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Complementarities between Workplace Organisation and Human Resource Management: Evidence from Swiss Firm-Level Panel Data

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Abstract

Owing to changes in the business environment, there has been a tremendous adoption of innovative workplace organisation (WO) and human resource (HR) practices during the last few decades. Assuming a holistic perspective on human resource management (HRM), the present study establishes the hypothesis of mutually reinforcing WO and HR practices that, thus, constitute a so-called high-performance work system. Precisely, it is argued that there may be a complementary relationship between a more *de*centralised way of allocating tasks and decision rights on the one hand and continuing training (or skilled labour), incentive pay or a more intensive use of long-term, as opposed to temporary, employment on the other. This hypothesis is examined empirically using latest nationally representative panel data of about 2,500 firms in Switzerland and applying econometric estimation techniques on the basis of an augmented Cobb-Douglas production function. The estimation results show statistically significant complementarities between the WO and HR practices mentioned above. In addition, so-called innovative HRM systems of mutually reinforcing WO and HR practices increase firm performance significantly. These results are robust to unobserved firm heterogeneity and to the problem of reversed causality.

JEL Classification: C23, J24, J31, J42, M5, M12

Keywords: strategic human resource management, HRM bundles, firm performance

1. Introduction

During the last few decades, changes in the business environment have led to reorganisation in corporations in favour of a delegation of decision making authority to subordinate hierarchical levels in connection with multitasking. Essentially, five factors are seen as being the driving force behind the introduction of multitasking and decentralised organisational structures (Snower 1999; Lindbeck and Snower 2000; Caroli, Greenan and Guellec 2001): (1) technical advances in the field of production technology that enable the firm to employ flexible production systems, (2) technical advances in the field of information technology that facilitate data processing and communication within the firm, (3) a relative increase in the supply of qualified personnel who are adept at utilizing the new technologies, (4) modified preferences of the employee towards more interesting and responsible task performance, (5) changed consumer preferences in the sense that consumers attribute less value to standardised products, instead preferring greater variety.

Owing to these changes in the business environment, the adoption of innovative workplace organisation (WO) or human resource (HR) practices during the last few decades has been tremendous. Kato and Morishima (2002) report diffusion rates for Japanese firms over a 32-year period. They consider practices that provide information sharing at the top management level through "Joint Labour-Management Committees" (JLMCs), employees' participation in decision making at the grassroots level through "Shop-Floor Committees" (SFCs), and financial incentives through "Employee Stock Ownership Plans" (ESOPs) and "Profit Sharing Plans" (PSPs). In 1960, JLMCs were used by 38% of all firms in the authors' economy-wide representative sample. In 1992, this proportion was 80%. During the same time period, the respective figure for SFCs has risen from 11% to 41%; for ESOPs from 4% to 95%; and for PSPs from 5% to 22%.

Many firms use innovative workplace practices aiming at enhancing decision making participation by employees. In Osterman's (1994) sample of US manufacturing establishments from 1992, 64% have a high penetration[1] of one to four practices out of (i) teamwork, (ii) job rotation, (iii) total quality management, and (iv) quality circles. Of those that use at least one of these practices, 56% use more than one. So, the majority of those establishments that use innovative workplace practices apply bundles of such practices. A review of the OECD (OECD

[1] The author defines high penetration as a situation in which over 50% of employees are covered by the respective practice.

1999) reports a similar pattern for a sample of eight European countries[2]. Here, 56% of all establishments introduced at least one innovative practice from 1993-96 out of (i) flattening of management structures, (ii) greater involvement of lower level employees, (iii) team-based work organisation, (iv) job rotation. Of these establishments, 48% introduced bundles of practices. So, it seems that those firms that reorganise often implement more than just one practice at the same time. Own calculations using the 2000 wave of the KOF firm panel described later in this paper reaffirm this pattern. 68% of all firms have introduced one or more practices out of (i) teamwork, (ii) job rotation, (iii) more decentralised decision-making, (iv) delayering between 1995 and 2000. Of these, 54% introduced bundles of practices. This suggests that there may be a benefit in implementing bundles of (complementary) WO and HR practices. Finally, several authors conclude from their descriptive analyses that there is no obvious pattern as of which WO or HR practices are combined with one another (Osterman 1994 for the USA, OECD 1999 for Europe).

This findings support the claim that different resources within a corporation should fit, i.e. they should complement each other contingent on other firm characteristics. Within the theory of factor complementarities, two factors are called Edgeworth complements if the effect of one factor on the dependent variable depends on the level of another factor (Milgrom and Roberts 1990, 1995). If this is the case, synergies between the respective variables can be exploited so that "the whole is more than the sum of the parts" (Cohen et al. 2003). In the context of reorganisation in firms this means that the performance effects of workplace organisation measures which enhance decision rights delegation and multitasking (teamwork, job rotation) may be larger if they are combined with other HR practices, such as, e.g., incentive pay, continuing training, or temporary employment.

The aim of this study is twofold. First, HR practices that are complementary to multitasking and delegation of decision-making authority are searched for. In particular, I separately consider incentive pay, continuing training, and temporary employment. The importance of these HR practices is elaborated on the ground of Principal-Agent-theoretical reasoning. Second, the impact of bundles of WO and HR practices, so-called HRM systems, on firm performance is estimated. In particular, I consider teamwork, job rotation and delegation of decision-making authority as means of workplace practices and the HR practices already mentioned.

[2] This sample refers to a survey undertaken by the European Foundation for the Improvement of Living and Working Conditions (EPOC 1997). Ten countries were covered by this survey: Sweden, UK, France, Netherlands, Ireland, Germany, Denmark, Italy, Spain, and Portugal. The figures in the text exclude Spain and Italy for reasons given in OECD (1999: 203, table 4.12).

For this purpose, nationally representative panel data of about 2,500 firms in Switzerland, collected by the Swiss Economy Institute (KOF) at the ETHZ (Swiss Federal Institute of Technology Zurich) in 2005 and 2008, are used. The KOF firm panel is especially rich on the coverage of WO and HR variables. On the basis of an augmented Cobb-Douglas production function, performance estimations are undertaken econometrically. Preferred performance measures are productivity – i.e., sales – and efficiency – i.e., sales divided by labour costs (see Cappelli and Neumark 2001). It is important to also examine the latter performance measure and to compare it to the former, because incentive pay is likely to increase a firm's payroll, thus partially offsetting potential positive productivity effects of work reorganisation (Osterman 2006). Complementarity effects between WO and single HR variables are captured by interaction terms in the sense of Bresnahan, Brynjolfsson and Hitt (2000). System effects as a whole are captured by HRM system dummy variables (Ichniowski, Shaw and Prennushi 1997).

The remainder of this paper is organised as follows. Section 2 provides the theoretical background of this study and elaborates the importance of the HR practices that are used in the empirical investigation presented later in this paper. Section 3 shortly discusses related empirical literature and emphasises the contribution of this study. Section 4 contains the empirical investigation reported in this study. At first, the dataset and the variables used are introduced and some descriptive results are provided. Subsequently, I explain the econometric modelling and present the results regarding (i) potential complementary effects between the WO and HR practices and (ii) the performance effects of HRM systems. Finally, Section 5 concludes.

