Paper to be presented at the

DRUID Society Conference 2014, CBS, Copenhagen, June 16-18

The Relative Importance of Human Resource Management Practices for a Firm?s Innovation Performance

Florian Seliger
ETH Zurich
Management, Technology and Economics
seliger@kof.ethz.ch

Tobias Stucki
ETH Zurich
KOF Swiss Economic Institute
stucki@kof.ethz.ch

Spyros Arvanitis
ETH Zurich
KOF Swiss Economic Institute
arvanitis@kof.ethz.ch

Abstract

Human resource management (HRM) practices are generally expected to stimulate a firm?s innovation performance. However, which of these practices do really pay off? Based on a unique dataset that includes detailed information for both a firm?s innovation activities and different types of HRM practices we find that primarily new workplace organization practices seem to enhance a firm?s innovation activities. Flexible practices of working time management and incentive payment schemes show only small effects on both innovation propensity and innovation success. Further training does only affect innovation success, but not innovation propensity. Overall, we find a stronger linkage between innovative HRM practices and innovation propensity than with innovation success.

Jelcodes:O31,-

The Relative Importance of Human Resource Management Practices for a Firm's Innovation Performance

Abstract

Human resource management (HRM) practices are generally expected to stimulate a firm's innovation performance. However, which of these practices do really pay off? Based on a unique dataset that includes detailed information for both a firm's innovation activities and different types of HRM practices we find that primarily new workplace organization practices seem to enhance a firm's innovation activities. Flexible practices of working time management and incentive payment schemes show only small effects on both innovation propensity and innovation success. Further training does only affect innovation success, but not innovation propensity. Overall, we find a stronger linkage between innovative HRM practices and innovation propensity than with innovation success.

Keywords: human resource management; workplace organization; innovation performance
JEL classification: O31

1 Introduction

Starting point of this study is the general idea that the internal organization of a firm plays an important role for high economic performance. Older economic literature has mostly focused on various types of incentive pay contracts as a main organizational arrangement for achieving greater effort from employees (see for a review in Murphy 1999). Incentive payment is always relevant; but in addition, managers introduce all kinds of human resource management (HRM) practices that complement (or even substitute) pure incentive pay plans. As Briody (2012) puts it in *Fiscal Times*: "Companies like IBM, Best Buy, Netflix and HubSpot, for example, have stopped counting employees' vacation days. Philip Rosedale, the founder of Second Life maker Linden Lab, recently had his employees vote on how to divvy up the quarterly bonuses. Google, for its part, is well known for having official 'hang out' spaces in the office, and allowing employees to spend 20% of their time on a side project of their choosing. Another CEO, Joe Reynolds of Red Frog Events in Chicago, Ill., even installed a tree house with a zip line in the middle of his office." How could such organizational arrangements pay off? The motivation that is often proclaimed by those who favor such arrangements is that new HRM practices could encourage employees to think independently, creatively and to feel more motivated in their work. Accordingly, the expectation is that HRM should directly stimulate innovation and economic performance of a firm. Newer theoretical research takes into consideration new human resource management (HRM) practices explicitly such as employee training, teamwork, job design and internal hierarchies that aim at enhancing employee performance (see reviews in Gibbons 1998; Ichniowski and Shaw 2003; and Bloom and Van Reenen 2010).

In this paper, we focus on the relative impact of a broad spectrum of factors of workplace organization and employment conditions on the propensity to innovate and on innovation success (as represented by the sales of innovative products), which is a rather under-researched topic as compared to existing empirical research on the influence of such practices on firm productivity. The idea is that not all HRM practices have the same impact on innovation performance.

The considered factors can be grouped into four categories. Factors that are related to (a) workplace organization (e.g., number of hierarchical levels, degree of decentralization), (b) working time management (e.g., flexibility of the work schedule, extent of part-time employment), (c) incentive pay (e.g., individual performance pay schemes, group performance pay schemes) and (d) training intensity.

As already mentioned, the relationship between innovation activities and HRM practices has been rarely analyzed so far. This is primarily due to limited data availability as it is hardly possible to find data that includes information on innovation activities and HRM practices at the same time (see Michie and Sheehan 1999). Accordingly, previous studies were mostly based on small samples comprising only one cross-section. Our dataset comes from a survey that includes both detailed information on the firms' innovation activities and their HRM practices. The survey is based on a representative sample of Swiss firms and was conducted in 2005, 2008 and 2011, respectively. The detailed information on different HRM practices allows us to analyze the relative impact of different HRM practices and the identification of cumulative effects when different practices are used simultaneously. A further asset of our study is the detailed information on a firm's innovation activities. While previous studies exclusively investigated simple indicators of innovation propensity, we also analyze the impact of HRM practices on a measure of innovation success.

We find that variables representing workplace organization show overall highly significantly positive associations with innovation propensity. Some of them seem to be more important than other "standard" determinants of innovation such as demand development, competition conditions or human capital endowment. New workplace organization practices are also important drivers for innovation success, their effect on innovation success is, however, limited. A further finding is that the intensity of further training is positively associated with innovation success, but not with innovation propensity. Working time management practices and incentive payment schemes appear to have only a small impact on both innovation propensity and innovation success. Overall, we find

much stronger linkages between innovative HRM practices and innovation propensity than with innovation success.

