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Performance pay, delegation and multitasking under uncertainty and innovativeness: An empirical investigation

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Abstract

It has been recently noted that the trade-off between risk and incentives that agency theory predicts turns out to be rather weak. We examine predictions from agency theory on the basis of data from a data set encompassing close to 1000 Danish firms. We find that the relation between performance pay and environmental uncertainty is indeed weak. We examine the relation between delegation and environmental uncertainty, and find that this relation is confirmed. We also examine the multi-tasking agency hypothesis that as risk increases, the flexibility of agents is restricted. We fail to find support for this hypothesis.

JEL classification: C35; L23

Keywords: Uncertainty; Pay-for-performance; Delegation; Innovation; Competition

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1. Introduction

Empirical work in agency theory is relatively scant, at least when compared to the abundance of theoretical papers that have appeared since the mid-1970s (Masten and Saussier, 2002), and to the rather large and cumulative body of empirical work in related areas, notably transaction cost economics (Shelanski and Klein, 1995). Moreover, the existing empirical evidence is somewhat inconclusive with respect to a number of the key predictions of the agency model. Although the reach of agency theory is considerably wider, the dominant portion of the extant empirical work has been taken up with examining the nature of the trade-off between risk and incentives and the implications thereof for contractual design, including the design of organizations and institutions. However, as Prendergast (1999, 2002) notes, the empirical relation between risk and incentives appears to be "tenuous." Moreover, many, perhaps most, other predictions from agency theory have not been subjected to empirical scrutiny. For example, multi-tasking agency theory (Holmström and Milgrom, 1991) predicts that an agent's flexibility (i.e., the number of tasks that he/she is allowed to engage in) will be restricted, the less reliable the performance measures for his/her main tasks become. Increasing environmental uncertainty will reduce the reliability of performance measures, leading to restrictions of agents' flexibility. This prediction has, to our knowledge, never been tested.[1]

In this paper, we undertake to examine the risk-incentives trade-off and related ideas from agency theory on the basis of data from a data set encompassing close to 1000 Danish firms. We find that the relation between the use of performance pay in these firms and the uncertainty they confront (which is one way to test the risk/incentives tradeoff) is indeed "tenuous". We then suggest, in line with, for example, Jensen and Meckling (1992), Mendelson and Pillai (1999) and Prendergast (2002), that this may be caused by the widespread use of delegation. Indeed, the paper may be read as (we believe) the first empirical test of Prendergast (2002). Thus, drawing on the Prendergast paper, we argue that an effect of delegation is breaking the simple relation between risks and incentives. We examine indications that suggest that firms that are more prone to use delegation of decision rights in their internal organization are also those firms that face a more uncertain environment than the rest of the population. We argue that this constitutes an indirect confirmation of the hypothesis. We also go beyond Prendergast (2002) by examining the multitasking agency hypothesis that as risk increases, the flexibility of agents is restricted (Holmström and Milgrom, 1991). We fail to find support for this hypothesis. We suggest that the reason for this finding is also related to the issue of delegation.

[1] At least explicitly. Holmström and Milgrom (1991) invoke earlier work by Anderson (1985) and Anderson and Schmittlein (1984) as indirectly yielding empirical support for their multitask agency model. Baker and Hubbard (2003) include multi-tasking considerations in their empirical analysis; however, their main interest is how multi-tasking considerations influence the boundaries of the firm rather than job-design per se.

2. Theory and hypotheses

2.1. Basic agency theory

We here briefly and simply restate the basics of the agency model (following the now standard model of Holmström and Milgrom, 1991). Consider a "task" with output x, that depends on the agent's effort, e, and a normal error term, ε, which has mean, μ and variance, σ^2, so that $x = e + \varepsilon$. μ, σ^2 and x are common knowledge for the agent and principal. e is unobservable to the principal, and σ^2 is uncontrollable for the agent. x is verifiable so that contracts, $s(x)$, specifying the payment from principal to agent can be (costlessly) written. The agent's preferences may be described by the exponential utility function, $-\exp[-r(s(x) - c(e))]$, where r is the coefficient of risk aversion and $c(e)$ is the agent's cost function.

In the standard formulation, the principal's problem is to choose s so that the agent puts effort forward and is not overly burdened with risk. Under certain assumptions (stated in Holmström and Milgrom, 1987), the second-best contract takes a linear form, $s(x) = \alpha x + \beta$, where α is a measure of how "high-powered" incentives are and β is simply an income transfer from the principal to the agent (which serves to satisfy the participation constraint). Maximizing the certainty equivalent of joint surplus, which is $u + \mu - 1/2r\alpha^2\ \sigma^2 - c(e)$, subject to the agent's first-order condition, $c'(e) = \alpha$, yields the best choice of α. Holmström (1989) gives the example of assuming $c(e) = 1/2ke^2$, which yields $\alpha = (1 + kr\sigma^2)^{-1}$. Inspection of this expression reveals that the agent receives a higher share, the lower his/her aversion to risk is and vice versa (α, the "piece rate," and r, the coefficient of risk aversion, varies inversely), and that incentives (α) and variance (σ^2) also varies inversely. This is the tradeoff between risk-sharing and provision of incentives to supply effort.

The standard model may be extended in various ways, notably by introducing monitoring considerations. In the above setting, higher risk leads to more monitoring because higher risk leads to a fall in α, which in turn reduces effort, prompting an increase in monitoring. The provision of incentives may also be influenced by changing the agent's opportunity costs, that is, controlling which other activities he/she can engage in, for how long time and so on. Intuitively, the less restricted an agent is (that is, the more discretion he/she has with respect to his/her choice of which activities to engage in and for how long), the more costly it is to induce him to work on a specific project. Consequently, the costs of providing incentives may be reduced by restricting the set of activities that an agent is allowed to work on (Holmström and Milgrom, 1990). The costs of measuring the agent's performance in the various activities play a key role for how much the agent will be restricted, as clarified by Holmström and Milgrom (1991). A key prediction from their multitask-agency model is that the more costly it is to measure the agent's performance in his/her main activities, the more his/her flexibility will be restricted. Since risk and measurement cost can reasonably be assumed to correlate directly, this reasoning would seem to predict that as risk increases, the agent would tend to become increasingly constrained. An interpretation is that activities will tend to be clustered in those activities that are easily measurable, and those that are not; different kinds of incentives will be provided for each.

2.2. Empirical work

In agency theory, environmental uncertainty has the effect of adding observation error to performance measures (i.e., increase measurement cost) (Holmström, 1979; Holmström and Milgrom, 1991; Prendergast, 2002). This increases the risk that is imposed on agents. Hence, the testable prediction is that risk and performance pay correlate negatively. However, as Prendergast (2002) documents at length, this prediction has not fared quite well in the face of the empirical evidence. Specifically, he considers the empirical evidence for the four classes of occupation of executives, sharecroppers, franchisees and sales force workers. In the case of executive compensation, the evidence is "inconclusive," although there is weak evidence for relative performance evaluation, an implication of the risk/incentives tradeoff. For sharecroppers, the fraction that they retain turns out to be increasing in the noisiness of financial returns that is directly counter to the agency prediction. Evidence from studies of franchising suggest that the choice of whether to keep outlets in-house or franchise them is influenced by uncertainty in a direction opposite to the prediction of agency theory; that is, the probability of choosing franchising is positively influenced by environmental uncertainty. The evidence on sales force integration is inconclusive. In sum, the empirical evidence would, on balance, seem to indicate that uncertainty and incentives are positively, rather than negatively, related. This contradicts the basic agency model.[2]

2.3. Resolving the uncertainty/performance relation

A strong candidate for explaining why the basic agency prediction seems to be falsified in the light of the empirical evidence is that basic agency theory fails to consider many of the benefits of delegation (Foss and Foss, 2002). Indeed, in the basic story, the *only* benefit of delegation seems to be economizing with the opportunity costs of the principal's time. If these were low or zero, the principal would carry out the task himself, particularly since differences in knowledge about how to carry out the task optimally do not seem to exist in the basic agency model.

In actuality, of course, much knowledge about how to carry out the task optimally resides with the agent and may be too costly to transfer to corporate headquarters (or other managerial layers) because of problems of eliciting the correct information or because the relevant knowledge is of a highly "impacted," tacit or complex, kind. Agents then have "real authority," in the sense of Aghion and Tirole (1997). In this situation, delegation co-locates decision rights with this knowledge. The attendant moral hazard problem may accordingly be reduced by using more output-based contracts. Organizational structure and reward mechanisms arguably reflects the relevant tradeoff (Jensen and Meckling). Thus, the choice of how to remunerate agents is one that is complementary to a host of other issues of organizational design (Holmström, 1999).

[2] Another possible explanation for the lack of empirical confirmation of the agency prediction is an "endogenous matching" problem (Ackerberg and Botticini, 2002). For instance, principal-agent matching may emerge when risk-loving or risk-neutral agents are attracted to more risky activities. Since agent's risk aversion is only imperfectly controlled for in most econometric studies, the associated endogeneity problem may cause misleading results.

