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The Importance of Sectoral Differences in the Application of Complementary HRM Practices for Innovation Performance

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ABSTRACT *Recent theoretical and empirical analysis in the field of economic organization has focused almost exclusively on identifying organizational practices and complementarities between such practices, without regard for the type of activity in question. However, organizational theory suggests that more knowledge-intensive production activities often involve higher degrees of strategic uncertainty for firms and performance ambiguity in relation to individual employees. Therefore, the 'organic' or 'clan' form of organization – involving the application of 'new' HRM practices – is expected to perform better within knowledge-intensive sectors of the economy, as compared to other sectors. A sample of 726 Danish firms with more than 50 employees in manufacturing and private services is studied. The results show that HRM practices are more effective in influencing innovation performance when applied together, as compared with situations in which individual practices are applied alone. In other words, organizational complementarities obtain. Moreover, the application of complementary HRM practices is more effective for firms in knowledge-intensive industries ('high' and 'medium' knowledge-intensive industries).*

Key words: Human resource management practices; Organisational complementarities; Innovation performance.

JEL classifications: C21, D21, D23.

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1. Introduction

This paper is concerned with the impact of complementary human resource management (HRM) practices on innovation performance. Given the close connection between knowledge possessed by the personnel of the firm and the products and services obtainable from the firm (Penrose,1959), it is uncontroversial that a firm's ability to produce new products and other aspects of performance are inextricably linked to how it organizes its human resources. Nevertheless, despite the widely held belief in the importance of managing knowledge and learning through human resource practices, their performance implications remain assumed rather than empirically corroborated. First, while recent research suggests that consistency among practices matters for firm-level performance, supporting evidence is sparse, and in many cases limited to particular industries (e.g., Arthur, 1994; MacDuffie, 1995; Ichniowski *et al.*, 1997; Mendelson and Pillai, 1999). Second, with a few exceptions (e.g., Arthur, 1994; Huselid, 1995; MacDuffie, 1995; Ichniowski *et al.*, 1997), the effect of HRM practices has been examined on an individual work practice basis. However, if Edgeworth complementarities obtain (i.e. doing more of one thing increases the returns of doing [more of] other things) the effectiveness of HRM practices will be greater, when such practices are applied in systems rather than when they are used alone. Therefore, such complementarity effects should be considered in the analysis. Third, theoretical analysis has focussed almost exclusively on identifying organizational practices and complementarities between such practices, invariant to the type of activity in question (e.g., Milgrom and Roberts, 1995). Finally, the assumption of sectoral invariance also applies to a number of empirical studies (e.g., Huselid, 1995; Michie and Sheehan, 1999; Laursen and Foss, 2002). Yet, while it might be obvious that, for example, an electronics firm will benefit from the application of formal HRM practices, it is not obvious that a smaller construction firm will gain (equally) from applying such practices. Hence, the empirical research of this paper is devoted to the more detailed unfolding of sectoral regularities in the effect of HRM practice complementarities on innovation performance, across an entire economy.

An empirical model of firm's ability to innovate is estimated, using data from a Danish survey of 1900 business firms (in manufacturing and services) conducted in 1996. The survey aimed at tracing the relationship between technical and organizational innovation. The survey data have subsequently been linked to Statistics Denmark's register data. In the attempt to estimate the effect of the application of HRM practices – and complementarities among them – firm size and linkages to users or suppliers are controlled for. The effect of three HRM variables ('team work', 'delegation of decision rights' and 'performance related pay') both individually ('the direct HRM effect') and when applied in systems ('the HRM complementarity effect') is examined. Given the expectation with respect to important differences in the effect of the HRM practices on performance, the model is estimated while allowing for varying parameters at the level of three broad sectoral categories of firms.

The paper is structured as follows. First, the theoretical link between the application of HRM practices and innovation performance is discussed (Section 2). Second, an empirical model is proposed and subsequently tested (Section 3). Section 4 concludes and draws some implications for future theoretical and empirical work.

2. Theoretical Considerations

'New HRM practices' is the overall label put on a host of contemporary changes in the organization of the employment relation, referring to team-based organization, continuous (often team-based) learning, decentralization of decision rights and incentives, emphasis on internal knowledge dissemination, etc. At the same time it should be noted that other types of practices, such as for instance, recruiting, training or career paths, are disregarded in the present analysis. While there may be strong financial performance effects, productivity effects and flexibility advantages of such new HRM practices (Huselid, 1995; Ichniowski *et al.*, 1997; Mendelson and Pillai, 1999), the main emphasis of this paper is on the impact on innovation performance, and in particular on product innovation.[1] This section will first lay out, in general terms, some of the links between the application of new HRM practices and innovation performance. Second, it will be argued that such practices are more effective with respect to performance, when implemented in knowledge-intensive firms.

