ServINNo
Service innovation in
the Nordic countries:
Key Factors for
Policy Design

High Performance Work Practices and Innovation in the Manufacturing and Service Sectors

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Abstract

The use of systems of human resource practices have within the last decade been argued to be crucial for the competitive advantage of firms. In order to verify this claim empirically it is necessary to identify the relevant systems. We apply latent class analysis on survey and register data from more than 2000 firms in order to generate a typology of firms with respect to their adoption of different human resource practices. The analysis is carried out separately for the manufacturing and the service sector. For the manufacturing sector we identify three separate types of firms with respect to adoption of different aspects of organisational, motivational, and skill practices. For the service sector we identify two separate types of firms with respect to the adoption. Our results show that the simultaneous adoption of all practices is positively related to firm performance in services as well as manufacturing.

This paper is part of the ServINNo project, Service Innovation in the Nordic Countries: Key Factors for Policy Design. Funding from the Nordic Innovation Centre is gratefully acknowledged.

1. Introduction

Factors such as globalization, deregulation of markets, changing demands and shorter product life cycles, pose new challenges for most firms. In order to be competitive, firms must be able to continually improve their performance by reducing costs and improving quality, productivity, and speed to the market, and being innovative in terms of introducing new products and services. Therefore, the ability to combine old and new knowledge in order to generate new products/services is key to the prosperity of the modern firm. An important aspect in this context is the human resources and the way they are managed. Thus, the identification of the most successful work practices in terms of their ability to facilitate the innovation of products/services is an important empirical challenge. In the following we refer to these practices as high performance work practices (HPWPs).

Much of the literature on HPWPs has concentrated on the manufacturing sector (Applebaum, 2000; Cappelli, 2001) including specific industries (Dunlup, 1996; Ichniowski, Shaw, & Prennushi, 1997; Paul, 2003; Youndt, 1996). However, the ever growing importance of the service sector, combined with the relatively few studies focusing on this particular sector, emphasizes the need for examining the service sector in more detail (Hunter, 2000).

The empirical analysis of innovation in the service sector is according to Coombs and Miles (2000) dominated by one of two distinctive approaches. The “assimilation approach” argues that innovation in services is fundamentally similar to innovation in manufacturing, and therefore the same concepts and tools may be used for studying innovation activities in the two sectors. However, innovation in services is more dependent on adopting externally developed technologies where the aim is to promote new service provision and/or enhance service productivity.

The “demarcation approach” highlights the difference between processes of innovation in manufacturing and services. Innovation in services is intangible and interactive in nature which indicates that service innovation is more oriented towards continuous changes rather than discrete step-wise changes which are central in manufacturing. The dynamics involve to a high degree customers’ requirements and as such the creative use of human skills is important.

The possible differences between the innovation processes in manufacturing and service makes it interesting to examine in what way HPWPs are used in the two sectors. Moreover, the lack of consensus in the literature on the nature of HPWP (Paauwe, 2005) implies that the application and effect of HPWPs may be different across the manufacturing and service sectors.

Several scholars have proposed and identified HPWPs. However, much of the research has focused on one single practice, see e.g. Mahoney (1995) and Huselid (1995), and the link between systems of practices or bundles of practices (MacDuffie, 1995), and different types of firm performance have scarcely been examined empirically (Arora & Gambardella, 1990; Ichniowski et al., 1997; Mendelson & Pillai, 1999; Michie & Sheehan, 2003).

According to Athey and Stern (1998), two types of approaches have been used in the literature. The first relies on testing whether the practices are positively correlated, conditional on observables, as for instance in Arora and Gambardella (1990). The second approach uses various regression techniques in order to measure the effect of a set of variables and their interaction terms on productivity. For instance, Ichniowski et al. (1997) find, by applying the second method a number of systems by using recent literature and bivariate correlations and argue by OLS estimation, that systems of practices determine productivity and quality, while marginal changes in individual work practices have little effect.

This approach suffers from the obvious limitation that the researcher in advance has to specify the exact combinations of practices to be included in the analysis. An alternative to this procedure is to identify bundles of practices using factor and or cluster analysis (Boselie, 2005; Laursen, 2002; Laursen & Foss, 2003; Lorenz et al., 2004). These methods involve a large degree of subjectivity both with respect to the number of practices considered as well as the particular combinations used. Traditional factor and cluster analysis is moreover best suited for continuous data, which is rare in measuring the adoption of various work practices.

In the present paper we introduce latent class analysis as an alternative to the above mentioned methods. Using latent class analysis we are able to generate a typology of firms with respect to their adoption of HPWPs according to organisation, motivational and skill practices. This has the advantage that instead of considering all possible combinations of practices we focus attention on the practices actually adopted. The method has a number of advantages: First, it takes a systematic approach to the generation of the particular combination of practices. Second, the method recognizes the often categorical nature of the measurements of practices. Finally, the method offers a statistical test of the validity of the model.

