vary with the uncertainty of the environment. Specifically, if multitasking concerns are greater in uncertain environments, then the results described above can reverse in that the standard negative trade-off can now be attained. To see why, consider the example of the construction company in Armenia and Canada. An obvious multitasking problem that can arise with construction projects is that the accounts can be "doctored" to show that a project is doing well when in fact it is a bust. This doctoring is done by the project manager to avoid canceling an inefficient project from which the manager gains private benefits. If the extent to which accounts can be manipulated does not vary between Canada and Armenia, the qualitative results of the basic model are unchanged: multitasking makes output-based contracting less desirable, but there are no qualitative implications for how uncertainty affects the trade-off between input and output monitoring. But if it is easier to distort performance measures in more uncertain environments (e.g., since accounting methods in Armenia are nonstandard), then the results can reverse in that a negative trade-off is now possible. The reason for this reversal is that there is now a countervailing effect whereby output-based contracts become increasingly distorted in uncertain settings. If the distortion increases sufficiently rapidly with uncertainty, it can swamp the beneficial returns to delegating. The upshot of this is that a positive trade-off of risk and incentives should be predicted only in situations in which good measures of performance are available, such as sharecropping and franchising, rather than in occupations in which observed measures are a poor reflection of performance.

The paper is largely motivated by the absence of a negative trade-off between incentives and observed measures of uncertainty in the empirical literature. I return to the empirical evidence in Section VI, where I consider the implications of this model for observed outcomes. I argue that the observed evidence is better explained by this model than the standard agency model. In standard econometric parlance, a difficulty with the existing empirical work is omitted variable bias. This model argues that uncertainty affects the responsibilities offered to workers, which in turn affects incentives. But responsibilities and discretion are rarely observed by the econometrician, so that omitted variable bias arises. I use existing evidence from the literature on franchising and sharecropping to address this and to argue that the data appear consistent with the insights of the model.

In the most general incarnation of the standard agency model, such as Grossman and Hart (1983), it is difficult to generate simple agency contracts in which one can talk about more or less incentives. The benchmark here is not such a general model, but the more commonly used model offered by Holmström and Milgrom (1991), where linear contracts are generated by assuming a dynamic model with exponential utility and normally distributed errors. For our purposes, this benchmark has two attractive features. First, optimal contracts are linear in measures of output, and second, the (sole) measure of incentives is decreasing in the (sole) measure of risk for a normal distribution, the variance. Anyone familiar with recent contributions to agency theory will recognize the by now common optimal piece rate $1/[1 + rC''(e)\sigma^2]$, where r is the degree of absolute risk aversion, $C(e)$ is the cost of effort to the agent, and σ^2 is the variance of the measurement error on performance. This yields the simple prediction that the piece rate will fall with the variance. I construct a model that in spirit is similar to this, though with risk-neutral agents, and show how the optimal piece rate increases with the measure of uncertainty, σ^2. It is also worth emphasizing at the outset that I make no claim that a positive relationship between observed measures of risk and incentive provision should necessarily be observed. Uncertainty surely affects incentive provision through the risk costs that are the focus of the existing literature. Instead, my claim is simply that there are plausible influences that can cause a positive relationship and they may be important enough to dominate.

I begin in Section II by documenting empirical evidence on the relationship between measures of risk and the incentives provided to workers, and I illustrate the paucity of evidence on a negative relationship between these variables. Following this, Section III considers the tradeoff between directing the actions of employees (and monitoring inputs) and delegating the choice to the worker (with endogenously optimal output-based monitoring). I show that the cost of assigning tasks to the agent is increasing in the uncertainty of the environment so that firms prefer to use output monitoring if the environment is risky enough. Section IV considers some implications and extensions of the model, and Section V considers the importance of good output measures. I examine the empirical implications of the model in Section VI, and I conclude the paper with a brief discussion in Section VII.

TABLE 1
THE TRADE-OFF OF RISK AND INCENTIVES FOR EXECUTIVES

Authors	Measure of Risk	Result
Lambert and Larcker (1987)	Volatility of returns	–
Garen (1994)	Volatility of returns	0
Yermack (1995) (options only)	Variance of returns	0
Bushman et al. (1996)	Volatility of returns	0
Ittner et al. (1997) (full sample)	Correlation of financial and accounting returns	0
Aggarwal and Samwick (1999)	Volatility of returns	–
Core and Guay (1999)	Idiosyncratic risk	+
Conyon and Murphy (1999)	Volatility of returns	0
Jin (2000)	Idiosyncratic risk	–
Core and Guay (in press)	Volatility of returns	+
Oyer and Shaefer (2001)	Options grants	+

II. The Evidence

This section provides a backdrop by surveying the existing evidence on how pay for performance varies with uncertainty. In each of the studies below, I use the following characterization: a minus sign implies that there is statistically significant evidence (at the 5 percent level) of a negative relationship, as predicted by the theory; a plus sign implies a significant positive relationship; and a zero means that there is no statistically significant relationship. For reasons that will become clearer below, I consider four different classes of occupations in which the trade-off has been tested: (i) executives, (ii) sharecroppers, (iii) franchisees, and (iv) sales force workers and others.

Table 1 gives the evidence on chief executive officers (and sometimes other executives), providing both the measure used and its results.[3] Here the evidence is inconclusive, with three studies finding a statistically

[3] In each of these cases, the test carried out addresses how the fraction of the firm held by the executive varies with some measure of uncertainty. The theory addresses how "piece rates" vary with uncertainty, so this is the closest available measure. Several studies present many sets of results, and I provide the most comprehensive model. Some elaboration is needed for two cases here. First, Ittner, Larcker, and Rajan (1997) offer some results with a significant negative effect and others with no significance. In a simple ordinary least squares regression, there is a negative relationship, but when endogeneity is controlled for via a structural estimation technique for their full sample, no noise variable is significant at the 5 percent level. I cite this latter result here. Second, Core and Guay (1999) offer a series of results, mostly on total equity compensation rather than on the share owned by the executive. The results cited here are taken from table 7 in their paper, which carries out the desired regression with %ownership as the dependent variable and shows a positive relationship with idiosyncratic risk.

TABLE 2
THE TRADE-OFF OF RISK AND INCENTIVES FOR SHARECROPPERS

Authors	Measure of Risk	Result
Rao (1971)	Variance of profits	+
Allen and Lueck (1992)	Coefficient of variation in yield	+
Allen and Lueck (1995)	Coefficient of variation in yield (within crop)	+

significant negative effect, three a significant positive relationship,[4] and five others finding no relationship between risk and incentives.

Table 1 offers weak evidence about the extent to which incentives are traded off against risk. While there may be such a trade-off, it hardly jumps out in the data.[5] At the very least, this suggests a role for considering other potential explanations for the relationship between uncertainty and contracts. Yet executives appear to be the occupation with the *strongest* evidence in favor of the trade-off. To see this, I now consider two other occupations that have attracted some testing of this hypothesis, namely, sharecropping and franchising.