The Role of New HRM Practices for Innovation

New HRM practices can be conducive to innovative activity for at least three types of reasons: (1) the application of HRM practices may increase the level of decentralization, and such an environment may better allow for the discovery and utilization of local knowledge in the organization; (2) team practices, involving job-rotation are likely to provide coordination advantages in the sense that engineers (or 'workers') perform several tasks and therefore understand the technological problems of colleagues better; and (3) teams often bring together knowledge and skills which – prior to the introduction of teams – existed separately, potentially resulting in incremental process and product improvements.

With regard to point (1), a notable feature of many new HRM practices is that they increase the decentralization process with respect to innovations/improvements, in the sense that problem-solving rights are delegated to the shop-floor. Accomplished in the right way, this amounts to delegating rights in such a way that they are co-located with the pertinent knowledge, much of which is inherently tacit. In other words, increased delegation may better allow for the discovery and utilization of local knowledge in the organization, particularly when there are incentives in place that foster such discovery (Hayek, 1948; Jensen and Meckling, 1992). The increased use of teams, which is an important component in the package of new HRM practices, also means that better use can be made of local knowledge, leading to improvements in processes and perhaps also to minor product improvements. Indeed, it is exactly for those reasons that Itoh (1994b) argues that the existence of Japanese incremental and continuous process innovations depend on the co-location of the relevant problems with the appropriate decision rights, at the team level, combined with appropriate pecuniary (typically in the form of performance-pay at the supra-individual level) and non-pecuniary incentives (typically in the form of long-term employment contracts and promotion schemes). Nevertheless, it should be pointed out that the inherent incentive-problem in introducing teams (that is, inputs, outputs and behaviour are not easily gauged and fairly rewarded) is somewhat mitigated since team-work involving job-rotation (within the team), is likely to facilitate monitoring and sanctioning among the members (Itoh, 1993).

As stated in point (2) above, if team-work/research involves participants performing more than one task, then coordination between the tasks is likely to become easier. Because the agents work jointly on all tasks, they will be able – at least to some degree – to share knowledge and information and to adjust their activities without a central unit (Itoh, 1994a). Then, if lateral communication (for example between engineers) has some advantages over centralized, vertical coordination, such a team-based organizational set-up will be superior. If engineers, for example, tend to have better information about their (local) tasks, lateral communication may have an advantage in utilizing such information, provided that communication is costly (Bolton and Farrell, 1990). It should be pointed out, however, that this coordination effect is to be measured against the negative effect due to the loss of specialization gains with respect to each individual task.

With respect to point (3), teams can do something more than to support local knowledge and to enhance coordination between tasks, since teams are often composed of different human resource inputs. In other words, teams often bring together knowledge that hitherto existed separately, potentially resulting in non-trivial process improvements, when teams are on the shop-floor or result in 'new combinations' that lead to novel products (Schumpeter, 1912/1934) when teams are used in product development departments. Generally, increased knowledge diffusion, for example, through job rotation, and increased information dissemination, for example, through IT, may also be expected to provide a positive contribution to the firm's innovation performance – for obvious reasons. In the context of product development, Aoki (1990) suggests that the use of team-work involving job-rotation, increases the interaction between the different key actors in various successive stages of product development. Since processes of product development are characterized by various feedback loops between the 'phases' (Kline and Rosenberg, 1986), job-rotation among different engineering offices, as well as between engineering jobs and supervisory jobs at the factory, facilitates the knowledge sharing needed for horizontal coordination among the different phases of development.

Thus, there are reasons to expect that the adoption of new HRM practices leads to better innovation performance. Arguably, the adoption of a single such practice may provide a contribution to innovative performance. For example, rewarding shop-floor employees for minor process improvements is likely to increase such incremental innovation activity, more or less regardless of the specific firm in which the reward system is implemented. However, other practices may not be expected to have significant impact on innovation performance, if implemented in isolation. At least to the extent that implementing new HRM practices is associated with extra effort or with disutility of changing to new routines, etc., employees will have to be somehow compensated. Thus, we would expect many new HRM practices to work well (in terms of both profits and innovation performance) only if accompanied with new, typically more incentive-based, remuneration schemes. In general and on a priori grounds, new HRM practices should be expected to be most conducive to innovation performance when adopted, not in isolation, but as a system of mutually reinforcing practices. The complementary nature of many of the elements of formal and informal organizational structure has been examined in an emerging important literature in organizational economics (notably Milgrom and Roberts, 1990; Aoki and Dore, 1994; Milgrom and Roberts, 1995; Holmström and Roberts, 1998). The arguments in favour of this are relatively straightforward. For example, when team-based HRM practices such as interdisciplinary work-

groups and quality circles are used, without at the same time allocating the appropriate decision rights down to the team level, team-based practices are not likely to be effective in influencing performance (Cohen and Bailey, 1995; Lawler, Mohrman and Ledford Jr, 1995). Moreover, all such practices are likely to be complements to various incentive-based remuneration schemes (in particular when based on team or firm performance), profit sharing arrangements, and promotion schemes (Zenger and Hesterly, 1997).