2. Theoretical Background

2.1 Underlying Theories

Recent review articles in strategic human resource management (HRM) have made the claim for assuming a holistic perspective on HRM, because HR practices are interrelated and thus may allow to exploit synergies in boosting organisational performance (Subramony 2009, Lepak et al. 2006, Combs et al. 2006, Delarue et al. 2008, see also Roca-Puig et al. 2008). Correspondingly, researchers should consider bundles of HR practices and not just single isolated practices. Indeed, there is much literature on so-called high-performance work systems,

describing the performance effects of an innovative HRM system, i.e. a bundle of mutually reinforcing HR practices (a recent review is provided by Boxall and Macky 2009).

This "holistic" claim is rooted in the *theory of factor complementarities* (TFC), which has been conceptualised by Milgrom and Roberts (1990, 1995) using lattice theory and the notion of supermodular functions. According to these authors, two factors are called Edgeworth complements if the effect of one factor on the dependent variable depends on the level of another factor (Milgrom and Roberts 1995). If this is the case, synergies between the respective variables can be exploited so that "the whole is more than the sum of the parts" (Cohen et al. 2003), which means that the effect resulting from a simultaneous adjustment is larger than the sum of the effects of individual adjustments of the variables. Then it is optimal to establish a system of mutually reinforcing WO and HR variables. So the TFC regards WO or HR activities not as isolated functions but as elements of an integrated concept for corporate governance.

Leading management theories also support the notion of complementary practices, factors or assets. The *Resource-Based View* (RBV) of the firm stresses the importance of critical, non-substitutable and non-imitable resources that are supposed to create a sustainable competitive advantage for a firm. In this context, interdependent resources or so-called co-specialised assets play an important role, because a combined application of these practices provides an additional barrier for competitors to substitute or imitate the superior resource position of the firm. So, both approaches, the TFC and the RBV, have in common that they consider maintaining internal fit of the workplace organisation and HRM (Guthrie et al. 2009).

The *framework of ability, motivation and opportunity* (AMO) is another related approach, which is often used in strategic HRM (Paauwe 2009). This approach focuses on employees' ability (through skills and qualification), motivation (through intrinsic and extrinsic incentives) and opportunity (through an adequate organisation of work and providing employees with the necessary information for their tasks) to contribute to corporate success. Additionally, the AMO framework stresses the importance of horizontal alignment among the AMO elements and vertical alignment of the AMO elements with the firm's business strategy. Horizontal alignment basically means coordinating workplace organisation and HR practices. So, again, the TFC and the AMO framework have in common that they pay much attention to internal fit.

2.2 Complementary HR Practices

According to OECD (1999) and Edwards and Wright (2001), a more decentralised way of allocating tasks and decision rights is the key to a holistic perspective on HRM. Following a central line of argument picked up by the principal-agent theory, a main benefit of delegating a job to an agent results from the fact that the principal can make use of the agent's superior knowledge with respect to the execution of the job. This is of special relevance if local information is needed for performing a task. The main drawback, however, is characterised by the potential moral-hazard problem in the case of asymmetrical distribution of information, i.e. the risk that the agent may behave opportunistically, so that the principal could even be better off by abstaining from delegation and re-centralising decision making instead. The described situation is also known as the *dilemma of organisational theory* (Mookherjee 2006, Aghion and Tirole 1997, DeVaro 2008).

Against this background, HR practices could serve as complements, i.e. they could mitigate negative side effects or strengthen positive effects of multitasking and decision-making delegation on performance.[3] The reverse, of course, could hold true as well, i.e. multitasking and decision-making delegation could complement certain HR practices. In this sense, as is argued in the present study, a conscious combination of workplace organisation and HRM can help solving the organisational dilemma. Specifically, I hypothesise that incentive pay, continuing training, and a more intensive use of long-term, as opposed to temporary, employment play an important role in constituting a HPWS – together with a more decentralised way of allocating tasks and decision rights. These HR practices will be discussed in turn.

A key problem of teamwork is the free rider problem, which is well-known in a prisoners' dilemma situation. The rents of cooperating are distributed to all team members, whereas the working effort has to be borne by the individual. As a consequence, cooperation between rational team members won't be achieved – at least not in a one-shot game. To solve this problem, speaking game-theoretically, the pay-offs to the players have to be changed. *Incentive pay* is a HR practice that helps doing this (Möller 2007). Employees could be granted a bonus

[3] In general, Horgan and Mühlau (2006) consider three processes which can cause complementarities among HR practices or between HR and workplace practices: reinforcement, flanking and compensation. Reinforcement refers to a HR practice whose performance effect is not strong enough to have a measureable impact. One example is communication which is always, like every signal, combined with some sort of noise. The stronger the noise, the more likely it is that the signal is misinterpreted. So, additional signals (i.e. HR practices) may be needed to avoid misinterpretation. Flanking refers to a setting in which one practice supports another practice achieving its goals more effectively. For instance, continuing training will lead to a higher learning success if employees are motivated to acquire new skills. Compensation refers to a HR practice that mitigates negative side effects of another HR practice. A prominent example for a negative side effect is crowding out of intrinsic motivation by introducing incentive pay. In this example, a compensating HR practice could be teamwork.

if a certain target has been achieved. Recognising that one's compensation depends on the effort of others, team members will keep an eye on each other, thus producing some pressure to perform. A small team size can make it easier to establish norms on the "right" effort level (Kandel and Lazear 1992). Alternative ways of paying for performance would be gain sharing, which could also be done on a team output basis, or stocks or stock options (Backes-Gellner, Lazear and Wolff 2001). Incentive pay motivates the employees to contribute to firm performance.

Multitasking and delegation of decision rights necessitate corresponding skills, because it could be counterproductive to let employees make certain decisions without providing them with the knowledge that is necessary to do so in a well-founded manner (Birdi et al. 2008, Möller 2007). So *continuous training*, i.e. investing in firm-specific human capital, increases the returns to multitasking and decision rights delegation, thereby serving as a complement. The same holds true for general human capital (Caroli and van Reenen 2001). Additionally, since teamwork implies interdependencies between actions of the team members, they have to adjust their activities to each other in order to achieve the optimal output. To do this, soft skills, like communication capabilities etc., are needed. Finally, to implement job rotation effectively, employees have to be able to execute multiple tasks, again implying the need to train them on the necessary skills. Continuous training gives the employees the abilities they need to contribute to firm performance.

Even if employees are given the ability, motivation and opportunity to contribute to firm performance, they may still be reluctant to do so. An innovative HR strategy is aimed at employees making suggestions to increase labour productivity. This bears the risk of making their own jobs redundant, if sales do not increase proportionally. For this reason, it has been argued that firms following an innovative HR strategy described so far should guarantee the job security to their workers to reduce employees' fear of downsizing (Brown, Reich and Stern 1993, Milgrom and Roberts 1995, Frick 2002, Felstead and Gallie 2004, Möller 2007). Following Cappelli and Neumark (2004) and Roca-Puig et al. (2008), *temporary employment* can be regarded as a proxy to employment *in*security of an establishment's workforce. The use of, e.g., fixed-term contracts or temporary agency workers in an establishment does not only imply a lower level of temporary employees' job security, relative to regular employees, but can also have adverse effects on core workers' perceived job security because they may feel threatened (Roca-Puig et al. 2008; Beckmann and Kuhn 2009; see also Chattopadhyay and George 2001; Davis-Blake, Broschak and George 2003). According to this reasoning, work-

ers' productivity-enhancing suggestions could be fostered by lowering the use of temporary employment. Consequently, temporary employment would be hypothesised as being a *substitute* for decision-making delegation, implying a negative interaction term in an econometric estimation.[4]

However, concerning the use of temporary employment, a rivalry view exists, which relates to the *core-periphery-hypothesis* (see, e.g., Roca-Puig et al. 2008). The core-periphery-hypothesis, which has intensively been debated theoretically and challenged empirically in recent years (see, e.g., Pfeifer 2005, Cappelli and Neumark 2004, Gramm and Schnell 2001, a review is provided by Kalleberg 2001), predicts a positive and complementary relationship between the use of numerical (temporary employment) and functional (teamwork, job rotation) flexibility. The aim of the core-periphery-approach is to internally implement a dual labour market that buffers core, or regular, workers by employing peripheral, or contingent, workers. This is supposed to lead to lower voluntary and involuntary turnover among core employees, to a higher level of commitment to the firm among core employees and eventually to better organisational performance. A strategy that implements the core-periphery-hypothesis posits that it is superior to use multiple means (numerical flexibility and functional flexibility) to achieve one goal (namely, enhancing firm performance by being able to react flexibly to demand fluctuations). The core-periphery-hypothesis would imply a *complementary* relationship between temporary employment and multitasking (teamwork, job rotation). So, with respect to temporary employment, there exist two rival hypotheses. This fact calls for an empirical investigation.