The purpose of this paper is, on an empirically sound basis, to identify the clusters of practices and document the effect of HPWPs on the innovativeness of firms in the manufacturing and service sectors respectively. This is implemented by analysing data from a Danish survey on organisation, employee skills and development of new products conducted in 2001, covering 2006 firms in the private manufacturing and service sector. The data refer to the period 1998-2000. The survey data is combined with register information from each employee who has been related to the firms during the analysed period.

The paper is organised as follows. Section 2 discusses the importance of bundles of HPWPs while section 3 presents the data. Section 4 presents the results from the latent class analysis. Finally, section 5 concludes.

2. The Importance of Systems of HPWPs

According to the resource-based view of the firm (Barney & Link, 1991; Penrose, 1959), competitive advantage can be developed and sustained by creating value in a way that is rare and difficult for competitors to imitate. The resource-based view of the firm argues that traditional sources of competitive advantage like natural resources, technology and economies of scale, are sources that are increasingly easy to imitate, especially in comparison to complex social structures like the employment system within the organisation. In this case human resource strategies may be an important source of sustained competitive advantage (Lado & Wilson, 1994; Pfeffer, 1994), because they may be valuable, rare, inimitable and non-substitutable (Wright, McMahan and McWilliams, 1994). According to Barney & Link (1991) causal ambiguity and path dependency are two of the key factors making human resource practices difficult to imitate. First, it may be difficult to understand the precise mechanisms behind human resource practices. Second, the functioning of human resource practices is often complex because the value is determined by the interplay between human resource practices and firm policies. Understanding these systems of practices is an organisational capability that is spread across departments and people in the firm. These systems are moreover path dependent since they often have been developed over time and cannot be purchased in the market by competitors. Even if single employees can be hired from the competitors, the management of competing firms may have difficulties in replicating socially complex elements like culture and interpersonal relationships. Others argue that it is the human resource itself which generates the competitive advantage of the firm.

The literature on HPWP's complementarities has grown during the last decade. Osterman (2000) finds that over the course of the 1990's firms at least in the US have adopted a rising number of practices. The reason for firms adopting a multiple number of practices is the emergence of complementarity among practices. Two or more practices are complements when "using one more intensely increases the marginal benefits of using the others more intensively" (Holmstrom & Milgrom, 1994:973). For instance firms that have implemented incentive pay plans for the employees may have difficulties in measuring the individual output. Instead evaluating group output is easier. However, group-based incentive pay may be undermined by free-riders. Kandel and Lazear (1992) argue that a number of practices may solve the problem. Practices such as screening new applicants which favour teamwork and subsequently introducing team-oriented practices in order to create team spirits may be beneficial. Milgrom and Roberts (1990; 1995) found, by looking at Japanese firms, that employees ideas for continuous productivity improvement (Kaisen), are a valuable form of employee participation. To achieve a high number of employee ideas, employees need training, information sharing and more careful screening of new applicants. However, improving productivity may on the other hand lead to fear of loosing jobs and the management may therefore offer some sort of employment security to avoid this (Aoki, 1988). Once the employment security is introduced, a broader set of complementary practices may be needed, including training in multiple job functions, greater labour-management communication, and more careful employee selection. Finally, due to a rising

number of multitasking jobs, firms may need multiple practices to ensure that employees make the right decisions regarding how to allocate their effort and time across different tasks.

In general, Bailey (1993) and Applebaum et al. (2000) identify three components of HPWPs. Bailey points out that such practices may have an influence on employee skills, motivation and through organisational structures. HPWPs influence employee skills through the acquisition and development of a firm's human capital. Recruiting procedures and selection regimes will influence the quality and type of skills new employees possess. HPWP activities providing informal or formal training as well as recruitment and selection have also shown to have an impact on productivity and market value (Delery, 1996; Huselid, 1995). However, the effectiveness of HPWPs will be limited if the employees lack motivation. Motivated employees may work harder and smarter. Practices with performance appraisals that assess individual or work group performance, such as performance related pay, may positively influence the motivation (Dowling & Richardson, 1997) or productivity (Lazear, 1996) of the employees.

Finally, Bailey notes that the contribution of even a highly skilled and motivated workforce will be limited if job content is are structured, or programmed, in such a way that employees, who presumably know their work better than anyone else, do not have the opportunity to use their skills and abilities to design new and better ways of performing their tasks. Thus, HPWPs which promote organisational structures that encourage participation among employees and allow them to improve the performance of their jobs may improve the organisational performance. Employee involvement in terms of delegation of responsibility and systems of collecting proposals from employees may have a positive impact on productivity (Arthur, 1994; Wallace, 1995). Other practices, like cross-functional teams, job rotation, quality circles, and integration of functions, may all contribute positively to labour productivity (Banker, Potter & Srinivasan, 1996).