Sectoral Differences in the Effectiveness of New HRM Practices

While the previous section pointed to the general observation that complementary HRM practices are likely to enhance innovative activity, it is unlikely that such practices are equally effective across different sectors of economic activity. In this respect, we know from the literature on the economics of technological innovation that the mode (according to the dominant source of knowledge input) and level (in terms of the innovation frequency) of innovation tend to follow broad sectoral regularities, in the sense that 'typical' firms can be identified for broader categories of economic activity (Pavitt, 1984). Although it is intuitively appealing that different economic activities should be governed in different ways, it is not obvious how such (different) activities should be governed in terms of the organizational structure and related HRM practices. However, the so-called contingency theories from the organizational literature can be of assistance, as a starting point for bridging this gap. One such contingency approach has been advanced by William Ouchi (e.g., 1980). Ouchi takes as his starting point the transactions cost approach and identifies the conditions which give rise to the cost of exchanges between individuals, namely goal incongruence and performance ambiguity. Performance ambiguity has to do with how easily inputs and outputs of the production process are measured. If inputs and outputs are not easily measured – for instance if both factors of production as well as outputs are intangible – performance ambiguity will be high. Goal incongruence refers to the fact that individuals (members of the organization) in many cases have only partly overlapping goals. Hence in these cases, when left on their own, the individuals will pursue incongruent objectives and their efforts would be uncoordinated. However, Ouchi (1979; 1980) argues that– when a group within a firm has been socialized in a certain way – goal congruence can in fact be high.

Different sizes of parameters with respect to the two variables then help in distinguishing three basic mechanisms of control as the efficient response to economic coordination, namely markets, bureaucracies, and clans. Markets are seen to be the efficient form of organization, when performance ambiguity is low and goal incongruence is high, while bureaucracies are argued to be the efficient form when both goal incongruence as well as performance ambiguity are moderately high. Moreover, a bureaucracy typically relies on the standardization of inputs, processes, jobs and behaviour, so that output can be approximated. But when performance ambiguity reaches very high levels – performance control becomes impossible. In such a situation clans are seen to be the most efficient form of organization, given that goal incongruence can be considered to be low, due to a particular socialization process. In this situation the best fit organizational arrangement can be characterized as being an 'organic form' (Burns and Stalker, 1961), that is a flexible, decentralized, informal and highly integrated organisational structure. Firms applying these organizations are typically active in technologically

advanced or closely integrated industries (Ouchi, 1980: 136), where teamwork is common and where technological change often leaves individual performance highly ambiguous. In this situation a bureaucracy will often fail, making the clan – relying on goal congruence – the only form of mediation. Therefore, given the attributes of the 'organic' or 'clan' type of organization, work practices associated with this organizational structure (reflecting team production and delegation of responsibility in particular) should suit firms in knowledge-intensive industries better, and hence a higher output in terms of new product development (innovations) from the application of these practices should be expected.

In addition to the effects identified by the contingency approaches, in terms of flexibility of organizations in adapting to changes in the external environment and in terms of goal congruence within firms, effects relating more directly to the knowledge-creation process might also be of importance in the context of sectoral differences. One such effect has to do with the observation that organic forms associated with new HRM practices can better assist in creating and utilizing local knowledge (as discussed above). Since the importance of local, specific knowledge is likely to be greater when production processes are more complex and knowledge-intensive, the effect of increased discovery and utilization of knowledge in the organization – by means of 'releasing' local knowledge using team-based HRM practices (involving increased delegation) – is likely to be stronger for firms affiliated to knowledge-intensive industries.