Summarizing the hypotheses developed in this section, a complementary relationship is expected between multitasking and decision-rights delegation on one hand and incentive pay and training (or skilled labour) on the other. With respect to temporary employment, there are theoretical arguments for both a complementary and a substitutional relationship. Putting things together, a bundle of several WO and HR practices, constituting a so-called high-performance work system, should be expected to lead to superior firm performance.

[4] Additionally, temporary employment could also be a substitute for multitasking. In a situation in which demand and sales slump, layoffs could be suggested. However, to execute given job security pledges, it may be necessary to shift jobs from one department, division, or function to another. Thus, job rotation may be a workplace practice whose performance effect may be increased by job guarantees and, accordingly, decreased by the use of temporary workers.

3. Related Literature

3.1 Complementary HR Practices

Regarding HR practices that have the potential to influence top management's choice of how to allocate tasks and decision rights within a firm, I first turn to *incentive pay*. Cappelli and Neumark (2001) run fixed-effects estimations using matched panel data of over 400 observations on US manufacturing establishments and provide evidence of existing complementarities between profit sharing and teamwork that are robust to unobserved heterogeneity. Boning, Ichniowski and Shaw (2007) base their analysis on 34 establishments that are representative for the US steel sector and could be observed over 60 months. The authors estimate a measure of productivity that gives the percentage of produced steel that meets the quality standards. Controlling for fixed effects, they find a significantly positive interaction term of teamwork and group incentive pay as well as a significantly positive three-way interaction term of team work, group incentive pay and a measure of production process complexity. The latter result indicates that allocating tasks and decision rights to the bottom is especially effective in complex (production) environments. Finally, Möller (2007) uses nationally representative data on over 15,000 German establishments and applies a quasi-panel method introduced by Black and Lynch (2001)[5] to control for unobserved heterogeneity in estimating value added. She finds significantly positive interaction terms of decentralization (delegation of decision rights) and gain sharing as well as decentralization and having a stock-ownership programme. Analogous interaction terms with teamwork instead of decentralization are insignificant.

Turning to *continuous training*, Birdi et al. (2008) estimate the value added of 308 UK manufacturing firms over a 22-year period. Their fixed-effects results find a significantly positive interaction term of teamwork and training. Möller (2007) finds a significantly positive interaction term of decentralization and training. Altogether, this implies a complementary relationship between multitasking and delegation of decision-making authority on the one hand and training (investing in human capital) on the other.

[5] Möller (2007) has only cross-sectional information on key explanatory variables available, but longitudinal information on value added. So she applies a two-step procedure introduced by Black and Lynch (2001). The first step consists of a within-estimation of a production function. From this estimation, the establishment fixed effect can be retrieved. In the second step, this fixed effect is regressed on the key explanatory variables and a set of control variables.

Lastly, the evidence on *temporary employment* is less clear-cut. Arvanitis (2005) examines the same nationally representative data set of about 1,400 firms in Switzerland that is also used for the present study. He tests interactions between external numerical and functional flexibility. The former means a high use of temporary employment (e.g., fixed-term contracts or temporary agency work), whereas the latter refers to multitasking (teamwork, job rotation), delegation of decision-making authority and a decrease in the number of hierarchical levels. The author's cross-section OLS heteroscedasticity-robust estimates reveal an insignificant coefficient of the functional flexibility variable for those firms that have a high level of numerical flexibility. This implies neither support for nor contradiction to the core-periphery-hypothesis.

However, Michie and Sheehan (2005) estimate the percentage change of total sales, the percentage change of labour productivity and the percentage change of pre-tax profitability of 360 establishments from the UK manufacturing and service sector. For all dependent variables in their cross-sectional estimations, the authors find a significantly positive interaction between external numerical flexibility and an additive HR index, which includes, among other things, employee participation and flexible job design. Moreover, Michie and Sheehan-Quinn (2001) use a sample of 240 UK manufacturing establishments to explain a subjective measure of relative financial performance[6]. The authors find a significantly positive interaction between numerical (temporary employment) and functional (multitasking) flexibility on the one hand and an additive HR index which includes, among other things, teamwork and flexible job assignments on the other. These results suggest a rather complementary relationship between temporary employment and a decentralised way of allocating tasks and decision rights, thus *supporting* the core-periphery-hypothesis.

On the contrary, other authors (Lepak, Takeuchi and Snell 2003, Roca-Piug et al. 2008) report evidence for a substitutional relationship between functional and numerical flexibility, thus *contradicting* the core-periphery-hypothesis. However, although they use temporary employment as proxy for numerical flexibility, they use the level of employees' education or the level of employers' training efforts as proxy for functional flexibility. Since, in the present study, functional flexibility is operationalised by multitasking and delegation of decision-making authority, these studies seem not to be completely comparable at this point.

[6] "The dependent variable is as follows: How does this site's current financial performance/profitability compare with other establishments in the same industry?" (Michie and Sheehan-Quinn 2001: 293)

3.2 HRM Systems

Ichniowski, Shaw and Prennushi (1997) use up to 2,190 monthly observations on 36 US steel finishing lines to estimate operational productivity[7] by fixed-effects regressions. The authors distinguish four HRM systems. HRM4 contains no innovative HR practice at all. HRM3 is defined as having initiated worker involvement in teams and enhanced labour-management communication. HRM2 adds extensive skills training and a high level of worker involvement in teams to the elements of HRM3. HRM1 furthermore adds extensive screening of new workers, job rotation, multitasking, and an implicit employment security pledge to the elements of HRM2. The authors label HRM4 the most traditional system, whereas they consider HRM1 the most innovative one. Each establishment in the sample is attributed to one of these HRM systems. The resulting HRM system dummy variables serve as explanatory variables in estimating establishment productivity. According to the results reported by the authors the impact of a HRM system is the larger the more innovative it is.

Kato and Morishima (2002) use panel data on 126 Japanese manufacturing firms over a period of 20 years. The authors consider participation practices on the top level and on the shop-floor level as well as financial incentive schemes through stock ownership and gain sharing programmes. Comprehensively controlling for fixed effects and reversed causality, they find significantly positive productivity effects of the most innovative HRM system.

Horgan and Mühlau (2006) report results of a cross-sectional study on 80 Irish and 300 Dutch establishments. Their HRM system consists of incentive pay, training, information sharing, career development and extensive recruitment. For the Irish sample, a high-performance HRM system performed significantly better, as measured by the questionnaire's key informant's subjective assessment of employee performance[8]. With respect to the Dutch sample, results are different. Here, a high-performance HRM system performed significantly worse.