As Prendergast (2002) points out, this kind of reasoning may help explain why we may, in fact, expect a positive relation between uncertainty and incentives; thus, as he notes, "uncertain environments result in the delegation of responsibilities, which in turn generates incentive pay based on output" (Prendergast, 2002, p. 1072). Thus, in stable environments, direct order-giving and input monitoring will be employed by the principal. In more uncertain environments, the principal may still be able to monitor the agent's activities, but will have less of an idea of which activities the agent should optimally work on and how these activities should be balanced. Information about these issues may reside with the agent rather than with the principal. In this situation, principals likely respond by offering output-based performance contracts (Barzel, 1997).

Clearly, we should expect the incidence and strength of the relation between environmental uncertainty and performance pay to be firm or industry dependent. There are a priori grounds for suspecting that it may be stronger in "high-tech"/"high knowledge-intensive", "dynamic" and "turbulent," firms and industries, as well those that are unregulated and/or facing global competition, than in the more traditional ones or in those that are regulated or do not facing global competition. We base this expectation on several arguments based on the observation that the use of delegation is likely to be more prevalent in the former kind of industries than in the latter (Mendelson and Pillai, 1999).

First, in industries that are low in knowledge intensity, managers are more likely to understand tasks, and there is, therefore, less asymmetrical information. Hence, the need for delegation and pay-for-performance is smaller, even under uncertainty. Second, given that firms in industries that are low in knowledge intensity on an average have a low-skilled workforce, it may be more difficult to delegate responsibility in such industries since such delegation likely requires a certain level of skills. Finally, in high knowledge-intensive industries, it may be that there is simply more "local" expert knowledge and, accordingly, that managers are forced to delegate responsibility more than in low knowledge-intensive industries, even when facing the same level of uncertainty.

Delegation has a role to play when it comes to multitasking environments as well. Notably, organizational practices such as planned job rotation and quality circles introduce multitasking environments. However, firms and industries in which multitasking is likely to be prevalent are also the firms and industries for which uncertainty is already high, relatively more output-based pay being used in response. Multitasking aggravates this since it adds to the difficulty of accurately measuring input performance and makes it even more attractive to substitute output-based pay for direct monitoring and other ways of restricting the agent. This contradicts the Holmstrom and Milgrom hypothesis that increasing risk under multitasking leads to restriction of the number of activities that an agent is allowed to work on: given that output-based pay is preferred under these circumstances, there is little reason to implement such restrictions. On the contrary, "dynamic" firms often stimulate multitasking for reasons of knowledge-integration and sharing.

2.4. Resolving hypotheses

A number of hypotheses may be derived from the above discussion. The first one is that as a general matter, the uncertainty/incentive relation is a positive one. Prendergast (2002) lists the relevant empirical evidence for this and develops a formal model that yields this relation. The evidence invoked by Prendergast is derived from rather different kinds of occupations (and underlying industries), making it relevant to consider whether the relation may in fact be a general one. Thus, we suggest that

Hypothesis 1. There is an overall positive and significant relation between environmental uncertainty and the use of performance pay.

The underlying "mechanism" driving the positive relation between uncertainty and incentives is, as it been argued, delegation. An implication of this argument, explicitly stated in Prendergast (2002), is that if indeed delegation is the correct explanation for the positive relationship between uncertainty and performance pay, then after controlling for delegation we should see no relationship between uncertainty and performance pay. Thus, based on the above, we would expect the following hypotheses to hold true:

Hypothesis 2a. Delegation and environmental uncertainty are positively correlated.

Hypothesis 2b. After controlling for delegation, there will be no relationship between uncertainty and performance pay.

Moreover, we would expect the strength of the correlation between environmental uncertainty and the use of performance pay to vary between firms belonging to different industries. In other words, not only do we expect the level of adoption of pay-for-performance to increase as a function of environmental (industry) uncertainty as stated in Hypothesis 1, we also expect the effectiveness of uncertainty as a predictor of pay-for-performance to be lower in less "dynamic" sectors of the economy:

Hypothesis 3. The strength of the correlation between environmental uncertainty and the use of performance pay is sector dependent, so that the correlation within more "dynamic" sectors is stronger than in less "dynamic" sectors.

Finally, we submit that contrary to the predictions from multitasking agency theory, firms in "dynamic," high-uncertainty industries, far from refraining from the use of multitasking, will actually use multitasking more frequently:

Hypothesis 4. Firms that are placed in environments characterized by high uncertainty will restrict the activities that their employees can engage in less than those that are placed in low uncertainty environments.

We examine these hypotheses empirically in the remainder of the paper.[3]

[3] Our hypotheses relate to issues of complementarity among organizational elements since we argue that high-powered performance incentives are complementary to delegation. We try to deal with this in various ways in the empirical section of this paper.

3. Empirical analysis

3.1. Measures

While the use of pay-for-performance, delegation of responsibility and multitasking can be approximated relatively well by the use of questionnaires (see, for instance, Capelli and Neumark, 2001; Laursen and Foss, 2003; Mendelson and Pillai, 1999; Vinding, 2006) or by observing contracts, the measurement of uncertainty is a more difficult endeavor.[4] In the empirical agency literature various measures has been used to gauge the level of uncertainty facing the relevant agent. In the sub-section on "Empirical Work" in Section 2 of this paper, we briefly mentioned the four types of occupation considered in the empirical agency literature (executives, sharecroppers, franchisees and salesforce workers). In some of this literature, the measure of environmental uncertainty is idiosyncratic/specific to the activity in question. Such an idiosyncratic measure has been used in the case of (for instance) the analysis of franchising decisions, where the average proportion of discontinued outlets in the franchising sector in which the franchisor operates has been adopted (Lafontaine, 1992). Another example of a specific measure is the number of calls it takes to close a sale, averaged across the salespeople at the responding firm (Coughlan and Narasimhan, 1992).[5] For the analysis of sharecroppers, the coefficient of variation of yield has been used (Allen and Lueck, 1992). In addition to the specific measures of uncertainty, variation over time of aggregate sales data has been applied in some studies (Martin, 1988; Norton, 1987) as well as survey-based data assessing the stability in sales and forecasting accuracy (John and Weitz, 1989). In the literature on executive pay, the most commonly used proxy for risk or uncertainty is variation in returns (see, for instance, Bushman et al., 1996; Lambert and Larker, 1987; Sloan, 1992). It should be pointed out, however, that since managers are to some extent capable of controlling variations in sales, stock returns or profitability, not all of the variance will reflect uncertainty (Bushman et al., 1996; Lafontaine, 1992).

We here consider three measures of uncertainty, namely (i) the extent to which firms are innovative, (ii) the perceived increase in the level of competition and (iii) within industry variance in profitability. We include different measures reflecting uncertainty since all such measures are imperfect. With respect to innovative activity as a measure of uncertainty, it is well known that innovation involves the lack of knowledge about the precise cost and outcomes of different alternatives in addition to lack of knowledge of what the alternatives are (Freeman and Soete, 1997; Nelson and Winter, 1982). However, it may be argued that innovation is an uncertain activity in the rare event of major "breakthroughs," while more pedestrian incremental innovation in terms of smaller improvements is in fact routinized and hence reasonably predictable. Empirical evidence has shown (Mansfield et al., 1977) that even when the fundamental knowledge base and the expected directions of advance are fairly well known, it is still often the case that firms must first engage in exploratory research,

[4] However, note that our measure of performance pay only concerns the percentage of employees that are given performance pay. Thus, the view of the individual employees regarding high-powered incentives is, strictly speaking, not captured by this measure.

[5] The argument is that the longer it takes to close a sale, the more important is sales efforts and the less important is environmental uncertainty (Coughlan and Narasimhan, 1992, p. 106).

development and design before the outcome will be known, what some manageable result will cost, or even whether useful results will emerge. As Dosi (1988, p. 1034) argues "even in the case of "normal" technical search (as opposed to the "extraordinary" exploration associated with the quest for new paradigms) strong uncertainty is present." Since innovation is not important to all firms and since it only partially reflects environmental uncertainty, we include the two other measures. With regard to the (increased) level of competition, the idea is that if the level of competition increases, the selection environment of the firm becomes tougher and the room for managerial slack becomes smaller. Hence, if the level of competition increases, the firm will become more dependent on the (uncertain) actions of the competitors.[6] The final measure is the more conventional measure of uncertainty used in the existing literature, namely within-firm/industry variance in profitability.