The standard principal-agent (P-A) literature suggests that pay-for-performance should be avoided in situations of high uncertainty, since efforts (inputs) from the agents cannot be measured easily under such circumstances (Holmström, 1979). Given the high level of uncertainty and given that efforts of agents are not easily gauged, the problem for the agent considered in P-A theory is that she is not able to assess whether she will be fairly rewarded, since she is not able control the (highly) uncertain environment. In order to accept the pay-for-performance arrangement, she will have to be compensated for the risk by the principal. Since more risk is transferred to the agent than is necessary (the agent is assumed to be risk-adverse), under conditions entailing greater levels of uncertainty, the use of pay-for-performance is not considered to be efficient within P-A theory. However, according to Prendergast (2000) this prediction is not supported by the available empirical evidence, since many studies exhibit a positive correspondence between measures of uncertainty and the use of pay-for-performance (output-based pay). Against this background, Prendergast infers that when agents work in more uncertain situations, the agents will know more than the principals about what the agents should be spending their time on. Therefore, given the information asymmetry and given that output can be measured, it is preferable to delegate responsibility to agents but, to constrain their discretion, to base compensation on observed output.[2] The reason is that an output-based employment contract is the only way to monitor the agents' efforts, although it implies higher wage-costs. Hence, if activities associated with high levels of knowledge-intensity are indeed more uncertain, as compared to other economic activities, we should expect the delegation of responsibility (for instance to teams) to be more effective in activities associated with high levels of knowledge-intensity.

In sum, theory would lead us to expect that (1) because of complementarities between new HRM practices, systems of HRM practices will be significantly more conducive to innovation than individual practices. Moreover, (2) the more knowledge-intensive production processes we are dealing with, the stronger the

impact on innovation performance from applying (complementary) HRM practices is expected to be. In the following, these ideas are empirically examined.

3. Empirical analysis

The Empirical Model

Based on the arguments put in the section above, the empirical model can be specified as follows:

$$a = f(\beta_1 z, \beta_2 x)_s \quad (1)$$

where a is the ability to produce innovations, β_1 and β_2 are parameter vectors, and z is a set of (exogenous) determinants of innovation, related to the application of human resource management practices, while x is a set of other variables explaining innovative performance across business firms. The variables included in the vector x, are arguably standard variables in explaining innovation performance (Geroski, 1990; Kleinknecht, 1996). This model can be made operational in the following way:

$$A_i = \alpha_s SECT_i + \delta_s SIZE_i + \upsilon_s LINK_i + \eta_s HRMP_i^j + \ldots + \eta_s HRMP_i^n + \epsilon_{ij} \quad (2)$$

where A_i expresses the firms' ability to innovate. If the firm in question is a non-innovator the variable takes the value of 0, if the firm has introduced (in the period 1993–95) a product or service new to the firm the value is 1, if the firm has introduced a product that is new in a Danish context over the period the value is 2, while the value for this variable is 3 if the firm has introduced a product (or service) which is new to the world. Hence, only the final category qualifies for being an innovation in the strict sense of the word. S indicates that the parameter is allowed to vary according to which sector each firm belongs. The sample includes 253 non-innovators, 333 firms that produced products or services that were new only to the firm itself, 73 firms that produced products or services that were new to the national market, while 67 firms introduced products or services that were new to the world (see Appendix 1 for a description of the questions from the survey on the basis of which the variables have been constructed).

The sectoral classification of the firms in the sample is key to this paper, since this classification is used to gauge whether or not firms engaged in activities associated with higher levels of knowledge-intensity carry out more innovative activity when they apply new complementary HRM practices. Details of the sectoral classification applied may be found in Appendix 2. Firm types with the strongest internal capacity to develop new products and services are assumed to belong to 'high knowledge-intensive industries' (see Laursen and Foss, 2002). Firms in such industries are producing specialized machinery and instrumentation, chemicals and pharmaceuticals and ICT (Information and Communication Technology) 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 etc.). 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').

As is common in studies aiming at explaining innovative performance (e.g. Geroski, 1990; Michie and Sheehan, 1999) firm size (*SIZE*) is controlled for. Another control variable measures whether or not the firm in question has increased its vertical interaction with other firms, either upstream or downstream (*LINK*). This variable is supposed to pick up the effect of interactions with suppliers and users for innovation performance as stressed by, for example, von Hippel (1988). Since the model is estimated, while allowing the parameters to differ according to sectoral affiliation, the intercepts should also be allowed to vary for each of the three sectors in the analysis.