The evidence on sharecropping in table 2 shows that the fraction of output sharecroppers keep is increasing in the noisiness of the financial returns, the opposite of the outcome suggested by the theory.[6] Equally, consider the relationship between the decision to franchise (with high pay for performance) and the decision to keep a store company-owned (with less pay for performance).[7] If the traditional trade-off is correct, we should expect to see a negative relationship between franchising and riskiness. However, table 3, taken from Lafontaine and Slade (2001), suggests the opposite.

As Lafontaine and Slade (2001) conclude, "these results suggest a robust pattern that is unsupportive of the standard agency model" (p. 10). Tables 2 and 3 should, I believe, be seen in combination as strong

[4] Oyer and Shaefer (2001) consider the use of option grants that are more broadly based than simply to executives. As such, this paper may be misplaced by including it with other studies on executives. However, the form of compensation (options) is so closely aligned to those of the other studies that I decided to include it here.

[5] It is also worth pointing out here that some of these studies consider only the cash compensation and bonus of executives (e.g., Lambert and Larcker 1987; Bushman, Indjejikian, and Smith 1996; Ittner et al. 1997), which is only a component of total incentives. However, restricting attention to only those papers that also include stock- and option-based compensation does not provide any more conclusive results.

[6] Ackerberg and Botticini (2002) use a different strategy to test for risk sharing in sharecropping by considering how farmer wealth, a proxy for ability to handle risk, affects contract choice. They find that after they control for matching issues, more wealth is correlated with a greater likelihood of renting, consistent with the usual risk-sharing story.

[7] Obviously, this raises the question of why asset ownership affects incentives. See Holmström and Milgrom (1991) on this.

TABLE 3
RISK AND THE DECISION TO FRANCHISE

Authors	Industry	Result
Martin (1988)	Panel across sectors	+
Norton (1988)	Restaurants and hotels	+
Lafontaine (1992)	Many sectors (business format franchising)	+
Anderson and Schmittlein (1984)	Electronics components	0
John and Weitz (1988)	Industrial firms	0

evidence against the traditional negative trade-off. The most generous interpretation of these data is that there is little evidence in its favor (particularly when one factors in the possibility of publication bias). Indeed, there is more evidence of a positive relationship between uncertainty and incentive provision, particularly outside the market for executives. It is this issue I explore in the theoretical sections of the paper.[8] Before doing so, for the sake of completeness, I include other tests on the trade-off in table 4 for a range of occupations, which show little systematic pattern.

III. Delegation and the Choice between Monitoring Inputs and Outputs

Firms do not choose compensation plans independent of other strategic decisions. In this section, I consider how the decision to delegate decision-making power affects contracts offered to workers and how that decision depends on the uncertainty of the economic environment. Specifically, firms delegate decision-making power more in uncertain environments but offer output-based contracts in order to constrain the possibility that they use their discretion in harmful ways. By contrast, in more certain environments, firms assign tasks to workers and find it more profitable to monitor actions directly.

This section formalizes this in the following way. A principal hires an agent to exert effort on *one* of n possible tasks. For the action on which the agent is employed, i, he chooses an effort level to exert, e_i, where

[8] There are at least two reasons why we might find little relationship between observed measures of risk and incentive pay. First, it may be that the empirical measures of risk and pay for performance are a poor reflection of the true environment facing employees. This is the standard empirical measurement error problem, and I have little to say about it. This is less likely to be a problem for the literature on executives or franchisees, since we observe the contracts they receive and can relatively easily compute the relevant measures of risk. For studies that address employees on implicit contracts, as in Brown (1990) or MacLeod and Parent (1999), this problem may be more severe. Second, it could be that our theories are missing something important about the relationship between the desire to induce individuals to exert effort and the riskiness of the environments in which they find themselves. It is this second point that I address here.

TABLE 4
RISK AND INCENTIVES IN OTHER INDUSTRIES

Authors	Industry	Result
Kawasaki and McMillan (1987)	Japanese subcontractors	−
Leffler and Rucker (1991)	Timber tracts	+
Mulherin (1986)	Natural gas contracts	+
MacLeod and Parent (1999)	Many sectors	0
Coughlin and Narasimhan (1992)	Sales force workers	0
John and Weitz (1989)	Sales force workers	0
Hallagan (1978)	California gold mining	0

i refers to activity i. Output from exerting effort on task i depends on the effort level and on a random variable ρ_i. Specifically, the performance of the firm is given by $y_i = \rho_i + e_i$. The cost of effort on activity i is $C(e_i)$, which has the following standard properties: $C'(e_i) > 0$, $C''(e_i) > 0$, and $C'(0) = 0$. The distribution of the n random variables ρ_i is given by Φ_i. The distributions differ only in their means: they are distributed according to a common distribution with mean $\bar{\rho}_i$ and variance σ^2. In what follows, I vary σ^2; an increase in σ^2 identifies a more uncertain environment. This is the measure of risk considered throughout the paper.

All individuals are risk-neutral, and throughout the paper, the reservation utility of the agent is normalized to zero. I model the agents as risk-neutral in order to ignore the standard trade-off. The premise of this section is that agents often have information not available to the principal.[9] I assume that the agent knows the true values of ρ_i for all i, whereas the principal knows only the distribution of the ρ_i. I also assume that the technology is such that the agent can carry out only a single activity; that is, the fixed cost of engaging in two activities is too large to make it worthwhile to get involved in more than one.

The principal can potentially collect two pieces of information with which to reward the agent. First, she can observe the efforts exerted by the agent, e_i, at a monitoring cost m_e. Second, she can collect information on output produced by the agent. This costs m_y to collect. Throughout this section, I assume that $m_y > m_e$. The monitoring costs of output are a metaphor to reflect any costs of introducing a pay-for-performance plan, such as multitasking concerns. (See Sec. IV for details.)

If the agent is indifferent about which activity he carries out, the problem has the following trivial solution, under the assumption that it is at least profitable to monitor inputs. First, as $m_e < m_y$, the principal

[9] For instance, an agent may know the right customers to focus on, which subordinate to let go, or, more generally, the right strategies that should be followed.

monitors inputs and offers a contract to the worker $w(e_i) = C(e_i)$ for all i. In other words, simply offer the worker a contract that pays him his costs of effort. As the agent knows the true value of ρ_i, he will choose the activity that yields the highest value of output among the n realized and will exert optimal effort on that activity. This optimal level of effort on that activity is given by e^*, where $C'(e^*) = 1$ (the i subscript is dropped for simplicity). This yields the first-best allocation of effort and activity selection and dominates any output-based contract, as $m_e < m_y$.

But I assume that the agents have personal preferences over which activity they enjoy most (the activities have a personal benefit given by B_i). To keep matters simple, I assume that these benefits are small enough so that they do not affect the calculation of the optimal activity to carry out.[10] The principal can, of course, extract these expected benefits through the salary paid to the agent.[11] As in Prendergast and Topel (1996) and Aghion and Tirole (1997), I also assume that the principal does not know the preferences of the agent, that is, which activities have which benefits. The agent knows his private benefits of the various activities. As a concrete example, I consider the case in which the agents have personal preferences such that they are indifferent to $n - 1$ of the activities ($B_i = 0$) but gain a small benefit $B > 0$ from the last one; the principal has no idea of the identity of i. The principal believes the distribution over the preferred activity to be uniform. I assume that there is no correlation between B_i and ρ_i, though Section IV relaxes this assumption.