3.2. The empirical model

Based on the discussion above, the probability of observing a certain organizational practice may be specified as follows:

$$o = f(\beta_1 z, \beta_2 x). \tag{1}$$

Here, o is the probability of adopting an organizational practice to a certain extent within the firm, β_1 and β_2 are parameter vectors and z is a set of (exogenous) determinants of the application of certain organizational practices related to environmental uncertainty, while x is a set of other variables explaining the adoption of a certain organizational practice across business firms. The model may be made operational in the following way:

$$\begin{aligned}\text{Prob}(O_i = 0 \ldots j) = {} & \chi\text{SECT}_i + \alpha\text{LOGSIZE}_i + \varphi\text{SUBSID}_i \\ & + \eta\text{INNO} + \psi\text{COMP}_i + \omega\text{PROFITVAR} + \varepsilon_i,\end{aligned} \tag{2}$$

where Prob($O_i = 0, \ldots, j$) expresses the firms' probability of adopting a given organizational practice (such as pay-for-performance or delegation of responsibility) to a certain degree within the firm ("0" = no use, "1" = less than 25 percent of the workforce involved, "2" = 25–50 percent of the workforce and "3" = more than 50 percent of the workforce involved). We control for firm size by including a continuous variable measuring the number of employees in each firm expressed in logs (LOGSIZE). Moreover, we control for sectoral affiliation (SECT) by including three sector categories (see the paragraph below for a description). Finally, we control for whether or not the firm is a subsidiary of a larger firm (SUBSID), since decisions on the adoption of organizational practices may (at least partly) be decided at the level of the headquarter. The three measures of uncertainty include the level of novelty of the innovations produced by the firm in question (INNOF, INNOC, INNOW) and the firm's perceived change in the level of competition (COMP) and the within-firm/industry variance in profitability (PROFITVAR). The measure of innovation

[6] Note, however, that the relation between uncertainty and competition may not be monotonic. Moving from monopoly to oligopoly, things depend increasingly on the uncertain actions of competitors. However, continuing from oligopoly towards perfect competition, the actions of competitors matter less and less, so increased competition at some point may indicate less uncertainty. Thanks to an anonymous reviewer for pointing this out.

Table 1
Descriptive statistics for a set of DISKO variables ($N = 993$)

		Number of firms	Percent of sample
Industry affiliation	Low-KI	390	39.3
	Medium-KI	366	36.9
	High-KI	237	23.9
Number of employees (SIZE[a])	31–100	312	31.4
	101–200	203	20.4
	>200	478	48.1
Subsidiary (SUBSID)	No	409	41.2
	Yes	584	58.8
Competition (COMP)	Strongly decreased	1	0.1
	Somewhat decreased	10	1.0
	Unchanged	194	19.5
	Somewhat increased	339	34.1
	Strongly increased	449	45.2
Product innovation	No innovation	391	39.4
(INNOF)	Innovation new to the firm	434	43.7
(INNOC)	Innovation new to the country	89	9.0
(INNOW)	Innovation new to the world	79	8.0
Pay-for-performance (PPAY)	Not used	525	52.9
	<25 percent of the workforce	194	19.5
	25–50 percent of the workforce	79	8.0
	>50 percent of the workforce	195	19.6
Delegation (DR)	Not used	103	10.4
	<25 percent of the workforce	240	24.2
	25–50 percent of the workforce	265	26.7
	>50 percent of the workforce	385	38.8
Quality circles (QC)	Not used	522	52.6
	<25 percent of the workforce	264	26.6
	25–50 percent of the workforce	111	11.2
	>50 percent of the workforce	96	9.7
Planned job rotation (PJR)	Not used	550	55.4
	<25 percent of the workforce	288	29.0
	25–50 percent of the workforce	93	9.4
	>50 percent of the workforce	62	6.2

[a] *Note:* The variable used in the subsequent regressions is continuous.

is split into three different variables, INNOF, INNOC and INNOW, all reflecting product innovations to various degrees of novelty. INNOF reflects the launch of innovations new to the firm, INNOC reflects innovations new to the country, and INNOW reflects the launch of innovations new to the world. All three variables take the value of "0" if no such innovation was introduced in the given period and the value of "1" if an innovation of a certain degree of novelty was introduced. For the possible values of COMP variables, see Table 1 below. The calculation of PROFITVAR is based on register data from Statistics

Denmark. The basis of the variable is firm profitability measured as firm profits divided by firm value added. The firms in the sample have been classified according to industry at the level of 83 industries by Statistics Denmark (see Appendix D to this paper).[7] However, given the fact that there are few firms in some industries, the industries have been aggregated up to a total of seventy industries in the cases where this seemed meaningful (see Appendix E for details of the aggregation). Since relatively complete data are available for the years 1992–1994, all firms with non-missing profit data for all of the 3 years are included in the analysis (in order to get a balanced panel). The number of firms with non-missing profit data are 1610 firms,[8] and hence we have 4830 observations on which to base the variance-in-profits variable. Based on those observations, the within-firm/industry (70 industries) variance is calculated, resulting in the PROFITVAR variable.[9] It follows from the hypotheses stated in Section 2 that we expect positive signs for the "uncertainty" variables.

The sectoral classification is key to Hypothesis 3 of this paper since we claim that firms in more "dynamic" sectors use performance pay to a larger extent than those in less "dynamic" sectors" for given levels of uncertainty (measured as innovation or increase in the level of competition). Details of the sectoral classification applied may be found in Appendices C and D to this paper. Firm types with the strongest internal capacity to develop new products and services are assumed to belong to "high knowledge-intensive industries" (see Appendix C and Laursen, 2002). Firms in such industries are producing specialized machinery and instrumentation, chemicals and pharmaceuticals and Information and Communication Technology (ICT) services, the latter including banking, accounting, consultancies, advertising, etc. Industries associated with the lowest capacity to develop new products and services internally ("low knowledge-intensity industries") are assumed to be the construction industry, retailing, cleaning and to some extent supplier dominated manufacturing industries (furniture, textiles, pulp, paper and paper products and so on). Scale-intensive manufacturing industries (bulk materials and assembly) and firms in the wholesale trade industry may be considered to be intermediate in relation to knowledge-intensity ("medium knowledge-intensity industries"). Based on this sectoral classification, we estimate the following model in order to test Hypothesis 3:

$$\begin{aligned}\text{Prob}(O_i = 0 \ldots j) = {} & \chi_s \text{SECT}_i + \alpha_s \text{LOGSIZE}_i + \varphi_s \text{SUBSID}_i \\ & + \eta_s \text{INNO} + \psi_s \text{COMP}_i + \omega_s \text{PROFITVAR} + \varepsilon_i, \end{aligned} \tag{3}$$

where the notation is the same as in Eq. (2). Footsign s indicates that the parameter is allowed to vary depending on to which sector each firm belongs.

7 The appendices are available at the Journal's website (...).

8 Note that in the calculation of the within-firm/industry variance in profits, we use all the possible observations available in the dataset. This contrasts to the econometric estimations to be found later in this paper, where we include the firms with more than 30 employees only (993 firms).

9 It can been observed from Appendix E, that there are two industries still (research and development and legal activities) in each of which there is only one firm present with non-missing profit data for all of the 3 years. However, in the estimations it does not matter significantly for the results whether or not these two industries are included in the analysis.

3.3. The data

The main source of data for this paper is the DISKO database. The database is based on a questionnaire that aims at tracing the relationship between technical and organizational innovation in a way that permits an analysis of new principles for work organization and their implications for the use and development of the employee's qualifications in firms in the Danish private business sector. The survey was carried out by the DISKO project at Aalborg University (DK) in 1996. The questionnaire was submitted to a national sample of 4000 firms selected among manufacturing firms with at least 20 full-time employees and non-manufacturing firms with at least 10 full-time employees. Furthermore, all Danish firms with at least 100 employees were included in the sample, corresponding to 913 firms. The resulting numbers of respondents are 684 manufacturing and 1216 non-manufacturing firms, corresponding to response rates of 52 percent and 45 percent, respectively. The response rate within manufacturing industries ranges from 41 to 62 percent (across 7 industries), while the response rate within service industries ranges from 42 to 57 percent (across 10 industries). Accordingly, it is concluded that there are no serious industry response biases in the data. For both service and manufacturing firms there is, however, a bias in the sense that larger firms were slightly more prone to answer the questionnaire. In manufacturing the response rate was 58 percent among firms in the largest size category (>100 employees), while the corresponding figure in services was 55 percent. However, the problem is to some extent alleviated in this paper since we use the firms with at least 30 employees only (see below).

The first descriptive analysis of the survey can be found in Lund and Gjerding (1996) and in Gjerding (1997). The database is held by Statistics Denmark, and the data on the firms in the database can be linked to regular register data that are also held by Statistics Denmark. For the purposes of the present paper, data have been obtained on the size and profitability of the firms in the sample from regular register data. The choice was made to work only with firms with more than 30 employees since we are dealing with the application of *formal* work practices, practices that are simply less meaningful for smaller companies (why use delegation if the firm is not larger than a typical work team?).[10] By retaining only firms in the sample that are larger than 30 employees, we end up with a total of 993 firms.

Table 1 displays descriptive statistics for the variables that are used in this paper. Appendix B can be inspected for a description of the questions from the survey on the basis of which the variables have been constructed. Only about 10 percent of the firms do not use delegation of responsibility (10.4 percent) to varying degrees, while just about half of the firms in the sample apply pay-for-performance (52.9 percent). Also about half of the firms report use of quality circles (47.4) and planned job rotation (44.6). Most firms (79.3 percent) indicate that the level of competition has increased over recent years. While it is clearly observed that the perceived level of competition is highly skewed, it is also evident that the perceived increased level of competition varies in degree. The sample includes 391 non-innovators, 434 firms that produced products/services that were new only to the firm itself, 89 firms that produced products/services that were new to the national market, while 79 firms introduced products/services that were new to the world.