The variables $HRMP_i^j \ldots HRMP_i^n$ are the new HRM variables, that is, those variables which are key to the analysis. Three variables are assumed to mirror the application of new HRM practices, each reflecting the application of performance related pay (PPAY), delegation of decision rights (DRESP) and team work (TEAM). The PPAY variable takes the value of zero if performance related pay (using question 1.f from Appendix 1) is not used by the firm in question, one if the practice is used by the less than 25 % of the firm's workforce, two if the practice involves 25–50 % of the workforce and the variable takes the value of three if more than 50 % of the employees are involved. The DRESP variable is constructed in a similar manner (using question 1.e from Appendix 1). However, the non-zero values of this variable have been made conditional on whether or not the firm responds that employees plan their daily work. The final HRM variable under consideration is the variable reflecting the extent to which team work is applied by the firm in question. This variable is made up of four components (questions 1.a–1.d from Appendix 1), each displaying the extent to which firms use 'interdisciplinary workgroups', 'quality circles', 'planned job rotation', and 'integration of functions'. These variables can individually take the values zero-to-three as in the case of the PPAY and DRESP variables. The four variables are then 'clustered' into one single variable (Cronbach's Alpha Coefficient = 0.64), reflecting the use of team work (TEAM). As a starting point, this variable has zero as its lowest possible value (none of the underlying four practices are used), and nine as its highest possible value (all of the underlying four practices are used by more than 50 % of the employees). However, in order to become comparable with the PPAY and DRESP variables, the TEAM variable has been standardized so that it takes values from zero to three.[3]

However, as argued earlier, work on complementarities suggests that HRM practices are more effective when they are applied in systems relative to when they are applied alone. Hence, models are constructed in which HRM practices enter the equation to be estimated, in certain configurations or systems:

$$A_i = \alpha_s SECT_i + \delta_s SIZE_i + \upsilon_s LINK_i + \eta_s HRMS_i + \epsilon_{ij} \qquad (3)$$

where the notation is the same as in Equation (3). $HRMS_i$ denote a HRM system, made up as the sum of the three HRM practices. Subsequently, the estimations made shall be compared, when applying the HRMPs individually, and when they appear in a HRM system. Concerning the signs of the parameters, all signs are expected to be positive.

The Data

The main source of data for this paper is the DISKO database. The database is based on a questionnaire which aims at tracing the relationship between technical and organisational 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 in 1996. The questionnaire was submitted to a national sample of 4,000 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, i.e. a total of 913 firms. The resulting numbers of respondents were 684 manufacturing and 1,216 non-manufacturing firms, corresponding to response rates of 52 % and 45 %, respectively. The first descriptive analysis of the survey can be found 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, also held by Statistics Denmark. In the case of this paper, data have been obtained on the size of the firms in the sample from regular register data. In this paper are included only the firms with more than 50 employees, since we are dealing with the application of *formal* HRM practices – practices which are simply less meaningful for smaller companies (why use team-work HRM practices, if the firm is not larger than a typical team?). By retaining only firms in the sample larger than 50 employees, we end up with a total of 726 firms.

Table 1. Descriptive statistics for a set of DISKO variables (n = 726)

		Number of firms	% of sample
Industry affiliation	Low-KI	249	34.2
	Medium-KI	280	38.6
	High-KI	197	27.2
SIZE	51–100 employees	223	30.7
	101–200 employees	261	36.0
	200+ employees	242	33.3
DRESP	Not used	314	43.3
	< 25% of the workforce	91	12.5
	25–50% of the workforce	123	16.9
	> 50% of the workforce	198	27.3
PPAY	Not used	362	49.9
	< 25% of the workforce	151	20.8
	25–50% of the workforce	58	8.0
	> 50% of the workforce	155	21.4
TEAM*	No or very sparse use	132	18.2
	Low use	224	30.9
	Medium use	181	24.9
	High use	189	26.0

Notes: KI = knowledge-intensity.

*The meaning of "no or very sparse use", "low use", "medium use" or "high use" is spelled out in footnote 3.

Table 1 displays descriptive statistics for the explanatory variables. About half of the firms use delegation of responsibility (56.7 %) to varying degrees, while just about the same is the case for the application of performance related pay (50.1 %). 49.1% of the firms in the sample report medium or high use of team work practices.

Estimation

Since the dependent variable is a discrete variable, an ordered probit model is applied as the means of estimation. Hence, the method is maximum likelihood estimation (MLE), which provides a means of choosing an asymptotically efficient estimator for a set of parameters (for an exposition of the properties of ML estimators, see Greene, 1997: 129).

The results of the estimation of Equation (2) are reported in Table 2, while the corresponding marginal effects from the ordered probit analysis are reported in Appendix Table A1. The null hypothesis that the slopes of the explanatory variables are zero is strongly rejected by the likelihood ratio test. This is also the case for the estimations of Equation (3), found in Table 3.