Applebaum et al. (2000) identify three basic components of HPWPs: (i) organisational practices which provide opportunities for employee participation such as team work and quality circles; (ii) training practices that provide the necessary skills to participate in problem solving; and finally (iii) pay and promotion policies (e.g. profit sharing which aims at providing the appropriate incentives to participate).

In addition, Doeringer et al. (2003) find that commitment incentives such as job security may serve to increase the time horizons of the employees and thus encourage them to invest in firm-specific skills.

An important aspect for the efficiency of HPWPs is the application of new information and communication technology. Bresnahan, Brynjolfsson, and Hitt (2002) discuss the importance of the complementary of workplace practices combined with application of information and communication technology. They argue that the decline in prices of information and communication technology leads to increased use of information and communication technology which again leads to implementation of new workplace practices. The existence of mutual dependence in terms of the use of different workplace practices, as well as the use of workplace

practices and information and communication technology indicates complexity which needs to be taken into account. Investments in ICT and workplace practices will change the relative demand of skilled labour, and Bresnahan et al. (2002) argue that upgrading the number of skilled employees will increase the benefits obtained by using ICT and workplace practices in combination.

The importance of complementarity among human resource practices supports the idea of constructing ideal combinations of practices on a priori grounds. However, Truss (2001) argues, by looking at which HPWPs financially successful firms use to achieve this level of performance, that it is difficult to determine the best HPWPs. Boselie et al. (2005) show the enormous variety of different practices being used in 104 analyzed articles. They conclude that there is no fixed list of generally applicable HPWPs or systems of practices that define and construct the best human resource management practice. The success of HPWPs depends of their internal organisational context e.g. the nature of production which might create restrictions with respect to the successful design of some practices (e.g. teamwork or performance related pay), but also the external context matters – e.g. the legislation and trade union influence. In this respect sectoral affiliation matters and for that reason this paper examines the difference between firms belonging to manufacturing and service sector respectively. Moreover, instead of testing preconceived forms of HPWP, we apply an explorative method which is in accordance with Wood (1999), Laursen and Foss (2003) and Lorenz et al. (2004).

3. Measurement of HPWP

The analysis is carried out on data from a survey on organisation, employee skills and development of new products (1998-2000). Data collection took place during spring 2001 by a postal questionnaire followed up by telephone interviews with non-responding firms. The respondents are primarily high-level executives. For the period 1998-2000 the survey covers issues such as: major organisational changes, work organisation principles, training and education, market innovations, and the introduction of new ICT. The survey was addressed to firms in the private business sector - traditional manufacturing, construction, and the service sector. The data set contains data from 2006 firms. The sample consisted of 6975 firm with 20 employees or more. The sample covered the total population of firms with more than 25 employees, whereas firms with 20-25 employees were selected randomly based on two-digit NACE industry classification. The overall response rate was 28.7%. In the manufacturing and service sectors the response rates were 29% and 28% respectively. The subsequent analysis of the response rates indicted no unacceptable variation within size and industry. However, in order to make the results as representative as possible weights according to size and two digits industry classification are constructed and utilized in the analysis.

As a supplement to the above mentioned survey we have recently had access to a survey completed in the second half of 2006. That survey allows us to compare the adoption of different

organizational practices across time. The response rate for the latter survey was 42.9 % and no systematic variation was indicated within size and industry. Due to the complex sampling scheme associated with the latter survey no weights have been computed for that survey.

In addition to the survey data we had access to register data for the firms participating in the survey. From the registers it is possible to retreive information about job turnover as well as the average level of education of employees in each individual firm.

As argued in Section 1, measurement of HPWPs requires that several dimensions of managerial practices are taken into account. Selecting employees and developing their skills through training is one dimension. The motivation of the employees created through pay and promotion practices is another. Finally, the use of various organisational practices constitutes a third dimension. Variables measuring these dimensions have in isolation or in combination been shown to have an impact on organisational performance.

The combination of the survey and register data makes it possible to investigate variables reflecting the three overall dimensions characterizing HPWPs.

For the *skill dimension* we have chosen the following indicators: First, for each employee within each firm we have register-based information about the highest completed education. These records are available for the years 1998 and 1999. This information is translated into the length, measured in years, of a particular education. Then, for each firm we calculate the average number of years of the highest completed education across the employees associated with the firm for each year. Finally, we split the firms according to their position above or below the mean increase in level of education for all firms within manufacturing and service respectively. Second, survey, data about the percentage of the workforce which had participated in supplementary training. The firms are divided into categories according to whether they are above or below the mean percentage calculated across all firms within manufacturing and service respectively. This information is available for three groups of employees: higher educated, vocationally trained, and other.