[10] In fact, including the entire sample does not change our results in any important way. The results using the entire sample can be obtained from the authors upon request.

3.4. Estimation

Since the dependent variables are discrete and inherently ordered multinomial choice variables, the ordered probit model is applied as the main means of estimation (for an exposition of ordered probit models, see Greene, 2000, pp. 875–879). However, the decision to adopt various work practices is likely to involve interdependency; for instance, we have argued that uncertainty gives rise to adoption of delegation of responsibility, which in turn gives rise to pay-for-performance. Hence, the two adoption decision equations are connected. Nevertheless, if we assume independence between the error terms in these two equations and further assume that errors are normally distributed, the equations can be estimated one by one. However, if the error terms in the two equations are not independent, estimates obtained via the ordered probit procedure are inconsistent, and joint estimation is required. One possible approach is to estimate a bivariate probit model (see Greene, pp. 849–856). However, this means that we have to reduce our dependent variables to binary (zero/one) variables. Another possibility is the estimation of a system of simultaneous equations. If the two decisions are simultaneously determined, this is a superior approach since we can then, in principle, obtain efficient, consistent and unbiased estimates of the coefficients in our model. However, it is also an approach that is computationally difficult (possibly impossible) with two ordered multinomial-choice equations.[11]

Given these difficulties, we have as a starting point estimated the models separately, although the requirements for using this approach are very strict. However, in order to check the robustness of our results, we have also estimated two of the models as full information maximum likelihood (FIML) bivariate probit models by collapsing our dependent variables into binary variables so that “0” becomes no adoption and “1” becomes adoption to any degree; in other words, when the original dependent variables take the values of “2” or “3,” they are recoded to take the value of “1.” By following this procedure we explicitly model the fact that the adoption procedures of delegation and pay-for-performance are connected. Using this method, however, we make the simplifying assumption that the decision regarding the adoption of delegation is made *before* the decision concerning adoption of pay-for-performance.

Tables 2 and 3 contain the estimations relevant to Hypotheses 1, 2a and 2b, while the estimations relevant to Hypothesis 3 can be found in Table 4. The results regarding Hypothesis 4 can be found in Table 5. The null hypothesis that the slopes of the explanatory variables are zero is strongly rejected by the likelihood ratio test for all of the estimated models found in Tables 2–5. We also need to report the marginal effects corresponding to the coefficients in Tables 2–5 in order to make meaningful interpretations of the coefficients (Greene, pp. 877–878). The marginal effects are found in Tables A.2–A.9 in Appendix A.

Model (i), in Table 2, tests Hypothesis 1 using the single equation ordered probit model (“*There is an overall positive and significant relation between environmental uncertainty and the use of performance pay*”). With respect to our control variables, it can be seen from

[11] Although estimating models with categorical dependent variables in a set of *simultaneous* equations is a task to be solved still, the issue of dependence between equations with categorical dependent variables has been dealt with by Mayer et al. (2004, pp. 1076–1077) using a two-step estimation procedure. Unfortunately, this approach requires specific regularities in the data.

Table 2
Ordered probit estimation explaining the adoption of delegation and pay-for-performance ($N = 993$)

Independent variables	Dependent variables							
	Model (i) pay-for-performance (PPAY)		Model (ii) delegation of responsibility (DR)		Model (iii) pay-for-performance (PPAY)		Model (iv) pay-for-performance (PPAY) × delegation of responsibility (DR)	
	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value	Estimate	*p*-Value
CONSTANT	−0.980	0.000	0.225	0.308	−1.205	0.000	−1.127	0.000
LOW_KI	Benchmark							
MEDIUM_KI	0.048	0.581	0.172	0.038	0.020	0.815	0.020	0.824
HIGH_KI	−0.046	0.640	0.236	0.013	−0.087	0.383	−0.018	0.855
LOGSIZE	0.125	0.002	0.105	0.009	0.109	0.008	0.128	0.002
SUBSID	0.152	0.054	0.077	0.317	0.142	0.074	0.182	0.023
INNOF	0.212	0.013	0.219	0.006	0.178	0.037	0.264	0.002
INNOC	0.262	0.062	−0.016	0.911	0.263	0.065	0.318	0.024
INNOW	0.477	0.002	0.217	0.117	0.446	0.003	0.503	0.001
COMP	−0.017	0.728	0.075	0.092	−0.026	0.601	−0.010	0.837
PROFITVAR	3.049	0.000	1.477	0.293	2.841	0.000	2.879	0.000
DELEGATION (DR)					0.194	0.000		
Log likelihood	−1144.73		−1265.37		−1131.67		−1396.27	
Restricted log likelihood	−1168.76		−1289.07		−1168.76		−1424.42	
Likelihood ratio test	0.000		0.000		0.000		0.000	

Note: The marginal effects corresponding to the coefficients found in this table are reported in Tables A.2–A.5 (Appendix A).

Table 3
FIML estimates of a bivariate probit model explaining the adoption of delegation and pay-for-performance ($N = 993$)

Independent variables	Dependent variable			
	Model (i) delegation of responsibility (DR)		Model (ii) pay-for-performance (PPAY)	
	Estimate	*p*-Value	Estimate	*p*-Value
CONSTANT	−0.160	0.636	−2.079	0.000
LOW_KI	Benchmark			
MEDIUM_KI	0.115	0.387	−0.018	0.850
HIGH_KI	0.115	0.455	−0.168	0.117
LOGSIZE	0.151	0.024	0.080	0.097
SUBSID	0.167	0.184	0.148	0.113
INNOF	0.348	0.007	0.134	0.192
INNOC	0.047	0.820	0.284	0.062
INNOW	0.159	0.492	0.491	0.005
COMP	0.076	0.261	−0.034	0.530
PROFITVAR	4.931	0.051	1.483	0.149
DELEGATION (DR)			1.689	0.000
Log likelihood		−965.140		
Likelihood ratio test		0.000		

Note: The marginal effects corresponding to the coefficients found in this table are reported in Table A.6 (Appendix A).

the estimation of model (i) that being a large firm increases the probability of adopting pay-for-performance. This conclusion can be made based on the fact that the parameter for LOGEMP is positive and significant, and moreover, the marginal effect for the LOGEMP variable is negative (see Table A.2 (Appendix A)) only in the case of no use (PPAY = 0), while the marginal effects are positive at all levels of use of performance pay (PPAY = 1–3). It can also be noted that the marginal effect is particularly large in the case of PPAY = 3. In other words, a one percent increase in size increases the probability of adopting pay-for-performance to a low degree (involving <25 percent of the workforce) by 0.9 percent, while the probability of adopting pay-for-performance to a medium degree (involving 25–50 percent of the workforce) is increased by 0.7 percent and the probability of adopting pay-for-performance to a high degree (involving >50 percent of the workforce) increases by 3.4 percent as a result of a 1 percent increase in size. Moreover, based on the estimations found in Table 2 and Appendix Table A.2 it can be seen that being a subsidiary increases the probability of adopting pay-for-performance to an increasing degree.

Of our three uncertainty measures, the parameter for increased level of competition is insignificant. In contrast, all parameters for the innovation variables (INNOF, INNOC, INNOW) are significant, and the marginal effect is negative only in the case of no use of pay-for-performance. The effect is by far strongest in the case of PPAY = 3 (>50 percent of the workforce involved). As would be expected, given that higher degrees of novelty are associated with higher degrees of uncertainty, the parameter increases in size as a function of the degree of novelty of the innovation. Moreover, the parameter for PROFITVAR is very significant and has the right sign, according to Hypothesis 1. Also in this case, the marginal

Table 4
Probit estimation explaining the adoption of pay-for-performance, sectoral estimation ($N = 993$)

	Estimate	*p*-Value
CONSTANT		
Low-KI	−0.764	0.047
Medium-KI	−0.602	0.109
High-KI	−1.961	0.000
LOGSIZE		
Low-KI	0.045	0.524
Medium-KI	0.128	0.033
High-KI	0.184	0.061
SUBSID		
Low-KI	0.275	0.034
Medium-KI	0.021	0.872
High-KI	0.201	0.228
INNOF		
Low-KI	0.240	0.078
Medium-KI	0.320	0.020
High-KI	0.020	0.918
INNOC		
Low-KI	0.336	0.208
Medium-KI	0.033	0.892
High-KI	0.460	0.055
INNOW		
Low-KI	0.240	0.411
Medium-KI	0.478	0.033
High-KI	0.685	0.027
COMP		
Low-KI	0.029	0.693
Medium-KI	−0.150	0.069
High-KI	0.104	0.317
PROFITVAR		
Low-KI	1.099	0.385
Medium-KI	6.739	0.019
High-KI	8.861	0.012
Log likelihood	−1134.3	
Restricted log likelihood	−1168.8	
Likelihood ratio test	0.000	

Note: The marginal effects corresponding to the coefficients found in this table are reported in Table A.7 (Appendix A).

effect is negative only in the case of no use of pay-for-performance (PPAY = 0). Here, the effect is strongly negative, while the effect is strongly positive in the case of PPAY = 3. In sum, we find rather strong support for Hypothesis 1.