The SIZE variable from Equation (2) is significant only for high knowledge-intensive industries ('high-KI') – and has a positive sign as expected.[4] Moreover, the

Table 2. Probit estimation with sector-specific slopes, explaining innovative performance across 726 Danish firms – three types of HRM practices

		Estimate	*p*-value
INTERCEPT	Low-KI	−2.508	0.613*
	Medium-KI	−1.964	0.452*
	High-KI	−2.290	0.000
SIZE	Low-KI	0.023	0.288
	Medium-KI	0.009	0.380
	High-KI	0.041	0.062
LINK	Low-KI	0.796	0.003
	Medium-KI	0.135	0.608
	High-KI	0.872	0.009
DRESP	Low-KI	−0.104	0.112
	Medium-KI	0.039	0.461
	High-KI	−0.038	0.575
TEAM	Low-KI	0.077	0.314
	Medium-KI	0.198	0.003
	High-KI	0.079	0.344
PPAY	Low-KI	0.118	0.078
	Medium-KI	0.058	0.294
	High-KI	0.136	0.040
Log likelihood		−812.3	
Restricted log likelihood		−852.5	
Likelihood ratio test		80.4	

Note: * *p*-values express whether or not the constants are significantly different from the benchmark i.e. ('High-KI').

results confirm that firms' external linkages are important to innovation, since the parameters for vertical linkages (LINK) are significantly different from zero in the case of both high and low knowledge-intensive sectors. This finding is in line with the predictions of von Hippel (1988) and as well as with the empirical findings of Rothwell *et al.*, (1974) and Malerba (1992).

However, the application of HRM practices is the main focus of the present analysis. Table 2 contains the estimation of the effects of the three individual HRM practices ('the direct HRM effect') as well. From this table it can be seen that delegation of responsibility (DRESP) is never significant, when viewed in isolation. Performance related pay (PPAY) turns out to be significant for firms both in industries associated with high knowledge-intensity, as well as for firms in industries with low knowledge-intensity. In this context, it is particularly interesting to note that performance related pay appears to be related to innovation performance for firms in industries associated with high knowledge-intensity. Since these firms are operating in an environment associated with high levels of (uncertain) technological change, standard P-A theory does not anticipate such a relationship. Hence, the finding is more in line with the P-A model due to Prendergast (2000)(discussed in Sub-section 2.2), rather with the standard P-A model. 'Team production' (TEAM), has a significant and positive effect for medium knowledge-intensive industries.[5] Hence, overall it may be concluded that the application of new HRM practices is somewhat related to innovation performance.

Nevertheless, the results from Table 2 can be compared to the estimations of HRMS in Table 3 ('the HRM complementarity effect'), where HRMS is made up by as the sum of three HRM practices reported in Table 2 (the corresponding marginal effects are reported in Appendix Table A2). From Table 3 it can be seen that 'the HRM complementarity effect' has a positive and significant impact for

Table 3. Probit estimation with sector-specific slopes, explaining innovative performance across 726 Danish firms – three HRM practices combined

		Estimate	*p*-value
INTERCEPT	Low-KI	−2.137	0.608*
	Medium-KI	−1.920	0.379*
	High-KI	−2.295	0.000
SIZE	Low-KI	0.017	0.438
	Medium-KI	0.009	0.361
	High-KI	0.042	0.058
LINK	Low-KI	0.859	0.001
	Medium-KI	0.167	0.524
	High-KI	0.887	0.008
HRMS	Low-KI	0.023	0.446
	Medium-KI	0.092	0.002
	High-KI	0.053	0.076
Log likelihood		−817.7	
Restricted log likelihood		−852.5	
Likelihood ratio test		69.6	

Note: * *p*-values express whether or not the constants are significantly different from the benchmark i.e. ("High-KI").

both firms in industries associated with medium knowledge-intensity as well as for firms in industries with high knowledge-intensity, while the parameter is insignificant in the case of firms belonging to low knowledge-intensive industries. This finding is in line with the 'sectoral hypothesis' stating that the application of complementary HRM practices is more effective for production activities associated with high levels of knowledge-intensity. However, it should be noted that the parameter is higher for firms in medium knowledge-intensive industries than it is for firms in high knowledge-intensive industries. This finding is in contrast to the 'sectoral hypothesis'. One can speculate that since new HRM practices are more widely diffused in the high knowledge-intensive industries, the potential gains to be obtained from adopting such practices are (now) smaller for firms in these industries, because the adoption is a source of competitive advantage to a smaller degree. The potential gain in terms of competitive advantage stemming from adopting new HRM practices may be greater in medium knowledge-intensive industries as such practices are less diffused in these industries.

3. Conclusions and Discussion

This paper began by observing a number of stylized facts pertaining to the ongoing changes in the nature of the employment relation – often conceptualized in the term, 'new HRM practices' – to the apparently systemic nature of these practices, and to their adoption by innovative firms. In particular, it was argued that while the adoption of individual HRM practices may be expected to positively influence innovation performance, an adoption of a package of complementary HRM practices could be expected to impact on innovation performance to a much higher degree. Moreover, it was argued that the more knowledge-intensive production processes we are dealing with, the higher will be the expected impact from applying HRM practices on innovation performance.