The *motivational dimension* is measured using two indicators. The first indicator utilizes survey data about the firms use of “performance related pay”. Three answer categories were available: “yes”, “no”, “do not know”. We have chosen to collapse the latter two categories and in addition we have assigned firms that did not answer this question to the “no/do not know” category. The second indicator is derived from register data. For the year 1998 we have for each employee within each firm information about their relation to their current work place in the following year. Thus for each firm we are able to calculate the share of employees in 1998 which has left their work place between 1998 and 1999. Our firms are then split according to their position above or below the average turnover rate, calculated for all firms within manufacturing and service respectively.

TABLE 1a, Descriptive statistics – manufacturing and service (weighted) – 2001

		Manufacturing		Service	
		Pct.	N	Pct.	N
Interdiscipl. Workgroups	Yes	39.32	277	54.37	116
	No	60.68	427	45.63	97
Quality circles	Yes	32.66	230	36.10	77
	No	67.34	474	63.90	136
Proposals collection	Yes	42.98	303	36.10	77
	No	57.02	401	63.90	136
Delegation of responsibility	Yes	84.52	595	86.76	185
	No	15.48	109	13.24	28
Integration of functions	Yes	34.90	246	44.51	95
	No	65.10	458	55.49	118
Job turnover	Below mean	57.88	408	65.73	141
	Above mean	42.12	296	34.27	73
Performance related pay	Yes	30.64	216	40.75	87
	No	69.36	488	59.25	126
Educational level	Above mean	47.90	337	37.56	80
	Below mean	52.10	367	62.44	133
Higher educated	Above mean	30.10	212	46.76	100
	Below mean	69.90	492	53.24	113
Vocational training	Above mean	37.63	265	41.08	88
	Below mean	62.37	439	58.92	125
Other	Above mean	28.35	200	33.71	72
	Below mean	71.65	504	66.29	141
Introduction of new tech.	Yes	63.47	447	68.73	146
	No	36.53	257	31.27	67

The dimension which addresses the *organisational practices* adopted by the firms, is measured using five indicators. All indicators build on survey information. The respondents have answered whether their firm made use of “interdisciplinary workgroups”, “quality circles”, “systems for collecting proposals from employees”, “delegation of responsibility”, and “integration of functions”. Three answer categories were available for each question: “yes”, “no”, “do not know”. We have again chosen to collapse the latter two categories and in addition we have assigned firms that did not answer the question to the “no/do not know” category. Finally, we have

information from the survey about whether the firms had “introduced new information and communication technology”. The answer categories were: “yes”, “no”, and “do not know”. As above we have collapsed the second and third category and assigned missing answers to this category.

Table 1a shows the distribution of variables for the manufacturing and service sector for the 2001 survey. The variables representing organisational practices are, as mentioned above: interdisciplinary workgroups, quality circles, proposals collection, delegation of responsibility, and integration of functions. The distribution shows that the percentage varies from 33% regarding use of quality circles to 85% with respect to delegation of responsibility for manufacturing. For the service sector the percentages of use of practices are slightly higher than for manufacturing in most instances.

Table 1b shows the distribution of variables for the manufacturing and service sector for the 2006 survey. The most distinctive feature concerning the 2006 survey relates to the marked increase in the adoption of the different organizational practices. For instance, more than 95% of all firms both within manufacturing as well as service make use delegation of responsibilities. Also more than 70% of the firms within manufacturing make use of interdisciplinary workgroups. For the service sector the number is more than 88%.

Motivation/pay and promotion practices are represented by job turnover and performance related pay. The former is based on calculation on register data and covers all employees who have been related to the firm during the period of 1998-1999. Within manufacturing 58% of the firms have had a turnover below average and 31% of the firms make use of performance related pay. The corresponding figures for services are 66% and 41%.

Skills/training practices are represented by four variables taken from the survey and register data.. Almost 48% of the firms within manufacturing have upgraded the formal education of the employees, whereas the number for service firms is 38%. The other three variables are survey based and are concentrated around employees who have participated in supplementary training. The distinction concerns higher educated, vocational trained and others. 30% and 47% of the employees with a higher education have participated in courses within manufacturing and services respectively. For the other two groups the percentages are 38% and 28% respectively for manufacturing. For services the figures are 41% and 34% respectively.

Finally, 63% of the firms within manufacturing have introduced new ICT, whereas for services the percentage is 69%.

