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Knowledge strategies, firm types, and complementarity in human-resource practices

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Abstract:

This paper argues that complementary human resource practices play an important role in the development of a knowledge-based theory of firm differences. We find that firm types and knowledge strategies impact combinations of human resource practices employed in support of current activity systems and innovation. While recent evidence suggests that consistency among human resource practices is conducive, e.g. for productivity increases, research on complementarities among human resource management practices remains sparse, and focussed on single industries or firms. Additionally, little is known whether and how human resource practices support activity systems in different firm types and innovation. This paper addresses this gap by investigating the impact of firm type, knowledge strategies pursued, and external linkages on the application of complementarity human resource practices in a multisectoral sample of 684 manufacturing and 1,216 non-manufacturing firms. We develop hypotheses from the knowledge-based perspective, the theory of complementarity, and the strategic human resource literature. Our results support prior findings about complementarity between human resource practices, but complementarity effects differ in strength. Additionally, combinations of practices applied differ significantly with contingency factors such as knowledge strategies pursued and firm type. Thus, calling for a stronger integration between strategic management and human resource management.

Keywords: human resource management practices, complementarities, knowledge strategies

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1. Introduction

Recent contributions in the strategic management literature seek to develop a knowledge based theory of firm differences, and as such they see the primary reason for firms in the creation, integration, and utilisation of knowledge (Demsetz, 1988; Winter, 1987; Kogut & Zander, 1992; Nonaka, 1994; Conner & Prahalad, 1996). Knowledge is also increasingly regarded as influential for firm strategies (Bierly & Chakrabarti, 1996; Foss, 1999). Conner & Prahalad (1996: 477), for example, go so far to suggest that "...a knowledge-based view is the essence of the resource-based perspective." Because there is 'close connection between knowledge possessed by the personnel of the firm and the services obtainable from its material resources' (Penrose, 1959:77), it is uncontroversial that a firm's strategy is inextricably linked to how it organises its human resources. This empirical paper is concerned with the impact of different firm types (e.g. Pavitt, 1984), knowledge strategies, (e.g. Bierly & Chakrabarti, 1996) and systems of human resource management practices employed to contribute to a firm's pursuit of competitive advantage through innovation.

Several authors suggest that human resources are not only important, but that they are among the most strategically relevant resources (Itami & Roehl, 1987; Castanias & Helfat, 1991; Ulrich & Lake, 1991; Mahoney, 1995). Consequently, scholars propose that strategic human resource management contributes to firm performance through applying both individual or systems of human resource practices, including the use of interdisciplinary teams, investment in training, quality circles, and performance pay (Castanias & Helfat, 1991; Lado & Wilson, 1994; Mahoney, 1995; Ulrich, 1996; Huselid, Jackson, Schuler, 1997). A small, but growing, empirical literature stream (McDuffie, 1995; Koch & McGrath, 1996; Becker & Gerhard, 1996; Pennings, Lee & van Witteloostuijn, 1998) confirms performance effects of human resources management practices. However, by ignoring the existence of contingency factors related to firm type and knowledge strategies, much of the HRM literature may seem somewhat pending from a strategic management perspective. While preliminary evidence is encouraging as it shows that human resource practices matter for performance in general, little is known, in particular, about how, and in which combinations human resource management practices matter, for example, when they are employed in different types of firms, or to support different knowledge strategies.

Only recently, scholars have begun to address complementarity effects (Milgrom & Robert, 1990; Holmström & Milgrom, 1994) among human resource management practices on a conceptual (Baron & Kreps, 1999) and at an empirical level (Ichniowski, Shaw & Prennushi, 1997; Mendelson & Pillai, 1999). While such

empirical studies have remained sparse, evidence suggests that when several human resource practices are used simultaneously and in particular system configurations (Ichniowski, Shaw & Prenzushi, 1997), productivity increases, beyond what individual human resource practices achieve in isolation. While productivity increases through complementary human resource practices contribute to competitive advantage (and its sustainability), still, little is known about how complementarity effects among particular practices might differ in strength. Additionally, although the empirical literature regarding the relation between human resource practices finds productivity effects, data sets used usually have imposed limitations by deriving conclusions mainly from case studies or from the analysis of particular industries. Moreover, while productivity measures capture improvements of what the firm already does, it is also important to know, for example, whether innovating firms employ complementary human resource practices to support their knowledge strategies (Bierly & Chakrabarti, 1996) in the renewal of competitive advantage through innovations.

The current study adds to the studies mentioned above, but it is also different in focus. We attempt to contribute to the empirical literature by focussing on the impact of firm type and knowledge strategies pursued on the deployment of combinations of complementary human resource practices. We first develop the argument that firm types and knowledge-strategies differ and that these differences are strongly reflected in complementary human resource practices used. We then assert that innovative firms may choose particular complementary human resource practice combinations. To study the impact of firm type, knowledge strategies, and innovative performance on the choice of complementary human resource practices, we examined a multi-sectoral sample of 684 manufacturing and 1,216 non-manufacturing Danish firms. In particular, regressing nine human resource practices on a set of observables (e.g. firm-type, knowledge-strategy, innovative performance, firm size) suggests significant effects of firm size, firm type, and knowledge strategies ('the first step'). A correlation analysis of the error terms from the first step suggests pair-wise complementary of work practice combinations, thus, providing further support for the existence of complementarity among work practices. Finally, we consider theoretical implications for advancing research on the relation between human resource practices, knowledge-strategies, and complementarity among work practices. Managerial implications follow.

2. Theoretical background and hypotheses

Under norms of rationality (Thompson, 1967), managers seek to employ combinations of human resource practices to contribute to their companies objectives. Human resource practices can contribute to competitive advantage through facilitating the development and utilisation of knowledge, based on complex social relationships organised through firm specific systems of human resource practice; thus, they support a firm's particular strategy (Barney, 1991; Reed & DeFillippi, 1990; Nonaka & Takeuchi, 1995). Several human resource practices have been distinguished in the literature (e.g. Ichniowski, Shaw & Prennushi, 1997; Baron & Kreps, 1998), including the practices we have chosen to analyse in the empirical part of this paper, namely the application of interdisciplinary work groups, collection of employee proposals, planned job rotation, delegation of responsibility, integration of functions, performance related pay, firm internal and external training. These practices may be interrelated or complementary, that is, mutually enhancing, in their supporting effects for achieving strategic goals. The latter, however, may be contingent on firm types and strategies pursued. As a consequence, the rational deployment of different combinations of human resource practices, may vary systematically across firm types and knowledge strategies pursued.