3.3 Contribution of the Present Study

The present study adds to the existing literature in several ways. First, it is the first study to examine performance effects of HRM systems on a panel basis for Switzerland. Second, this is the first study ever to analyse a nationally representative Swiss data set with respect to potential complementary effects between multitasking and decision rights delegation on the one

[7] This operational productivity indicator is called uptime. "Uptime is the percent of scheduled operating time that the line actually runs" (Ichniowski, Shaw and Prennushi (1997: 293).
[8] Employee performance refers to: job performance, employee cooperation, problems with theft, drug and alcohol, absenteeism, and negligence (Horgan and Mühlau 2006: 427).

hand and incentive pay or continuous training on the other. Studying Swiss data appears to be especially interesting because labour relations are in some ways similar to those in the US or UK (e.g., rather low influence of unions on the wage-setting process) while at the same time being in other ways similar to labour relations in Germany (e.g., relatively high importance of dual apprenticeship training). Therefore, an empirical investigation on Swiss firms may provide a valuable contribution to that field. Third, against the background of less clear-cut results in the literature on potential complementarities that involve temporary employment, the present study adds some evidence in favour of the core-periphery-hypothesis. Fourth, regarding the sectoral distribution of existing studies, there are only few that use representative data for the whole economy (e.g., Arvanitis (2005) for Switzerland, Möller (2007) for Germany, and DeVaro (2008), Procter and Burridge (2008), and Wood and de Menezes (2008) for the UK). Often, manufacturing or, more specifically, steel establishments or firms are examined (e.g., Ichniowski, Shaw and Prennushi 1997; Cappelli and Neumark 2001). Empirical results can be generalised only by using nationally representative data which is done in the present study.

Finally, the panel structure of the data set used in the present study allows tackling two major methodological issues. First, unobserved time-invariant firm characteristics (such as management quality) are likely to influence both performance and WO or HR variables. Being endowed with more than one observation per firm allows controlling for unobserved firm heterogeneity. Second, as noted by many scholars, the problem of reversed causality deserves special attention (e.g., Paauwe 2009; Wood and Wall 2007; Combs et al. 2006; Boselie, Dietz and Boon 2005; Wright et al. 2005; Hamilton and Nickerson 2003). This view is supported by the evidence which is provided by Nickell, Nicolitsas and Patterson (2001) according to whom firms that face low demand or competitive or financial problems are more likely to reorganise. Despite this, only few studies have tried to correct for this endogeneity bias in the past (e.g., Bauer 2003; Colombo, Delmastro and Rabbiosi 2007; DeVaro 2008). Therefore, in the present study, alternative specifications are tested using not only present but also lagged key explanatory variables.

4. Empirical Investigation

4.1 Data, Variables, Correlations

The data used in the present study were collected by the Swiss Economy Institute (KOF) at the ETHZ (Swiss Federal Institute of Technology Zurich) in 2005 and 2008[9]. This panel data set covers a nationally representative stratified sample of about 2,500 firms in Switzerland. Stratification criteria are 28 sectors and three categories of size. The KOF firm panel is especially rich on the coverage of workplace organisation (WO) and human resource (HR) variables. Firms with less than 20 employees were dropped because key explanatory variables were not available for them.

Dependent variables are log sales, measured in CHF (*lnY*) – to provide an indicator for productivity – and log sales minus log wages or, equivalently, the log of sales over wages ($\ln Y/W$, where W is the total payroll of a firm) – to provide an indicator for labour efficiency (see Cappelli and Neumark 2001). It is important to also examine the latter performance measure because incentive pay may increase a firm's payroll, thus partially offsetting potential positive productivity effects of work reorganisation (Osterman 2006).

Key explanatory WO variables are (i) the extent of the use of teamwork on a 0-5 scale, standardised (*team_std*), (ii) the extent of the use of job rotation on a 0-5 scale, standardised (*rot_std*), and (iii) the degree of decentralization of decision-making authority between an employee and his/her supervisor (*decentr_std*). This decentralisation index is created by summing up seven variables that are each measured on a five-point Likert scale, so that the resulting index is on a 0-28 scale.[10] Since the first two variables indicate the degree of multitasking (*task_std*) within a firm, they are combined in the following way:

$$task\_std = team\_std + rot\_std.$$

An overall WO index, covering both multitasking and decentralization of decision-making authority, is:

$$WO\_std = task\_std + decentr\_std.$$

[9] It is planned to repeat this survey every three years so that, in 2011/12, even more sophisticated estimation techniques than those presented later in this paper can be applied.

[10] These questions cover different fields of how work is organised: Who decides upon the pace of work? Who decides upon the course of tasks to be executed? Who allocates the tasks among employees? Who decides upon the way how tasks are executed? Who is responsible in case of problems in the production process? Who is responsible for the contact to customer? Who deals with customer complaints?

Key explanatory HR variables are (i) the percentage of employees that have taken part at continuous training curses during the last year (*train*), (ii) the percentage of employees that hold a university of higher education degree (*skilled*), (iii) the importance of incentive pay that depends on individual, team, or corporate performance, on a 0-12 scale, standardised (*incentive_std*)[11], and (iv) the importance of temporary employment as a means of flexibility on a five-point Likert scale (*temp_std*). Since the first two variables are indicators of the level of human capital within a firm (*HC_std*), they are combined in the following way:

$$HC\_std = train\_std + skilled\_std.$$

Control variables are: gross investments (*lnK*), measured in CHF as proxy for capital input, number of employees (*lnL*) as proxy for labour input, the year in which the firm has been founded (*founded*), whether the firm is foreign or domestic owned (*foreign*), the export share relative to total sales (*export*), the numbers of competitors on a five-point Likert scale, standardised (*compet_std*)[12], the intensity of competition concerning price or non-price conditions on a 0-8 scale, standardised (*intens_std*), whether a firm has introduced (i) product innovation, (ii) process innovation, or (iii) process innovation with significant reduction in production costs on a 0-3 scale, standardised (*inno_std*), technological potential outside of the firm (scientific knowledge base etc.) on a 0-4 scale, standardised (*tech_std*) and controls for seven sectors and seven regions. Descriptive statistics on all variables are displayed in table A1 in the appendix.

To get a first idea of the bundle nature of the variables just described, tables 1 and 2 report spearman correlation coefficients of all key explanatory variables. Table 1 lists those explanatory variables that are used for the search for complementary HR practices. Table 2 lists those explanatory variables that are used to build the HRM systems.

[Insert tables 1 and 2 about here]

As can been seen, most correlations are significant and positive, indicating that firms often use these WO and HR practices simultaneously. However, such correlations could be caused by managers' preferences for these practices or just by fashion. For this reason, simple correlation analyses of WO and HR practices are not sufficient to identify complementarities

[11] Each of the three questions – dependence on individual, dependence on team, and dependence on corporate performance – is measured on a five-point Likert scale.
[12] Thereby, a value of 1 refers to 1-5 competitors, 2 refers to 6-10 competitors, 3 refers to 11-15 competitors, 4 refers to 16-50 competitors, and 5 refers to more than 50 competitors.

(Brynjolfsson and Hitt 2000). Therefore, the next two subsections report econometrical analyses based on the estimation of production functions.