TABLE 1b, Descriptive statistics – manufacturing and service – 2006

		Manufacturing		Service	
Pct. of the firms employees covered by		Pct.	N	Pct.	N
Interdiscipl. Workgroups	None	23.97	134	11.23	31
	Below 25%	26.83	150	21.01	58
	25-50%	25.40	142	23.55	65
	Above 50%	20.39	114	43.84	121
	Don't know	3.40	19	0.36	1
Quality circles	None	29.60	164	36.53	100
	Below 25%	23.47	130	19.05	52
	25-50%	21.12	117	15.02	41
	Above 50%	23.83	132	23.44	64
	Don't know	1.99	11	5.86	16
Proposals collection	None	27.99	157	30.66	84
	Below 25%	22.99	129	21.17	58
	25-50%	16.22	91	14.96	41
	Above 50%	29.77	167	23.37	75
	Don't know	3.03	17	5.84	16
Delegation of responsibility	None	3.64	21	1.42	4
	Below 25%	15.25	88	9.96	28
	25-50%	30.50	176	14.59	41
	Above 50%	49.74	287	74.02	208
	Don't know	0.87	5	0.00	0
Integration of functions	None	25.54	142	21.11	57
	Below 25%	28.60	159	22.96	62
	25-50%	21.40	119	15.19	41
	Above 50%	17.99	100	34.07	92
	Don't know	6.47	36	6.67	18

4. Results

Exploratory analysis using latent class analysis usually proceeds by estimating the latent class model with one class. Evaluation of the Goodness-of-Fit tests then determines whether it is necessary to use a two class model. If so, the procedure is repeated with a two class model.

TABLE 2, SUMMARY STATISTICS MANUFACTORING

	L^2	BIC (L^2)	AIC (L^2)	(BIC+AIC)/2	p-value	Log-likelihood
2 Cluster	1361.89	-2893.46	63.89	-1414.79	0.10	-4799.09
3 Cluster	1337.57	-2917.78	39.57	-1439.10	0.26	-4786.93
4 Cluster	1347.37	-2894.87	53.37	-1420.75	0.33	-4791.83
5 Cluster	1323.19	-2833.81	55.19	-1389.31	0.30	-4779.74
6 Cluster	1306.08	-2785.35	58.08	-1363.64	0.23	-4771.19

Table 2 shows the results from the analysis of the Danish data concerning manufacturing with 12 manifest variables and one through six latent classes. As we see, the latent class model is rejected with one class. However, a latent class model with two to six latent classes cannot be rejected on the basis of the p-value. In addition, using the two information criteria, AIC and BIC, we see that AIC suggests a three class model, whereas BIC suggests a six class model. All taken together we decided on a latent class model with three classes. The resulting latent class probabilities as well as the conditional probabilities are shown in Table 4.

TABLE 3, SUMMARY STATISTICS SERVICE

	L^2	BIC (L^2)	AIC (L^2)	(BIC+AIC)/2	p-value	Log-likelihood
2 Cluster	698.73	-185.88	368.73	91.43	0.05	-1421.07
3 Cluster	701.95	-145.14	385.95	120.41	0.03	-1422.67
4 Cluster	670.11	-118.00	376.11	129.05	0.03	-1406.75
5 Cluster	673.53	-71.69	395.53	161.92	0.02	-1408.46
6 Cluster	667.85	-45.21	401.85	178.32	0.02	-1405.62

Table 3 shows the corresponding results for service firms. Here the preferred solution is a latent class model with two classes. Table 5 reports the latent class probabilities as well as well as the conditional probabilities.

TABLE 4, 3 CLUSTER SOLUTION - MANUFACTURING, WEIGHTED

		Cluster 1	Cluster 2	Cluster 3	All firms	N
		40.61	38.64	20.75		704
Job turnover	Below mean	61.84	51.76	61.53	57.88	408
	Above mean	38.16	48.24	38.47	42.12	296
Educational level	Above mean	54.91	40.66	47.64	47.90	337
	Below mean	45.09	59.34	52.36	52.10	367
Interdiscipl. Workgroups	Yes	65.09	1.18	59.89	39.32	277
	No	34.91	98.82	40.11	60.68	427
Quality circles	Yes	52.64	5.44	44.22	32.66	230
	No	47.36	94.56	55.78	67.34	474
Proposals collection	Yes	60.69	13.71	62.83	42.98	303
	No	39.31	86.29	37.17	57.02	401
Delegation of responsibility	Yes	95.77	69.04	91.31	84.52	595
	No	4.23	30.96	8.69	15.48	109
Integration of functions	Yes	56.63	6.36	45.52	34.90	246
	No	43.37	93.64	54.48	65.10	458
Performance related pay	Yes	37.81	18.71	38.81	30.64	216
	No	62.19	81.29	61.19	69.36	488
Introduction of new tech.	Yes	71.70	46.03	79.81	63.47	447
	No	28.30	53.97	20.19	36.53	257
Higher educated	Above mean	23.08	5.40	89.80	30.10	212
	Below mean	76.92	94.60	10.20	69.90	492
Vocational training	Above mean	28.68	16.14	95.14	37.63	265
	Below mean	71.32	83.86	4.86	62.37	439
Other	Above mean	9.37	9.82	100.00	28.35	200
	Below mean	90.63	90.18	0.00	71.65	504

For manufacturing we interpret the three different clusters as follows. *Cluster 1* firms which account for 40% of the total number of manufacturing firms are most likely to adopt the various organisational practices. All the conditional probabilities are well above 50 % and in excess of the share of adoptions for all firms taken together. With respect to the motivation factors cluster 1 firms are below the average firm, and the proportion of firms having introduced performance related pay is above the general average. The increase in the educational level is also above the average. However, cluster 1 firms are much less inclined to use supplementary training.