2.1 Human resource practices and complementarity effects

Strategy researchers suggest that achieving competitive advantage depends upon the firm's ability to utilize existing knowledge and its ability to generate new knowledge more efficiently and effectively relative to competitors (Mahoney, 1995; Penrose, 1959; Prahalad & Hamel, 1990; Nonaka, 1994). Human resource practices can contribute to the mobilization and utilization of knowledge in a number of ways (e.g. Lado & Wilson, 1994). For example, increased delegation of responsibility may better allow for the discovery and utilization of local and dispersed knowledge in the organization (Hayek 1945; Jensen & Meckling 1992), which in itself may be a source of novel products, or processes. Additionally, interdisciplinary team-work, for example, may also be conducive to innovation, among other things because teams often bring together knowledge that hitherto existed separately resulting in "new combinations" (Schumpeter 1934). Teamwork can also facilitate cross-functional communication, enhance worker involvement, and develop or better utilize talent to

serve strategic aspiration. Through integrating knowledge of individual member, teams may not only blend knowledge and insights beyond what individual members may achieve; new knowledge development may also be stimulated by conversations and language based learning in teams (e.g. Brown & Duguid, 1991; Boland & Tenkasi, 1995). For example, Brown & Duguids (1991) analysis of communities of practice suggests that shared learning is inextricably linked to social interaction in teams. Through such learning, group-specific communication codes or combinative capabilities (Arrow, 1974; Kogut & Zander, 1992; Monteverde, 1995) are generated based on which different ‘communities of knowing’ can engage in strategic conversation to creatively combine and blend a variety of knowledge (Boland & Tenkasi, 1995; Ford & Ford, 1995; Leonard & Sensiper, 1998).

Furthermore, compensation systems have been regarded as influential to elicit employees’ contribution (Gomez-Mejia & Balkin, 1992). For example, high-powered incentives may be used to induce contributions through providing larger shares of quasi-rents to employees (Williamson, 1996). Firm-internal and external training may also contribute to corporate prosperity. For example, firms upgrade skills and expertise of workers through on-the-job training, seminars, learning-by-doing to create firm specific human capital (Becker, 1964). Such training can also contribute to organizational knowledge creation (Nonaka & Takeuchi, 1995) through social interaction in processes of socialization (experiencing interaction with tacit knowledge), internalization (learning by doing, where explicit knowledge is internalized), externalization (articulating prior tacit knowledge), and combination of explicit knowledge (cognitive learning). Finally, job rotation can be very effective in mobilizing personal knowledge as it helps organizational members to understand a company’s business from a variety of perspectives (Inkpen, 1996).

Recent contributions (Ichniowski, Shaw & Prennushi, 1997; Baron & Kreps, 1998) suggest that much research has focussed too narrowly on isolated human resource practice effectiveness; this might be a limiting factor in advancing research on human resource practices. As a consequence, a focus on complementarity effects (Milgrom & Robert, 1990; Holmström & Milgrom, 1994) resulting from a combination of practices is recommended. Arthur (1994), for example, found that in steel mini mills, a combination of human resource practices designed to elicit employee commitment

was associated with higher productivity. Building on these results, Huselid (1995) illustrated the significant impact of a combination of several work practices on employee turnover and corporate financial performance. Relatedly, Ichniowski, Shaw & Prennushi, (1997: 311) conclude from their study of steel production that “...systems of innovative HRM practices have large effect on production worker’s performance, while changes in individual work practices have little or no effect.” As a consequence of the arguments and findings presented above we expect:

H1: Complementaries among human resource practices obtain

Case studies of Lincoln Electric and Hewlett-Packard provide further support for the importance of complementary effects in systems of human resource practices (Milgrom & Roberts, 1995; Baron & Kreps, 1998). Although the practices used are complementary in that they elicit employee behaviour in a mutually reinforcing way, both companies also use different combinations of practices. Moreover, in both cases, complementary, but differently composed work practices are tailored to fit the companies’ strategy, firm type, and culture.

2.2 Human resource practice, knowledge strategies and firm types

It is an essential insight of strategy research that creating and sustaining firm differences in terms of resource and resource deployment contributes to firm’s competitive advantage (Conner, 1991; Peteraf, 1993; Prahalad & Hamel, 1994). Additionally, however, firms play different roles in the economy. One aspect of this observation is that firms’ management may wish to apply different human resource management practices as a function of the size of the firm. If channels of communication (Daft & Legel, 1986) are important to successful orchestration of firms’ organisations and knowledge flows (Gupta & Govindarajan, 1991), we may expect that internal co-ordination problems are less severe in small firms. Relatedly, simply because of the larger number of internal relations between the agents within large firms, co-ordination is more complex. Hence, large firms may need more formal human resource management practices in order to be efficiently governed in comparison with smaller firms, which might be efficiently governed without such practices. Therefore, we may then assert that:

H2: Large firms are more prone to adopt formal human resource management practices than small firms.

Another aspect of the observation that firms play different roles in the economy is that they engage in different principal activities. In the context, Pavitt (1984) distinguishes between science based-, specialised supplier-, scale intensive-, and supplier dominated firms according to technological diversification and sources of technology among a set of other criteria. Moreover, managers of different types of firms make choices "...that shape and direct the organizations's learning process" (Bierly & Chakrabarti , 1996: 123). It is through such choices in knowledge strategies (e.g. innovators, exploiters), that managers seek to augment the performance of a firm's current and innovative activities.¹ As a consequence, the rational deployment of combinations of human resource practices may vary systematically across firm types, principal activities and knowledge strategies pursued.