The results from the empirical analysis showed that in the current setting – when looking at firms with more than 50 employees and when allowing the parameters to differ according to three categories of firms – firm size had little effect on the propensity to innovate across the sample. However, the variable measuring the strength of vertical linkages to other firms proved to be associated with innovative activity for firms in the low as well as for the high knowledge-intensive industries.

For the variables important to the two chief hypotheses of this paper, namely the variables related to the application of HRM practices, it may be said overall, that these variables were found to affect innovation performance positively. As regards individual practices, some effect was detected, in particular for 'performance related pay'. However, when all of the HRM practices were combined into one single variable, the effect was found to be stronger. Hence, this finding is consistent with hypothesis (1), since this result is consistent with the view that complementarities between the various practices obtain. With regard to hypothesis (2) (the 'sectoral hypothesis'), it could be concluded that firms in sectors with seemingly higher levels of knowledge-intensity in their production processes (firms located in medium and high knowledge-intensive industries), perform better in terms of innovation output, while engaging in the application of new complementary HRM practices, as compared to firms affiliated to low knowledge-intensive industries. However – and in contrast to the 'sectoral hypothesis' – the parameter for HRM systems was found to be higher for medium knowledge-intensive industries, as compared to high knowledge-intensive industries.

Theoretical analysis in the field of economic organization has focused almost exclusively on identifying organizational practices and complementarities between such practices, invariant to the type of activity in question (e.g., Milgrom and Roberts, 1995). The results of this paper are therefore of interest, since they strongly suggest that this simplifying assumption is not reflected in reality. At the theoretical level there appears to be a need for an integration of contingency factors with the theory of organizational complementarity. Nevertheless, while this paper has brought us some way towards displaying the effect of HRM systems, it still remains limited in a number of ways. First, while the DISKO data set is quite detailed when it comes to variables measuring how work is organized ('job rotation', 'inter-disciplinary workgroups', etc.), the data set remains very limited when it comes to variables measuring incentives within firms (such as various remuneration schemes).The lack of such measures makes it difficult to provide a more precise analysis of where the complementarity effects really stem from. Second, while the HRM complementarity effect on innovation performance is interesting *per se*, it should be corroborated by analyses making use of other measures of performance, such as productivity and profit rates.

Notes

1. For an in-depth discussion of innovation performance vis-á-vis other measures of performance, see Laursen and Foss (2002).
2. It should be pointed out that when team-work is applied, individual contributions to output are often not easily be identified, and compensation must therefore be based on team performance, rather than on individual performance. Under such circumstances a number of free-riding problems within the teams arise, especially when workers vary in their ability. For a good discussion of the topic, see Prendergast (1999, pp. 39–44).
3. More precisely, if the sum of the four variables corresponds to zero or one, the value of the TEAM variable is set to zero (no or very sparse use). If the sum of the variables is two or three, the value is set to one (low use). Moreover, if the sum of the four variables turns out to be four or five, the value of the TEAM variable is set to two (medium use). Finally, if the sum of the four underlying is larger than five, the value of the TEAM variable is set to three (high use).
4. The marginal effects from the probit analysis (corresponding to the coefficients reported in Table 2), reported in Appendix Table A1, show that the probability of introducing an innovation with a higher degree of novelty increases with firm size for high knowledge-intensive firms, since the marginal effect for the SIZE variable is negative only in the case of no innovation (A = 0), while the marginal effect is positive in the case of innovation at all levels of novelty (A = 1, 2, 3). Indeed, this is the interpretation which can be put on all of the significant coefficients (including the parameters for the HRM variables), since the marginal effects are negative only in the case of no innovation (A = 0) for all significant coefficients.
5. While the significant estimates for the HRM variables is consistent with the with view that the application of 'new' HRM practices is conducive to high innovation performance, it is equally clear that – given the cross-sectional nature of the data – strong inferences about causality cannot be made. In fact it is possible (as suggested by a referee) that more innovative firms may be more financially successful than other firms, and that, if this is the case, such firms may be better able to experiment with new work practices.

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Appendix 1: The questions from the DISKO survey used in this paper

1. How large a share of the firm's workforce is involved in following ways of organising work? (none, < 25%, 25%–50%, > 50%, corresponding to a 4 point Lickert scale)

a. Interdisciplinary working groups [TEAM1]
b. Quality circles [TEAM2]
c. Planned job rotation [TEAM3]
d. Integration of functions (e.g. sales, production/service, finance) [TEAM4]
e. Delegation of responsibility [DRESP]
f. Performance pay (not piece work) [PPAY]

2. To what extent did the firm develop a closer co-operation with the following actors during the period 1993–95? (4 point Lickert scale).

a. Customers
b. Subcontractors

If the respondent answered 'to a high extent' or 'to some extent', the variable reflecting vertical linkages (customers and subcontractors) [LINK] was given the value of one, otherwise the variable were coded with the value of 0.