Cluster 2 firms generally tend not to use any of the HPWP practices. The use of organisational practices is well below average and the same goes for the use of motivation and promotion

practices. Also the use of training practices is well below the average. This group constitutes around 40 % of the firms.

Cluster 3 firms are very similar to the cluster 1 firms. However, the use of supplementary training is much more utilized among the cluster 3 firms. This group make up 20 % of the firms. According to Milgrom and Holmstrom (1995) these firms may have the greatest incentives to increase the competitive advantage i.e. in terms of productivity (Ichniowski et al., 1997) or innovation (Laursen et al., 2003; Lorenz et al., 2004; Michie & Sheehan, 1999).

The results are in line with Bresnahan et al. (2002). They find that increasing the use of ICT in the firm will increase the demand for more skilled people, and in combination with organisational practices, also the propensity to innovate.

TABLE 5, 2 CLUSTER SOLUTION - SERVICES, WEIGHTED

		Cluster 1	Cluster 2	All firms	N
		66.01	33.99		203
Job turnover	Below mean	72.12	53.31	65.73	141
	Above mean	27.88	46.69	34.27	73
Educational level	Above mean	32.93	46.55	37.56	80
	Below mean	67.07	53.45	62.44	133
Interdiscipl. Workgroups	Yes	81.79	1.10	54.37	116
	No	18.21	98.90	45.63	97
Quality circles	Yes	48.36	12.29	36.10	77
	No	51.64	87.71	63.90	136
Proposals collection	Yes	43.53	21.69	36.10	77
	No	56.47	78.31	63.90	136
Delegation of responsibility	Yes	100.00	61.05	86.76	185
	No	0.00	38.95	13.24	28
Integration of functions	Yes	66.79	1.24	44.51	95
	No	33.21	98.76	55.49	118
Performance related pay	Yes	41.82	38.67	40.75	87
	No	58.18	61.33	59.25	126
Introduction of new tech.	Yes	74.40	57.73	68.73	146
	No	25.60	42.27	31.27	67
Higher educated	Above mean	58.18	24.59	46.76	100
	Below mean	41.82	75.41	53.24	113
Vocational training	Above mean	53.70	16.57	41.08	88
	Below mean	46.30	83.43	58.92	125
Other	Above mean	42.32	16.99	33.71	72
	Below mean	57.68	83.01	66.29	141

For the service firms table 5 shows that *Cluster 1* firms have a high probability of using the various organisational practices. The job turnover is below average and the use of performance related pay is above average. Typically, these firms use supplementary training. However, the increase in the formal level of education is below average. This group accounts for 66 % of the service firms.

Cluster 2 firms, on the other hand, rarely use the organisational practices. They are much more reluctant to use supplementary training. They have, however, increased the formal level of education above the level of the average firm. This group accounts for 33 % of the service firms.

The literature has only recently started to focus on the relation between organisational practices and the innovative performance of the firm. A positive relationship is found between a firm's ability to innovate and the application of bundles of HRM practices in a number of studies (Laursen, 2002; Laursen et al., 2003; Lorenz et al., 2004; Michie et al., 1999, 2003).

Table 6 shows the innovative performance of the manufacturing firms in the different classes. The introduction of major organisational changes is clearly related to the different clusters of firms. 75% of cluster 3 firms have introduced an organisational change. For cluster 1 firms the corresponding fraction is 61%,, whereas it is 38% for firms in cluster 2.

TABLE 6, THE 3 CLASSES WITHIN MANUFACTORING DISTRIBUTED ACCORDING TO DIFFERENT TYPES AND DEGREE OF INNOVATION, PERCENTAGE

	Cluster 1	Cluster 2	Cluster 3	All firms	N
INTRODUCTION OF MAJOR ORGANISATIONAL CHANGE					
Yes	60.79	38.35	76.18	55.31	389
No / do not know	39.21	61.65	23.82	44.69	315
DEVELOPMENT OF NEW PRODUCTS/SERVICES - numbers					
No new products/services	34.35	63.57	27.99	44.32	312
One new product/service	21.58	15.11	24.09	19.60	138
More than one new products/services	44.07	21.32	47.91	36.08	254
DEVELOPMENT OF NEW PRODUCTS/SERVICES – novelty					
No new product/service	34.35	63.57	27.99	44.32	312
New to the firm only	37.95	22.94	48.87	34.42	242
New to either domestic and world market	21.48	10.70	19.85	16.97	120
New to both domestic and world market	6.23	2.79	3.29	4.29	30