Firm types

Based on an analysis of more than 2000 post-war innovations in Britain, Pavitt (1984), suggests a taxonomy of firms, according to principal activity, sources of technology; the nature of users needs; and means of appropriation. Four types of firms were identified, namely supplier dominated firms, scale-intensive firms, specialised suppliers and science-based firms. *Supplier dominated* firms are typically small and most technology used comes from suppliers of equipment and material. Such firms "...make only minor contributions to their process or product technology" (p. 356). Additionally, because R&D capabilities are rather low, such firms build their business on professional skills, design, trademarks and advertising (ditto). *Scale intensive*, by contrast are firms which rely on internal sources of technology, such as strong R&D departments to support product innovation. External sources of technology include

¹ Bierly & Chakrabarti (1996) distinguish for example between (a) *innovator strategies* (e.g. effective combination of internal and external learning; both radical and incremental learning; high learning speed); (b) *loner strategies* (e.g. internal rather external learning; incremental rather than radical learning; low learning speed); and (c) *exploiter strategies* (e.g. low internal learning and high external learning; incremental rather than radical learning).

mainly interactive learning with specialised suppliers, but also inputs from science-based firms play an important role. *Specialised suppliers* are firms, which are producers of, typically, production equipment and control instrumentation. Their main internal sources are primarily design and development. External sources of technology are users, such as science-based and scale-intensive firms. Finally, *science based firms* rely heavily on internal R&D and production engineering. Important external sources of technology include universities, but also specialised suppliers.² As a consequence of the arguments and findings presented above we expect:

H3: Systems of human resource practices employed vary with firm-types

Innovator's knowledge strategy

While firms play different roles in the economy and engage in different principal activities, they may additionally follow different knowledge strategies. For example, based on an empirical study of knowledge strategies in US pharmaceutical firms, Bierly & Chakrabarti (1996) suggest that a firm's knowledge base are influenced by managerial choices. These choices imply focussing on either or both (a) external vs. internal learning (b) radical vs, incremental learning, (c) fast vs. low learning speed, and (d) a narrow or broad knowledge base (e.g. Cyert, Kunert, & Williams, 1993; Cohen & Levinthal, 1991; March, 1991, Prahalad & Hamel, 1994). Interestingly, it is the combination of these choices, which leads the authors to identify clusters of knowledge strategies (e.g. innovators, loners, exploiters). This study focuses on 'innovator strategies'. Innovators in Bierly & Chakrabarti's (1996) study are characterised by high levels of internal learning, strong linkages to external knowledge sources, as well as high internal learning speed. Achieving competitive advantage through innovation depends upon the firm's ability to utilise existing

² Since the Pavitt taxonomy was created mainly with the manufacturing sector in mind (although our *crafts* sector could be included in the *supplier dominated* sector, if one were to follow the original Pavitt taxonomy), and since we are conducting an analysis of firms in both manufacturing as well as in services, we have added five additional firm types. *ICT intensive* firms provide business services and financial services. *Wholesale trade firms* consists of firms selling bulk materials or machines. *Scale intensive services* consists of typically large firms in the transport industries, cleaning service as well as of supermarkets and warehouses. *Specialised service firms* is made up of smaller firms including miscellaneous shops, hotels and restaurants, taxi companies etc. *Crafts* consists of firms in construction business, as well as of automobile repair shops.

knowledge and its ability to generate new knowledge more efficiently and effectively relative to competitors. Human resource practices (in our case the use of interdisciplinary work groups, collection of employee proposals, planned job rotation, delegation of responsibility, integration of functions, performance related pay, training of employees) contribute to the mobilisation and utilisation of internal and external knowledge in complex social relations. Thus, we are entitled to expect:

H4: Innovative capacity is positively related to the application of new human resource practices

The strategic literature has increasingly stressed the importance of knowledge access and absorption (Cohen & Levinthal, 1989) through inter-partner learning both in vertical relations and through linkages to external knowledge institution (e.g. Hamel, 1991, Lei & Slocun, 1992, Lyles & Schwenk, 1996; Inkpen & Baemish, 1997; Dyer & Singh, 1998; Bartolomev, 1999; Porter, 1994). Such collaborations can contribute to a firm's innovation strategy. As such, collaboration can be seen as mechanisms for gaining access to and absorbing partners' knowledge; supporting innovator strategies they may provide a 'window on their partners valuable capabilities (Hamel, 1991). However, whether and how fast, for example innovating firms can access, absorb, and integrate external knowledge depends depend on the 'organisational absorptive capacity' (Cohen & Levinthal, 1991); that is, the ability of the firm to acquire and utilize external knowledge internally. As Matusik & Hill (1999: 685) argue that research on cooperative organizational arrangements, "...highlights the importance of integration mechanisms in gaining knowledge from partnerships...Boundary-spanning positions, resources committed to attaining information, formal strategy toward knowledge acquisition, and rewards for attaining information are some examples of external knowledge-integration mechanisms." Moreover, the role of interactive learning between cooperating firms (in particular interaction between suppliers and users) and institutions has been increasingly stressed (Stalk & Lyles, 1996; Dyer & Singh, 1998) Because, human resource practices influence an organisational absorptive capacity and inter-partner learning, we expect:

H5: Vertical linkages and linkages to knowledge institutions are positively related to deploying new human resource management practices

3 Sample and descriptive statistics

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 organisation 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, respectively, 52 per cent and 45 per cent. 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 our case we have obtained data on the size of the firms in the sample from regular register data.

Table 1 displays descriptive statistics for our variables. It can be seen from the Table 1 that between 39 and 84 per cent of the firms in our sample apply each one of the nine HRMPs, described above. 39 per cent apply performance related pay, while 84 per cent apply delegation of responsibility. In our sample we have 934 non-innovators, 733 firms which produced products/services new only to the firm itself, 127 firms which produced products/services new on the national market, while 103 firms introduced products/services, new to the world. As is common in studies of this type (e.g. Lorentz, 1998; Michie & Sheehan, 1999) we control for firm size and firm-type. We include four size categories³ and nine firm-types. For what concerns the firm classification, we apply the Pavitt taxonomy. As pointed out above, we construct five additional firm types for the service firms (scale intensive services, specialised

³ In the stratification of the sample, firms with less than 10 employees were excluded from the analysis. However in our analysis, we have a size category containing firms smaller than 10 employees. The reason for this is that when the sample was stratified, size was measured at a given point in time. However, in this paper we measure size as the number of full time employees over a full year.

Table 1: Descriptive statistics for a set of DISKO variables (n=1897)

Variable	Number of firms	% of total sample
Interdisciplinary workgroups	933	49.2
Quality circles	712	37.5
Systems for collection of employee proposals	834	44.0
Planned job rotation	675	35.6
Delegation of responsibility	1598	84.2
Integration of functions	1070	56.4
Performance related pay	741	39.1
Firm-internal training	986	52.0
Firm-external training	1313	69.2
Vertical linkages	1581	83.3
Link to knowledge institutions	815	43.0
Subsidiary of other firm	828	43.6
Non-innovators	934	49.2
Introduced product/services new to the firm	733	38.6
Introduced product/services new to the country	127	6.7
Introduced product/services new to the world	103	5.4
Scale intensive	254	13.4
Supplier dominated	225	11.9
Science based	67	3.5
Specialised suppliers	138	7.3
Crafts	273	14.4
Wholesale trade	334	17.6
Specialised services	373	19.7
Scale intensive services	101	5.3
ICT intensive services	132	7.0
1-10 employees	234	12.3
11-50 employees	979	51.6
51-100 employees	205	10.8
100+ employees	479	25.3

services, wholesale trade and crafts) in our sample. All firms in our sample have been classified according to industry by Statistics Denmark. Based on that categorisation we further aggregate the industries into the 9 sectors. The assignment of 83 industries into our 9 sectors can be traced in the appendix to this paper. Both for what concern size and firm-type, it can be seen from Table 1 that the firms are in general spread equally across our categories.