Model (ii) in Table 2 examines Hypothesis 2a ("Delegation and environmental uncertainty are positively correlated") using the single equation ordered probit model. In this case, LOGSIZE is significant, but the relevant marginal effects (see Table A.3 (Appendix

Table 5
Ordered probit estimation explaining the adoption of quality circles and planned job rotation ($N = 993$)

Independent variables	Dependent variables			
	Model (i) Quality circles (QC)		Model (ii) Planned job rotation (PJR)	
	Estimate	*p*-Value	Estimate	*p*-Value
CONSTANT	−1.133	0.000	−1.456	0.000
LOW_KI	Benchmark			
MEDIUM_KI	0.006	0.943	0.119	0.168
HIGH_KI	0.226	0.021	0.021	0.832
LOGSIZE	0.140	0.001	0.166	0.000
SUBSID	0.203	0.014	0.066	0.414
INNOF	0.293	0.001	0.248	0.004
INNOC	0.250	0.057	0.286	0.035
INNOW	0.184	0.202	0.412	0.004
COMP	0.005	0.908	0.070	0.136
PROFITVAR	1.152	0.314	1.108	0.362
Log likelihood	−1122.42		−1045.62	
Restricted log likelihood	−1152.94		−1073.64	
Likelihood ratio test	0.000		0.000	

Note: The marginal effects corresponding to the coefficients found in this table are reported in Tables A.8 and A.9 (Appendix A).

A)) are only positive in the case of DR = 3. That is, firms affiliated with a larger firm are only more prone to adopt delegation of responsibility when more than 50 percent of the employees are involved. In fact, the marginal effect is high and negative if less than 25 percent of the workforce is involved. The parameter for INNOF is significant at the 1 percent level, and again, the marginal effect is only positive for what concerns PPAY = 3 (>50 percent of the workforce involved). Another measure that reflects uncertainty, COMP, is significant at the 10 percent level, but once more the marginal effect is positive only for what concerns PPAY = 3. In other words, firms facing tougher competition are more likely to adopt delegation of responsibility only when more than 50 percent of the employees are involved in the delegation. The parameter for PROFITVAR is not significant. To conclude on Hypothesis 2a, it can be said that the hypothesis finds support to the extent that if firms face more competitive environments and/or they have introduced a product new to the firm, then they are more likely to use delegation of responsibility, conditional on whether delegation involves the majority of the workforce.

Model (iii) in Table 2 examines Hypothesis 2b ("*After controlling for delegation, there will be no relationship between uncertainty and performance pay*"). The hypothesis is not supported by the single equation ordered probit estimations since the parameters for the innovation and PROVITVAR variables remain significant. However, we do get an indication that adoption decisions concerning work practices involving delegation and pay-for-performance are related and perhaps complementary, given the strongly significant parameter for DR. Nevertheless, even when we have accounted for delegation, the results of the single equation ordered probit estimations indicate that uncertainty induces adoption of work practices involving pay-for-performance. However, we have no way of precisely asserting whether this result is due to the fact that our measures are only imperfect measures of uncertainty, whether there is some other mechanism linking uncertainty and delegation as well, or whether the result is due to the estimation technique, which requires very strict assumptions to hold true.

Although this paper is not a direct test of complementarity effects, our hypotheses do relate to issues of complementarity among organizational elements (as noted earlier) since we argue that high-powered performance incentives are complementary to delegation. Athey and Stern (1998) discuss the challenges of empirically identifying complementarities in organization form, noting how difficult it is to argue that practice A is complementary to characteristic B even if A and B usually appear jointly in organizations. However, Athey and Stern show that when we have adoption of (two) complementary work-practices on the right-hand side and some performance measure on the left-hand side, we can gauge complementarity effects by examining the influence of the interaction term between the two practices on the dependent variable. However, in this paper we have the complementary work-practices on the left-hand side, and accordingly, we cannot use interaction terms in the same fashion as suggested by Athey and Stern. Nevertheless, we include the interaction term as a dependent variable, reflecting joint implementation of delegation of responsibility and pay-for-performance in model (iv) of Table 2. The results show joint implementation of delegation of responsibility, and pay-for-performance is indeed related to two of our measures of uncertainty, innovation and firm/industry variance in profits, thus giving further support to Hypotheses 1 and 2a.

Another way of dealing with the issue of joint implementation of the two work practices is to estimate the model as a binary, bivariate probit with delegation as an endogenous variable, as mentioned in the introduction to this section of the paper. The estimations of this model allow for dependence in the estimation of the two practices, delegation and pay-for-performance, although it has to be acknowledged that the downside of using this procedure is the loss of information accruing due to the transformation of the dependent variables from ordered variables, with four possible outcomes, down to binary variables. Nevertheless, the results of the estimations using this procedure can be found in Table 3.

First, we confirm the finding that the firm/industry variance in the profits measure (PROFITVAR) is significant in explaining the adoption of delegation of responsibility. This is consistent with Hypothesis 2a of this paper. Moreover, when we control for delegation, PROFITVAR is no longer significant in explaining the adoption of pay-for-performance. This is consistent with Hypothesis 2b of this paper, a hypothesis that could not be confirmed when using the ordered probit model. It can be noted that using a single equation binomial probit model (these results not shown for reasons of space), the parameter for PROFITVAR is significant in explaining the adoption of pay-for-performance, a result which is consistent with Hypothesis 1.[12]

[12] It should be noted, however, that when delegation is entered in the pay-for-performance equation while using the binomial single equation estimation procedure, PROFITVAR becomes insignificant as well ($p = 0.101$). Hence, at least some of the explanation for the difference between the results using the ordered probit model and the bivariate probit model (allowing for dependence between the equations) has to do with the fact that the variables have been transformed to binary ones.

Hypothesis 3 (“The strength of the correlation between environmental uncertainty and the use of performance pay is sector dependent, so that the correlation within more “dynamic” sectors is stronger than in less “dynamic” sectors”) is put under scrutiny in Table 4, where the parameters are allowed to differ for each variable according to whether the firms belong to low, medium, or high knowledge-intensive sectors. LOGSIZE is again significant, but now only for medium and high knowledge-intensive firms. Being a subsidiary of a larger firm increases the probability of adopting pay-for performance for what concerns low knowledge-intensive sectors, whereas the parameter is insignificant with respect to medium and high knowledge-intensive firms. The marginal effects are particularly strong for PPAY = 3 (>50 percent of the workforce involved) for low knowledge-intensive sectors (see Table A.7 (Appendix A)).

Again, as when a common parameter was assumed, COMP is insignificant and even negative in the case of medium knowledge-intensive firms. However, the second set of variables reflecting uncertainty (the innovation variables) are significant for low knowledge-intensive firms only in the case of the lowest degree of novelty (INNOF), while the innovation variables are significant for high knowledge-intensive firms in the case of the cases of medium (INNOC) and high (INNOW) degrees of novelty (the marginal effects are negative only in the case of no use of PPAY for all significant variables). This finding is in accordance with the hypothesis. When it comes to the profit-variance measure (PROFITVAR), we find that the results are strongly consistent with Hypothesis 3 of this paper since the parameter is significant in the case of medium and high knowledge-intensive firms. Moreover, the parameter is larger for high knowledge-intensive firms than for medium knowledge-intensive firms. For both of the two significant types of firms, the interpretation of the parameters is straightforward since the marginal effects are negative only in the case of no use of PPAY. Overall, the findings give strong support to Hypothesis 3.

With respect to Hypothesis 4 (“Firms that are placed in environments characterized by high uncertainty will restrict the activities that their employees can engage in less than those that are placed in low uncertainty environments”), we apply two measures of “multitasking.” The first has to do with the use of “quality circles” (QC), while the second has to do with the application of “planned job rotation.” In both cases we argue that the two work practices allow for more multitasking and hence restrict the employees less. The relevant estimations can be found in Table 5. In the two models, the marginal effects for all variables (except for the three intercepts) are negative (see Tables A.8 and A.9 (Appendix A)) only in the case of no use (QC, PJR = 0), while the marginal effects are positive in the case of at all levels of adoption (QC, PJR = 1–3). SIZE is positive and significant for what concerns both QC and PJR. Hence, larger firms seem more likely to adopt quality circles and planned job rotation.

Innovations at all levels of novelty (INNOF, INNOC, INNOW) are positive and significant in both models as well, implying that firms with the ability to produce (uncertain) innovations are more prone to adopt QC and PJR. The other proxy for uncertainty, COMP, is insignificant in affecting both the likelihood of adopting planned job rotation and of quality circles, although for planned job rotation, the variable is not strongly insignificant. PROFITVAR has no explanatory power, although the parameter is non-negative, in contrast to the prediction of the standard agency multitasking model. In sum, the evidence is somewhat supportive of Hypothesis 4.

