AN EMPIRICAL ANALYSIS OF RISK, INCENTIVES AND THE DELEGATION OF WORKER AUTHORITY

*JED DEVARO AND FIDAN ANA KURTULUS**

The authors empirically test Prendergast's (2002) theory that incorporates the delegation of worker authority into the principal-agent model to explain the lack of consistent empirical support for a tradeoff between risk and incentives. Using data from the 1998 British WERS, the authors investigate whether there is: 1) evidence of a risk-incentives tradeoff as predicted by the principal-agent model; 2) evidence of a positive relationship between incentive pay and the delegation of worker authority; 3) evidence of a positive relationship between risk and authority; 4) support for the main testable implication of Prendergast's model, namely that the evidence favoring a risk-incentives tradeoff should strengthen when authority controls are added to the empirical model. The answers are affirmative for all four questions, thereby providing evidence clarifying the relationship between risk and incentive pay and how managers optimally bundle incentive pay and the delegation of worker decision rights to cope with risk.

The trade-off between risk and incentives, a key feature of the principal-agent model, has received significant scholarly attention since the original papers published by Holmström (1979) and Shavell (1979). Specifically, the model proposes that risk-averse workers are reluctant to accept output-contingent compensation contracts in production settings characterized by a high degree of risk, meaning situations in which output is determined largely by stochastic factors beyond the worker's control. The firm's response is thus to decrease the amount of output-based pay as the degree of risk or uncertainty in the production environment increases. This theoretical prediction has been the subject of a vast number of empirical tests, but the collective evidence has been inconclusive. Some tests have found the predicted negative relationship, whereas others have found a positive or no relationship between risk and incentive pay.

Prendergast (2002) proposed a theory that potentially explains why the empirical evidence has been inconclusive. At the heart of his explanation is the delegation of worker authority which, he argued, is a key element that the standard agency model ignores. In production settings characterized by a low level of uncertainty, the firm has a clear sense of what tasks should be performed and how they should be performed. In such settings, the firm is content to monitor labor inputs. Conversely, when the production setting is characterized by

* Jed DeVaro is the Wang Family Professor, Department of Management and Department of Economics, at California State University–East Bay, and Fidan Ana Kurtulus is Assistant Professor at the Department of Economics, University of Massachusetts–Amherst.

The authors acknowledge the Department of Trade and Industry, the Economic and Social Research Council, the Advisory, Conciliation and Arbitration Service and the Policy Studies Institute as the originators of the 1998 Workplace Employee Relations Survey data, and the Data Archive at the University of Essex as the distributor of the data. The authors are grateful for helpful comments from numerous colleagues and from seminar participants at the University of Massachusetts at Amherst, University of Illinois at Urbana-Champaign, the University of Victoria, and the 2006 meeting of the Society of Labor Economists. All programs are available upon request from Jed DeVaro at jed.devaro@csueastbay.edu or Fidan Ana Kurtulus at fidan@econs.umass.edu, and the data used in this study are publicly available via the U.K. data Archive.

Industrial and Labor Relations Review, Vol. 63, No. 4 (July 2010). © by Cornell University.
0019-7939/00/6304 $05.00

a high level of uncertainty, the firm understands less what decisions need to be made and which tasks should be performed. The firm responds by delegating more authority to the worker, who is closer to the production process and often has better information than does the firm about what tasks should be performed.[1] The firm accompanies this delegation of authority with output-based pay to hold the worker accountable for his decisions and to ensure that the worker does not misuse his discretion by choosing the wrong tasks.[2] That is, when the degree of uncertainty increases, the firm shifts from monitoring inputs and retaining control over tasks to monitoring outputs and delegating authority over tasks.

This suggests a positive relationship between incentive pay and risk (operating through the channel of worker authority), in contrast to the negative relationship (operating through the channel of insurance) implied by standard agency theory. Thus, the main testable result of Prendergast's model is that the predicted sign of the relationship between risk and incentives is ambiguous. He states the empirical problem as follows:

> The empirical difficulty here is that worker discretion is typically unobserved that could bias econometric estimates . . . 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. (pp. 1096–1097)

Thus, Prendergast argues that controlling for worker authority in a regression of incentive pay on risk should decrease the coefficient on risk.

Prendergast cites several empirical papers that provide indirect support for his theory, but a direct test requires that worker authority be incorporated into the standard risk-incentives regressions. A practical difficulty with implementing this test is that measures of worker authority over task selection are rarely available in existing data sets. Furthermore, these measures must be available in conjunction with measures of incentive pay and risk for the theory to be tested. Our empirical tests solve this dilemma. They are based on a large, nationally representative cross section of British establishments from the 1998 Workplace Employee Relations Survey (WERS98) containing information on risk, multiple dimensions of worker authority (both as perceived by workers and as perceived by employers), and incentive pay.

A potential concern is that a control for worker authority appearing on the right-hand side of a risk-incentives regression model might be endogenous; since it is chosen by the employer along with the structure of the compensation plan, the unobserved determinants of both choices are likely to be correlated, biasing the coefficients. To address this issue, we estimate a bivariate probit model, treating both incentive pay and worker authority as endogenous variables. The parameters in the bivariate probit model with a dummy endogenous variable on the right-hand side are identified (except in pathological cases, such as one demonstrated in Maddala 1983, that do not apply here) even in the absence of exclusion restrictions (Heckman 1978; Wilde 2000; Monfardini and Radice 2008). An exogeneity test in this model reveals that the null hypothesis that worker authority is exogenous cannot be rejected.

We address four empirical questions in this paper. Is there empirical support for (1) the risk-incentives trade-off predicted by agency theory? (2) a positive relationship between authority and incentives? (3) a positive relationship between risk and authority? (4) the main testable implication of Prendergast's model, namely that the risk coefficient in an incentives regression should become smaller (that is, less positive or more negative) when delegation of worker authority is incorporated into the risk-incentives regression model? Though in some cases the relevant parameters are estimated with modest precision, our empirical results

[1] The argument that the agent should receive more authority the greater his informational advantage is was formalized by Aoki (1986). See also Dessein (2002) for a discussion of recent trends in firms pushing decision rights lower in their organizational hierarchies in order to profit from the local knowledge possessed by lower level managers.

[2] The argument that authority and incentives go hand in hand was formalized in the literature prior to Prendergast (2002). Jensen and Meckling (1992) analyzed how the decentralization of decision rights to agents with specific knowledge and abilities increases efficiency and argued that these decision rights should be accompanied by a control mechanism such as pay-for-performance in order to motivate individuals to use their decision rights optimally. Holmström and Milgrom (1994) derived a formal model in which the effectiveness of incentives is enhanced when simultaneously implemented with delegation of responsibility to agents.

support affirmative answers to all four questions. Thus, our analysis contributes to the literature by providing evidence clarifying the relationship between risk and incentive pay and how managers optimally bundle incentive pay and the delegation of worker decision rights to cope with risk. In particular, we reconcile the mixed nature of the empirical literature concerning evidence for a risk-incentives trade-off by empirically addressing Prendergast's extension of the standard principal-agent model.

Related Literature

Our first question concerns whether or not empirical support exists for the risk-incentives trade-off. Many empirical studies have been conducted using data from a variety of industries and worker types, testing for the negative relationship between risk and incentives, as standard agency theory predicts. Some of these tests have found the predicted negative relationship (Lambert and Larcker 1987; Kawasaki and McMillan 1987; Aggarwal and Samwick 1999 and 2002; Mengistae and Xu 2004; Adams 2005; Gibbs et al. 2006; Wulf 2007). Other tests found a positive relationship (Rao 1971; Norton 1988; Leffler and Rucker 1991; Allen and Lueck 1992; Lafontaine 1992; Martin 1988; Core and Guay 1999 and 2002; Conyon and Murphy 2000; Ackerberg and Botticini 2002; Oyer and Schaefer 2005; Foss and Laursen 2005; Shi 2005). Still others found no statistically significant relationship at all (Anderson and Schmittlein 1984; John and Weitz 1989; Yermack 1995; Bushman; Indjejikian and Smith 1996; Ittner, Larcker and Rajan 1997; Garen 1994; Nagar 2002).[3] The majority of these studies did not include a control for authority in the regressions of incentives on risk.