Other variables include whether or not the firm in question has increased its vertical interaction with other firms, being it either upstream or downstream ('vertical linkages'), and whether or not the firm in question has increased its interaction with knowledge institutions ('link to knowledge institutions'), including technical support institutions, consultancies or with universities. Although both variables concern whether the firms have increased their external linkages, we interpret these variables more broadly as measuring the strength of the respective linkages. The reason for this

is that we argue that respondents who have strong linkages with external partner are very likely to answer that they have *increased* interaction with partners. Finally, we control for whether or not the firm is a subsidiary of a larger firm (for a discussion of the effect of this variable, see Harris & Trainor, 1995).

4. Analysis and results

As argued by Athey & Stern (1998), two types of approaches for measuring (Edgeworth) complementarities (i.e. undertaking more of one strategy raises the marginal value of the other) have been applied in the literature. The first type has been build on the empirical productivity literature. The approach relies on a regression (various techniques have been applied) of a measure of productivity on a set of regressors, including the interaction effect between different practices, as estimates of complementarity parameters. A prominent example of an application of this procedure can be found in Ichniowski, Shaw and Prennushi (1997), discussed in Section 2.1 above. The second approach tests whether the correlation among practices is positive, conditional on observables. Applying this type of methodology, Colombo and Mosconi (1995) find complementarities between the application of new process technology on the one hand and organisational and managerial innovations on the other hand. Likewise, Arora and Gambardella (1990) find that certain strategies of 81 large chemical and pharmaceutical producers are indeed complementary.

In this paper we apply the Arora and Gambardella (1990) approach for gauging possible complementarities between HRM practices. The advantage of this procedure is that it is applicable when the value of complementarities cannot be tested directly, since the value of the practices might not be directly measured. In this case we are constrained to testing an important implication of complementarity. The logic can be illustrated by an example. If for instance, an increase in application of the delegation of responsibility increases the value of applying a work practice implying an integration across functions, it is intuitively persuasive that we would expect that firms which apply the work practice associated with the delegation of responsibility, would also tend to apply the work practice implying integration across functions in the firm. To put it differently, if the two strategies are complements, one would expect them to be positively correlated.

However, it should be pointed out that a simple correlation might be spurious, given the fact that a common set of factors might influence both of the variables. Such

factors include a set of firm-specific characteristics such as size, but also factors such as innovator's knowledge strategies including external linkages to suppliers, customers and knowledge institutions (e.g. universities, consultancies etc.). This implies that we have to account for such factors.

Accordingly, we follow a two step procedure, suggested by Arora & Gambardella (1990). First we regress our nine HRM practices on a set of regressors, as displayed in Table 1. The first nine variables in Table 1 are dependent variables (the nine HRM practices), while the rest of Table 1 contains our explanatory variables. All variables are binary, except for the innovation variable, which takes the value of 0 if the firm in question is a non-innovator, 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 new in Denmark 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. The second step of the procedure consists of making a correlation analysis of the residuals from the first step in order to reach some conclusions concerning whether or not our nine human resource management practices can be seen to be complementary.

Table 2 contains the estimations conducted in the first step. From the table it can be seen that our observables explain the application of interdisciplinary work groups and of firm-internal training much better the other work practices, since we in those cases explain about 20 per cent of the variation, while we only explain about 10 per cent in the other cases.

Concerning the relationship between size and the application of the nine work practices, and judging from the relative size of the parameters, it can be seen from the table that large firms in general, are more prone to apply new HRM practices than are smaller firms. This result supports hypothesis *H2*, from Section 2, asserting that large firms are more prone to adopt formal human resource management practices than

Table 2: Regression results for OLS models explaining the application of nine work practices

Dependent variable	Interdisciplinary workgroups		Quality circles		Systems for collection of employee proposals		Planned job rotation		Delegation of responsibility		Integration of functions		Performance related pay		Firm-internal training		Firm-external training	
	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
Independent variables	R ² = 0.23		R ² = 0.10		R ² = 0.09		R ² = 0.11		R ² = 0.08		R ² = 0.10		R ² = 0.08		R ² = 0.20		R ² = 0.09	
<i>SIZE controls</i>																		
1-10 employees	0.547	0.000	0.282	0.000	0.357	0.000	0.286	0.000	0.800	0.000	0.516	0.000	0.282	0.000	0.618	0.000	0.326	0.000
11-50 employees	0.511	0.000	0.319	0.000	0.378	0.000	0.298	0.000	0.832	0.000	0.539	0.000	0.348	0.000	0.604	0.000	0.386	0.000
51-100 employees	0.716	0.000	0.434	0.000	0.520	0.000	0.347	0.000	0.884	0.000	0.660	0.000	0.340	0.000	0.674	0.000	0.432	0.000
100+ employees	0.805	0.000	0.476	0.000	0.511	0.000	0.393	0.000	0.919	0.000	0.618	0.000	0.481	0.000	0.803	0.000	0.425	0.000
<i>FIRM TYPE controls*</i>																		
Scale intensive	-0.125	0.011	-0.062	0.229	0.022	0.682	0.180	0.000	-0.116	0.003	-0.087	0.099	0.071	0.177	-0.202	0.000	0.055	0.267
Supplier dominated	-0.213	0.000	-0.046	0.373	0.001	0.989	0.174	0.001	-0.114	0.004	-0.057	0.285	0.050	0.342	-0.241	0.000	0.128	0.010
Science based	-0.174	0.011	0.001	0.985	0.063	0.395	0.154	0.029	-0.113	0.038	0.028	0.704	0.051	0.487	-0.133	0.056	0.057	0.407
Specialised suppliers	-0.054	0.321	0.016	0.787	0.021	0.725	0.094	0.094	-0.117	0.007	0.054	0.356	0.047	0.422	-0.226	0.000	0.123	0.026
Crafts	-0.323	0.000	-0.127	0.011	-0.103	0.046	-0.088	0.075	-0.149	0.000	-0.181	0.001	0.074	0.149	-0.286	0.000	0.102	0.035
Wholesale trade	-0.187	0.000	-0.114	0.018	-0.024	0.623	-0.021	0.660	-0.060	0.104	-0.017	0.735	0.137	0.005	-0.145	0.002	0.061	0.190
Specialised services	-0.256	0.000	-0.055	0.247	-0.001	0.991	0.010	0.827	-0.119	0.001	-0.152	0.002	0.066	0.173	-0.232	0.000	0.127	0.006
Scale intensive services	-0.244	0.000	-0.176	0.004	-0.013	0.833	0.076	0.211	-0.030	0.515	-0.100	0.112	0.105	0.093	-0.187	0.002	0.191	0.001
ICT intensive services	Benchmark		Benchmark		Benchmark		Benchmark		Benchmark		Benchmark		Benchmark		Benchmark		Benchmark	
Innovation capacity	0.039	0.004	0.025	0.080	0.044	0.003	0.046	0.001	0.023	0.031	0.035	0.017	0.075	0.000	0.072	0.000	0.006	0.662
Vertical linkages	0.102	0.000	0.085	0.005	0.078	0.012	0.058	0.051	0.123	0.000	0.124	0.000	0.072	0.019	0.133	0.000	0.154	0.000
Link to knowledge inst.	0.100	0.000	0.111	0.000	0.098	0.000	0.080	0.001	0.054	0.002	0.059	0.012	0.047	0.045	0.108	0.000	0.184	0.000
Subsidiary	0.087	0.000	0.044	0.068	0.052	0.035	0.019	0.434	0.031	0.088	0.055	0.025	0.084	0.001	0.150	0.000	0.024	0.294