Table 6 further shows the three latent classes in relation to the propensity to develop new products and services. The first dimension has to do with the intensity of innovation, measured as the number of new products/services introduced within a 2 year framework; whereas the second dimension has to do with the novelty of the new products/services. The results show that there is a relation between the application of HPWPs and innovation activity. 66% of the firms in cluster 1 and 72% of the firms in cluster 3 have developed one or more new products within the past 2 years. For cluster 2 only 36% of the firms have developed one or more new products. With respect to novelty the same overall pattern emerges. Although cluster 3 firms have a higher propensity to innovate compared to cluster 1 firms, the latter are more likely to develop new products which are either new to the domestic world market.

For service firms the application of HPWPs and innovation shows the same pattern. Cluster 1 firms are more likely than cluster 2 firms to develop new services as well as develop services which are new to the domestic or world market.

TABLE 7, THE 2 CLASSES WITHIN SERVICE DISTRIBUTED ACCORDING TO DIFFERENT TYPES AND DEGREE OF INNOVATION, PERCENTAGE

	Cluster 1	Cluster 2	All firms	N
INTRODUCTION OF MAJOR ORGANISATIONAL CHANGE				
Yes	72.83	38.40	61.13	130
No / do not know	27.17	61.60	38.87	83
DEVELOPMENT OF NEW PRODUCTS/SERVICES - numbers				
No new products/services	37.55	63.95	46.53	99
One new product/service	16.00	19.06	17.04	36
More than one new products/services	46.44	16.99	36.43	78
DEVELOPMENT OF NEW PRODUCTS/SERVICES – novelty				
No new product/service	37.55	63.95	46.53	99
New to the firm only	44.10	26.80	38.22	81
New to either domestic and world market	14.08	7.60	11.88	25
New to both domestic and world market	4.27	1.66	3.38	7

For both manufacturing and service firms the descriptive results thus supports the literature that bundles of HPWPs in the sense of complementarities between organisational, skills and motivational practices are positively related to innovation (Laursen, 2002; Laursen et al., 2003; Lorenz, 2004; Michie and Sheehan, 1999, 2003).

5. Conclusion

Globalization, deregulation of markets, changing demands and shorter product life cycles have all increased the pressure of firms. An important asset in this context is the human resources that a firm possesses, or more specifically the application of high performance work practices (HPWPs) on the employees of a firm. This study focuses on organisational, motivational and skill dimensions of such HPWPs. Although the importance of HPWPs has been documented in a number of studies, these studies have to a large degree focused on the manufacturing sector. The importance of service firms in the economy and the different approaches in the literature to innovation in the manufacturing and service sector highlights the importance of research in this field. In addition, the complexity of HPWP has required that several dimensions need to be taken into account. The literature has shown a limited use of methods that apply a systematic, categorical nature of measurements of HPWP as well as objective tests statistics. However, by applying latent class analysis on a Danish survey covering 2006 firms in the manufacturing and service sector, the present paper identifies different patterns of HPWPs. 40% of the manufacturing firms have high probabilities of applying dimensions in HPWP which have to do with organisational and motivational factors. 21% of the firms in the manufacturing sector are likely to apply all three dimensions, i.e. organisational, motivational and skills, whereas 39% are not likely to apply any HPWPs. For service firms latent class analysis identifies two clusters. 66% are likely to apply organisational, motivational and skills dimensions in HPWPs, and 34% of the service firms has considerable lower probabilities of applying any of the practices.

The result shows that there is a dispersion among Danish firms in applying HPWP. This is true for both manufacturing and service firms. Some are intensive users of HPWPs while others are very reluctant. However, to argue that Danish firms are reluctant in implementing HPWP practices is difficult. The reason may be found in the Danish industry structure, which is classified as being traditional and low tech-oriented and for that reason the level of application of HPWP in Denmark may not be underestimated. Nevertheless, traditional and low-tech oriented firms may on the other hand benefit in terms of increased productivity or innovation by applying HPWP.

For firms in both manufacturing and services which have large probabilities of applying HPWPs, the same firms also have higher probabilities of developing new products/services as well as higher probabilities of introducing products/services new to the market. However, manufacturing firms which are less likely to apply the skill dimension of HPWPs tend to develop new products with a higher degree of novelty than manufacturing firms which also take the skill dimension into

account. The former firms may already have a high level of employee skills and hence no need to develop the skills further.

The difference between manufacturing and service firms seems to be small and a managerial implication for both sectors is that the application of HPWP which take all three dimensions into account may contribute to the innovativeness of the firms.