Our second question refers to the relationship between authority and incentives. Previous empirical evidence demonstrates that incentive pay accompanies the delegation of authority (MacLeod and Parent 1999; Nagar 2002; Colombo and Delmastro 2004; Foss and Laursen 2005; Wulf 2007). Regarding our third question, direct empirical evidence regarding a positive correlation between delegation and risk is rare since data spanning multiple firms and industries typically do not contain information on the extent of authority delegated to workers. Nonetheless, some empirical support can be found from franchises, sharecropped farms, retail banking, and Danish firms (Lafontaine 1992; Rao 1971; Nagar 2002; Foss and Laursen 2005).

The evidence on these first three questions from the sample of British establishments we study in this paper complements the evidence from previous analyses. In our view, however, the main contribution of our study is the evidence we present on the fourth empirical question. Our data are particularly well suited for testing Prendergast's model, given the availability of an authority measure that closely matches the concept as he outlined it. Several previous studies have incorporated authority into a risk-incentives regression model, and these are most closely related to our paper as we now discuss.

Foss and Laursen (2005) studied 993 Danish firms sampled in 1996. Though their measures of incentive pay and authority are roughly similar to ours, their main risk measure, which they refer to as "within-industry variance in profitability," differs substantially. To construct this variable, they assigned each firm in their sample to one of 70 industry categories. Within each of these 70 groups, they computed the variance of firm profits. Each firm's value for the risk measure is the variance that was computed for all firms belonging to the same industry category, so that the risk variable in their analysis assumes only 70 possible values. They then estimated an ordered probit model using incentive pay as the dependent variable and the 70-valued risk measure as an independent variable, along with a set of controls.

Estimating the Foss and Laursen model using their risk measure is computationally identical to estimating a more general model that includes 70 industry dummies (in lieu of their risk measure) but that also imposes 70 parametric restrictions, so that the ratio of every pair of coefficients on the industry dummies is constrained to equal a constant that the researcher specifies. The 70 restrictions implicitly imposed in the Foss and Laursen model are testable, but they are not tested in their paper. Implicit in these 70 restrictions is the

[3] A table that summarizes the variables, data and econometric models used in these papers is available from the authors upon request.

strong assumption that the coefficients of each industry dummy reflect the effect of risk and nothing else. Since that assumption is unlikely to be correct, there is reason to suspect that the test might fail. Our risk measure, which we describe below, does not impose such restrictions on the coefficients of industry dummies.

Adams (2005) analyzed the manufacturing establishments from the 1998 WERS (a subsample of 166 establishments of the 1590 we consider), treating the worker rather than the establishment as the unit of observation. Incentive pay, however, is not observed in the 1998 WERS at the level of individual workers, so he attempted to infer this measure using establishment-level questions about what fraction of the workers in the given worker's occupation receives either profit-related pay or participates in Employee Stock Ownership Plans (ESOPs) (if more than 80% of the workers receive such payments, the given worker is assumed to receive it; if less than 20% of the workers receive such payments, the given worker is assumed not to receive it; if between 20% and 80% of the workers receive such payments, the given worker is dropped from the sample). We prefer to conduct the analysis at the establishment level because the risk measure available in the WERS varies only across establishments—not across workers within an establishment. So for the purpose of measuring the risk-incentives trade-off, no additional information comes from disaggregating to the worker level, since this parameter is identified only by variation across establishments.

Wulf (2007) used a panel of 250 publicly traded U.S. firms to show that in the presence of a control for whether division managers have officer status (such as president, CFO, VP) the trade-off between division-level risk and managerial incentives is stronger than when the control is omitted. This result is consistent with the notion of authority as a mitigating factor in the risk-incentives relationship. One aspect of the analysis that complicates an interpretation of this as a direct test of Prendergast's main proposition, however, is that the set of covariates in the regressions that omit authority are different from those that include authority.

Nagar (2002) used a cross section of 100 retail banks in the United States in 1994 to show that, holding constant the authority delegated from top bank management to branch managers (in terms of hiring, promotions, hours, and investment decisions), a negative though statistically insignificant relationship exists between uncertainty (as proxied by volatility in earnings and bank growth) and incentive pay (as reflected in the proportion of bank managers' pay comprised of bonuses). Since that study did not estimate models that omit authority, however, we are unable to compare the relationship between risk and incentives when authority is controlled as opposed to when it is not, so the study does not provide a test of our fourth empirical question.

Shi (2005) used data on 2900 CEOs from the Compustat Execucomp database in the period spanning 1992–2001, providing evidence consistent with Prendergast's main testable prediction if we interpret Shi's definition of CEO ability to respond to risk broadly as Prendergast's definition of decision-making authority. Specifically, Shi found that CEO incentives—measured by the share of firm profits held by the CEO—increase with industry-wide risk. This risk is measured as the variance of industry stock returns, which Shi argued is risk to which the CEO can respond by collecting industry information and making decisions based on it; this positive relation diminishes as the definition of industry is broadened, so that the CEO is less able to act on collected information. An advantage of our analysis, by contrast, is that whereas Shi focuses only on CEOs, our study is based on a broad sample of employee-types, both managerial and non-managerial.

Finally, Ben-Ner, Kong, and Lluis (2007) analyzed 640 observations from the Minnesota Human Resources Management Practices Survey, a 1994–1995 survey of private, for-profit, Minnesota-based firms. Using an authority measure similar to ours, their binary incentives measure indicates the "existence of an individual incentives plan." Their analysis considered two measures of risk or uncertainty, namely "external uncertainty" and "internal uncertainty." The external uncertainty measure is similar to that constructed by Foss and Laursen (2005), as described above. The internal uncertainty measure is the sum of three components that the authors argue should be related to internal uncertainty (that is, complexity, variability, and routine, each of which is measured on a Likert scale). Some

of the evidence in Ben-Ner, Kong, and Lluis is consistent with ours (such as the positive relationships between incentives and delegation and between delegation and risk). However, as was the case with Wulf (2007), one aspect of their analysis that complicates an interpretation of the results as a direct test of Prendergast's main proposition is that the specifications in the regressions that omit authority are different from those that include authority.

Though Prendergast's model is one of the earliest and probably the best known in the theoretical literature aiming to reconcile agency theory with the mixed empirical support for a risk-incentives trade-off, alternative theoretical approaches for explaining the empirical puzzle have been proposed (see, for example, Zabojnik 1996; Core and Qian 2002; Baker and Jorgensen 2003; Raith 2003; Oyer 2004; Adams 2005; Raith 2008; Serfes 2005; Shi 2005). Many of these theories do not concern issues of delegation of authority, and some of them are based on ideas that our data are ill-equipped to address (such as distinguishing between two alternative types of risk, as in Zabojnik 1996 and Baker and Jorgensen 2003), so we do not address them in this paper. At the same time, the empirical support for Prendergast's model that we find in this paper does not diminish the validity of these alternative theories.

Theoretical Analysis and Hypotheses

In Prendergast's (2002) model, the risk-neutral agent exerts effort on one of n tasks. The principal chooses either an input-based or an output-based compensation contract and either assigns the agent a task or delegates authority to the agent to choose a task. In a literal interpretation of the model, the worker who has been delegated authority chooses *what* task to perform. In real-world organizations, it is often the upper-level managers who have the authority to choose the tasks whereas front-line workers are granted authority not over *what* tasks to perform but rather authority over *how and when* to perform them; in other words, the actual tasks—*what* is supposed to be done—are determined higher up in the organization. We argue that a broader interpretation of the term "task delegation" (extending to *how and when*) in Prendergast's model is appropriate, and in that case his model also applies to non-managerial workers. For example, a worker doing a job consisting of multiple tasks can choose the emphasis to place on each, so Prendergast's assumption that a worker chooses one out of n tasks could be interpreted as the emphasis the worker places on a particular task or the frequency with which it is performed.

As in earlier work (e.g. Holmström 1979; Holmström and Milgrom 1991) Prendergast (2002) interpreted risk as uncertainty in the economic environment. The firm's output is $y_i = e_i + \varepsilon_i$, where i denotes the agent's task, and e_i is the agent's effort. The n random variables, ε_i, have common variance, σ^2, but differ in their means, with an increase in σ^2 implying a more uncertain production environment.