* For the sector controls the levels of significance refer to being significantly different from the benchmark. For the rest of the parameters the levels of significance refer to being significantly different from the zero

small firms. The differences in the size of the parameters are particularly striking for what regards interdisciplinary workgroups, quality circles and performance related pay. In those cases the difference between the size of the parameter for the group of the smallest firms and for the group of the largest firms is about factor 2-2.5.

The results from Table 2 also display important firm-type variation in the propensity to adopt new work practices. For instance, it can be seen that ICT firms are more likely to apply interdisciplinary workgroups as well as firm-internal training. Firms of the science based firm-type seem in general more prone to adopt any of the work practices (except for firm-external training), as the parameter for this sector is consistently among the highest firm-type parameters. In contrast, craft firms are in general less likely to use the new work practices from our analysis.

If one looks at Table 2 from the point of view of the application of individual work practices, it can be seen that firms located in the three 'high-tech' firm-types (manufacturing: science based firms and specialised suppliers, services: ICT intensive service firms) use *quality circles* as well as *integration of functions* more than other firms. The application of *systems for collection of employee proposals* and *delegation of responsibility* as well as *firm-external training* appear to be almost invariant to firm type. With regard to *planned job rotation*, this practice is more often applied in the manufacturing sectors than by firms in the service sectors. *Performance related pay* is more intensively used in the wholesale trade as well as in scale-intensive services. Hence it can overall be concluded that hypothesis *H3*, stating that systems of resource practices employed vary with the type of firm in question, is partly supported by the empirical evidence, since six out of our nine work practices are applied with different intensities, across firm-types.

With respect to the effect of firms being innovators on the application of HRM practices, it can be seen that innovation performance is related to the application of all work practices, except for firm-external training. This finding squares with the finding of Lorenz (1998), who found British firms are more likely to adopt new work practices, given higher levels of R&D intensity. The finding is also in line with our hypothesis (*H4*) stating that innovative activity is related to the our application of the work practices in question.

It can also be concluded from Table 2, that the application of all types of new work practices are complementary to the strength of firms' external relations, being it either

to suppliers or users or to knowledge institutions. This finding supports hypothesis *H5*, which asserts that firms which apply new human resource management practices are also more prone to have strong external linkages than are other firms. Hence our results confirms the results due to Forsgren, Pedersen and Foss (1999), since they found that firm-internal strength (e.g. technological expertise) were strongly related to the strength of firms' external relations, in particular to lead users and to suppliers.

Being a part of a larger firm (subsidiary) appears to affect to the likelihood of adopting interdisciplinary workgroups, performance related pay as well as firm-internal training. In this context we can speculate that parent firms are likely to impose these types of HRM practices on their subsidiaries.

As explained above, the second step consists of performing a correlation analysis on the residuals from the regressions reported in Table 2. The outcome of this correlation analysis is reported in Table 3. From Table 3 it can be concluded that all our work practices are pair-wise complementary in the sense that all combinations of work practices correlate, when observable factors are controlled for. Hence, hypothesis *H1*,

Table 3: Correlations among the residuals

	IW*	QC	EP	JR	DR	IF	PRP	FI
Quality circles (QC)	0.34							
<i>p</i> -value	0.000							
Systems for collection of employee proposals (EP)	0.28	0.30						
<i>p</i> -value	0.000	0.000						
Planned job rotation (JR)	0.24	0.28	0.26					
<i>p</i> -value	0.000	0.000	0.000					
Delegation of responsibility (DR)	0.22	0.16	0.19	0.16				
<i>p</i> -value	0.000	0.000	0.000	0.000				
Integration of functions (IF)	0.25	0.24	0.18	0.19	0.28			
<i>p</i> -value	0.000	0.000	0.000	0.000	0.000			
Performance related pay (PRP)	0.18	0.20	0.21	0.21	0.16	0.22		
<i>p</i> -value	0.000	0.000	0.000	0.000	0.000	0.000		
Firm-internal training (FI)	0.20	0.19	0.11	0.13	0.14	0.11	0.11	
<i>p</i> -value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Firm-external training (FE)	0.09	0.07	0.11	0.06	0.13	0.07	0.05	0.06
<i>p</i> -value	0.000	0.001	0.000	0.010	0.000	0.004	0.026	0.006

* Interdisciplinary workgroups

stating that complementarities between the application of work practices obtain, is in general supported by our results. However, particularly strong complementarities ($\rho > 0.23$, admittedly an arbitrary value) can be detected between the implementation of interdisciplinary workgroups on the one hand and quality circles, systems for collection of employee proposals, planned job rotation, and integration of functions, on the other hand. Also particular strong complementarities can be found between the use of quality circles on the one hand and systems for collection of employee proposals, planned job rotation, and integration of functions, on the other hand. Integration of functions relatively strongly complements delegation of responsibility. Firm-external training, but also to some extent firm-internal training are not particularly strong complements to the application of other practices.