4.2 Complementary HR Practices

4.2.1 Econometric Model

The present study employs an approach that has been used by Huselid and Becker (1997) and Bresnahan, Brynjolfsson and Hitt (2000) and that follows directly from the definition of Edgeworth complements. To detect potential complementarities between an innovative workplace organisation, characterised by a high level of multitasking and decentralised decision making, and various HR practices, such as training (or skilled labour), incentive pay and temporary employment, an Cobb-Douglas production function is estimated which is augmented by three dummy variables (D_1-D_3) indicating a firm's "innovativeness" with respect to its workplace organisation (WO) and various HR practices. The splitting point is set at the median value. So for instance, regarding WO and training, D_1 indicates that the respective firm has an *above*-median value of the WO index and a *below*-median value of training. D_2 indicates that the respective firm has a *below*-median value of the WO index and an *above*-median value of training. D_3 indicates that the respective firm has an *above*-median value of both the WO index and training. The reference category is represented by firms with a *below*-median value of both indices (D_0). An analogous procedure applies to skilled labour, incentive pay and temporary employment, each separately combined with WO. Table A2 in the appendix is meant to make this procedure more clear. Table A3 in the appendix shows the distribution of the dummy variables for each of the HR variables. As noted by Bresnahan, Brynjolfsson and Hitt (2000), it need not necessarily be the case that each dummy variable has the same mean. The cross-section estimation equation is:

$$\ln Y_t = \beta_0 + \beta_1 \ln K_t + \beta_2 \ln L_t + \gamma_1 D_{1t} + \gamma_2 D_{2t} + \gamma_3 D_{3t} + \sum_{j=1}^{n} \delta_j X_{jt} + u_t, \qquad (1)$$

where u_t is an i. i. d. random variable and t refers to the wave of 2008. It is often argued that high-performance firms can afford to introduce "innovative" WO or HR practices. This reversed-causality problem can lead to biased cross-sectional estimates. Therefore, an alternative specification is tested in the present study using lagged key explanatory variables:

$$\ln Y_t = \beta_0 + \beta_1 \ln K_t + \beta_2 \ln L_t + \gamma_1 D_{1,t-1} + \gamma_2 D_{2,t-1} + \gamma_3 D_{3,t-1} + \sum_{j=1}^{n} \delta_j X_{jt} + u_t, \qquad (2)$$

where *t-1* refers to the 2005 wave. Still, estimates could be biased, if some unobserved time-invariant firm characteristics (such as management quality) have an influence on both the dependent and one or more key explanatory variables. Therefore, a two-stage-procedure, introduced by Black and Lynch (2001) and applied, e.g., by Zwick (2006), Ludewig and Sadowski (2009), Beckmann and Kuhn (2009) as well as others, is also applied here. The first step consists of a within-estimation of a Cobb-Douglas production function using the 2005 and 2008 waves:

$$\ln Y_{it} = \beta_0 + \beta_1 \ln K_{it} + \beta_2 \ln L_{it} + \eta YEAR + v_i + u_{it}\,. \tag{3}$$

From this estimation, the firm fixed effect can be retrieved (Verbeek 2004):

$$\hat{v}_i = \overline{\ln Y_i} - \hat{\beta}_{1FE}\overline{\ln K_i} - \hat{\beta}_{2FE}\overline{\ln L_i} - \hat{\eta}\overline{YEAR}, \tag{4}$$

where the bars over the variables represent the corresponding mean values. In the second step, this fixed effect is regressed on the dummy variables (D_1-D_3) and a set of control variables X:

$$\hat{v}_i = \gamma_0 + \gamma_1 D_1 + \gamma_2 D_2 + \gamma_3 D_3 + \sum_{j=1}^{n} \delta_j X_{ij} + \zeta_i, \tag{5}$$

where ζ_i is an i. i. d. random variable. The estimated coefficients $\hat{\gamma}_1, \hat{\gamma}_2, \hat{\gamma}_3$ are of special interest, because they represent the particular effect of the dummy variables (D_1-D_3) on the fixed effect of an establishment's productivity. It is important to note that, in this specification, the dummy variables (D_1-D_3) are from 2005, while the fixed effect is from 2005 and 2008. Given this setting, there should not be any remaining reversed causality problems left. So, from a theoretical point of view, this is the researcher's preferred specification. For the efficiency specification it is proceeded analogously.

4.2.2 Empirical Results

Tables 3 and 4 display the results of the estimation of complementary HR practices. Due to space limitations, only the coefficients of D_1-D_3 as well as F-tests of equality of D_1-D_3 with each other are shown.[13] In table 3, the dependent variable is productivity. In table 4, the dependent variable is labour efficiency. In each table, there are four panels: one for each of the HR practices (training, skilled labour, incentive pay, temporary employment). Each panel reports four regressions: one for the cross-section 2008 to provide a baseline specification,

[13] The full regression outputs can be obtained from the author upon request.

two for the specification with lagged key explanatory variables (with and without the full set of control variables[14]) to correct for reversed causality, and one for the second step of the Black/Lynch two-step-procedure to correct for unobserved heterogeneity and reversed causality. The first step regressions are shown in table A4 in the appendix.

[Insert tables 3 and 4 about here]

As can be seen from the coefficients and F-tests shown in table 3, firms with an innovative workplace organisation (i.e., an above-median level of decentralised tasks and decision rights) and a high (i.e., an above-median) level of training (D_3) perform significantly better than those firms that also feature a high level of training but still have a more traditional workplace organisation (i.e., an below-median level of decentralised tasks and decision rights) (D_2). Turning to skilled labour, it becomes even more convincing that firms with an innovative workplace organisation and a highly-skilled workforce (D_3) perform significantly better than either firms with just a innovative workplace organisation (D_1) or with just a highly-skilled workforce (D_2). Regarding incentive pay, there is no clear pattern but – if at all – that an innovative workplace organisation alone (D_1) seems to be preferable to a strong incentive scheme alone (D_2). Finally, with respect to temporary employment, there appears to be clear evidence that a combined use of both temporary employment and decentralised allocation of tasks and decision rights (D_3) is superior to a high level of temporary employment alone (D_2).

Estimates in table 4 concerning efficiency reach basically the same results as those in table 3 concerning productivity. However, coefficient sizes and significance levels are lower. This indicates that part of the productivity gain through simultaneous adjustment of several HR practices is shared with employees through higher wages. But, on net, firms still profit from such reorganisational measures. Overall, the results reported in this subsection provide evidence in favour of complementarities between multitasking and decision-rights delegation on one hand and several HR practices – i.e., training, skilled labour, incentive pay, and temporary employment – on the other.

[14] However, each regression also includes capital and labour – except for the 2-step regressions which use these controls in the first step – as well as controls for seven economic sectors and seven geographical regions. The regressions labelled "no controls" lack the following control variables: *founded*, *foreign*, *export*, *compet_std*, *intens_std*, *inno_std*, *tech_std*. These variables are described in part 4.1.