The agent knows the true value of ε_i whereas the principal only knows its distribution; this asymmetry justifies the delegation of authority, given that the worker frequently has more accurate information than does the manager about the idiosyncrasies of the production process by virtue of being closer to it. For example, a sales clerk would be better informed than the store manager about customers' impressions concerning a new product (i.e., demand variability). Likewise, a line worker is more likely than the plant manager to know whether a particular machine being operated is about to break down and lead to a production bottleneck (i.e., supply variability).

When σ^2 is sufficiently low, the principal assigns the agent a task and compensates that worker using an input-based contract; conversely, when σ^2 is sufficiently high, the principal allows the worker to choose the task but compensates him or her using an output-based contract. If agents are risk-averse, the standard risk-incentives trade-off is also present, and the net effect of risk on incentives is ambiguous in sign. From this discussion, four points emerge that can be addressed empirically:

1. In the absence of a control for delegation of worker authority, the sign of the risk-incentive relationship is ambiguous.
2. Incentive pay and delegation of worker authority should be positively correlated.
3. Authority and risk should be positively correlated.
4. When a control for worker authority is included in a regression of incentive pay on risk, the risk coefficient should decrease (that

is, become less positive or more negative).

Methods

Data

Our sample is drawn from both the management and worker questionnaires in the 1998 British Workplace Employee Relations Survey (WERS98), jointly sponsored by the Department of Trade and Industry, ACAS, the Economic and Social Research Council, and the Policy Studies Institute. Distributed via the U.K. 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 et al. 1999) after excluding the out-of-scope cases.[4] 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. In addition, a random sample of up to 25 employees per establishment was surveyed, producing the responses for the employee questionnaire.

The "risk" question was only asked of establishments in the private sector, producing 1591 responses. Of these, 1590 establishments responded to the questions about performance-related pay. Descriptive statistics for all variables in our analysis are displayed in Table 1 for the analysis sample of 1590 establishments. In Table 1 and in all of our analyses we use establishment weights; in most cases, worker weights yield the same qualitative results. Some of the variables in our analysis contain missing values, and we estimate all of our models using list-wise deletion. The main source of missing information is the measure of worker authority, since only 1277 of the 1590 establishments reported any worker responses to the authority question. A table of means on this smaller subsample of N = 1277 closely matches Table 1.

Measures

Incentive Pay

In the principal-agent model, the firm consists of a single worker whose individual output (or net revenue) coincides with that of the firm. Taken literally, the model abstracts from some relevant details of the workplace, such as the fact that most firms comprise more than one worker, and a broader interpretation is therefore required if the theory is to be helpful in understanding behavior in a large sample of employers. In practice, employers rarely design incentive compensation systems tailored to the characteristics of individual workers. Rather, in the typical workplace, the employer designs the incentive pay system to apply to broad groups of workers (such as all workers within an establishment or perhaps all workers in a particular occupation within the establishment). Thus, from the standpoint of empirical work that tests the theory, a measure of pay-for-performance at the level of the establishment (as opposed to the level of the individual worker) is acceptable. We use the following measure from the management survey:

Performance Pay = 1 if any employees at the workplace receive payments or dividends from individual or group performance-related schemes; = 0 otherwise.[5]

In the principal-agent model, the relevant notion of incentive pay is a linear piece rate, or

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

[5] The wording of the question permits group-based as well as individual-based schemes, whereas the relevant theories pertain to individual-based schemes. This does not present a problem for our analysis. The majority of establishments reporting pay-for-performance use individual-based schemes in our data, and restricting the incentive pay measure to equal one only when it is certain that individual-based performance pay is used yields results very similar to those we report here.

Table 1. Descriptive Statistics

	Mean	*Min*	*Max*	*Median*	*Std. Dev.*
Basic Firm Characteristics:					
Risk	0.218	0	1	0	0.388
Single-Establishment Firm	0.350	0	1	0	0.435
Fixed-Term Workers Over One Year	0.140	0	1	0	0.401
Fixed-Term Workers Under One Year	0.233	0	1	0	0.493
Operation Over Five Years	0.899	0	1	1	0.297
Main Activity of Establishment	0.686	0	1	1	0.457
Temporary Workers	0.193	0	1	0	0.483
Establishment Size	0.062	0.002	28.971	0.106	0.928
Fraction of Part Time Workers	0.310	0	1	0.132	0.287
Number of Recognized Unions	0.637	0	10	1	1.893
100% Workers Unionized	0.236	0	1	0	0.444
80–99% Workers Unionized	0.045	0	1	0	0.323
60–79% Workers Unionized	0.035	0	1	0	0.251
40–59% Workers Unionized	0.018	0	1	0	0.178
20–39% Workers Unionized	0.007	0	1	0	0.097
1–19% Workers Unionized	0.016	0	1	0	0.132
0% Workers Unionized	0.644	0	1	0	0.500
Firm Ownership:					
Private Sector Publicly Traded Non-franchise	0.016	0	1	0	0.122
Private Sector Publicly Traded Franchise	0.329	0	1	0	0.495
Private Sector Non-franchise	0.027	0	1	0	0.109
Private Sector Franchise	0.469	0	1	0	0.473
Industry:					
Manufacturing	0.166	0	1	0	0.376
Electricity, Gas, and Water	0.002	0	1	0	0.176
Construction	0.041	0	1	0	0.209
Wholesale and Retail	0.235	0	1	0	0.382
Hotels and Restaurants	0.088	0	1	0	0.256
Transport and Communication	0.345	0	1	0	0.246
Financial Services	0.039	0	1	0	0.232
Other Business Services	0.115	0	1	0	0.315
Public Administration	0.020	0	1	0	0.176
Education	0.098	0	1	0	0.293
Health	0.110	0	1	0	0.297
Other Community Services	0.038	0	1	0	0.209
Largest Occupational Group at Workplace:					
Managers and Administrators	0.006	0	1	0	0.075
Professional Occupations	0.099	0	1	0	0.326
Associate Professional and Technical Operations	0.056	0	1	0	0.267
Clerical and Secretarial Occupations	0.145	0	1	0	0.349
Craft and Skilled Service Occupations	0.132	0	1	0	0.324
Personal and Protective Service Occupations	0.170	0	1	0	0.333
Sales Occupations	0.162	0	1	0	0.343
Plant and Machine Operatives	0.138	0	1	0	0.365
Other Occupations	0.092	0	1	0	0.319
Incentive Pay:					
Performance Pay	0.196	0	1	0	0.440
Worker Authority:					
Authority1	0.078	0	1	0	0.277
Authority2	0.078	0	1	0	0.244
Authority3	0.526	0	1	1	0.495
Authority4	0.317	0	1	0	0.451
$AUTHORITY_{HOW}(W)1$	0.032	0	1	0	0.141
$AUTHORITY_{HOW}(W)2$	0.307	0	1	0	0.443
$AUTHORITY_{HOW}(W)3$	0.660	0	1	1	0.453
$AUTHORITY_{HOW}(F)1$	0.072	0	1	0	0.276
$AUTHORITY_{HOW}(F)2$	0.209	0	1	0	0.445
$AUTHORITY_{HOW}(F)3$	0.441	0	1	0	0.496
$AUTHORITY_{HOW}(F)4$	0.278	0	1	0	0.410
Sample Size = 1590					

Note: Tabulations are for the 1590 establishments in the private sector for which data on both risk and incentives are non-missing and excluding those establishments in public administration. Some of the above statistics are based on a smaller sample, however, due to missing values. Establishment sSize is measured in thousands.

the slope of the relationship between the agent's compensation and output, whereas our binary measure of performance pay describes whether performance-related pay is used at all, providing no information on its intensity. In the context of testing Prendergast's specific model, however, our binary measure actually matches the theory better than would a continuous measure of incentive pay within the establishment. The reason for this is that Prendergast's model (taken literally) predicts that the principal chooses either output-based pay or input-based pay and never a mix of the two, though the basic logic of Prendergast's argument should extend to the proportion of compensation that is output-based. Furthermore, since we have a large sample of establishments, with plenty of variation in the use of incentive pay, our binary measure provides valuable information, though more detailed data on a continuous measure of incentive pay within each establishment would be even more informative.