5. Discussion

This research examined a multi-sectoral sample of 684 manufacturing and 1,216 non-manufacturing Danish firms to clarify the impact of firm type (e.g. size, science based, specialised supplier, scale intensive) and innovator strategies pursued on the deployment of combinations of complementary human resource practices. Our results suggest that the application of systems of human resource practice can be explained by differences of firm type, firm size, as well as knowledge strategies pursued. In particular, regressing nine human resource practices on a set of observables (e.g. firm-type, knowledge-strategy, innovative performance, firm size) suggests significant effects of firm size, firm type, and knowledge strategies. A correlation analysis of the error terms from the first step suggests pair-wise complementary of work practice combinations, thus, providing further support for the existence of complementarity among work practices. In contrast to previous research, which has focused on productivity or financial performance effects of human resource practices systems in selected industries or firms, in the current research we focused on contingency factors influential for how and when human resource practices are beneficially employed in support of strategies (e.g. innovator) or activity systems of different firm types. We further note that these findings emerged in a rich data set encompassing different types of firms across a variety of sectors. Our results have important implications for managerial practice and advancing research related to knowledge strategies, human

resource system design, and complementarity effects among human resource practices.

Ichniowski, Shaw & Prennushi (1997) suggests that productivity increases through deploying human resource practices may be expected only when there are complementarities (Milgrom & Roberts, 1995) between a variety of human resource practices. Previous research based mainly on the single firms or industries has demonstrated that complementarity among human resource practices lead to productivity increases. Controlling for sector and firm differences, our results support prior research on complementarity-effects between human resource practices in general. However, our research based on our multi-sectoral sample suggests that human resource practice combinations also support elements of a firm's knowledge strategy including innovative capacity, as well as external linkages to suppliers, customers, and research institutions. We also learn from this research that complementarity-effects between human resource practices differ in strength. For example, there are strong complementarities between interdisciplinary teams and planned job rotation ($\rho = 0.24$), while complementarities between external training and job rotation ($\rho = 0.06$) are relatively weaker. Thus, human resource managers intending to support firm strategies (e.g. innovation) through introducing human resource practices may establish priority in the combination of human resource practices according to the strength of complementarity effects among certain practices.

While this holds quite independently from firm-type, or knowledge strategy pursued, we also observe that the latter variables can also act as selector in the introduction of human resource practices. This observation advances previous research in that contingency factors are introduced, which help managers to decide what firm types and strategies pursued are supported by certain human resource practice combination. For example, innovative capacity is strongly supported by interdisciplinary groups, performance related pay, firm internal training; it also receives support from quality circles, but to a lower degree. Finally, external training cannot be argued to support innovative capacity. As a consequence, when a firm seeks to increase innovative capacity, sending employees to external training and seminars is most likely not the

best practice to start with. The firm type and size results are also important. Large firms in our study were more prone to introduce human resource practices and intensities of human resource practices differ among firm types. By implication not each type of human resource practices is equally important for different firm types and strategies pursued. These findings highlight the importance for human resource managers to fine tune the application of human resource practice combinations, and intensities to adapt them to strategies pursued.

Limitations and Future Research

The strengths of this research include empirical support for human resource practice complementarities in the context of innovation strategies, the cross-sectional sample, and the introduction of new contingency factors, which help explaining when and how human resource practice combinations are introduced to contribute to firm business activities and knowledge strategies. Nevertheless, this research is not without limitations. First, we have addressed only one (innovator) of several possible knowledge strategies. Second, although we found substantial support for our hypotheses, we do not know whether our findings are specific for the Scandinavian context only. Thus, one direction for further research is to expand this research by including other knowledge strategies pursued in multiple industries and/or other geographic markets. In doing so, researchers reach progress in future studies by exploring other contingency factors influential for managerial choices related to the introduction and beneficial management of human resource management practices.

Managerial Implications

Our findings have direct implications for management practice. For strategic human resource managers wishing to contribute to value creations and corporate objectives, our study suggests that (1) because complementarity effects among human resource practices differ in strength, human resource practice combinations can be prioritized accordingly; (2) different firm types and knowledge strategies pursued are supported by different intensities and types of human resource practices; and (3) supporting strategic objectives through human resource practice combinations should be guided by a search for complementarity effects among practices. Our study also suggest, that fine tuning human resource practices to strategic objectives and firm type helps focussing human resource management efforts on value creation. While it is clearly

shown that innovative capacity is supported by a combination of new human resource practices, not every firm follows an innovation strategy. Thus, managers should incorporate strategic objectives and firm types as crucial contingency factors in the application of strategic human resource practices.

6 Conclusions

One of the most powerful recent trends in strategic management research is the thrust to develop a knowledge-based theory of the firm differences. Because knowledge is inextricably linked to human resources, strategic human resource practices help organising complex social relations in and between firms for competitive success. Although, there is wide agreement that "...investment in human resources are a potential of competitive advantage...", Huselid et al. (1997: 186) found that "...scholars have very little understanding of the processes required to realize this potential, or the specific conditions under which the potential is realized." This study addressed the research gap by examining innovative capacity, firm type, and knowledge strategy in relation to the beneficial application of systems of human resource practices in a large scale and cross sectional sample. A key finding of our study is that (a) complementarity effects between human resource practices obtain, but that they also differ in strength; (b) human resource practices combinations and intensities employed are contingent on firm types and knowledge strategies pursued (e.g. innovator strategies). In sum, our research contributes to the strategic human resource literature by showing when and how human resource practice combinations support strategic objectives. Our results suggest that competitive advantage through innovation is supported by complementary human resource practice. Thus, our research begins to contribute to a better understanding of how and when human resource management practices support selected strategic objective as a crucial element in a knowledge-based theory of firm differences.