4.3 HRM Systems

4.3.1 Econometric Model

In the preceding subsection, the focus has been on pairwise complementarities. There, the purpose was to empirically indentify potential elements of a high-performance work system. The purpose of the present subsection is to go one step further and integrate all complementary WO and HR variables considered in this study into HRM systems. Proceeding that way, a procedure is chosen which is similar to that used in Ichniowski, Shaw and Prennushi (1997), Kato and Morishima (2002) or Horgan and Mühlau (2006). An auxiliary variable is created counting how many WO or HR variables of a firm assume an above-median value. The following practices are considered here: teamwork, job rotation, decentralised decision making, human capital, incentive pay, temporary employment.[15] Those firms that always score below the median are assigned to the system HRM_0. Those that score above the median in one (two, three, …) variable are assigned to the system HRM_1 (HRM_2, HRM_3, …). Table A5 in the appendix shows the distribution of the auxiliary variable. Since there are not enough firms scoring high in five or six WO or HR variables, they are all assigned to the system HRM_4. Table A6 in the appendix displays the distribution of the six WO and HR variables across the various HRM systems. As can be seen, HRM_4 is the most "innovative" system. The specification for the estimation relies, again, upon a Cobb-Douglas production function that is augmented by HRM system dummy variables:

$$\ln Y_t = \beta_0 + \beta_1 \ln K_t + \beta_2 \ln L_t + \sum_{k=1}^{4} \gamma_k HRM_{kt} + \sum_{j=1}^{n} \delta_j X_{jt} + u_t \,. \qquad (6)$$

As in the preceding subsection, the estimates could be biased due to reversed causality and unobserved time-invariant firm characteristics. Therefore, the same alternative specifications are tested here. For redundancy reasons, the reader is referred to part 4.2.1.

4.3.2 Empirical Results

The estimation results are displayed in tables 5 and 6. In table 5, the dependent variable is productivity. In table 6, the dependent variable is labour efficiency. Each table reports six regressions: two for the cross-section 2008 (with and without the full set of control variables[16]), two for the specification with lagged key explanatory variables, and two for the sec-

[15] See table 2 for correlations among these variables.

[16] However, each regression also includes capital and labour – except for the 2-step regressions which use these controls in the first step – as well as controls for seven economic sectors and seven geographical regions. The

ond step of the Black/Lynch two-step-procedure. The first step regression is shown in table A4 in the appendix.

[Insert tables 5 and 6 about here]

As can be seen from both tables, there is consistent evidence that the most innovative HRM system (HRM_4) is associated with a significantly higher productivity and efficiency than the reference category (neither WO nor HR practices). Depending on the specification, there is also a significant performance effect of the systems HRM_2 or HRM_3. This result strongly confirms the notion of a positive link between human resource management systems and firm performance. Additionally, it can be seen that productivity effects are larger than efficiency effects, again indicating that productivity gains are shared between firms and employees.

5. Conclusion

So-called high-performance work systems are thought of as bundles of mutually reinforcing workplace organisation (WO) and human resource (HR) practices. The present study aimed at testing this complementary hypothesis in the Swiss context based on a nationally representative firm panel data set. Econometric estimations of an augmented Cobb-Douglas production function reveal the following key results. First, the combined use of a decentralised allocation of tasks and decision rights and of a qualified workforce allows exploiting synergies with respect to firm performance. Second, increasing incentives for employees by attaching more importance to pay for performance may have the potential to lead to adverse effects on firm performance if a traditional workplace organisation stays unchanged. Third, the core-periphery-hypothesis gains support insofar as a combination of functional and numerical flexibility is superior to an isolated use of either multitasking and decentralised decision-making or temporary employment. Finally, a human resource management system consisting of four or more WO or HR practices leads to considerable performance effects. These results are robust to unobserved firm heterogeneity and to the problem of reversed causality.

On the theoretical level, the evidence reported in this study supports the recent claim made by several review articles in strategic human resource management (HRM) in favour of assuming a holistic perspective on HRM (Subramony 2009, Lepak et al. 2006, Combs et al. 2006, Delarue et al. 2008, see also Roca-Puig et al. 2008). This leads to basic management implica-

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regressions labelled "no controls" lack the following control variables: *founded*, *foreign*, *export*, *compet_std*, *intens_std*, *inno_std*, *tech_std*. These variables are described in part 4.1.

tions for practitioners. HRM has a great potential to increase organisational performance. This holds especially true if WO and HR practices are combined effectively.

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Tables

Table 1: Spearman correlation coefficients between workplace organisation and HR practices

	WO_std	train_std	skilled_std	incentive_std	temp_std
WO_std	1.000				
train_std	0.270***	1.000			
	(0.000)				
skilled_std	0.290***	0.248***	1.000		
	(0.000)	(0.000)			
incentive_std	0.120***	0.013	0.067**	1.000	
	(0.000)	(0.703)	(0.041)		
temp_std	0.046	-0.034	0.015	0.080**	1.000
	(0.166)	(0.300)	(0.659)	(0.015)	

Legend: Regression Subsample Cross Section 2008, n = 922
rho (p-value)

Table 2: Spearman correlation coefficients between elements of HRM systems

	team_std	rot_std	decentr_std	HC_std	incentive_std	temp_std
team_std	1.000					
rot_std	0.129***	1.000				
	(0.000)					
decentr_std	0.114***	-0.038	1.000			
	(0.001)	(0.253)				
HC_std	0.262***	0.036	0.257***	1.000		
	(0.000)	(0.281)	(0.000)			
incentive_std	0.177***	0.113***	-0.059*	0.030	1.000	
	(0.000)	(0.001)	(0.076)	(0.366)		
temp_std	0.103***	0.028	-0.030	-0.036	0.080**	1.000
	(0.002)	(0.396)	(0.361)	(0.274)	(0.015)	

Legend: Regression Subsample Cross Section 2008, n = 922
rho (p-value)

Table 3: Regression results: Complementary HR practices explaining productivity
Dependent Variable: lnY

	Cross section 08	Lagged D_i-s	Lagged D_i-s (no controls)	2-Step
		D1-D3: TRAIN		
D1	0.244***	0.196**	0.233***	0.173*
	(0.000)	(0.015)	(0.007)	(0.065)
D2	0.130**	0.028	0.028	0.089
	(0.037)	(0.715)	(0.725)	(0.254)
D3	0.223***	0.123	0.204**	0.326***
	(0.003)	(0.134)	(0.013)	(0.001)
R^2	0.7855	0.8224	0.8024	0.2797
N	922	542	542	708
Test D1 = D2	2.74*	2.83*	3.84*	0.71
	(0.0985)	(0.0932)	(0.0507)	(0.400)
Test D2 = D3	1.73	1.09	3.64*	5.62**
	(0.1892)	(0.2967)	(0.0571)	(0.0180)
Test D1 = D3	0.08	0.63	0.09	1.78
	(0.7734)	(0.4275)	(0.7596)	(0.1821)
		D1-D3: SKILLED		
D1	0.156***	0.150*	0.182**	0.112
	(0.006)	(0.077)	(0.036)	(0.195)
D2	0.176***	0.224***	0.295***	0.109
	(0.006)	(0.001)	(0.000)	(0.240)
D3	0.352***	0.324***	0.438***	0.423***
	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.7877	0.8258	0.8100	0.2864
N	922	542	542	708
Test D1 = D2	0.07	0.83	1.73	0.00
	(0.7931)	(0.3638)	(0.1889)	(0.9726)
Test D2 = D3	5.70**	1.71	3.48*	7.89***
	(0.0172)	(0.1918)	(0.0627)	(0.0051)
Test D1 = D3	6.41*	4.14**	8.48***	6.72***
	(0.0115)	(0.0423)	(0.0038)	(0.0097)
		D1-D3: INCENTIVE		
D1	0.149***	0.252***	0.304***	0.224***
	(0.006)	(0.001)	(0.000)	(0.004)
D2	-0.129**	0.042	0.077	-0.013
	(0.036)	(0.538)	(0.283)	(0.883)
D3	0.150**	0.077	0.180**	0.181
	(0.038)	(0.302)	(0.021)	(0.102)
R^2	0.7854	0.8240	0.8036	0.2765
N	922	542	542	708
Test D1 = D2	14.64***	4.88**	5.81**	5.31**
	(0.0001)	(0.0276)	(0.0163)	(0.0214)
Test D2 = D3	10.32***	0.15	1.28	2.25
	(0.0014)	(0.6973)	(0.2586)	(0.1342)
Test D1 = D3	0.00	4.31**	2.13	0.14
	(0.9814)	(0.0385)	(0.1450)	(0.7134)
		D1-D3: TEMP		
D1	0.083	0.135*	0.207***	0.185**
	(0.194)	(0.082)	(0.010)	(0.038)
D2	-0.118**	-0.054	-0.023	0.050
	(0.030)	(0.481)	(0.782)	(0.521)
D3	0.194***	0.101	0.178**	0.323***
	(0.004)	(0.178)	(0.015)	(0.001)
R^2	0.7861	0.8224	0.8024	0.2784
N	922	542	542	708
Test D1 = D2	8.43***	4.20**	5.57**	1.94
	(0.0038)	(0.0409)	(0.0187)	(0.1644)
Test D2 = D3	22.2***	2.64	4.41**	7.23***
	(0.0000)	(0.1047)	(0.0363)	(0.0073)
Test D1 = D3	2.27	0.20	0.13	1.59
	(0.1319)	(0.6554)	(0.7162)	(0.2080)