Risk or Uncertainty

In the principal-agent model, the agent's output or net revenue (which equals the output or net revenue of the entire single-worker firm) is determined both by the agent's effort level and by a stochastic component. The variance of the stochastic component of output is referred to as risk or uncertainty. Consider the piece-rate system used to compensate the installers of automobile windshields at Safelite Glass Corporation. Safelite designs a "one-size-fits-all" piece-rate scheme that is applied uniformly to all workers in the job, in consideration of broad, market-level risks that are expected to influence the outputs of large groups of workers. Our measure from the management survey is as follows:

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

Though the potential for such market-level turbulence to affect managerial output is clear, it is perhaps less obvious how the behavior of non-managerial workers might be affected. At Safelite Glass Corporation, market turbulence can be expected to affect the productivity (output) of non-managerial workers even if they have some authority over the work process, as overall demand uncertainty for windshields trickles down to the typical windshield installer. This captures Prendergast's notion of uncertainty in the production environment, but since it is a broad measure it is also likely to capture measurement noise.

Worker Authority

Prendergast drew a key "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*" (p. 1072; emphasis added). Prendergast's notion of authority, therefore, corresponds to delegating workers the power to make their own decisions about which tasks to perform.[6] The WERS employee survey contains a question that closely corresponds to this notion. At each establishment, up to 25 employees are randomly sampled and asked the following question: "In general, how much influence do you have about the range of tasks you do in your job?" Responses are recorded on a four-point scale (1 = "none," 2 = "a little," 3 = "some," 4 = "a lot"). We code all responses of "don't know" as missing. Since our measures of incentive pay, risk, and firm characteristics are measured at the establishment level, for the authority measure we aggregate the worker authority responses to the establishment level by taking the modal worker response.[7] The idea is that the most frequently occurring worker response to the authority questions within an establishment reflects the degree of authority experienced by the typical worker in that establishment. In the main analysis we use the following four-valued authority measure and the four binary indicators implied by it:

Authority = 1 if establishment's modal worker response is "none"
= 2 if establishment's modal worker response is "a little"= 3 if

[6] Other studies that formalize the notion of the delegation of authority in the agency framework include Aghion and Tirole (1997) and Al-Najjar (2001).

[7] We also aggregated using the median rather than the mode throughout the paper, finding very similar results to those we report here. These are available upon request. The median results are virtually insensitive to how the median is defined when the number of workers sampled at the establishment is even (i.e. whether observation n/2 or observation n/2 + 1 is defined as the median).

establishment's modal worker response is "some"= 4 if establishment's modal worker response is "a lot"

Authority1 = 1 if establishment's modal worker response is "none"= 0 otherwise

Authority2 = 1 if establishment's modal worker response is "a little"= 0 otherwise

Authority3 = 1 if establishment's modal worker response is "some"= 0 otherwise

Authority4 = 1 if establishment's modal worker response is "a lot"= 0 otherwise

We also consider some alternative measures of authority in our sensitivity analysis.

In addition to our key variables (i.e. risk, incentives, and authority), we include a large set of controls for firm characteristics in our models, including establishment size; main activity of the establishment; industry; whether the establishment is a single independent establishment or one of multiple establishments; ownership (private versus public, franchise versus non-franchise, publicly traded versus non-publicly traded); whether the establishment produces a single product or multiple products; fraction of part-time workers; presence of temporary workers; presence of fixed-term workers less than one year; presence of fixed-term workers more than one year; number of recognized unions; fraction of establishment that is unionized; and whether the establishment has been in operation for more than five years. These controls are defined in the appendix. Most are included simply to absorb employer attributes that may be correlated with the main variables of interest, though a few are included because of a clear theoretical rationale, particularly unionization and establishment size. Given that unions exert considerable influence over both the level of compensation and its composition, the number of recognized unions at the establishment as well as the fraction of the workforce that is unionized can be expected to influence the probability that an establishment will use incentive pay. Regarding establishment size, monitoring difficulty increases as the number of employees grows, making the establishment more likely to grant employees pay for performance as a substitute for costly monitoring. Coordinating and directing workers also becomes more costly as the number of employees increases, so larger organizations are more likely to resort to decentralization of decision-making and delegation.

Empirical Analysis

To investigate whether the trade-off between risk and incentives that standard agency theory predicts can be identified in the WERS data, we estimate the following probit model:

$$\text{Prob}(\text{Performance Pay}_i = 1) = \Phi(\alpha Risk_i + X_i\beta)$$

where X_i is a vector of controls for firm characteristics, and i indexes establishments. Agency theory predicts $\alpha < 0$. Our results in Table 2 support this prediction, though they are estimated with modest precision. In the first specification, the effect is statistically insignificant. As the second and third specifications demonstrate, however, once industry controls are included in the model, the effect is statistically significant at the ten percent significance level on a one-tailed test.[8] Based on the third specification that includes the full set of controls, the change in the predicted probability that incentive pay is offered when *Risk* increases from 0 to 1 (evaluating other covariates at their means) is −0.051. This magnitude is substantial, given that the mean of *Performance Pay* is 0.196. On average, an increase in *Risk* from 0 to 1 is associated with a decrease of 26 percent in the predicted probability that performance-related pay is used.

We next investigate whether there is empirical support for a positive relationship between authority and incentives. The rationale for a positive correlation is that in risky settings, the principal wants to switch from monitoring labor inputs to monitoring outputs. In such settings, the firm delegates decision-making authority to the worker but accompanies this authority with output-based pay. To test this empirically, we estimate the following probit model:

$$\text{Prob}(\textit{Performance Pay}_i = 1) = \Phi(\beta_2 Authority_{2i} + \beta_3 Authority_{3i} + \beta_4 Authority_{4i} + X_i\beta).$$

Empirical support for a positive correlation between authority and incentives would be

[8] Since the negative relationship between risk and incentives predicted by the principal-agent model is a directional hypothesis, we use one-tailed hypothesis tests as the criterion for statistical significance. We adhere to this convention throughout the paper whenever a directional hypothesis is implied by the theory.

Table 2. Evidence of a Tradeoff Between Risk and Incentives

	Dependent Variable: Performance Pay		
Independent Variables:			
Risk	–0.039	–0.061*	–0.051*
	(0.046)	(0.039)	(0.036)
Industry Controls:			
Manufacturing		–0.123***	–0.108***
		(0.027)	(0.026)
Electricity, Gas, and Water		–0.060	–0.100***
		(0.045)	(0.018)
Construction		–0.120***	–0.107***
		(0.027)	(0.023)
Hotels and Restaurants		–0.128***	–0.108***
		(0.026)	(0.022)
Transport and Communication		–0.078*	–0.083***
		(0.042)	(0.027)
Financial Services		0.115	0.064
		(0.087)	(0.083)
Other Business Services		–0.095***	–0.078***
		(0.031)	(0.028)
Public Administration		–0.109***	–0.111***
		(0.033)	(0.022)
Education		–0.171***	–0.156***
		(0.023)	(0.026)
Health		–0.194***	–0.167***
		(0.023)	(0.021)
Other Community Services		–0.121***	–0.101***
		(0.024)	(0.021)
Firm Controls:			
Single-Establishment Firm			0.003
			(0.033)
Fixed Term Workers Over One Year			–0.011
			(0.048)
Fixed Term Workers Under One Year			0.041
			(0.029)
Private Sector **Publicly** Traded Non-franchise			0.058
			(0.123)
Private Sector Publicly Traded Franchise			–0.017
			(0.068)
Private Sector Non-**franchise**			0.089
			(0.173)
Private Sector Franchise			–0.093
			(0.070)
Operation Over Five Years			0.040
			(0.032)
Main Activity of Establishment			0.083**
			(0.032)
Temporary Workers			0.017
			(0.029)
Establishment Size			0.036
			(0.024)
Fraction of Part-Time Workers			–0.130**
			(0.056)
Number of Recognized Unions			0.017
			(0.013)
100% Workers Unionized			–0.070
			(0.047)
80–99% Workers Unionized			–0.045
			(0.041)
60–79% Workers Unionized			–0.005
			(0.045)
40–59% Workers Unionized			–0.106
			(0.068)
20–39% Workers Unionized			0.035
			(0.102)
1–19% Workers Unionized			–0.169
			(0.106)
Sample Size	1546	1546	1546

Note: Results are probit marginal effects evaluated at the mean of the independent variable or, for binary independent variables, the change in predicted probabilities when the independent variable increases from 0 to 1 (evaluating all other covariates at their means). Robust standard errors are in parentheses. Reference group for industry dummies is Wholesale and Retail. Reference group for % unionized dummies is 0% Workers Unionized.