4. Concluding discussion

This paper began by observing the seemingly tenuous tradeoff between risk and uncertainty. We then went on to suggest (in line with other authors) that this might be caused by the widespread use of delegation of decision rights. Moreover, we argued firms should restrict their employees less when faced with a more uncertain environment. This prediction is in contrast to the prediction of the standard agency theory. Subsequently, we made an attempt to shed light on these matters empirically, as empirical research on these matters may be characterized as relatively scant. It was further argued that firms' ability to produce innovations of an increasing degree of novelty and firms' perceived change in competition regime, as well as with-in industry variations in profitability, might serve as (imperfect) measures of environmental uncertainty.

The evidence was found to be consistent with the hypothesis stating that there is an overall positive and significant relation between environmental uncertainty and the use of performance pay in the sense that the likelihood of adopting pay-for-performance increases with firms' ability to produce product innovations, in particular when the majority of the workforce is involved in the pay-for-performance schemes. However, not only did we conjecture that there is an overall positive and significant relation between environmental uncertainty and the use of pay-for-performance, we also added the prediction that the strength of the correlation between environmental uncertainty and the use of performance pay is sector dependent so that firms in more "dynamic" sectors are more likely to use performance pay than those in less "dynamic" sectors, given a certain level of uncertainty. It was concluded that if firms produce innovations to an increasing degree of novelty, they are much more likely to adopt pay-for-performance involving the majority of the workforce and that this relationship was found to be the strongest for firms affiliated to high knowledge-intensity sectors. Moreover, we found that the relationship between the level of adoption of pay-for-performance schemes and uncertainty, measured as within-firm/industry variance in profits, becomes increasingly strong when the level of knowledge-intensity increases.

With respect to the hypothesis claiming that delegation and environmental uncertainty are positively correlated, we found support for this claim to the extent that if firms face more uncertain environments, then they are more likely to use delegation of responsibility, conditional on the observation that delegation involves the majority of the workforce. Although the parameter for the measure of within-firm/industry variance in profitability turned out not to be significant (albeit positive) in explaining the use of delegation in firms, when using the ordered probit model, the opposite prediction from standard agency theory (a negative relation) found no support in the available evidence. Moreover, when using the bivariate estimation technique, within-firm/industry variance in profitability was found to be a predictor of delegation. However, it should be noted that since an econometric technique for estimation of simultaneous equations while allowing for ordered discrete data does not yet exist, this question is not yet definitely resolved.

We also examined the specific multitasking agency hypothesis (the Holmström–Milgrom hypothesis) which states that as risk increases, the flexibility of agents is restricted. We found no evidence of such a relationship. First, we found that the parameter for within-firm/industry variance in profitability was positive (although not significant). Second, we found some evidence consistent with the view that firms that are placed in environments characterized by high uncertainty will restrict the activities that their employees can engage in *less* than those that are placed in low uncertainty environments. In this context, we found that firms with the ability to produce (uncertain) innovations are more prone to adopt quality circles and planned job rotation. Moreover, we found the final proxy for uncertainty, an increased level of competition, to affect positively the likelihood of adopting planned job rotation. Multitasking adds to the difficulty of accurately measuring input performance and makes it more attractive to substitute output-based pay for direct monitoring and other ways of restricting the agent. Given that output-based pay is preferred under these circumstances, there is little reason to implement such restrictions. On the contrary, we conjecture that "dynamic" firms often stimulate multitasking for reasons of knowledge-integration and sharing.

In closing, we touch on a problem of a deep methodological nature that points to the necessity of future empirical work on the issues treated herein. Our reasoning has essentially assumed that all firms in the sample are optimally organized, which then allows us to draw inferences about the proper relationship between underlying attributes and organizational characteristics (e.g., delegation) simply by observing what firms actually do. However, suppose some firms are doing it right while others are doing it wrong and that evolutionary market processes are not sufficiently strong or are still going on, so that inefficient firms have not been weeded out. The fact that we observe a particular attribute–characteristics pair will then not tell us much about the optimality of that pair. One possible answer to this problem is to take more of a process approach. For example, a priori reasoning may suggest that certain firms are "appropriately" aligned (in terms of underlying attributes and organizational characteristics), and the analyst may then examine their performance *over time*. Do appropriately organized firms do better over time than inappropriately organized firms? If not, this is indication that either a priori theorizing is faulty or market processes do not work efficiently. Future work will take such an approach to the issues treated here.

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Appendix A

See Tables A.1–A.9 .

Table A.1
Distribution of the degree of innovativeness, across low, medium and high knowledge-intensive industries

	NOINNO	INNOF	INNOC	INNOW
Low knowledge-intensive	63.6	29.8	4.0	2.6
Medium knowledge-intensity	37.5	47.8	7.3	7.3
High knowledge-intensity	28.4	47.9	13.2	10.5
Total sample	49.2	38.6	6.7	5.5

Table A.2
Marginal effects from probit estimations, adoption of pay-for-performance of across 993 Danish firms

	PPAY = 0	PPAY = 1	PPAY = 2	PPAY = 3
CONSTANT	0.390	−0.067	−0.059	−0.265
MEDIUM_KI	−0.019	0.003	0.003	0.013
HIGH_KI	0.019	−0.003	−0.003	−0.013
LOGSIZE	−0.050	0.009	0.007	0.034
SUBSID	−0.061	0.010	0.009	0.041
INNOF	−0.084	0.014	0.013	0.057
INNOC	−0.104	0.018	0.016	0.071
INNOW	−0.190	0.032	0.028	0.129
COMP	0.007	−0.001	−0.001	−0.005
PROFITVAR	−1.213	0.207	0.182	0.823

Table A.3
Marginal effects from probit estimations, adoption of delegation of responsibility across 993 Danish firms

	DR = 0	DR = 1	DR = 2	DR = 3
CONSTANT	−0.039	−0.044	−0.003	0.086
MEDIUM_KI	−0.030	−0.034	−0.003	0.066
HIGH_KI	−0.041	−0.046	−0.003	0.090
LOGSIZE	−0.018	−0.021	−0.002	0.040
SUBSID	−0.013	−0.015	−0.001	0.030
INNOF	−0.038	−0.043	−0.003	0.084
INNOC	0.003	0.003	0.000	−0.006
INNOW	−0.037	−0.043	−0.003	0.083
COMP	−0.013	−0.015	−0.001	0.029
PROFITVAR	−0.254	−0.289	−0.022	0.564

Table A.4
Marginal effects from probit estimations, adoption of pay-for-performance of across 993 Danish firms (Including delegation as an explanatory variable)

	PPAY = 0	PPAY = 1	PPAY = 2	PPAY = 3
CONSTANT	0.479	−0.085	−0.074	−0.321
MEDIUM_KI	−0.008	0.001	0.001	0.005
HIGH_KI	0.035	−0.006	−0.005	−0.023
LOGSIZE	−0.043	0.008	0.007	0.029
SUBSID	−0.056	0.010	0.009	0.038
INNOF	−0.071	0.013	0.011	0.047

Table A.4 (*Continued*)

	PPAY = 0	PPAY = 1	PPAY = 2	PPAY = 3
INNOC	−0.105	0.019	0.016	0.070
INNOW	−0.177	0.032	0.027	0.119
COMP	0.010	−0.002	−0.002	−0.007
PROFITVAR	−1.130	0.201	0.174	0.756
DR	−0.077	0.014	0.012	0.052

Table A.5
Marginal effects from probit estimations, interaction between pay-for-performance and delegation of responsibility, across 993 Danish firms

	PFPDR = 0	PFPDR = 1	PFPDR = 2	PFPDR = 3	PFPDR = 4	PFPDR = 5	PFPDR = 6
CONSTANT	0.445	−0.011	−0.033	−0.088	−0.021	−0.104	−0.188
MEDIUM_KI	−0.008	0.000	0.001	0.002	0.000	0.002	0.003
HIGH_KI	0.007	0.000	−0.001	−0.001	0.000	−0.002	−0.003
LOGSIZE	−0.051	0.001	0.004	0.010	0.002	0.012	0.021
SUBSID	−0.072	0.002	0.005	0.014	0.004	0.017	0.030
INNOF	−0.104	0.003	0.008	0.021	0.005	0.024	0.044
INNOC	−0.125	0.003	0.009	0.025	0.006	0.029	0.053
INNOW	−0.199	0.005	0.015	0.039	0.010	0.046	0.084
COMP	0.004	0.000	0.000	−0.001	0.000	−0.001	−0.002
PROFITVAR	−1.136	0.028	0.085	0.224	0.055	0.265	0.480

Table A.6
Marginal effects from bivariate probit estimations, adoption of delegation and pay-for-performance across 993 Danish firms