Assigned actions and input-based contracts.—The principal has two functions: (i) to assign an allowable set of tasks that the worker can carry out and (ii) to decide how to reward the agent for the allowed set of tasks. First, consider a contract that rewards solely on effort (an input-based contract) and leaves the choice of tasks entirely to the agent. If the principal offers the contract $w(e_i) = C(e_i)$ for all i, the agent will simply carry out the activity that he enjoys most, since he gets rents of B from that activity. This will in expectation yield a surplus (and hence benefits to the principal) of

$$\frac{\sum_{i=1}^{n} \bar{\rho}_i}{n} + e^* - C(e^*) + B - m_e,$$

where $1 = C'(e^*)$. If $\rho_i \neq \rho_j$ for some i and j and B is small, this is dom-

[10] If the benefits were large, the principal could allow the agent to carry out an activity even when it is output-dominated by another and charge the agent for carrying out that activity.

[11] I ignore the agent's individual rationality constraint here by assuming that the worker signs a contract before observing ρ_i. This allows up-front transfers such that the usual mechanism design issues with an informed agent can be ignored; instead, the principal's objective is to maximize surplus.

inated by a strategy in which the principal restricts the allowed activities and offers $w(e_i) = C(e_i)$ only for those activities. (If the agent carries out any other activities, he is simply penalized a sufficiently large amount of money that he will never do that activity.) Let activity k be the task with the highest mean, $\bar{\rho}_k$. If this is unique,[12] the expected profits for the firm from this strategy are

$$\bar{\rho}_k + e^* - C(e^*) + \frac{B}{n} - m_e.$$

As the private benefits are assumed small, this dominates delegating the activity choice to the agent if $\rho_i \neq \rho_j$, for some i and j. If the firm could monitor only inputs, this would be the optimal solution.[13] Note also that with assigned tasks, there is no value to offering an output-based contract since $m_e < m_y$.

Delegated actions and output-based contracts.—Now consider another option, to delegate the choice of action to the agent. This can be optimal only if the agent is paid on output; otherwise, the agent chooses the action with the highest private benefits. If output contracting is used, the optimal piece rate is such that the agent chooses the optimal level of effort, e^*, *and chooses the correct activity,* j, that is, the one that maximizes $y_i - C(e_i) + B_i$. In other words, the purpose of offering pay for performance here is not simply to induce effort, since an input-based contract could do this, but to induce the agent to carry out the right kinds of efforts. (This, of course, is nothing more than a relabeling of what effort means, but here the marginal return to inducing this kind of effort varies with the riskiness of the environment.)

In order to determine the return to offering output-based contracts, consider the distribution of the first order statistic of the realization of the ρ_i. The reason this is necessary is that if the agent is offered an output-based contract, he will choose the highest realization of ρ_i among

[12] In the case in which m of the n observations are tied with the highest mean $\bar{\rho}_k$, the optimal input contract allows the agent to work on any of these m tasks, and the profits from this strategy are

$$\bar{\rho}_k + e^* - C(e^*) + \frac{mB}{n} - m_e.$$

In the case in which all ρ_i have identical means, the agent is allowed to work on any activity.

[13] I have restricted attention to the case in which $w(e_i) = C(e_i)$. With input monitoring, there is no better contract, though there are obviously others that can replicate the efficient outcome. In another possible mechanism, the principal auctions off the right to carry out various activities; e.g., the principal could offer a price at which the agent could carry out activity i. A natural case would be to offer the agent the opportunity to carry out activity k at no price but a positive price of B to carry out any other activity. But this cannot do any better than a contract that simply mandates the agent to carry out a task, since the agent is ex ante indifferent to all ρ_i in an input monitoring plan.

the n. By contrast, if the agent is offered an input-based contract, he is assigned to activity k, which has mean $\bar{\rho}_k$. What matters then is the difference between the distribution of the first order statistic ρ'_1 from the n realizations relative to $\bar{\rho}_k$. The idea here is that this difference is likely to be increasing in the variance of the environment. In other words, when the variance of the distribution of the ρ_i is large, the value of sampling the first order statistic is larger than when it is small. If the variance is very small, the principal knows that if he simply assigns a task to the agent, the expected marginal cost of being mistaken is likely to be small. As a result, there is little cost to input monitoring. On the other hand, when σ is large, the firm will likely use output-based monitoring, since there is little certainty about the right kinds of activities to engage in.

I illustrate this with two cases in which I can get simple closed-form solutions: the normal distribution and the uniform distribution. There is one important difference between these two examples, namely between the case in which all actions look ex ante identical (example 1) and the case in which some actions look better than others from an ex ante perspective (example 2).

Example 1: the normal distribution.—Assume that $n = 2$ and that both random variables $\rho_i \sim \mathcal{N}(0, \sigma^2)$. Therefore, all activities look identical to the principal. If input monitoring is used, the principal allows the agent to work on any activity and the expected surplus from input monitoring is $e^* - C(e^*) - m_e + B$. With output monitoring, the agent chooses the activity that maximizes surplus since a piece rate of one is optimal. As B is small, this implies that the agent chooses the activity with the highest ρ_i. The expected value of the first order statistic of the two random variables $E[\rho'_{1(2)}]$ is $E[\rho'_{1(2)}] = \sigma/\sqrt{\pi}$. Note that the first order statistic is increasing in σ^2 and that the profits from output monitoring are

$$\frac{\sigma}{\sqrt{\pi}} + e^* - C(e^*) + \frac{B}{n} - m_y,$$

also increasing in σ^2. Output contracting is therefore preferred if and only if

$$\frac{\sigma}{\sqrt{\pi}} \geq m_y - m_e + \frac{B(n-1)}{n} \qquad (1)$$

(if the right-hand side is nonnegative, as is necessarily the case when $m_y > m_e$). The agent is more likely to be offered an output-based contract in riskier environments since the critical level of variance, σ^{2*}, above which output monitoring is used is given by

$$\sigma^{2*} = \left[m_y - m_e + \frac{B(n-1)}{n}\right]^2 \pi. \qquad (2)$$

This trivial example provides the intuition for the paper's main results. When the environment is more uncertain, the cost of assigning the agent to carry out a particular action is high, since there is likely to be another with a significantly better return. As a result, the firm optimally chooses to delegate choice of action in sufficiently uncertain settings but constrains the agent's choice in that setting by basing pay on output. Thus incentive pay goes hand-in-hand with uncertainty.

A more general result.—An important part of example 1 is that the returns to all the actions are drawn from the same distribution. For this case, a more general result arises. Assume that all the random variables are drawn from the same distribution and that $y_i = \rho_i + e_i$. In that case, there is a single critical value of σ above which output contracts are optimal and below which assigned actions with input contracts are optimal. This arises from the fact that for a distribution ρ_i with common mean $\bar{\rho}$ and variance σ^2, the expected value of the first order statistic from n draws of a probability density function of the form $\sigma^{-1}g[(\rho_i - \bar{\rho})/\sigma]$ can be characterized as

$$E[\rho'_{1\{n\}}] = \bar{\rho} + \sigma H_n,$$

where H_n is independent of σ^2 and $\bar{\rho}$ but depends on n. See Cox and Hinkley (1990) for details. Thus, as in example 1, the value of the first order statistic is linearly increasing in σ, whereas the return to input contracts is not. Therefore, one can easily generalize the insights from example 1 to other distributions.