*Statistically significant at the .10 level; **at the .05 level; *** at the .001 level, using a one-tailed test for Risk and two–tailed tests for all other covariates.

Table 3. Relationship between Incentive Pay and Worker Authority

	Dependent Variable: Performance Pay		
Independent Variables:			
Authority2	0.028	–0.037	–0.025
	(0.110)	(0.083)	(0.069)
Authority3	–0.012	0.014	0.000
	(0.087)	(0.064)	(0.052)
Authority4	0.069	0.110**	0.100**
	(0.090)	(0.066)	(0.057)
Industry Controls	NO	YES	YES
Firm Controls	NO	NO	YES
Sample Size	1245	1245	1245

Note: Results are probit marginal effects evaluated at the mean of the independent variable or, for binary independent variables, the change in predicted probabilities when the independent variable increases from 0 to 1 (evaluating all other covariates at their means). Robust standard errors are in parentheses.
*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level, using a one-tailed test for Authority2, Authority3, Authority4. See Appendix for definitions of industry and firm controls.

implied by positive and statistically significant estimates of β_2, β_3, and β_4; furthermore, there should be a monotonic pattern in the marginal effects, so that (relative to $Authority_1$) the effect of $Authority_3$ is higher than the effect of $Authority_2$, and the effect of $Authority_4$ is highest of all. As Table 3 illustrates, in the first specification the relevant effects are statistically insignificant. However, once industry controls are included in the model, the estimated effect of $Authority_4$ is positive and significant at the five percent level on a one-tailed test, though the estimated effects of $Authority_2$ and $Authority_3$ remain statistically insignificant. In the end, our results support a monotonic pattern in the marginal effects, though only the effect of $Authority_4$ is statistically significant.

We next investigate whether empirical support exists for a positive relationship between risk and delegation of authority. A component of Prendergast's model is that delegation of authority is more likely to occur in risky settings, so that authority and risk are positively related. To test this empirically, we estimate an ordered probit model in which the four-valued dependent variable is *Authority*, and *Risk* is the key independent variable. The results, displayed in Table 4, clearly support a positive relationship between authority and risk. In the most controlled specification, on average, the increase in the probability of the highest degree of authority being delegated that is associated with *Risk* is 11.9 percentage points, amounting to a 37.5% increase in the probability that the highest level of authority is delegated.

Finally, we address the central empirical question of this paper, namely whether there is empirical support for the main testable implication of Prendergast's model. Prendergast argued that if controls for worker authority are added to risk-incentives regressions, the coefficient on risk should decrease. That is, if the coefficient were positive without controls for authority, it should be less positive once authority is added as a control, and if the coefficient were negative in the absence of the authority control, it should be greater in magnitude once authority is added. As a starting point we augment the model in Table 2 with controls for worker authority as follows:

$$\text{Prob}(Performance\ Pay_i = 1) = \Phi(\alpha \text{Riski} + \beta_2 Authority_{2i} + \beta_3 Authority_{3i} + \beta_4 Authority_{4i} + X_i\beta)$$

Prendergast's argument suggests that the relatively weak statistical evidence of a risk-incentives trade-off that we found at the start of the section should strengthen when authority controls are added to the model. Table 5 displays the marginal effects. The first six columns of the table should be read in pairs (that is, columns 1 and 2 correspond to one specification, which is presented both with and without authority controls; columns 3 and 4 correspond to another specification that includes industry controls; and columns 5 and 6

Table 4. Relationship between Worker Authority and Risk

	Dependent Variable: Authority		
Independent Variables:			
Risk	0.084*	0.094**	0.119**
	(0.055)	(0.052)	(0.053)
Industry Controls	NO	YES	YES
Firm Controls	NO	NO	YES
Sample Size	1245	1245	1245

Note: Results are probit marginal effects for Prob(Authority = 4) evaluated at the mean of the independent variable or, for binary independent variables, the change in the predicted Prob(Authority = 4) when the independent variable increases from 0 to 1 (evaluating all other covariates at their means). Robust standard errors are in parentheses.
*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level, using a one–tailed test for Risk. See Appendix for definitions of industry and firm controls.

correspond to a third specification that includes both industry and firm controls). When industry controls are included in the model, a statistically significant effect of *Risk* emerges. In the third and most controlled specification, when authority is omitted from the model, *Risk* is associated with a 5.7 percentage point decrease in the probability of incentive pay being used, whereas when authority is included as a control, this magnitude increases to 6.8 percentage points, strengthening the evidence of a risk-incentives trade-off, as Prendergast's model predicts. A statistical test of the null hypothesis that the *Risk* coefficient is equal between the model that includes authority controls and the model that excludes authority controls (versus the alternative hypothesis that the *Risk* coefficient is lower in the model that includes authority controls than in the model that excludes authority controls) in the most controlled specification reveals that the null can be rejected at the ten percent significance level, and nearly at the five percent significance level (p-value = 0.052). Furthermore, the marginal effect of $Authority_4$ ¬in that specification is positive and statistically significant, confirming the positive relationship between authority and incentive pay that we documented earlier in this section.

The results thus far appear to support the main testable implication of Prendergast's model. As we discuss in the introductory section, however, worker authority is potentially endogenous in a risk-incentives regression. Our results in the sixth column of Table 5 suggest that $Authority_4$ is the authority variable that matters the most. We thus aggregate authority to two categories (that is, we use only the dummy variable $Authority_4$) and estimate a bivariate probit model of incentives and authority to account for this endogeneity, allowing for correlation between the unobserved determinants of both variables. The bivariate probit model includes a dummy endogenous regressor (that is, $Authority_4$) in the incentives equation. Note that in this model, except in rare cases that do not apply here, identification of the parameters is attained even in the absence of exclusion restrictions (Heckman 1978; Wilde 2000; Monfardini and Radice 2008). The recursive structure of the model is consistent with Prendergast's theory wherein "uncertain environments result in the delegation of responsibilities, which in turn generates incentive pay based on output" (Prendergast 2002: 1072).

Results from the bivariate probit are presented in the last two columns of Table 5, along with marginal effects, the point estimates (in square brackets), and their standard errors (in parentheses below the point estimates). The essential point to note from the bivariate probit results is that an exogeneity test reveals that the null hypothesis that worker authority is exogenous cannot be rejected. That is, the null hypothesis that $\varrho = 0$ cannot be rejected, where ϱ is the correlation in the disturbances in the incentives and authority equations. This means that in the empirical tests it is reasonable to use a comparison of columns 5 and 6 of Table 5 that treated authority as exogenous in evaluating the main testable prediction of Prendergast's model. We conclude that when authority controls are added to the risk-incentives model,

Table 5. Testing the Main Prediction of Prendergast (2002)

	Probit						*Bivariate Probit*	
	Dependent Variable: Performance Pay						*Dependent Variable: Performance Pay*	*Dependent Variable: Authority4*
Independent Variables:	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***	***(7)***	***(8)***
Risk	**–0.051**	**–0.057**	–0.065*	–0.074*	–0.057*	–0.068**	–0.075 [–0.412]**	0.139 [0.405]**
	(0.052)	(0.052)	(0.043)	(0.041)	(0.040)	(0.039)	(0.235)	(0.174)
Authority2		0.025		**–0.043**		**–0.032**		
		(0.110)		(0.084)		(0.070)		
Authority3		–0.013		0.010		–0.001		
		(0.088)		(0.067)		(0.055)		
Authority4		0.071		**0.113***		0.104**	**0.172** [0.947]	
		(0.092)		(0.069)		(0.060)	(0.757)	
Industry Controls	**NO**	**NO**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Firm Controls	**NO**	**NO**	**NO**	**NO**	**YES**	**YES**	**YES**	**YES**
ρ							**–0.209**	
							(0.437)	
Sample Size	**1245**	**1245**	**1245**	**1245**	**1245**	**1245**	**1245**	**1245**

Note: Results in the first 6 columns are probit marginal effects for Prob(Performance Pay = 1) evaluated at the mean of the independent variable or, for binary independent variables, the change in the predicted Prob(Performance Pay = 1) when the independent variable increases from 0 to 1 (evaluating all other covariates at their means), with robust standard errors in parentheses. For the bivariate probit results in the last 2 columns, marginal effects are displayed to the left of the parameter estimates and their robust standard errors (in square brackets and parentheses, respectively); ρ denotes the correlation between the disturbances in the two equations.