Further research is need in order to clarify if some HPWP are initiators for other HPWP and is it possible to locate a best line of HPWP as argued by Pfeffer (1994) when the time dimension is taken into account. The time dimension makes it possible to investigate the relation between productivity and workplace practices. Another point is the job turnover of the employees with respect to systems or bundles of HPWP.

APPENDIX A

Latent Class Analysis

HPWP is identified by latent class analysis which is a part of a larger set of methods, latent structure analysis, introduced by sociologist Paul Lazarsfeld in the fifties, see e.g. (Lazarsfeld, 1950, 1968). It is a statistical method to find related cases from multivariate categorical data. As such, the method is related to the familiar cluster analysis for continuous data. Specifically, the data input to the method is a cross-classification table of a number of categorical variables. In our case, the table is the produced by cross-classifying the variables mentioned in the previous section.

However, beside the ability to handle categorical data, latent class analysis builds on the assumption that there are observed (manifest) variables and unobserved (latent) variables. Therefore, the method is also often seen as an analogue, for categorical responses, to the factor analysis model for multivariate normal responses, albeit with only one factor.

In relation to factor analysis the basic premise is identical. The apparent *dependence* in the cross-classification table is spurious (similar to the spurious correlation matrix in factor analysis, which vanishes when controlling for the latent variable/factors). Instead, the model assumes that the observed cross-classification table is the outcome of a mixture of separate cross-classification tables. Each of these tables has the *independence* property. Thus, each of these tables can be modelled using a multinomial distribution, where the (joint) probabilities of each cell can be calculated as a product of the relevant marginal probabilities. In the latent class model the mixing distribution is also a multinomial.

We need to estimate the pertinent parts of the model, which are the probabilities of the mixing distribution as well as the conditional marginal probabilities associated with each cross-classification table. In the following we provide a brief review of the latent class model. The method takes as point of departure a cross-classification of two or more categorical variables, i.e. a contingency table. In the following we use the notation from (Goodman, 1974). Assume that we have a cross-classification table of $M=3$ variables, A, B, and C. Variable A can take values $i=1,\ldots,I$. Variable B can take values $j=1,\ldots,J$, whereas variable C can take values $k=1,\ldots,K$. Let π_{ijk} denote the joint probability that an individual will be at level i with respect to variable A, at level j with respect to variable B, and at level k with respect to variable C. Assume that there is one latent variable X that can take values $t=1,\ldots,T$. The different levels of the latent variable X is referred to as latent classes. Let π_{ijkt} denote the joint probability that an individual will be at level i,j,k,t with respect to the joint variables A,B,C,X. We assume that:

$$\pi_{ijk} = \sum_{t=1}^{T} \pi_{ijkt} \qquad (1)$$

That is, every individual belongs to one and only one of the latent classes, i.e. the latent classes are exhausting and mutually exclusive. In addition we assume **local independence**:

$$\pi_{ijkt} = \pi_t \cdot \pi_{it} \cdot \pi_{jt} \cdot \pi_{kt} \qquad (2)$$

where π_t is the probability that an individual will be at level *t* with respect to the latent variable *X*. π_{it} is the conditional probability, that an individual will be at level *i* with respect to variable *A*, conditional on being at level *t* with respect to the latent variable *X*. The two other conditional probabilities π_{jt} and π_{kt} are defined analogously. The latent class probabilities π_t constitute along with the conditional probabilities π_{it}, π_{jt}, and π_{kt} the fundamental quantities of latent class analysis.

Notice, that according to (2) the manifest variables are mutually independent within each of the latent classes. The probabilities on the right hand side of (2) meet the usual conditions:

$$\sum_{t=1}^{T} \pi_t = \sum_{i=1}^{I} \pi_{it} = \sum_{j=1}^{J} \pi_{jt} = \sum_{k=1}^{K} \pi_{kt} = 1 \qquad (3)$$

Combining (1) and (2) allow us to interpret the latent class model as a parametric multinomial model, since the probabilities related to observed quantities π_{ijk} is specified as a function of the fundamental quantities.

The model can be estimated using either maximum likelihood or the EM algorithm. For an elaborate review see e.g. (Hagenaars, 2003). The result of the estimation is parameter estimates $\hat{\pi}_t$, $\hat{\pi}_{it}$, $\hat{\pi}_{jt}$, and $\hat{\pi}_{kt}$ of the fundamental parameters.

To assess the models ability to cope with the data we also compute the Akaike information criteria (AIC) and the Baysian information criteria (BIC) both based on the likelihood function:

$$AIC = -2 \cdot \ln L + 2 \cdot \#\text{ estimated parameters} \qquad (4)$$

$$BIC = -2 \cdot \ln L + \ln n \cdot \#\text{ estimated parameters} \qquad (4)$$

Where *n* is the number of observations. Both criteria seek to strike a balance between model fit and parsimony.

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