3. Has the firm introduced new products/services during the period 1993–95 when excluding 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 innovation variable [A] was coded with the value of 1 ('new to the firm'). If the respondent answered that a similar product could be found on the world market, but not on the Danish market, the innovation variable was coded with the value of 2 ('new to the country'). If the respondent answered that similar product could neither be found on the Danish market, nor on the world market, the innovation variable was coded with the value of 3 ('new to the world'). If the respondent answered no the first question under (4), the variable was assigned with the value of 0 (non-innovator).

Appendix 2: 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	Mfr. of wearing apparel; dressing etc. of fur	Low-KI
8	Mfr. of leather and leather products	Low-KI
9	Mfr. of wood and wood products	Low-KI
10	Mfr. 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	Mfr. of refined petroleum products etc.	Med-KI
15	Mfr. of chemical raw materials	High-KI
16	Mfr. of paints, soap, cosmetics, etc.	Med-KI
17	Mfr. of pharmaceuticals etc.	High-KI
18	Mfr. of plastics and synthetic rubber	Med-KI
19	Mfr. of glass and ceramic goods etc.	Low-KI
20	Mfr. of cement, bricks, concrete ind. etc.	Med-KI
21	Mfr. of basic metals	Med-KI
22	Mfr. construction materials of metal etc.	Med-KI
23	Mfr. of hand tools, metal packaging etc.	Low-KI
24	Mfr. of marine engines, compressors etc.	High-KI
25	Mfr. of other general purpose machinery	High-KI
26	Mfr. of agricultural and forestry machinery	High-KI
27	Mfr. of machinery for industries etc.	High-KI
28	Mfr. of domestic appliances n.e.c.	Med-KI
29	Mfr. of office machinery and computers	High-KI
30	Mfr. of radio and communication equipment etc.	High-KI
31	Mfr. of medical and optical instruments etc.	High-KI
32	Building and repairing of ships and boats	Med-KI
33	Mfr. of transport equipment excl. ships, etc.	Med-KI
34	Mfr. of furniture	Low-KI
35	Mfr. of toys, gold and silver articles etc.	Low-KI
36	General contractors	Low-KI
37	Bricklaying	Low-KI
38	Install. 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
46	Ws. of agricul. 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

Appendix 2: Continued

No.	Industry	Sector
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 Table A1. Marginal effects from probit estimation with sector-specific slopes, explaining innovative performance across 726 Danish firms, marginal effects – three types of HRM practices

		A = 0	A = 1	A = 2	A = 3
SIZE	Low-KI	−0.009	0.002	0.003	0.003
	Medium-KI	−0.003	0.001	0.001	0.001
	High-KI	−0.015	0.004	0.005	0.006
LINK	Low-KI	−0.291	0.084	0.089	0.118
	Medium-KI	−0.050	0.014	0.015	0.020
	High-KI	−0.297	0.086	0.090	0.121
DRESP	Low-KI	0.038	−0.011	−0.012	−0.016
	Medium-KI	−0.014	0.004	0.004	0.006
	High-KI	0.012	−0.003	−0.004	−0.005
TEAM	Low-KI	−0.028	0.008	0.009	0.011
	Medium-KI	−0.073	0.021	0.022	0.030
	High-KI	−0.028	0.008	0.008	0.011
PPAY	Low-KI	−0.043	0.013	0.013	0.018
	Medium-KI	−0.021	0.006	0.007	0.009
	High-KI	−0.049	0.014	0.015	0.020

Appendix Table A2. Marginal effects from probit estimation with sector-specific slopes, explaining innovative performance across 726 Danish firms – three HRM practices combined

		A = 0	A = 1	A = 2	A = 3
SIZE	Low-KI	−0.006	0.002	0.002	0.003
	Medium-KI	−0.003	0.001	0.001	0.001
	High-KI	−0.015	0.004	0.005	0.006
LINK	Low-KI	−0.315	0.090	0.095	0.130
	Medium-KI	−0.061	0.017	0.019	0.025
	High-KI	−0.298	0.085	0.090	0.123
HRMS	Low-KI	−0.009	0.002	0.003	0.004
	Medium-KI	−0.034	0.010	0.010	0.014
	High-KI	−0.020	0.006	0.006	0.008