*Statistically significant at the .10 level; **,at the .05 level; *** at the .01 level, using a one-tailed test for Risk, Authority2, Authority3, and Authority4. See Appendix for definitions of industry and firm controls.

the evidence of a risk-incentives trade-off strengthens, supporting Prendergast's main testable implication.

Sensitivity Analysis: Alternative Measures of Authority and Incentive Pay

Although the measure of worker authority we use throughout our analysis closely matches the notion described in Prendergast (2002), we also consider some alternative authority measures. Specifically, these are measures of worker discretion over how tasks are executed (as opposed to the range of tasks performed). The questions are asked both of the employer and of the workers, allowing us to construct the following employer-perceived and worker-perceived measures of authority:

Worker-Perceived Worker Authority Measures

$AUTHORITY_{HOW}(W)1$ = 1 if the establishment's modal worker response to the amount of worker discretion over how tasks are executed is "none" or "a little"
= 0 otherwise

$AUTHORITY_{HOW}(W)2$ = 1 if the establishment's modal worker response to the amount of worker discretion over how tasks are executed is "some"
= 0 otherwise

$AUTHORITY_{HOW}(W)3$ = 1 if the establishment's modal worker response to the amount of worker discretion over how tasks are executed is "a lot"
= 0 otherwise

Firm-Perceived Worker Authority Measures

$AUTHORITY_{HOW}(F)1$ = 1 if firm-perceived worker discretion over how tasks are executed is "none"
= 0 otherwise

$AUTHORITY_{HOW}(F)2$ = 1 if firm-perceived worker discretion over how tasks are executed is "a little"
= 0 otherwise

$AUTHORITY_{HOW}(F)3$ = 1 if firm-perceived worker discretion over how tasks are executed is "some"
= 0 otherwise

$AUTHORITY_{HOW}(F)4$ = 1 if firm-perceived worker discretion over how tasks are executed is "a lot"
= 0 otherwise

The variable names include "(W)" or "(F)" to indicate which worker authority measures reflect worker perceptions and which reflect firm perceptions. The lowest two categories of the worker-perceived measure are aggregated from four categories to three due to an extremely small count in the lowest cell. One difference between the worker-perceived measures and the firm-perceived measures is that the question in the employer survey pertains to the discretion of workers in the establishment's largest occupational group, whereas the question from the worker survey is based on a random sample of workers in the establishment. That is, in the employer survey, the respondent is asked to rate the level of worker authority in the establishment's "largest occupational group" rather than in the establishment as a whole.

We estimate models that include different combinations of authority controls (authority over range of tasks performed, worker-perceived authority over how tasks are executed, employer-perceived authority over how tasks are executed). Results are displayed in Table 6. When reading Table 6, compare the marginal effect of *Risk* in the first column to the marginal effect of *Risk* in each of the remaining columns, to see how the risk-incentives relationship changes when different configurations of authority controls are added to the model. The results reveal that the authority measure that individually suggests the strongest empirical support for Prendergast's theory is also the measure that best matches the notion of authority discussed in his paper (namely authority over the range of tasks performed), since the risk effect decreases by the most when these particular authority measures are included as controls.

Statistical tests of the null hypothesis that the *Risk* coefficient is equal between the model that includes authority controls (that is, column 2, 3, 4, 5, or 6) and the model that excludes authority controls (column 1), versus the alternative hypothesis that the *Risk* coefficient is lower in the model that includes authority controls than in the model that excludes authority controls, reveals that the null is virtually always rejected

Table 6. Test of Prendergast's (2002) Main Prediction with Alternative Measures of Worker Authority

	Dependent Variable: Performance Pay					
Independent Variables:	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Risk	–0.057*	–0.067**	–0.057*	–0.065**	–0.059*	–0.067**
	(0.040)	(0.039)	(0.040)	(0.039)	(0.039)	(0.038)
Authority2		–0.052		–0.029		–0.023
		(0.070)		(0.067)		(0.066)
Authority3		–0.001		0.000		0.007
		(0.055)		(0.054)		(0.055)
Authority4		0.105**		0.113**		0.119**
		(0.060)		(0.059)		(0.059)
$\text{Authority}_{\text{HOW}}(W)2$			0.007	0.014		0.003
			(0.101)	(0.103)		(0.103)
$\text{Authority}_{\text{HOW}}(W)3$			0.018	–0.009		–0.025
			(0.098)	(0.100)		(0.100)
$\text{Authority}_{\text{HOW}}(F)2$					0.087**	0.089**
					(0.050)	(0.047)
$\text{Authority}_{\text{HOW}}(F)3$					0.038	0.042
					(0.048)	(0.047)
$\text{Authority}_{\text{HOW}}(F)4$					0.071*	0.055
					(0.050)	(0.047)
Firm and industry controls	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**
Sample Size	1241	1241	1241	1241	1241	1241

Note: Results are probit marginal effects for Prob(Performance Pay = 1) evaluated at the mean of the independent variable or, for binary independent variables, the change in the predicted Prob(Performance Pay = 1) when the independent variable increases from 0 to 1 (evaluating all other covariates at their means). Robust standard errors are in parentheses.

*Statistically significant at the .10 level; ** at the .05 level; *** at the .01 level, using a one-tailed test. Firm and industry controls are those listed in Table 2. See the Appendix for their definitions.

when the main measures of authority are used but not when the alternative measures are used. More precisely, the null can be rejected at the ten percent significance level in columns 1 versus 2 (p-value = 0.057) and in columns 1 versus 6 (p-value = 0.088), and it narrowly misses rejection at the ten percent significance level in columns 1 versus 4 (p-value = 0.107). When only the alternative measures are used, the null is not at all close to rejection; the p-value is 0.440 for columns 1 versus 3, and the p-value is 0.283 for columns 1 versus 5. Thus, statistical evidence supporting Prendergast's main prediction emerges only for the main authority measure and not for alternative authority measures.

Turning now to alternative measures of incentive pay, a potential drawback of our measure is that it refers to group performance-related schemes as well as to individual performance-related schemes, though the theory we address in this paper pertains to individual performance-related schemes. To explore this issue, we use some additional information in the WERS employer survey. If the respondent reports that performance-related pay is used at the establishment and that "any non-managerial occupations [are] eligible," the respondent is then asked what measures of performance are used to determine the amount of performance-related pay. Respondents can list as many of the following responses as they wish, in addition to providing their own responses not on the list: "1 = Individual performance / output," "2 = Group or team performance / output," "3 = Workplace-based measures," "4 = Organization-based measures." The most common response is "1," either alone or in combination with other choices. Using this information, we modify the binary performance measure we have used throughout the analysis. If an establishment reports the use of performance-related pay but does not include "1 = Individual performance / output" in its list of responses to the above question, we reclassify the binary performance pay measure for this observation from 1 to 0. The idea behind this reclassification is to create a binary incentive pay measure that equals one only if it can be determined with certainty (abstracting from reporting and coding errors) that performance-related pay is used *and* at least some of it is based on individual performance or output.

Two points are worth noting about this

modified measure. First, when the respondent lists more than one answer to the question of what type of performance-related scheme is used at the establishment, there is no way to discern the relative importance of the responses listed. Second, because the question is only asked if performance-pay is used and "any non-managerial occupations [are] eligible," if performance pay is used at the establishment but non-managerial occupations are not eligible for it, we have no information on what type of performance pay is used. Thus, we only have information on the type of performance-related pay used for 357 of the 418 establishments that report the use of performance-related pay. For the remaining 61 establishments we define the binary incentive measure as "1" even though in some of these cases the performance-pay might not be based on individual performance / output. The mean of the modified incentive pay measure is 0.151, as opposed to 0.196 for the unmodified measure we use throughout the paper. Replicating all of our analysis in the paper using the modified measure yields no qualitative changes to our conclusions. All of these results are available upon request.