A difficulty in proving general results arises for the case in which the random variables are drawn from distributions with different means. Problems arise in finding closed-form solutions to carry out comparative statics. For this case, I consider the simplest distribution in which closed-form solutions are possible, namely, the uniform distribution, where we find results similar to those above.

Example 2: the uniform distribution.—Assume that $\rho_i \sim U[-x + \bar{\rho}_i, x + \bar{\rho}_i]$ and that $n = 2$. By renormalization, let the distributions be $\rho_1 \sim U[-x, x]$ and $\rho_2 \sim U[-x + \Delta, x + \Delta]$, where $\Delta = \bar{\rho}_2 - \bar{\rho}_1$. Therefore, the two activities are uniformly distributed with common variance $x^2/3$, but activity 2 has a mean that is Δ higher than activity 1. With input monitoring, the agent will be assigned to work on activity 2 and paid his costs of effort. This has expected return $\Delta + e^* - C(e^*) - m_e + (B/2)$. If offered an output-based compensation plan, the agent chooses the highest value of ρ_i, and expected profits are $E[\rho'_{1\{2\}}] + e^* - C(e^*) + (B/2) - m_y$. Then calculations similar to those in example 1 yield

$$E[\rho'_{1\{2\}}] - \Delta = \begin{cases} \frac{1}{6}\left(1 - \frac{\Delta}{2x}\right)^2 (2x - \Delta) & \text{if } \Delta < 2x \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

Then delegation is preferred if

$$\max\left\{0, \frac{1}{6}\left(1 - \frac{\Delta}{2x}\right)^2 (2x - \Delta)\right\} \geq m_y - m_e. \tag{4}$$

But $\max\{0, \frac{1}{6}[1 - (\Delta/2x)]^2(2x - \Delta)\}$ is nondecreasing in x (and nonincreasing in Δ), and the variance of the uniform distribution, $x^2/3$, is increasing in x. Therefore, as the variance increases, so also (weakly) does the return to using an output-based contract to induce the agent to choose the activity correctly. Thus, once again, this example points to the positive correlation between risk and incentive pay based on outputs.[14]

To summarize, consider a more concrete example, the franchise decision. There is more use of pay for performance for franchisees than for managers of company-owned stores. Furthermore, we saw from table 4 that franchises are more common in uncertain environments than in certain settings. The interpretation that I place on this is that in uncertain environments, headquarters has less idea of the kinds of products that should be offered, their prices, the number of employees to hire, and so on than in more certain situations. As a result, it responds by offering output-based contracts, which are less necessary than when the headquarters knows with more certainty what should be done.

At a more general level, this section raises what I feel is an aspect of the agency literature that is often overlooked, namely, that uncertainty is likely to affect both the compensation and optimal distribution of actions of employees. Typically in agency theory, we treat uncertainty in the economic environment as synonymous with measurement error; yet, as illustrated here, uncertainty has other effects on the employment relationship that confound the usual negative trade-off between risk and incentives.

[14] It is important to note that I am not claiming that accuracy of monitoring is irrelevant to contracting problems. In fact, one can easily reinterpret these results to say that in more certain environments some measure of total incentives is at least as high as in less certain environments; all that differs is that monitoring occurs on inputs in the certain environments and on outputs in the less certain environments. But note that empirical researchers never see inputs, so that the objective of this paper has been to understand why empirical work that traces the relationship between outputs and uncertainty is unlikely to find a negative relationship.

IV. Extensions

In this section, I consider some implications of the model and also show that the basic insights are robust to other modeling assumptions.

A. *Complexity*

Recent contributions to agency theory focused on multitasking (Holmström and Milgrom 1991) suggest that complex jobs are less likely to use incentive pay. Complex jobs have many dimensions of performance, some of which are poorly observed, so that rewarding on the observed dimensions typically has harmful effects on the unobserved dimensions. Thus the marginal cost of output contracting in complex positions is high. However, it is also the case that the benefits of contracting on output are likely to be especially high in complex positions. Indeed, a simple parameterization of this model suggests a *positive* relationship between complexity and the likelihood of incentive pay. The reason for this is that it is more difficult to monitor complex positions than those for which it is easy to identify the optimal course of action; as a result, output-based contracts are more desirable in complex positions. A natural measure of complexity in the model is given by n, the number of activities that the individual can carry out. In this model, as the number of activities increases, so also does the desire to induce the agent to choose the right one to work on. As a result, output-based pay is more likely in complex settings.

To see this, consider example 1 with the normal distribution. Now suppose that the agent can choose among three activities, $n = 3$ rather than $n = 2$ in the basic setup. Let $E[\rho'_{1\{n\}}]$ be the expected value of the first order statistic from n draws. Then it is the case that

$$E[\rho'_{1\{3\}}] = \frac{3\sigma}{2\sqrt{\pi}} > \frac{\sigma}{\sqrt{\pi}} = E[\rho'_{1\{2\}}],$$

and output monitoring is used when $\sigma^2 < \tilde{\sigma}^{2*}$, where

$$\tilde{\sigma}^{2*} = \frac{4\pi[m_y - m_e + (2B/3)]^2}{9}. \qquad (5)$$

Remember that the critical variance when $n = 2$ is given by

$$\sigma^{2*} = \left(m_y - m_e + \frac{B}{2}\right)^2 \pi > \tilde{\sigma}^{2*}$$

for B low, as is assumed here. Therefore, when the number of activities increases, the range of (variance) parameters in which output-based contracts are used also increases. What this suggests is that the returns to offering incentive-based pay are greatest for complex jobs, where there is an overall measure of performance.

The logic of this section is simply that those employees who carry out well-defined jobs, where the activities that keep the person (optimally) busy from one end of the day to the other are known, can easily be rewarded on input-based contracts. However, when the range of activities that the person engages in increases, it becomes harder to identify what the person should be doing, and so output-based contracts become necessary.

B. *Partial Delegation*

So far, I have described two options available to the principal: he either assigns a task to the agent or allows the agent unrestricted choice over actions. However, in some settings, it may be optimal to allow the agent to choose actions from a limited set, but a set that is not a singleton. This is not an issue when there are only two actions (as in examples 1 and 2). However, when there are more than two actions, the principal may partially delegate tasks in the following way: (i) for low levels of uncertainty, the principal assigns an action and monitors inputs (as above); (ii) for high levels of uncertainty, the principal allows the agent unrestricted choice over actions but with an output-based contract (again, as above); but (iii) for intermediate levels of uncertainty, he allows the agent to choose between a subset of actions and uses input monitoring. In effect, the principal excludes some actions, those that are believed to be the least profitable. As a result, allocation of tasks can vary more continuously with our measure of uncertainty (variance) than in the basic model above. Yet it remains the case that output contracting is used only in sufficiently uncertain settings. I illustrate this by another simple example in which $n = 3$ and the distributions are uniform but have different means.