Legend: Coefficient / test statistic (p-value) */**/*** indicates significance at the 10/5/1%-level

Notes: All 16 regressions include labour and capital – except for the 2-step regressions which use these controls in the first step – as well as 6 regional and 6 sector dummies.

Table 4: Regression results: Complementary HR practices explaining efficiency
Dependent Variable: ln(Y/W)

	Cross section 08	Lagged D_i-s	Lagged D_i-s (no controls)	2-Step
		D1-D3: TRAIN		
D1	0.152***	0.116*	0.149**	0.111*
	(0.001)	(0.069)	(0.027)	(0.094)
D2	0.031	0.048	0.051	-0.002
	(0.510)	(0.401)	(0.384)	(0.966)
D3	0.126**	0.072	0.134**	0.146**
	(0.013)	(0.281)	(0.038)	(0.022)
R^2	0.2875	0.3331	0.2940	0.2848
N	908	533	533	693
Test D1 = D2	4.55**	0.82	1.63	2.95*
	(0.0332)	(0.3652)	(0.2024)	(0.0861)
Test D2 = D3	3.01*	0.11	1.49	6.20**
	(0.0833)	(0.7378)	(0.2235)	(0.0130)
Test D1 = D3	0.22	0.35	0.04	0.22
	(0.6419)	(0.5549)	(0.8443)	(0.6398)
		D1-D3: SKILLED		
D1	0.113**	0.108*	0.133**	0.130**
	(0.016)	(0.088)	(0.037)	(0.033)
D2	0.042	0.093	0.135**	0.090
	(0.359)	(0.119)	(0.024)	(0.107)
D3	0.173***	0.119*	0.210***	0.201***
	(0.001)	(0.099)	(0.003)	(0.004)
R^2	0.2884	0.3342	0.3000	0.2874
N	908	533	533	693
Test D1 = D2	1.70	0.04	0.00	0.32
	(0.1928)	(0.8370)	(0.9796)	(0.5691)
Test D2 = D3	6.54**	0.14	1.19	2.75*
	(0.0107)	(0.7057)	(0.2763)	(0.0977)
Test D1 = D3	1.05	0.02	1.06	0.76
	(0.3059)	(0.8794)	(0.3037)	(0.3832)
		D1-D3: INCENTIVE		
D1	0.106**	0.146**	0.187***	0.160***
	(0.018)	(0.028)	(0.007)	(0.004)
D2	-0.073*	0.083	0.100*	0.049
	(0.100)	(0.122)	(0.068)	(0.384)
D3	0.107**	0.078	0.150***	0.116*
	(0.032)	(0.173)	(0.009)	(0.070)
R^2	0.2886	0.3355	0.2969	0.2855
N	908	533	533	693
Test D1 = D2	11.16***	0.72	1.36	2.56
	(0.0009)	(0.3972)	(0.2438)	(0.1103)
Test D2 = D3	9.16***	0.00	0.60	0.76
	(0.0026)	(0.9456)	(0.4394)	(0.3835)
Test D1 = D3	0.00	0.90	0.28	0.37
	(0.9733)	(0.3439)	(0.6000)	(0.5448)
		D1-D3: TEMP		
D1	0.072	0.099	0.154**	0.124**
	(0.138)	(0.121)	(0.016)	(0.031)
D2	-0.042	0.017	0.036	0.005
	(0.302)	(0.756)	(0.534)	(0.922)
D3	0.154***	0.046	0.101	0.145**
	(0.008)	(0.483)	(0.114)	(0.019)
R^2	0.2899	0.3327	0.2944	0.2845
N	908	533	533	693
Test D1 = D2	6.09**	1.63	3.23*	3.27*
	(0.0138)	(0.2019)	(0.0729)	(0.0709)
Test D2 = D3	14.64***	0.19	0.95	4.33**
	(0.0001)	(0.6630)	(0.3300)	(0.0378)
Test D1 = D3	1.90	0.60	0.65	0.08
	(0.1681)	(0.4372)	(0.4204)	(0.7725)

Legend: Coefficient / test statistic (p-value) */**/*** indicates significance at the 10/5/1%-level

Notes: All 16 regressions include labour and capital – except for the 2-step regressions which use these controls in the first step – as well as 6 regional and 6 sector dummies.

Table 5: Regression results: HRM systems explaining productivity
Dependent Variable: lnY

	Cross section 08		Lagged HRM_i-s		2-Step	
		no controls		no controls		no controls
HRM1	0.029	0.037	0.070	0.095	-0.068	-0.049
	(0.663)	(0.598)	(0.459)	(0.290)	(0.500)	(0.649)
HRM2	0.029	0.090	0.214**	0.279***	0.084	0.108
	(0.651)	(0.196)	(0.031)	(0.004)	(0.422)	(0.341)
HRM3	0.232***	0.302***	0.084	0.192**	0.127	0.227*
	(0.003)	(0.000)	(0.395)	(0.047)	(0.273)	(0.069)
HRM4	0.162**	0.283***	0.088	0.218*	0.351**	0.600***
	(0.049)	(0.002)	(0.481)	(0.097)	(0.045)	(0.001)
R^2 (overall)	0.7843	0.7658	0.8222	0.8011	0.2794	0.2057
N	922	922	542	542	708	708

Legend: Coefficient (p-value) */**/*** indicates significance at the 10/5/1%-level

Notes: All 6 regressions include labour and capital – except for the 2-step regressions which use these controls in the first step – as well as 6 regional and 6 sector dummies.

Table 6: Regression results: HRM systems explaining efficiency
Dependent Variable: ln(Y/W)

	Cross section 08		Lagged HRM_i-s		2-Step	
		no controls		no controls		no controls
HRM1	-0.011	-0.006	0.043	0.052	-0.038	-0.024
	(0.845)	(0.923)	(0.582)	(0.479)	(0.571)	(0.719)
HRM2	-0.029	0.007	0.138*	0.173**	0.066	0.069
	(0.608)	(0.902)	(0.092)	(0.028)	(0.347)	(0.321)
HRM3	0.101	0.144**	0.027	0.082	0.026	0.062
	(0.104)	(0.026)	(0.747)	(0.309)	(0.742)	(0.433)
HRM4	0.098	0.172**	0.153*	0.230***	0.080	0.165*
	(0.155)	(0.017)	(0.092)	(0.009)	(0.419)	(0.079)
R^2 (overall)	0.2856	0.2422	0.3371	0.2980	0.2802	0.2471
N	908	908	533	533	693	693

Legend: Coefficient (p-value) */**/*** indicates significance at the 10/5/1%-level

Notes: All 6 regressions include labour and capital – except for the 2-step regressions which use these controls in the first step – as well as 6 regional and 6 sector dummies.