Discussion

Using a large, nationally representative cross-section of British establishments that includes responses from both employers and multiple workers in each establishment, we addressed the four empirical questions we posed in the introduction. In answer to the first question, we find statistically weak evidence of the negative relationship between risk and incentives predicted by the standard principal-agent model. On average, greater turbulence in the market for the establishment's main product or service is associated with a lower probability of performance-related pay for the establishment as a whole. In answer to the second and third questions, we find evidence supporting a positive relationship between performance-related pay and the degree of worker authority over the range of tasks performed, and evidence supporting a positive relationship between risk and the degree of worker authority.

In answer to the fourth question, our results suggest that when measures of worker authority are included in a risk-incentives model, the relationship between risk and incentives becomes more negative, and the potential endogeneity of authority in this model does not appear to be a concern. We interpret the overall evidence in this empirical test to support Prendergast's theory. The evidence from the WERS data suggests that Prendergast's theory is at least part of the reason why a vast empirical literature has failed to uncover the negative relationship between risk and incentives that has been central to agency theory for nearly three decades.

We conclude with four comments. First, though some of our main results are estimated with high precision, others are not. Throughout the analysis, we rely on one-tailed hypothesis tests since the relevant theory implies directional hypotheses. However, in some cases our results would not achieve statistical significance at conventional levels if the more stringent two-tailed tests were used instead.

Second, while our results on the risk-incentives trade-off represent only one study in a vast empirical literature that has found mixed evidence, we believe the breadth of our sample (which is nationally representative of all British establishments) makes our results particularly interesting. Many analyses of the risk-incentives trade-off have been conducted, but the heavy focus has been on a relatively small set of worker groups, and in particular on groups that, it is fair to say, are atypical. For example, though the number of jobs held by either CEOs or sharecroppers is negligible, the majority of previous empirical studies focus on these two groups. The general point is that it is difficult to know what relative weights to assign to the various empirical studies in forming an overall evaluation. We think the present study, based on a broad and nationally representative sample of establishments, contributes to forming such an overall evaluation.

Third, we hope that our results will stimulate further research in this area using other data sets. Panel data would be particularly helpful to convincingly identify causal parameters; the cross sectional nature of our data is a limitation of our analysis. In addition, since we have focused only on Britain, given the strengths of the WERS data for testing Prendergast's theory, it would be useful for future tests to use data from the United States and other countries. We cannot rule out the possibility that the empirical support of Prendergast's model is specific to

Britain; we will be rather surprised, however, if this is confirmed in future work. We see nothing peculiar to Britain in the fundamental workplace issues Prendergast's model addresses, and we therefore expect the empirical support for his model in Britain to generalize to data sets from other countries. Furthermore, though our binary measure of incentive pay proved to be quite informative, more detailed information concerning how the intensity of incentive pay varies across organizations would also be valuable.

Finally, we believe our results suggest that Prendergast's theory at least partially explains why previously published empirical literature has failed to uncover a risk-incentives trade-off; at the same time, this does not rule out the possibility that alternative theories may also play a role. Our focus on Prendergast's theory in this analysis is driven largely by the availability of an authority measure that corresponds closely to the notion that Prendergast discussed. Though we believe our evidence supports Prendergast's theory, we do not see it as casting doubt on the alternative models; in fact, we see investigation of these alternatives as a promising direction for future work with other data sets.

Appendix
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 U.K. establishment of a foreign organization = 0 if the establishment is one of a number of different establishments within a larger organization
Establishment Size	= total number of full time, part time, and temporary workers at the establishment (measured in thousands)
Fraction of Part Time Workers	= number of part time workers at the establishment as a fraction of establishment size
Temporary Workers	= 1 if there are temporary agency employees working at the establishment at the time of the survey = 0 otherwise
Fixed-Term Workers Under One Year	= 1 if there are employees who are working on a temporary basis or have fixed-term contracts for less than one year = 0 otherwise
Fixed-Term Workers Over One Year	= 1 if there are employees who have fixed-term contracts for one year or more = 0 otherwise
Number of Recognized Unions	= total number of recognized unions at the workplace
100% Workers Unionized	= 1 if 100% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure) = 0 otherwise
80–99% Workers Unionized	= 1 if 80–99% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure) = 0 otherwise
60–79% Workers Unionized	= 1 if 60–79% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure) = 0 otherwise
40–59% Workers Unionized	= 1 if 40–59% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure) = 0 otherwise
20–39% Workers Unionized	= 1 if 20–39% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure) = 0 otherwise
1–19% Workers Unionized	= 1 if 1–19% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure) = 0 otherwise
0% Workers Unionized	= 1 if 0% of all employees, including managers, are covered by collective bargaining either at this workplace or at a higher level (employee-perceived measure) = 0 otherwise

Continued

Appendix *Continued*
Firm Characteristics Used as Control Variables

Main Activity of Establishment	= 1 if the main activity of the establishment is to produce goods or services for consumers = 0 for any of the following other possibilities: supplier of goods or services to other companies; supplier of goods or services to other parts of the organization to which we belong; do not produce goods or provide services for sale in the open market; an administrative office only
Single Product	= 1 if the establishment is concentrated on one product or service = 0 if it is concentrated on several different products or services
Private-Sector Franchise	= 1 if the establishment is a private-sector company and a franchise = 0 otherwise
Private-Sector Non-franchise	= 1 if the establishment is a private-sector company but not a franchise = 0 otherwise
Private-Sector Publicly Traded Franchise	= 1 if the establishment is a publicly traded private sector unit and a franchise = 0 otherwise
Private-Sector Publicly Traded Non-franchise	= 1 if the establishment is a publicly traded private sector unit but not a franchise = 0 otherwise
Operation Over Five Years	= 1 if the workplace has been operating at its present address for 5 years or more = 0 otherwise
Industry Controls:	Manufacturing; Electricity, Gas, and Water; Construction; Wholesale and Retail; Hotels and Restaurants; Transport and Communication; Financial Services; Other Business Services; Public Administration; Education; Health; Other Community Services

REFERENCES

Ackerberg, Daniel A., and Maristella Botticini. 2002. "Endogenous Matching and the Empirical Determinants of Contract Form." *Journal of Political Economy*, Vol. 110, No. 3, pp. 564–91.

Adams, Christopher P. 2005. "Worker Discretion, Adverse Selection, and the Risk-Incentive Trade-off." FTC Working Paper, Washington D.C. (May).

Aggarwal, Rajesh K., and Andrew A. Samwick. 1999. "The Other Side of the Trade-off: The Impact of Risk on Executive Compensation." *Journal of Political Economy*, Vol. 107, No. 1, pp. 65–105.

____ and Andrew A. Samwick. 2002. "The Other Side of the Trade-off: The Impact of Risk on Executive Compensation—A Reply." Unpublished Working Paper, Dartmouth College.

Aghion, Philippe, and Jean Tirole. 1997. "Formal and Real Authority in Organizations." *Journal of Political Economy*, Vol. 105, No. 1, 1 – 29.

Al-Najjar, Nabil I. 2001. "A Reputational Model of Authority." *Journal of Economic Behavior and Organization*, Vol. 46, No. 2, pp. 165–91.

Allen, Douglas, and Dean Lueck. 1992. "Contract Choice in Modern Agriculture: Cash Rent versus Cropshare." *Journal of Law and Economics*, Vol. 35, No. 2, pp. 397–426.

Anderson, Erin, and David C. Schmittlein. 1984. "Integration of the Sales Force: An Empirical Examination." *RAND Journal of Economics*, Vol. 15, No. 3, pp. 385–95.

Aoki, Masahiko. 1986. "Horizontal versus Vertical Information Structure of the Firm," *American Economic Review*, Vol. 76, No. 5, pp. 971–83.

Baker, George, and Bjorn Jorgensen. 2003. "Turbulence, Risk, and Incentives." Unpublished Working Paper, Harvard University.