Example 3: the uniform distribution and $n = 3$.—Assume that there are three activities, 1, 2, and 3, where action 1 has the lowest mean payoff and action 3 has the highest. Specifically, let $\rho_i \sim U[-x + (i-2)\Delta, x + (i-2)\Delta]$ and $y_i = \rho_i + e_i$. Therefore, the three activities are uniformly distributed with common variance $x^2/3$, but activity 2 has a mean that is Δ higher than activity 1, and activity 3 has a mean that is Δ higher than activity 2.

Three optimal outcomes are possible. First, the agent can be assigned action 3 and paid on inputs. Second, the agent can be offered an output-based compensation plan and given complete discretion over which action to choose. So far, there is nothing conceptually different from the previous sections. However, there is also an intermediate strategy that can be optimal in which the agent is offered an input-based contract and is then given discretion over actions 2 and 3 only: action 1 is excluded. This partial delegation occurs for intermediate levels of uncertainty.

To see this, consider the value of a strategy in which the agent is monitored on inputs but can choose from actions 2 and 3. Let the expected value of the first order statistic *between these two* be given by $E[\rho'_{1\{2\}}]$. This is identical to the problem in example 2 and is given by

$$E[\rho'_{1\{2\}}] - \Delta = \begin{cases} \frac{1}{6}\left(1 - \frac{\Delta}{2x}\right)^2 (2x - \Delta) & \text{if } \Delta < 2x \\ 0 & \text{otherwise.} \end{cases} \tag{6}$$

Now consider the value of allowing the agent to also choose the final action 1. Let $E[\rho'_{1\{3\}}]$ refer to the first order statistic chosen from the realization of all three. Straightforward calculations show that

$$E[\rho'_{1\{3\}}] - E[\rho'_{1\{2\}}] =$$

$$\begin{cases} \frac{1}{6}\left(1 - \frac{\Delta}{x}\right)^2 \left(1 - \frac{\Delta}{2x}\right)(x - \Delta)\left(3 - \frac{\Delta}{2x}\right) & \text{if } \Delta < x \\ 0 & \text{otherwise.} \end{cases} \tag{7}$$

The right-hand side of (7) is the return to allowing the agent access to the first action over the restricted choice if he always chooses the action that is preferred by the principal. The problem, of course, is that he may not do so with an input contract.

The principal chooses one of these three options: delegate all tasks with output contracts, assign to task 3 with an input contract, or allow choice between 2 and 3 with an input contract. Assigning task 3 to the agent yields profits of $\Delta + e^* - C(e_2^*) - m_e + (B/3)$. Allowing the agent complete discretion with an output-based contract yields profits of $E[\rho'_{1\{3\}}] + e^* - C(e_i^*) + (B/3) - m_y$. Finally, if the agent is offered an input-based contract and allowed to choose between actions 2 and 3, expected profits are given by[15]

$$\frac{1}{3}\Delta + \frac{1}{3}E[\rho'_{1\{2\}}] + e_i^* - C(e_i^*) + \frac{2B}{3} - m_e.$$

[15] This arises as follows. With probability two-thirds, the agent's preferred action is 2 or 3, and he carries out his preferred action. This has a conditional expected value of ρ_i of $\Delta/2$. With residual probability one-third, action 1 is his preferred action. But this is excluded, and so he chooses the principal's preferred action, yielding an expected equilibrium value of ρ_i of $E[\rho'_{1\{2\}}]$.

It is simple to show that partial delegation will then arise if there exists some value of x (the parameter measuring variance) such that

$$\frac{1}{3}\Delta + \frac{1}{3}E[\rho'_{1\{2\}}] + \frac{B}{3} \geq \max\{\Delta,\ E[\rho'_{1\{3\}}] - m_y - m_e\}. \tag{8}$$

Note that for $\Delta < x$, $E[\rho'_{1\{3\}}] - E[\rho'_{1\{2\}}]$ is increasing in x, as is $E[\rho'_{1\{2\}}]$. This implies that the value of each strategy can be ordered with respect to the variance of the distribution. As a result, (i) for low variance, the agent is assigned action 3; (ii) for intermediate levels, he may be excluded only from action 1 and offered an input-based contract; and (iii) for high variance, the agent can choose any action but is offered an output-based contract.[16] Thus, for some cases, delegation is assigned in a more continuous way with respect to variance than in the stark outcomes above, yet it remains the case that output contracting is used in sufficiently uncertain settings.

C. *Communication*

Note that I have restricted attention to two types of contracts: one in which the worker is delegated the task and one in which the principal simply chooses the set of tasks. Yet there is another option: one in which the agent communicates something to the principal, and the allocation is based on the message sent by the agent. There is one form of communication that can improve the allocation here, in that a Pareto-improving message can be sent: the agent tells the principal the set of actions that are neither (i) the agent's preferred project nor (ii) the principal's preferred project. In the equilibrium in which the principal chooses the action of the agent, excluding these projects benefits both parties.[17]

Yet the basic insight of the model remains with this extension. Consider the case in which $n = 3$, and the random variables $\rho_i \sim \mathcal{N}(0,$

[16] As a trivial example, consider the case in which $m_y = \infty$, so that output-based contracts are never profitable. Then the optimal actions are (i) for low x, assign action 3 to the agent; and (ii) for higher values of x, allow the agent to choose between actions 2 and 3. In both cases, input monitoring is used.

[17] It is the indifference of the agent over many actions that allows a role for communication here. If the agent is not indifferent between any activities (in terms of private benefits), there can be no role for communication when output is not observed. But if output is observed, then there is no role for communication since there are no further distortions beyond the monitoring cost.

σ^2). If the agent is monitored on outputs, there is no role for communication and the outcome is as above, with an expected return of

$$\frac{3\sigma}{2\sqrt{\pi}} + e^* - C(e^*) + \frac{B}{3} - m_y.$$

By contrast, if input contracts are used, there is now a role for communication between the agent and principal. Assume that the principal can specify a number of possibilities to propose and a rule for choosing among them. The optimal communication mechanism is one in which the agent puts forward two projects, one of which is his own preferred project and the other the principal's preferred project; he excludes the project that neither wants.[18] (In the case in which the agent's preferred option and the principal's preferred option are the same, he proposes that project plus a dummy project.) The principal then randomly chooses between the two projects that the agent puts forward, and expected surplus is given by

$$\frac{3\sigma}{4\sqrt{\pi}} + e^* - C(e^*) + \frac{B}{2} - m_e,$$

and so the agent is delegated the task (and offered an output-based contract) if $\sigma^2 < \tilde{\sigma}^{2**}$, where

$$\tilde{\sigma}^{2**} = \frac{16\pi[m_y - m_e + (B/6)]^2}{9}. \quad (9)$$

Without communication, when $n = 3$, output contracts are preferred when the variance parameter exceeds $\tilde{\sigma}^{2*}$ in (5), which is lower than $\tilde{\sigma}^{2**}$ for small B. Thus communication reduces the parameter values for which output-based contracts occur but retains the qualitative relationship between contracts and uncertainty.