Appendix

Table A 1: Descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
lnY	922	17.279	1.428	12.827	23.121
ln(Y/W)	884	-3.402	0.593	-4.500	0.000
lnL	922	4.683	1.124	3.045	9.063
lnK	922	13.707	1.773	8.517	18.857
team	922	2.292	1.712	0.000	5.000
rot	922	0.548	1.222	0.000	5.000
task	922	2.839	2.226	0.000	10.000
course	922	1.464	0.874	0.000	4.000
distribution	922	0.996	0.761	0.000	4.000
execution	922	1.512	0.928	0.000	4.000
pace	922	1.720	0.808	0.000	4.000
problems	922	1.095	0.803	0.000	4.000
contact	922	1.679	1.166	0.000	4.000
complaints	922	1.150	0.970	0.000	4.000
decentr	922	9.616	3.751	0.000	21.000
train	922	30.120	28.714	0.000	100.000
skilled	922	21.575	18.771	0.000	100.000
HC	922	51.696	36.858	0.000	185.000
incentive_ind	922	3.238	0.789	0.000	4.000
incentive_team	922	1.839	1.132	0.000	4.000
incentive_corp	922	2.406	1.087	0.000	4.000
incentive	922	7.483	2.279	1.000	12.000
temp	922	1.550	1.263	0.000	4.000
founded	922	1943.706	44.182	1610.000	2005.000
foreign	922	0.178	0.383	0.000	1.000
export	922	27.011	35.553	0.000	100.000
compet	922	2.441	1.402	1.000	5.000
tech	922	2.841	1.108	1.000	5.000
intens	922	5.044	1.409	0.000	8.000
inno	922	1.296	1.103	0.000	3.000
reg1	922	0.081	0.274	0.000	1.000
reg2	922	0.215	0.411	0.000	1.000
reg3	922	0.151	0.358	0.000	1.000
reg4	922	0.226	0.418	0.000	1.000
reg5	922	0.195	0.397	0.000	1.000
reg6	922	0.092	0.289	0.000	1.000
reg7	922	0.039	0.194	0.000	1.000
sec1	922	0.524	0.500	0.000	1.000
sec2	922	0.121	0.327	0.000	1.000
sec3	922	0.133	0.340	0.000	1.000
sec4	922	0.044	0.206	0.000	1.000
sec5	922	0.054	0.227	0.000	1.000
sec6	922	0.085	0.278	0.000	1.000
sec7	922	0.038	0.191	0.000	1.000
compet_std	922	0.000	1.000	-1.028	1.824
intens_std	922	0.000	1.000	-3.579	2.097
inno_std	922	0.000	1.000	-1.175	1.545
tech_std	922	0.000	1.000	-1.661	1.948
team_std	922	0.000	1.000	-1.338	1.582
rot_std	922	0.000	1.000	-0.448	3.645
task_std	922	0.000	1.000	-1.276	3.217
decentr_std	922	0.000	1.000	-2.564	3.035

WO_std	922	0.000	1.000	-2.626	3.008
train_std	922	0.000	1.000	-1.049	2.434
skilled_std	922	0.000	1.000	-1.149	4.178
incentive~td	922	0.000	1.000	-2.844	1.982
temp_std	922	0.000	1.000	-1.227	1.939

Note: Basis: Productivity regression 2008

Table A 2: Concept of median split

TRAIN

Median split	high train	low train
high WO	D_3	D_1
low WO	D_2	

INCENTIVE

Median split	high incentive	low incentive
high WO	D_3	D_1
low WO	D_2	

SKILLED

Median split	high skilled	low skilled
high WO	D_3	D_1
low WO	D_2	

TEMP

Median split	high temp	low temp
high WO	D_3	D_1
low WO	D_2	

Table A 3: Distribution of firms to cells according to table 3, column 1

Variable	Obs	Mean	Std.Dev.	Min	Max
D1-D3: TRAIN					
D0	922	0.335	0.472	0.000	1.000
D1	922	0.248	0.432	0.000	1.000
D2	922	0.165	0.371	0.000	1.000
D3	922	0.252	0.434	0.000	1.000
D1-D3: SKILLED					
D0	922	0.312	0.464	0.000	1.000
D1	922	0.197	0.398	0.000	1.000
D2	922	0.188	0.391	0.000	1.000
D3	922	0.303	0.460	0.000	1.000
D1-D3: INCENTIVE					
D0	922	0.354	0.478	0.000	1.000
D1	922	0.293	0.455	0.000	1.000
D2	922	0.146	0.354	0.000	1.000
D3	922	0.207	0.405	0.000	1.000
D1-D3: TEMP					
D0	922	0.275	0.447	0.000	1.000
D1	922	0.272	0.445	0.000	1.000
D2	922	0.225	0.417	0.000	1.000
D3	922	0.228	0.420	0.000	1.000

Note: Basis: Productivity regression 2008

Table A 4: Regression results: 1st step of Black/Lynch-procedure

Dependent variable:	**lnY**	**ln(Y/W)**
2nd step with	D1-3; HRM1-4	
lnK	0.074 (0.250)	0.036 (0.275)
lnL	0.397** (0.034)	-0.139 (0.477)
yr08	0.099** (0.021)	0.052* (0.095)
_cons	14.278*** (0.000)	-3.281*** (0.000)
R^2 (overall)	0.7243	0.0007
F	16.51***	2.16*
Prob>F	(0.0000)	(0.0928)
N	1,630	1,601
n	1,367	1,349
Legend:	Coefficient / test statistic (p-value)	*/**/*** indicates significance at the 10/5/1%-level

Table A 5: Distribution of number of HR practices

Number of HR practices	**Freq.**	**Percent**	**Cum.**
0	77	8.35	8.35
1	220	23.86	32.21
2	275	29.83	62.04
3	189	20.50	82.54
4	128	13.88	96.42
5	28	3.04	99.46
6	5	0.54	100.00
Total	922	100.00	

Note: Basis: Productivity regression 2008

Table A 6: Description of HRM systems

HRM-System	**HRM0**	**HRM1**	**HRM2**	**HRM3**	**HRM4**
N	77	220	275	189	161
team_std	-0.739 (0.764)	-0.470 (0.851)	-0.085 (0.952)	0.318 (0.909)	0.769 (0.819)
rot_std	-0.448 (0.000)	-0.363 (0.465)	-0.079 (0.941)	0.158 (1.111)	0.660 (1.318)
decentr_std	-0.749 (0.681)	-0.310 (0.920)	-0.052 (1.045)	0.307 (0.896)	0.510 (0.886)
HC_std	-0.873 (0.268)	-0.489 (0.736)	0.034 (0.969)	0.385 (1.018)	0.576 (0.974)
incentive_std	-0.645 (0.735)	-0.351 (0.874)	-0.087 (1.009)	0.278 (0.964)	0.611 (0.877)
temp_std	-0.733 (0.386)	-0.309 (0.938)	0.005 (1.010)	0.159 (1.015)	0.577 (0.877)

Legend: mean
(standard deviation)

Note: All variables had been standardised to a mean of zero and a standard deviation of one before HRM-systems have been created.
Basis: Productivity regression 2008