Ben-Ner, Avner, Fanmin Kong, and Stephanie Lluis. 2007. "Uncertainty and Organization Design." Unpublished Working Paper, University of Minnesota.

Colombo, Massimo G., and Marco Delmastro. 2004. "Delegation of Authority in Business Organizations: An Empirical Test." *Journal of Industrial Economics*, Vol. 52, No. 1, pp. 53–80.

Conyon, Martin J., and Kevin J. Murphy. 2000. "The Prince and the Pauper? CEO Pay in the United States and United Kingdom." *The Economic Journal*, Vol. 110, No. 467, pp. 640–71.

Core, John, and Wayne Guay. 1999. "The Use of Equity Grants to Manage Optimal Equity Incentive Levels." *Journal of Accounting and Economics*, Vol. 28, No. 2, pp. 151–84.

____ ,and Wayne Guay. 2002. "The Other Side of the Trade-off: The Impact of

Risk on Executive Compensation. A Revised Comment." Unpublished Working Paper, University of Pennsylvania.

____, and Jun Qian. 2002. "Project Selection, Production, Uncertainty, and Incentives." Working Paper, University of Pennsylvania.

Cully, Mark, Stephen Woodland, Andrew O'Reilly, and Gill Dix. 1999. *Britain at Work: As Depicted by the 1998 Workplace Employee Relations Survey.* London: Routledge.

Department of Trade and Industry, Advisory, Conciliation and Arbitration Service, Workplace Employee Relations Survey: 1998 [computer file]. Colchester, Essex: The Data Archive, 22 March 1999.

Dessein, Wouter. 2002. "Authority and Communication in Organizations." *Review of Economic Studies*, Vol. 69, No. 4, pp. 811–38.

Foss, Nicolai J., and Keld Laursen. 2005. "Performance Pay, Delegation and Multitasking Under Uncertainty and Innovativeness: An Empirical Investigation." *Journal of Economic Behavior and Organization*, Vol. 58, No. 2, pp. 246–76.

Garen, John E. 1994. "Executive Compensation and Principal-Agent Theory." *Journal of Political Economy*, Vol. 102, No. 6, pp. 1175–99.

Gibbs, Michael, Kenneth A. Merchant, Wim A. Van der Stede, and Mark E. Vargus. 2006. "Performance Measure Properties and Incentives." Unpublished Working Paper, University of Chicago (September).

Heckman, James J. 1978. "Dummy Endogenous Variables in a Simultaneous Equation System." *Econometrica*, Vol. 46, No. 4, pp. 931–59.

Holmström, Bengt. 1979. "Moral Hazard and Observability," *Bell Journal of Economics*, Vol. 10, No. 1, pp. 74–91.

____, and Paul Milgrom. 1991. "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design." *Journal of Law, Economics, and Organization*, Vol. 7 (Supplement), pp. 24–52.

____, and Paul Milgrom. 1994. "The Firm as an Incentive System." *American Economic Review*, Vol. 84, No. 4, pp. 972–91.

Ittner, Christopher D., David F. Larcker, and Rajan V. Madhav. 1997. "The Choice of Performance Measures in Annual Bonus Contracts." *The Accounting Review*, Vol. 72, No. 2, pp. 231–55.

Jensen, Michael C. and William H. Meckling. 1992. "Specific and General Knowledge, and Organizational Structure." In Lars Werin and Hans Wijkander, eds., *Contract Economics*, pp. 251–74. Oxford, U.K.: Blackwell.

John, George and Barton Weitz. 1989. "Salesforce Compensation: An Empirical Investigation of Factors Related to Use of Salary Versus Incentive Compensation." *Journal of Marketing Research*, Vol. 26, No. 1, pp. 1–14.

Kawasaki, Seiichi and John McMillan. 1987. "The Design of Contracts: Evidence from Japanese Subcontracting." *Journal of the Japanese and International Economies*, Vol. 1, No. 3, pp. 327–49.

Lafontaine, Francine. 1992. "Agency Theory and Franchising: Some Empirical Results." *RAND Journal of Economics*, Vol. 23, No. 2, pp. 263–83.

Lambert, Richard A., and David F. Larcker. 1987. "An Analysis of the use of Accounting and Market Measures of Performance in Executive Compensation Contracts." *Journal of Accounting Research*, Vol. 25 (Supplement), pp. 85–125.

Leffler, Keith B., and Randal R. Rucker. 1991. "Transactions Costs and the Efficient Organization of Production: A Study of Timber-Harvesting Contracts." *Journal of Political Economy*, Vol. 99, No. 5, pp. 1060–87.

MacLeod, W. Bentley and Daniel Parent. 1999. "Job Characteristics and the Form of Compensation." In Solomon Polacheck, ed., *Research in Labor Economics*, Vol. 18, pp. 177–242. Stamford, Conn.: JAI.

Maddala, G.S. 1983. *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press.

Martin, Robert E. 1988. "Franchising and Risk Management." *The American Economic Review*, Vol. 78, No. 5, pp. 954–68.

REFERENCES

Mengistae, Taye, and Lixin Colin Xu. 2004. "Agency Theory and Executive Compensation: The Case of Chinese State-Owned Enterprises." *Journal of Labor Economics*, Vol. 22, No. 3, pp. 615–37.

Monfardini, Chiara, and Rosalba Radice. 2008. "Practitioner's Corner: Testing Exogeneity in the Bivariate Probit Model: A Monte Carlo Study." *Oxford Bulletin of Economics and Statistics*, Vol. 70, No. 2, pp. 271–82.

Nagar, Venky. 2002. "Delegation and Incentive Compensation." *The Accounting Review*, Vol. 77, No. 2, pp. 379–95.

Norton, Seth W. 1988. "An Empirical Look at Franchising as an Organizational Form." *Journal of Business*, Vol. 61, No. 2, pp. 197–218.

Oyer, Paul. 2004. "Why Do Firms Use Incentives That Have No Incentive Effects?" *Journal of Finance*, Vol. LIX, No. 4, pp. 1619–49.

____, and Scott Schaefer. 2005. "Why Do Some Firms Give Stock Options to All Employees?: An Empirical Examination of Alternative Theories." Journal of Financial Economics, Vol. 76, No. 1, pp. 99–133.

Prendergast, Canice. 2002. "The Tenuous Trade-off Between Risk and Incentives." *Journal of Political Economy*, Vol. 110, No. 5, pp. 1071–1102.

Raith, Michael. 2003. "Competition, Risk, and Managerial Incentives." *American Economic Review*, Vol. 93, No. 4, pp. 1425–36.

____. 2008. "Specific Knowledge and Performance Measurement." *RAND Journal of Economics*, Vol. 39, No. 4, pp. 1059–79.

Rao, C. H. Hanumantha. 1971. "Uncertainty, Entrepreneurship, and Sharecropping in India." *Journal of Political Economy*, Vol. 79, No. 3, pp. 578–95.

Serfes, Konstantinos. 2005. "Risk Sharing vs. Incentives: Contract Design Under Two-sided Heterogeneity." *Economics Letters*, Vol. 88, No. 3, pp. 343–49.

Shavell, Steven M. 1979. "Risk Sharing and Incentives in the Principal and Agent Relationship." *Bell Journal of Economics*, Vol. 10, No. 1, pp. 55–73.

Shi, Lan. 2005. "Respondable Risk and Incentives for CEOs: the Role of Information-collection and Decision-making." Unpublished Working Paper, University of Washington (November).

Wilde, Joachim. 2000. "Identification of Multiple Equation Probit Models with

Endogenous Dummy Regressors." *Economics Letters*, Vol. 69, No. 3, pp. 309–12.

Wulf, Julie. 2007. "Authority, Risk, and Performance Incentives: Evidence from Division Manager Positions Inside Firms." *Journal of Industrial Economics*, Vol. 55, No. 1, pp. 169–96.

Yermack, David. 1995. "Do Corporations Award CEO Stock Options Effectively." *Journal of Financial Economics*, Vol. 39, No. 2, pp. 237–69.

Zabojnik, Jan. 1996. "Pay-Performance Sensitivity and Production Uncertainty. *Economic Letters*, Vol. 53, No. 3, pp. 291–96.