D. Symmetric Information and Recontracting

I have assumed that the agent has information on the payoff to various actions, which the principal cannot ascertain. Yet there is another case in which this idea becomes relevant, namely in situations in which there is symmetric uncertainty but there are recontracting costs. For example, consider a new firm in which there is enormous uncertainty about what

[18] This mechanism uses the fact that the agent is indifferent between all projects that are not his preferred choice. As a result, given the equilibrium strategy that the principal randomizes between the two put forward by the agent, the agent truly is indifferent between proposing the principal's preferred choice and proposing any other. In order to give this communication game the best chance possible, I assume that he does report the principal's preferred project as the other element of his recommended set.

the firm will be doing in the near future. In these circumstances, it is difficult to write an input-based contract for the simple reason that no one knows what the agent should be doing; to provide such a contract would involve recontracting extremely frequently, since actions which were optimal yesterday might not be tomorrow. In such circumstances, firms may simply offer output-based contracts because they do not need to be frequently recontracted; the agent simply orients his actions to whatever increases the bottom line. Again, this idea predicts that when there is uncertainty about what the agent should be doing, output-based contracts should be used, though here the reason is that input-based contracts would have to be more frequently renegotiated, which is likely to be costly.

E. *Another Form of Uncertainty*

I have so far considered the case in which the private benefits of the agent are sufficiently small that they do not change the efficient allocation. However, consider an alternative in which the only uncertainty arises from not knowing the (nontrivial) private benefits of carrying out various actions, rather than the profitability of the actions. Many employers give their employees tasks to carry out and simply ask that they be completed in some specified period of time, rather than telling them what to do at every moment. Thus they delegate the choice of when to do the task. The reason for this is that employers realize that workers have preferences that vary from hour to hour, and they allow their employees discretion to perform tasks when they most feel like it. At some points in the day, they may be tired and will do routine things, and save their most arduous tasks for times in which they feel most attentive. As with the basic model, this points to the importance of uncertainty, in this case about the agent's costs, because if an employer knew the agent's preferences at all points in time, he would simply tell him what to do. The agent is allowed such discretion because of uncertainty about the agent's within-day or within-week costs. But when such discretion is offered, another means of monitoring is necessary, which is typically based on getting the task done (i.e., output). Thus I feel that the insight about delegation and uncertainty extends to other forms of uncertainty.

F. *Correlated Preferences*

Thus far I have assumed that the preferences of the agent are uncorrelated with those of the principal. This assumption does not affect the qualitative results of the paper but does change the critical value of uncertainty above which delegation occurs. Intuitively, it results in a greater region for which input monitoring occurs for the simple reason that the agent is now more likely to pick the right activity without the constraint of an output-based contract. To see this, consider the case in example 1, except that the agent's preferred action ($B_i > 0$) is correlated with probability p with the preferred action of the principal (i.e., the first order statistic of the two normally distributed variables). This increases the return to the strategy in which the agent is allowed to choose the action that he wants but inputs are monitored. This yields expected returns of

$$p\frac{\sigma}{\sqrt{\pi}} + e^* - C(e^*) + B - m_e, \quad (10)$$

so that output-based contracts are preferred over this strategy only if $\sigma^2 \geq \tilde{\sigma}^{2*}$, where

$$\tilde{\sigma}^{2*} = \frac{\{m_y - m_e + [B(n-1)/n]\}^2\pi}{(1-p)^2} > \sigma^{2*}. \quad (11)$$

As a result, it remains the case that there exists a critical variance above which output-based contracts are optimal, but that level is higher than in the uncorrelated case.

G. *The Fixed Costs of Monitoring Output*

I have assumed that the costs of monitoring output are fixed, given by m_y. This is meant as a metaphor for any costs that firms incur from monitoring outputs and rewarding agents on the basis of those measures. Indeed, if these were simply monitoring costs, one could construct a random monitoring mechanism along the lines of Becker (1968) to overcome this cost. As a result, I see the fixed costs as representing any deadweight loss from the optimal output-based contract. It is for this reason that I have retained the standard agency issue of inducing effort decisions in the model, since the monitoring costs are meant to reflect any distortions in effort decisions made from contracting.[19]

The standard costs of output-based contracts in the literature are either risk costs imposed on the worker or costs that arise as a result of multitasking. These are not fixed costs, but costs that increase with the chosen piece rate. The more general insight from this section is that when one is considering a compensation plan, the costs of forcing an action on the agent must be balanced against the benefits of reducing

[19] Note that in both the input and output monitoring cases above, effort occurs at the first-best level. For this reason, without further elaboration, it is not clear why effort is in the model at all.

risk on workers,[20] or reducing multitasking concerns, rather than simply a fixed monitoring expense.

To see this and also the important role for effort in the model, consider the following rent-seeking example provided in Prendergast (1999).[21] Assume the same technology as in the normal distribution example above ($n = 2$, $\rho_i \sim \mathcal{N}(0, \sigma^2)$), and assume that the agent has a cost of effort given by $C(e_i) = ce_i^2/2$. If the principal uses input-based monitoring, he allows the agent to choose the activity (since both appear identical ex ante), observes e_i, and rewards via the contract described above. This yields surplus of $(1/2c) + B - m_e$.

If the principal uses an output-based contract, there is no cost to observing output per se, but the agent can carry out some dysfunctional activity, b_i, which increases observed output, $\tilde{y}_i$, but has no effect on true surplus. For example, the agent could spend resources distorting accounting numbers that have little relation to true profitability. I call this a rent-seeking activity. Specifically, the agent can produce observed output $\tilde{y}_i = y_i + b_i$, and the (deadweight) cost of the rent-seeking activity is given by $K(b_i) = \kappa b_i^2/2$.

This model differs from the model above in that there is no monitoring cost to observing output, but there is a cost to using output-based contracts in that they induce rent seeking. This results in optimal piece rates of less than unity, even with risk-neutral agents. Straightforward calculations show that the optimal output piece rate is given by $\beta_1^* = 1/[1 + (c/\kappa)]$, and the resulting surplus is

$$S^* = E[\rho'_{1(2)}] + \left[\frac{1}{1 + (c/\kappa)}\right]\left[\frac{1}{c} - \frac{1}{1 + (c/\kappa)}\left(\frac{1}{2c} + \frac{1}{2k}\right)\right] + \frac{B}{2}.$$

In this case, the analogue to m_y in Section III is given by

$$\frac{1}{2c} - \frac{1}{1 + (c/\kappa)}\left[\frac{1}{c} - \frac{1}{1 + (c/\kappa)}\left(\frac{1}{2c} + \frac{1}{2k}\right)\right] > 0$$

for $\kappa < \infty$. It follows by substitution that there exists a critical value of σ^2 above which output-based contracts are optimal, so that the logic generalizes to scenarios in which the costs of using output-based contracts are not fixed.

[20] It is difficult to obtain a closed-form solution for the costs of risk here, even in the commonly considered case of exponential utility functions initially used in Holmström and Milgrom (1991), which requires normally distributed errors. The reason for this is that the first order statistic of the normal distribution is not itself normally distributed, and so the usual certainty equivalence calculation does not apply.

[21] This is a simple model of influence, introduced by Milgrom and Roberts (1988).