References

- Arrow, K. 1974. *The limits of organization*, New York: W.W. Norton & Co.
- Arthur, J. B. 1994. Effects of human resource systems on manufacturing performance and turnover. *Academy of Management Journal* 37: 670-687.
- Athey, S. and S. Stern, 1998, An Empirical Framework for Testing Theories About Complementarity in Organizational Design, NBER Working Paper 6600
- Balkin, D., & Gomez-Mejia, L. 1992. Matching compensation and organizational strategies. *Strategic Management Journal*, 11, 153-169.
- Barney, J. 1991. Firm resources and sustained competitive advantage. *Journal of Management*, 17: 99-120.
- Baron, J. N & D, M. Kreps. 1999. Consistent human resource practice. *California Business Review*, 41, 3: 30-52.
- Becker, B., & Gerhart, B. 1996. The impact of human resource management on organizational performance: Progress and prospects. *Academy of Management Journal*, 39: 779-801.
- Becker, G. S. 1964. *Human capital*. New York: Columbia University Press.
- Boland, R. J. & Tenkasi, R.V. 1995. Perspective making and perspective taking in communities of knowing. *Organization Science*, 6: 350-372.
- Brown, J.S. & Duguid, P. 1991. Organizational learning and communities-of-practice: Towards a unified view of working, learning, and innovation. *Organization Science*, Vol. 2, No. 1, February, 40 - 57.
- Castanias, R. P., & Helfat, C. E. 1991. Managerial resources and rents. *Journal of Management*, 17: 155-171.
- Cyert, R. M., P. Kumar & J. R. Williams. 1993. Information, market imperfections and strategy. *Strategic Management Journal*, Winter Special Issue, 14, 471.
- Coff, R.W. 1997. Human assets and management dilemmas: Coping with the hazards on the road to resource-based theory." *Academy of Management Review*. 22: 374-402.
- Cohen W. & Levinthal, D. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35, 128-152.
- Colombo, M. and R. Mosconi, 1995, Complementarity and cumulative learning effects in the early diffusion of multiple technologies, *The Journal of Industrial Economics* 43, 13-48.
- Conner, K. R. & C. K. Prahalad. 1996. A resource based theory of the firm: Knowledge versus opportunism. *Organization Science*, 7 5: 477-501.
- Daft, R., & Lengel, R. 1986. Organizational information requirements, media richness and structural design. *Management Science*, 32: 554-571.
- Delany, J. T., & Huselid, M. A. 1996. The impact of human resource management practices on perceptions of organizational performance. *Academy of Management Journal* 39: 949-969.
- Dyer & J. Singh. 1998. Relational Advantage. *Academy of Management*, 23, 4: 660-679.
- Forsgren, M., T. Pedersen & N.J. Foss, 1999, Accounting for the strength of MNC subsidiaries: the case of foreign-owned firms in Denmark, *International Business Review* 8, 181-196.
- Foss, N. 1999. Research in the Strategic Theory of the Firm. Isolationism and Integrationism, *Journal of Management Studies*, 36(6): 725-755.
- Gambardella, A. & A. Arora, 1990, Complementarities and external linkages: the strategies of the large firms in biotechnology, *The Journal of Industrial Economics*, 38, 361-379.
- Gjerding, A.N., (Editor), 1997, *Den fleksible virksomhed: Omstillingspres og fornyelse i dansk erhvervsliv* (Erhvervsudviklingsrådet, Copenhagen).
- Grant, R. 1996. Toward a knowledge-based theory of the firm, *Strategic Management Journal* 17: 109-122.
- Gupta, A. and V. Govindarajan. 1991. Knowledge flows and the structure of control within multinational corporations. *Academy of Management*, 16, 4: 768-792.
- Hall, R. 1993. A Framework linking intangible resources and capabilities to sustainable competitive advantage, *Strategic Management Journal*, Vol. 14, 607 - 618.

- Hamel, G. 1991. Competition for competence and interpartner learning within international strategic alliances. *Strategic Management Journal*,12: 83-103.
- Harris, R.I.D. & M. Trainor, 1995, Innovations and R&D in Northern Ireland Manufacturing: A Schumpeterian Approach, *Regional Studies* 29, 593-604.
- Hayek, F A. 1945. The Use of Knowledge in Society, in idem. 1948. *Individualism and Economic Order*. Chicago: University of Chicago Press.
- Holmström, B. & P. Milgrom, 1994 , The firm as an incentive system , *American Economic Review* 84 , 972-991.
- Hull, R. 1992. The strategic analysis of intangible resources. *Strategic Management Journal*, 13, 135 - 144.
- Huselid, M. A. 1995. The impact of human resource management practices on turnover, productivity, and corporate financial performance. *Academy of Management Journal* 38: 635-672.
- Ichniowski, C., K. Shaw & G. Prennushi, 1997, The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines, *American Economic Review* 87, 291-313.
- Inkpen, A. C. 1996. Creating knowledge through collaboration. *California Management Review*, 39(1): 123-140.
- Inkpen, A. C. & P.W. Beamish 1997. Knowledge, bargaining power, and international joint venture stability. *Academy of Management Review*, 22,1: 337-369.
- Itami, H., & Roehl, D. 1987. *Mobilizing invisible assets*. Cambridge, MA: Harvard University Press.
- Jensen, M. C., & Meckling, W. H. 1992. Specific and general knowledge, and organizational structure. In: *Main currents in contract economics*, L. Werin and H. Wijkander, eds., Basil Blackwell, Oxford.
- Koch, M. J., & McGrath, R. G. 1996. Improving labor productivity: Human resource management policies do matter. *Strategic Management Journal*, 17: 335-354.
- Kochan, T., & Osterman, P. 1994. *The mutual gains enterprise*. Boston: Harvard Business School Press.
- Kogut, B., & Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, 3: 383-397.
- Lado, A. A., & Wilson, M. C. 1994. Human resource systems and sustained competitive advantage: A competencybased perspective. *Academy of Management Review*, 19: 699-727.
- Leonard, D. & Sensiper, S. 1998. The role of tacit knowledge in group innovation. *California Management Review* 40/3: 112-132.
- Lorentz, E., 1998, Organisational Innovation, Governance Structure and Innovative Capacity in British and French Industry, mimeo (University of Compiègne, Compiègne).
- Lund, R. and A.N. Gjerding, 1996, The flexible company innovation, work organisation and human resource management, DRUID Working Paper no. 17 (IKE Group/DRUID, Department of Business Studies, Aalborg).
- Lyles M. & J. Stalk. 1996. Knowledge acquisition from foreign parents in international joint ventures, *Journal of International Business Studies*, 27,5: 877-904.
- MacDuffie. 1995. Human resource bundles and manufacturing performance : organizational logic and flexible production systems in the world auto industry. *Industrial and Labor Relations Review* :197-221.
- Mahoney, J. T. 1995. The management of resources and the resource of management. *Journal of Business Research*, 33: 91-101.
- March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science*, 2: 71-87.
- Matusik, S. & C. Hill. 1998. The utilization of contingent work, knowledge creation, and competitive advantage. *The Academy of Management Review*, 23, 4: 680-697.
- Michie, J. and M. Sheehan, 1999, HRM Practices, R&D Expenditure and Innovative Investment: Evidence from the UK's 1990 Workplace Industrial Relations Survey, *Industrial and Corporate Change* 8, 211-234.