	DR	PPAY
CONSTANT	−0.049	−1.440
MEDIUM_KI	0.035	−0.012
HIGH_KI	0.035	−0.116
LOGSIZE	0.046	0.055
SUBSID	0.051	0.102
INNOF	0.106	0.093
INNOC	0.015	0.197
INNOW	0.049	0.340
COMP	0.023	−0.024
PROFITVAR	1.506	1.027
DR		1.170

Table A.7
Marginal effects from probit estimation with sector-specific slopes, adoption of pay-for-performance across 993 Danish firms

	PPAY = 0	PPAY = 1	PPAY = 2	PPAY = 3
CONSTANT				
Low-KI	0.304	−0.053	−0.047	−0.204
Medium-KI	0.240	−0.042	−0.037	−0.161
High-KI	0.780	−0.136	−0.120	−0.524

Table A.7 (*Continued*)

	PPAY = 0	PPAY = 1	PPAY = 2	PPAY = 3
LOGSIZE				
Low-KI	−0.018	0.003	0.003	0.012
Medium-KI	−0.051	0.009	0.008	0.034
High-KI	−0.073	0.013	0.011	0.049
SUBSID				
Low-KI	−0.109	0.019	0.017	0.073
Medium-KI	−0.009	0.002	0.001	0.006
High-KI	−0.080	0.014	0.012	0.054
INNOF				
Low-KI	−0.096	0.017	0.015	0.064
Medium-KI	−0.127	0.022	0.020	0.086
High-KI	−0.008	0.001	0.001	0.005
INNOC				
Low-KI	−0.134	0.023	0.021	0.090
Medium-KI	−0.013	0.002	0.002	0.009
High-KI	−0.183	0.032	0.028	0.123
INNOW				
Low-KI	−0.095	0.017	0.015	0.064
Medium-KI	−0.190	0.033	0.029	0.128
High-KI	−0.273	0.048	0.042	0.183
COMP				
Low-KI	−0.012	0.002	0.002	0.008
Medium-KI	0.060	−0.010	−0.009	−0.040
High-KI	−0.042	0.007	0.006	0.028
PROFITVAR				
Low-KI	−0.437	0.076	0.067	0.294
Medium-KI	−2.681	0.468	0.412	1.801
High-KI	−3.525	0.615	0.541	2.368

Table A.8
Marginal effects from probit estimations, adoption of quality circles of across 993 Danish firms

	QC = 0	QC = 1	QC = 2	QC = 3
CONSTANT	0.451	−0.135	−0.135	−0.181
MEDIUM_KI	−0.003	0.001	0.001	0.001
HIGH_KI	−0.090	0.027	0.027	0.036
LOGSIZE	−0.056	0.017	0.017	0.022
SUBSID	−0.081	0.024	0.024	0.032
INNOF	−0.117	0.035	0.035	0.047
INNOC	−0.100	0.030	0.030	0.040
INNOW	−0.073	0.022	0.022	0.029
COMP	−0.002	0.001	0.001	0.001
PROFITVAR	−0.459	0.138	0.137	0.184

Table A.9
Marginal effects from probit estimations, adoption of planned job rotation across 993 Danish firms

	PJR = 0	PLJ = 1	PLJ = 2	PLJ = 3
CONSTANT	0.575	−0.241	−0.169	−0.166
MEDIUM_KI	−0.047	0.020	0.014	0.014
HIGH_KI	−0.008	0.004	0.003	0.002
LOGSIZE	−0.066	0.028	0.019	0.019
SUBSID	−0.026	0.011	0.008	0.008
INNOF	−0.098	0.041	0.029	0.028
INNOC	−0.113	0.047	0.033	0.033
INNOW	−0.163	0.068	0.048	0.047
COMP	−0.028	0.012	0.008	0.008
PROFITVAR	−0.437	0.183	0.128	0.126

Appendix B. The questions from the DISKO survey that are used in this paper

1. How large a share of the firm's workforce is involved in following ways of organizing work? (none, <25 percent, 25–50 percent, >50 percent, corresponding to a 4 point Likert scale)
   a. Delegation of responsibility [DR].
   b. Performance pay (not piece work) [PPAY].
   c. Quality circles [QC].
   d. Planned job rotation PLJ].
2. Has the firm introduced new products/services during the period 1993–1995 when excepting minor improvements of existing products? (yes/no)

If the respondent answered yes to this question he/she was asked whether similar products/services could be found . . .

a. . . . on the Danish market (yes/no);
b. . . . on the world market (yes/no).

If the respondent answered that a similar product could be found both on the Danish market and on the world market, the first innovation variable (INNOF) was coded with the value of 1 ("new to the firm"); otherwise it was coded with the value of 0. If respondent answered that a similar product could be found on the world market, but not on the Danish market, the second innovation variable (INNOC) was coded with the value of 1 ("new to the country"); otherwise it was coded with the value of 0. If the respondent answered that a similar product could neither be found on the Danish market, nor on the world market, the third innovation variable (INNOW) was coded with the value of 1 ("new to the world"); otherwise it was coded with the value of 0.

3. To which extent has competition from other firms changed during recent years?
   a. Strongly decreased.
   b. Somewhat decreased.
   c. Unchanged.
   d. Somewhat increased.
   e. Strongly increased.

If the respondent answered “strongly decreased”, the variable was coded with the value of 0, while the variable was coded with the value of 4 in the case where respondent answered “strongly increased”.

Appendix C. The sectoral classification applied in the present paper

The starting point for our classification of firms into low-, medium- and high knowledge-intensive industries is the Pavitt taxonomy. Pavitt (1984) identifies differences in the importance of different sources of innovation according to which broad sector the individual firm belongs. The Pavitt taxonomy, based on grouping firms according to their principal activity, emerged out of a statistical analysis of more than 2000 post-war innovations in Britain. The underlying explanatory variables are the sources of technology, the nature of users’ needs and firms’ means of appropriation. Based on this, four overall types of firms were identified, namely supplier dominated firms, scale-intensive firms, specialised suppliers and science-based firms. *Supplier dominated* firms are typically small. Most technology comes from suppliers of equipment and material. *Scale intensive* firms are found in bulk materials and assembly. Their internal sources of technology are production engineering and R&D departments. External sources of technology include mainly interactive learning with specialised suppliers, but also inputs from science-based firms are of some importance. *Specialised suppliers* are small firms that are producers of production equipment and control instrumentation. Their internal sources of technology are design and development. External sources are users (science-based and scale-intensive firms). *Science-based firms* are found in the chemical and electronic sectors. Their main internal sources of technology are internal R&D and production engineering. Important external sources of technology include universities, but also specialised suppliers. In the present paper we considers supplier-dominated industries to be “low knowledge-intensity” industries, while scale intensive industries are considered to be “medium knowledge-intensity” industries. Science based and specialised supplier industries are considered to be “high knowledge-intensity” industries.

In the 1984 version of the Pavitt taxonomy, all service firms were considered to be supplier dominated (i.e. “low knowledge-intensity” industries). However, later on Pavitt (1990) acknowledged that some service firms had become increasingly innovative, including business services and financial services. Hence, we have classified firms in these industries as “high knowledge-intensity” industries. Moreover, we found in our sample that firms in the wholesale industries appear to produce a substantial amount of innovation since 63 percent of firms in these industries report that they have introduced an innovation over the period in question. Hence, rather than following the Pavitt taxonomy and classifying these industries as “low knowledge-intensity,” we decided to classify them as “medium knowledge-intensity” industries. Finally, we follow Pavitt (1984) and consider the rest of the services industries to be supplier dominated (i.e. “low knowledge-intensity” industries). For a detailed assignment of all industries into our three sectors, see Appendix D to this paper. From Table A.1 (Appendix A) it can be seen that the high-knowledge-intensive firms are indeed the most innovative firms since 71.6 percent of firms in these industries reported that they are innovative to some degree. 62.5 percent of the firms in medium knowledge-intensity industries are innovative while only 36.4 percent of low knowledge-intensive industries are innovative.