V. On What Do These Results Depend?

One critical assumption generates the positive correlation between uncertainty and the use of output-based incentives, namely, that the measure of output be reliable and that the extent of reliability not be correlated with the uncertainty of the environment. Much of the recent work on agency theory starts from the premise that one difficulty with basing contracts on output is that observed measures typically do not reflect true output. It is well known that such concerns reduce the likelihood of output-based pay. However, an additional implication in the context of this model is that if such dysfunctional behavior is more difficult to detect in uncertain environments, the positive correlation between uncertainty and output-based incentives can reverse.

To see this, I make one change to my simplest case, example 1, in which $n = 2$ and both random variables $\rho_i \sim \mathcal{N}(0, \sigma^2)$. Remember that in this case, if input monitoring is used, expected output is $e^* - C(e^*) - m_e + B$. Now, however, I follow Baker (1992) and assume that the measure on which the agent can be rewarded is not true output y_i, but a corrupted measure of output $\hat{y}_i$, which is given by

$$\hat{y}_i = \rho_i + \mu e_i, \tag{12}$$

where $\mu \sim \mathcal{N}(0, \sigma_\mu^2)$. (I assume that μ is independent of i and ρ for simplicity.) Also assume that the cost of effort is given by $C(e_i) = e_i^2/2$ and that only the agent knows the true value of μ. The difficulty that this gives rise to is that the agent is rewarded on $\hat{y}_i$, which depends on μ, whereas surplus does not.

If the principal uses solely the monitoring of inputs, this extension has no effect on our earlier results. However, difficulties arise if only output contracting is used, as follows. If the firm chooses to reward the agent on $\hat{y}_i$, the optimal piece rate on output[22] is given by $\beta^* = 1/(1 + \sigma_\mu^2)$, and the ensuing surplus from the contract is given by

$$S = \frac{\sigma}{\sqrt{\pi}} + \frac{1}{2(1 + \sigma_\mu^2)} + \frac{B}{n} - m_y.$$

If σ_μ^2 and σ^2 are uncorrelated, this extension does not pose any problem to the qualitative results of the paper: the dysfunctional responses imply only that the critical value of uncertainty above which output contracting occurs is higher than without such responses. The reason

[22] I assume, as in Baker (1992), that more complex mechanisms are not possible to extract information on μ.

is that the multitasking concerns act like a fixed cost (in σ space) of contracting on output. Specifically, the critical value is now given by

$$\sigma^{2***} = \left[m_y - m_e + \frac{\sigma_\mu^2}{2(1+\sigma_\mu^2)} + \frac{B(n-1)}{n}\right]^2 \pi > \sigma^{2*}. \tag{13}$$

This result does not hold, however, if it is easier to engage in dysfunctional actions in more uncertain settings. It is not hard to imagine why such a correlation would arise. For example, consider a surgeon who is rewarded on the basis of mortality rates. Such a surgeon may avoid operating on particularly risky cases. Yet the opportunities for the surgeon to engage in such activities would likely be greater in the case of experimental surgery than with a routine procedure such as an appendectomy. Because appendectomies are characterized by little uncertainty, peer review is likely to be alert to a surgeon's attempts to avoid a tricky case. This will not be so with experimental procedures, which are less well known and less subject to standardized guidelines. Thus dysfunctional responses may be easier to get away with in more uncertain settings.

This correlation is important since it can cause the results above to reverse in such a way that incentives are no longer positively correlated with uncertainty. To see this, consider the following simple form of correlation between the two sources of uncertainty: $\sigma_\mu^2 = \tilde{\sigma}_\mu^2 + k\sigma^2$. Here, k picks up the degree of correlation in how multitasking opportunities vary with the underlying uncertainty of the environment. Then designing the optimal output-based contract still implies a piece rate of $\beta^* = 1/(1+\sigma_\mu^2)$, and the ensuing surplus from the contract (if used) is given by

$$\frac{\sigma}{\sqrt{\pi}} + \frac{1}{2(1+\sigma_\mu^2)} + \frac{B}{n} - m_y,$$

which equals

$$\tilde{S} = \frac{\sigma}{\sqrt{\pi}} + \frac{1}{2(1+\tilde{\sigma}_\mu^2 + k\sigma^2)} + \frac{B}{n} - m_y. \tag{14}$$

In contrast to the previous sections, this term (which measures the value of an output-based contract) is no longer necessarily increasing in σ^2. In other words, it is no longer necessarily the case that the value of output contracting is increasing in uncertainty, since the opportunities for dysfunctional behavior also increase in the uncertainty of the environment. Only if k is small (i.e., when dysfunctional behavior is not much more a problem in uncertain than in certain settings) will the result necessarily hold. By contrast, for k sufficiently large, $\tilde{S}$ must decrease in σ^2 because the effect on the dysfunctional responses will be larger than the benefit from a better choice of activity.[23] Indeed, for the case in which k is large enough and $m_e > m_y$, the results of the model above are reversed: for low uncertainty, output-based contracts are used, and for higher rates of uncertainty, input-based contracts are used.[24]

This implies that an important assumption to obtain a positive correlation between uncertainty and incentives is that good measures of output are available. The point of this is that a positive relationship between uncertainty and incentives occurs most likely in tests of franchising, executive pay, or sharecropping, where such measures are available, rather than, for example, expecting output-based incentives in exploratory surgery, which, though characterized by considerable uncertainty, is subject to the type of multitasking concerns described in Leventis (1997).

VI. Empirical Implications

The results of the paper rely on two key assumptions. First, when monitoring of inputs is costly, firms will respond by offering output-based contracts with delegation of tasks. Second, determining the optimal course of action is more difficult in uncertain circumstances, so that delegation of responsibility is more likely in risky settings. There are tests of the first assumption in the context of the franchising decision. These data are, again, taken from a recent survey by Lafontaine and Slade (2001). Specifically, they survey existing evidence to see how (more prosaic) monitoring costs affect the decision to franchise. The available research conclusively shows that franchising is more likely (a plus sign in table 5) when direct monitoring costs are high.

These papers use a measure of direct monitoring costs (how far it is to travel to the franchise, whether there are other franchises nearby, whether the franchise is situated in a rural area, and so on) and show that when monitoring costs are high, franchising is more likely. In terms of the model above, it is more effective simply to delegate decision making to the agent in such settings, but to offer output-based contracts. This supports the first assumption of the model.

The second assumption is that monitoring is more costly in uncertain environments and that delegation is more likely to occur in such uncertain environments. The empirical difficulty here is that worker dis-

[23] There is one other strategy, ignored here, in which the principal chooses to monitor *both* inputs and outputs. Although costly, it may be the optimal way to resolve the agency problems with both effort and activity choice. This becomes optimal when σ^2 is large enough. I have ignored it here simply because I wish to show how the results above can reverse, which will be the case if the monitoring costs are large enough that monitoring of both does not happen.

[24] Little can be said about intermediate levels since $\tilde{S}$ need not be monotonic in σ^2.