- Monteverde, K. 1995. Technological dialog as incentive for vertical integration in the semiconductor industry, *Management Science*, 41: 1624-16-1638.
- Nonaka, I. & H. Takeuchi. 1995. *The knowledge creating company*. Oxford University Press.
- Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. *Organization Science* 5: 14-37.
- Pavitt, K.L.R., 1984, Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory, *Research Policy* 13, 343-373.
- Pennings;L; L. Lee & A. van Witteloostuijn. 1998. Human capital, social capital, and firm dissolution. *Academy of Management Journal*: 425-440.
- Penrose, E. 1959. *The theory of the growth of the firm* . Oxford: Basil Blackwell.
- Peteraf, M. A. 1993. The cornerstones of competitive advantage: A resource-based view. *Strategic Management Journal* 14: 179-191.
- Porter, M. 1994. Towards a dynamic theory of strategy. In: Rumelt, R., D. Schendel, and D. Teece (1994) *Fundamental Issues in Strategy, A Research Agenda*, Boston, Harvard Business School Press, 423-461.
- Reed, R. & DeFillippi, R. 1990. Causal ambiguity, barriers to imitation, and sustainable competitive advantage. *Academy of Management Review*, 25: 88-102.
- Rumelt, R. P. 1984. Towards a strategic theory of the firm. *Competitive Strategic Management*, R. B. Lamb, ed., Prentice-Hall, Engelwood Cliffs, NJ: 556-570.
- Schumpeter, J. A. 1950. *Essays on Entrepreneurs, Innovations, Business Cycles, and the Evolution of Capitalism*, Transaction Publishers, New Brunswick.
- Thompson, J. D. 1967. *Organizations in action*. New York: McGraw-Hill.
- Ulrich , D. 1996. *Human resource champions: the next agenda for adding value and delivering results*. Boston, Ma.: Harvard Business School Press
- Wright, P. M., & McMahan, G. C. 1992. Theoretical perspectives for strategic human resource management. *Journal of Management*, 18: 295-320.

Appendix: The assignment of industries into our nine sectoral categories

No. Industry	Sector	No. Industry	Sector
1 Production etc. of meat and meat products	SCAI	43 Sale of motor vehicles, motorcycles etc.	SSER
2 Manufacture of dairy products	SCAI	44 Maintenance and repair of motor vehicles	CRAF
3 Manufacture of other food products	SCAI	45 Service stations	SSER
4 Manufacture of beverages	SCAI	46 Ws. of agricul. raw materials, live animals	WTRA
5 Manufacture of tobacco products	SCAI	47 Ws. of food, beverages and tobacco	WTRA
6 Manufacture of textiles and textile products	SDOM	48 Ws. of household goods	WTRA
7 Mfr. of wearing apparel; dressing etc. of fur	SDOM	49 Ws. of wood and construction materials	WTRA
8 Mfr. of leather and leather products	SDOM	50 Ws. of other raw mat. and semimanufactures	WTRA
9 Mfr. of wood and wood products	SDOM	51 Ws. of machinery, equipment and supplies	WTRA
10 Mfr. of pulp, paper and paper products	SDOM	52 Commission trade and other wholesale trade	WTRA
11 Publishing of newspapers	SDOM	53 Re. sale of food in non-specialised stores	SCIS
12 Publishing activities, excl. newspapers	SDOM	54 Re. sale of food in specialised stores	SSER
13 Printing activities etc.	SDOM	55 Department stores	SCIS
14 Mfr. of refined petroleum products etc.	SCAI	56 Retail sale of phar. goods, cosmetic art. etc.	SSER
15 Mfr. of chemical raw materials	SCIB	57 Re. sale of clothing, footwear etc.	SSER
16 Mfr. of paints, soap, cosmetics, etc.	SCAI	58 Re. sale of furniture, household appliances	SSER
17 Mfr. of pharmaceuticals etc.	SCIB	59 Re. sale in other specialised stores	SSER
18 Mfr. of plastics and synthetic rubber	SCAI	60 Repair of personal and household goods	SSER
19 Mfr. of glass and ceramic goods etc.	SDOM	61 Hotels etc.	SSER
20 Mfr. of cement, bricks, concrete ind. etc.	SCAI	62 Restaurants etc.	SSER
21 Mfr. of basic metals	SCAI	63 Transport via railways and buses	SCIS
22 Mfr. construction materials of metal etc.	SCAI	64 Taxi operation and coach services	SSER
23 Mfr. of hand tools, metal packaging etc.	SDOM	65 Freight transport by road and via pipelines	SSER
24 Mfr. of marine engines, compressors etc.	SPEC	66 Water transport	SCIS
25 Mfr. of other general purpose machinery	SPEC	67 Air transport	SCIS
26 Mfr. of agricultural and forestry machinery	SPEC	68 Cargo handling, harbours etc.; travel agencies	SCIS
27 Mfr. of machinery for industries etc.	SPEC	69 Monetary intermediation	ITIS
28 Mfr. of domestic appliances n.e.c.	SCAI	70 Other financial intermediation	ITIS
29 Mfr. of office machinery and computers	SCIB	71 Insurance and pension funding	ITIS
30 Mfr. of radio and communication equipment etc.	SCIB	72 Activities auxiliary to financial intermediates	ITIS
31 Mfr. of medical and optical instruments etc.	SPEC	73 Letting of own property	SSER
32 Building and repairing of ships and boats	SCAI	74 Real estate agents etc.	SSER
33 Mfr. of transport equipment excl. ships, etc.	SCAI	75 Renting of machinery and equipment etc.	SSER
34 Mfr. of furniture	SDOM	76 Computer and related activity	ITIS
35 Mfr. of toys, gold and silver articles etc.	SDOM	77 Research and development	ITIS
36 General contractors	CRAF	78 Legal activities	ITIS
37 Bricklaying	CRAF	79 Accounting, book-keeping and auditing activities	ITIS
38 Install. of electrical wiring and fittings	CRAF	80 Consulting engineers, architects etc.	ITIS
39 Plumbing	CRAF	81 Advertising	ITIS
40 Joinery installation	CRAF	82 Building-cleaning activities	SCIS
41 Painting and glazing	CRAF	83 Other business services	ITIS
42 Other construction works	CRAF		

SCAI = Scale intensive firms; SDOM = Supplier dominated firms; SCIB = Science based firms; SPEC = Specialised suppliers; CRAF = Crafts; WTRA = Whole sale trade; SSER = Specialised services; SCIS = Scale intensive services; ITIS = ICT intensive services.