Appendix D. The assignment of industries/firms into three sectoral categories

No.	Industry	Sector
1	Production, etc. of meat and meat products	Med-KI
2	Manufacture of dairy products	Med-KI
3	Manufacture of other food products	Med-KI
4	Manufacture of beverages	Med-KI
5	Manufacture of tobacco products	Med-KI
6	Manufacture of textiles and textile products	Low-KI
7	Manufacture of wearing apparel; dressing, etc. of fur	Low-KI
8	Manufacture of leather and leather products	Low-KI
9	Manufacture of wood and wood products	Low-KI
10	Manufacture of pulp, paper and paper products	Low-KI
11	Publishing of newspapers	Low-KI
12	Publishing activities, excl. newspapers	Low-KI
13	Printing activities, etc.	Low-KI
14	Manufacture of refined petroleum products, etc.	Med-KI
15	Manufacture of chemical raw materials	High-KI
16	Manufacture of paints, soap, cosmetics, etc.	Med-KI
17	Manufacture of pharmaceuticals, etc.	High-KI
18	Manufacture of plastics and synthetic rubber	Med-KI
19	Manufacture of glass and ceramic goods, etc.	Low-KI
20	Manufacture of cement, bricks, concrete ind., etc.	Med-KI
21	Manufacture of basic metals	Med-KI
22	Manufacture construction materials of metal, etc.	Med-KI
23	Manufacture of hand tools, metal packaging, etc.	Low-KI
24	Manufacture of marine engines, compressors, etc.	High-KI
25	Manufacture of other general purpose machinery	High-KI
26	Manufacture of agricultural and forestry machinery	High-KI
27	Manufacture of machinery for industries, etc.	High-KI
28	Manufacture of domestic appliances n.e.c.	Med-KI
29	Manufacture of office machinery and computers	High-KI
30	Manufacture of radio and communication equipment, etc.	High-KI
31	Manufacture of medical and optical instruments, etc.	High-KI
32	Building and repairing of ships and boats	Med-KI
33	Manufacture of transport equipment excl. ships, etc.	Med-KI
34	Manufacture of furniture	Low-KI
35	Manufacture of toys, gold and silver articles, etc.	Low-KI
36	General contractors	Low-KI
37	Bricklaying	Low-KI
38	Installation of electrical wiring and fittings	Low-KI
39	Plumbing	Low-KI
40	Joinery installation	Low-KI
41	Painting and glazing	Low-KI
42	Other construction works	Low-KI
43	Sale of motor vehicles, motorcycles, etc.	Low-KI
44	Maintenance and repair of motor vehicles	Low-KI
45	Service stations	Low-KI

Appendix D (*Continued*)

No.	Industry	Sector
46	Ws. of agricultural raw materials, live animals	Med-KI
47	Ws. of food, beverages and tobacco	Med-KI
48	Ws. of household goods	Med-KI
49	Ws. of wood and construction materials	Med-KI
50	Ws. of other raw mat. and semimanufactures	Med-KI
51	Ws. of machinery, equipment and supplies	Med-KI
52	Commission trade and other wholesale trade	Med-KI
53	Re. sale of food in non-specialised stores	Low-KI
54	Re. sale of food in specialised stores	Low-KI
55	Department stores	Low-KI
56	Retail sale of phar. goods, cosmetic art., etc.	Low-KI
57	Re. sale of clothing, footwear, etc.	Low-KI
58	Re. sale of furniture, household appliances	Low-KI
59	Re. sale in other specialised stores	Low-KI
60	Repair of personal and household goods	Low-KI
61	Hotels, etc.	Low-KI
62	Restaurants, etc.	Low-KI
63	Transport via railways and buses	Low-KI
64	Taxi operation and coach services	Low-KI
65	Freight transport by road and via pipelines	Low-KI
66	Water transport	Low-KI
67	Air transport	Low-KI
68	Cargo handling, harbours, etc.; travel agencies	Low-KI
69	Monetary intermediation	High-KI
70	Other financial intermediation	High-KI
71	Insurance and pension funding	High-KI
72	Activities auxiliary to financial intermediates	High-KI
73	Letting of own property	Low-KI
74	Real estate agents, etc.	Low-KI
75	Renting of machinery and equipment, etc.	Low-KI
76	Computer and related activity	High-KI
77	Research and development	High-KI
78	Legal activities	High-KI
79	Accounting, book-keeping and auditing activities	High-KI
80	Consulting engineers, architects, etc.	High-KI
81	Advertising	High-KI
82	Building-cleaning activities	Low-KI
83	Other business services	High-KI

Note: Low-KI, low knowledge-intensity sectors; Med-KI, medium knowledge-intensity sectors; High-KI, high knowledge-intensity sectors.

Appendix E. The assignment of industries/firms into profit variance categories

No.	Industry	*N*	Variance
V1	Production etc. of meat and meat products (i1)	30	0.024
V2	Manufacture of dairy products (i2)	27	0.047
V3	Manufacture of other food products (i3) Manufacture of tobacco products (i5)	129	0.043

Appendix E (*Continued*)

No.	Industry	*N*	Variance
V4	Manufacture of beverages (i4)	15	0.011
V5	Manufacture of textiles and textile products (i6)	69	0.042
V6	Manufacture of wearing apparel; dressing, etc. of fur (i7)	48	0.070
	Manufacture of leather and leather products (i8)		
V7	Manufacture of wood and wood products (i9)	75	0.022
V8	Manufacture of pulp, paper and paper products (i10)	66	0.085
V9	Publishing of newspapers (i11)	42	0.006
	Publishing activities, excl. newspapers (i12)		
V10	Printing activities, etc. (i13)	75	0.065
V11	Manufacture of refined petroleum products, etc. (i14)	24	0.030
	Manufacture of chemical raw materials (i15)		
V12	Manufacture of paints, soap, cosmetics, etc. (i16)	63	0.036
V13	Manufacture of pharmaceuticals, etc. (i17)	27	0.035
V14	Manufacture of plastics and synthetic rubber (i18)	135	0.023
V15	Manufacture of glass and ceramic goods, etc. (i19)	81	0.024
	Manufacture of cement, bricks, concrete ind., etc. (i20)		
V16	Manufacture of basic metals (i21)	69	0.045
V17	Manufacture construction materials of metal, etc. (i22)	84	0.018
V18	Manufacture of hand tools, metal packaging, etc. (i23)	102	0.030
V19	Manufacture of marine engines, compressors, etc. (i)24	54	0.033
V20	Manufacture of other general purpose machinery (i)25	105	0.057
V21	Manufacture of agricultural and forestry machinery (i26)	27	0.082
V22	Manufacture of machinery for industries, etc. (i27)	108	0.019
V23	Manufacture of domestic appliances n.e.c. (i28)	30	0.036
V24	Manufacture of office machinery and computers (i29)	84	0.068
V25	Manufacture of radio and communication equipment, etc. (i30)	51	0.060
V26	Manufacture of medical and optical instruments, etc. (i31)	90	0.045
V27	Building and repairing of ships and boats (i32)	24	0.101
V28	Manufacture of transport equipment excl. ships, etc. (i33)	60	0.091
V29	Manufacture of furniture (i34)	156	0.022
V30	Manufacture of toys, gold and silver articles, etc. (i35)	36	0.017
V31	General contractors (i36)	177	0.030
V32	Bricklaying (i37)	36	0.019
V33	Install. of electrical wiring and fittings (i38)	114	0.014
V34	Plumbing (i39)	66	0.008
V35	Joinery installation (i40)	84	0.015
V36	Painting and glazing (i41)	66	0.018
V37	Other construction works (i42)	33	0.010
V38	Sale of motor vehicles, motorcycles, etc. (i43)	243	0.061
V39	Maintenance and repair of motor vehicles (i44)	51	0.008
	Service stations (i45)		
V40	Ws. of agricul. raw materials, live animals (i46)	48	0.026
V41	Ws. of food, beverages and tobacco (i47)	96	0.065
V42	Ws. of household goods (i48)	150	0.037
V43	Ws. of wood and construction materials (i49)	51	0.051
V44	Ws. of other raw mat. and semimanufactures (i50)	87	0.034
V45	Ws. of machinery, equipment and supplies (i51)	336	0.049
V46	Commission trade and other wholesale trade (i52)	24	0.015
V47	Re. sale of food in non-specialised stores (i53)	63	0.032
	Department stores (i55)		

Appendix E (*Continued*)

No.	Industry	*N*	Variance
V48	Re. sale of food in specialised stores (i54)	15	0.004
V49	Retail sale of phar. goods, cosmetic art., etc. (i56)	120	0.007
V50	Re. sale of clothing, footwear, etc. (i57)	78	0.029
V51	Re. sale of furniture, household appliances (i58)	90	0.019
	Repair of personal and household goods (i60)		
V52	Re. sale in other specialised stores (i59)	51	0.018
V53	Hotels, etc. (i61)	63	0.086
V54	Restaurants, etc. (i62)	39	0.010
V55	Transport via railways and buses (i63)	18	0.015
V56	Taxi operation and coach services (i64)	30	0.003
V57	Freight transport by road and via pipelines (i65)	165	0.008
V58	Water transport (i66)	15	0.107
	Air transport (i67)		
V59	Cargo handling, harbours, etc.; travel agencies (i68)	96	0.028
V60	Monetary intermediation (i69)	15	0.089
	Other financial intermediation (i70)		
	Insurance and pension funding (i71)		
	Activities auxiliary to financial intermediates (i72)		
V61	Letting of own property (i73)	18	0.012
	Real estate agents, etc. (i74)		
V62	Renting of machinery and equipment, etc. (i75)	18	0.633
V63	Computer and related activity (i76)	69	0.023
V64	Research and development (i77)	3	0.025
V65	Legal activities (i78)	3	0.000
V66	Accounting, book-keeping and auditing activities (i79)	33	0.003
V67	Consulting engineers, architects, etc. (i80)	90	0.019
V68	Advertising (i81)	18	0.006
V69	Building-cleaning activities (i82)	45	0.007
V70	Other business services (i83)	27	0.079

Note: The numbers in brackets (i1, . . ., i70) refers to the industry number in Table A.2 (Appendix A).

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