TABLE 5
DIRECT MONITORING COSTS AND THE DECISION TO FRANCHISE

Authors	Measure Used	Result
Brickley and Dark (1987)	Distance from headquarters	+
Bercovitz (1998)	Distance from headquarters	+
Minkler (1990)	Distance from headquarters	+
Norton (1988)	Rural	+
Brickley et al. (1991)	Low population density	+
Carney and Gedajlovic (1991)	Low population density	+
Lafontaine (1992)	Absence of other franchises in the zip code	+
Kehoe (1996)	Absence of other franchises in the zip code	+

cretion is typically unobserved that could bias econometric estimates. A natural implication of this is that without controlling for some measure of responsibility, we are likely to find a positive relationship between uncertainty and incentives; but if we can control for task assignment, we would expect to see no such relationship.[25]

The most likely place to observe data on the correlates of agents' responsibilities is in the franchising literature; franchisees are offered more responsibilities than the managers of company-owned stores. This theory suggests that the decision to franchise (and hence delegate responsibility to the agent) will be positively correlated with uncertainty, but *conditional on franchising*, there is no reason to expect such a relationship. In the strict terms of the model provided above with risk-neutral agents, there would be no relationship between uncertainty and the extent of output-based incentives. Yet adding risk preferences to the model would recover the traditional negative relationship if franchisees are risk-averse. The only evidence I am aware of that tests this proposition is in the paper by Lafontaine (1992), who considers how uncertainty affects both (i) the decision to franchise and (ii) the royalty rate offered to the franchisee. She finds (see her table 5) that the decision to franchise is statistically significant and *positively* related to her measure of uncertainty (the likelihood of bankruptcy); but royalty rates are *negatively* related, though with a *t*-statistic of only 1.4. This clearly suggests that risk plays a different role in the decision to allocate tasks to the agent than in the case in which it is simply providing insurance and incentives. As such, I take this result as supportive of the model in that

[25] This model also suggests that workers who report that they have considerable discretion over their jobs should be more likely to be offered pay for performance. The only empirical work that I am aware of that tests this is MacLeod and Parent (1999) and Nagar (2001), both of which find that delegation increases incentives.

it suggests that delegation of decision making occurs in uncertain environments, but conditional on the delegation decision, there is little reason to expect such a relationship.

Rao's (1971) analysis of sharecropping also seems apposite. He examines the frequency of renting versus sharecropping for rice and tobacco farmers in Andhra Pradesh. Although rice yields are characterized by much less uncertainty than tobacco yields, rice farmers are less likely to have fixed rental contracts than tobacco farmers. This is obviously counter to the standard theory, which suggests that fixed rents are more common for crops with little uncertainty.

To resolve this puzzle, Rao notes (as in this paper) that the standard agency model "omits any consideration of the scope for decision making in the face of uncertainty" (p. 582). Such decision-making rights are particularly important in situations of uncertainty since "relative economic certainty in the sense of limited decision making seems to be necessary for the prevalence of sharecropping," whereas "situations of high uncertainty may necessitate fixed-cash rents" (p. 582). Rao specifically attributes this difference to the greater role for "entrepreneurship" in responding to economic conditions for tobacco than for rice. One important feature is how farmers respond to changing relative prices of crops. Changing acreage under cultivation in response to changing relative prices is an important part of the effort decisions that farmers make: higher prices should result in the farming of more marginal land. Rao argues (in standard agency terminology) that the reason for the difference in contracts is that the marginal return to effort in response to such uncertainty is lower in rice than in tobacco. He notes that "the area under rice cultivation responded little to changes in its relative price" (p. 583) because soil suitable for rice is typically unsuitable for other crops.[26] In effect, there is little response that farmers can make to area grown when the relative price of rice changes. As a result, there is less need to offer agents incentives for rice, whereas for tobacco there are more opportunities to respond, and so fixed-rent contracts are more common. As with the model above, this approach stresses how uncertainty affects the returns to costly actions.[27]

[26] As a result, low elasticities of areas cultivated to relative price are found for rice, in the range of 0.03–0.08 (see Rao [1971] for the appropriate references).

[27] Ackerberg and Botticini (2002) offer an alternative argument why there can be little observed relationship between risk and incentives, also based on omitted variable bias. They focus on the role of matching of workers to tasks on the basis of unobserved characteristics. For example, consider the case in which workers have different risk preferences. If less risk averse farmers match with the riskier crops, as seems reasonable, then their greater risk tolerance may imply more pay for performance in riskier crops, as suggested by the data. If an econometrician could observe risk tolerance, these positive effects would disappear (in much the same way that would occur if she could observe task assignment in my model); but as they do not, it is easy to generate a positive relationship between risk and incentives.

Finally, I return to the literature on executives. In contrast to the evidence on franchising and sharecropping, the literature on the trade-off between risk and incentives for executives is inconclusive. One possible reason for the absence of a positive correlation between risk and incentives is simply that there is little variation in the delegation of tasks across executives. These results rely on the assumption that there exists a body that can constrain the actions of agents. In the context of a chief executive officer, this likely would be the board of directors, which could conceivably veto some of his desires. But if empirically chief executive officers are little constrained by their boards of directors, there is no reason to expect the omitted variable bias that generates the positive trade-off in this paper. Only in cases in which principals respond to uncertainty by delegating more responsibility will a positive trade-off be expected.

VII. Conclusion

In prior work (Prendergast 2000), I provided an example illustrating how more uncertainty can imply delegation and contracts for the reasons described above.[28] This paper has three additional contributions. First, I fully develop the generality and limits of the theoretical argument in Sections III–V. I do so by considering other distributional assumptions, allowing other contracts (such as those with communication), considering the effect of complexity of tasks, and, finally, giving agents additional responses to contracts. Perhaps most important, I illustrate here that the effects are limited by how the value of output-based contracting depends on uncertainty in Section V. Second, I carefully detail in Section II how existing empirical work does not support the negative trade-off between risk and incentives, and show instead that there appears to be more evidence of a positive relationship. Third, I develop empirical implications of the theory in Section VI. Also related is work that considers the choice between monitoring the actions of agents and allowing agents the discretion to choose their own actions, such as in Lazear (2000). The novelty of this paper is not the introduction of this dichotomy, but rather how it can be used to explain the absence of an empirical relationship between output-based contracting and measures of uncertainty. Most closely related is the paper by Lafontaine and Bhattacharyya (1995), who argue that the decision to franchise can be explained by a model in which franchisors choose between assigning effort levels to employees and delegating the choice of effort to franchisees,

[28] See Prendergast (2002) for other reasons why a negative relationship between risk and incentives may not be recovered.

but they are constrained by output-based contracts. Their numerical simulations are based on insights similar to those provided here.

In summary, the trade-off between risk and incentives has become a mantra among economists working on agency issues, despite the rather lukewarm evidence in its favor. Indeed, in some occupations there is more convincing evidence of a positive relationship. The objective of this paper has been to understand why we might not expect to find such a relationship in the data. I argue that the marginal returns to delegation are likely to be higher in more uncertain environments, since a principal may have little idea what the right kinds of effort are in such cases. In more stable environments, they can simply tell the agent what to do, whereas in riskier settings, they may have little choice but to offer agency contracts to induce appropriate behavior, since there are no other good measures of performance on which to base pay. Thus incentives and uncertainty are positively related.

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