The paper is structured as follows: Section 2 provides the conceptual background, results from previous empirical studies and our research hypotheses. Section 3 describes the data we use in our estimations. Section 4 discusses our econometric approach and the variables we use in our estimations. Section 5 presents the estimations results. In Section 6, we summarize our results and draw conclusions.

2 Conceptual background, related empirical literature and research hypotheses

2.1 Conceptual background

The main rationale for firms applying HRM systems is that a firm needs a system for assigning decision rights to individuals who have the knowledge and abilities relevant to such decisions (Jensen and Meckling 2005). The impact of HRM practices, particularly the impact of workplace organization on productivity has been widely studied in both management and economic literature. Economic literature has widened its focus from focusing on incentive pays to including various HRM practices concerning employee training, hiring criteria, teamwork, job design and employee hierarchies (see Ichniowski & Shaw 2003). In management literature, a major concern is the proper alignment of competitive strategy with HRM practices and potential complementarity of these practices. The main focus is on the impact of HRM practices bundled in HRM systems on firm performance measures (Huselid 1995).

The economic literature distinguishes between “innovative” and “traditional” HRM practices. However, there is no consensus for an all-encompassing list of practices that can be assigned to one or the other group. For example, Ichniowski and Shaw (2003, p. 157) list several HRM practices that can be considered “innovative”: “Problem-solving teams are aimed at involving production

workers or other non-managerial workers in solving production problems. Rotation of workers across jobs is used to increase worker flexibility and increase teamwork. Careful screening and selection of workers is required to identify those who have both high-level job- and task-related skills and also "team skills" to work together to solve problems. Job security is used to assure workers that improvements in production performance will not result in the direct loss of jobs. Information sharing is important to provide the information and motivation for greater involvement and decision making. Training is needed to do problem solving, to increase knowledge for better decision making and to introduce workers to the skills needed for more job tasks. Finally, incentive pay, in a wide variety of forms, is introduced to provide the incentive for greater employee effort and employee involvement in decision making."

Generally, with innovative HRM practices, workers make decisions both individually and collectively necessitating greater exchange of information within teams (Mookherjee 2006). In contrast, more traditional HRM practices typically include hourly or salaried pay with little connection of pay to performance outcomes, assignment of workers to narrowly defined jobs with no job rotation, no work teams, hiring practices with limited screening for non-managerial or professional jobs, little formal training, limited sharing of operating data with employees and layoffs of employees when product demand declines.

Innovative HRM is expected to have a larger impact on a firms' performance. According to Mookherjee (2006), a theory explaining the superiority of innovative HRM practices would need to incorporate costs of communication, information processing and contract renegotiation as these factors would make the difference between innovative HRM and traditional HRM practices (in the absence of such costs, the value of centralized decision-making should be higher). However, delegated decision making is associated with other costs of control loss and a lack of coordination, which have to be traded off against enhanced flexibility. Further advantages of innovative HRM practices such as decentralization and information sharing are increased firms' speed of response to market changes and higher job satisfaction (Bloom et al. 2010).

Whereas most concepts focus on the impact of HRM practices on productivity, the question whether innovative HRM practices also stimulate innovative activity and innovative performance has gained much less attention. The question deserves our interest as innovation is very often a team activity and incentive systems for innovations work different than in other economic contexts. (Holmström 1989; Azoulay and Lerner 2013). Teamwork might enhance a more efficient use of knowledge and lead to recombination of separated knowledge. In addition, decentralization allows for the discovery and utilization of knowledge and job rotation might increase knowledge diffusion (Laursen and Foss 2003). Finally and according to Zoghi et al. (2010), firms might offset some of the coordination costs of decentralization and information-sharing by using incentive pay.

In sum, there is a bundle of explanations for a positive effect of innovative HRM practices on firm performance (and innovation), but – as stated by Mookherjee (2006) – there is a lack of theoretical models (especially formal models) going beyond descriptive formulations and speculations, and – as we will see in the next section – limited exchange between theoretical and empirical literature.

2.2 Related empirical literature

Most studies found empirical support for the hypothesis that investments in HRM practices are associated with greater productivity (e.g., Huselid 1995; Ichniowski 1997; Black and Lynch 2001; for a review see Bloom and Van Reenen 2010). The results of Huselid (1995) indicated that high performance work practices have a significant impact on turnover and productivity as well as short- and long-term measures of corporate financial performance. Black and Lynch (2001) found that it is more important for the impact on productivity how a work practice is implemented rather than whether a work practice is implemented. Boning et al. (2001) showed that group-based incentive pay raises productivity and that the adoption of teams in addition to incentive pay leads to a further increase in productivity (especially in complex production lines). In a seminal paper, Bresnahan et al. (2002) showed that the effects of information technology (IT) on labor demand are greater when IT is combined with workplace reorganization. Bloom and Van Reenen (2007; 2010) found that

survey-based measures of monitoring, target-setting and incentives are strongly associated with firm-level productivity and other measures of firm performance.

The question whether there is an impact of HRM practices on innovation has received less attention. Michie and Sheehan (1999) showed that innovative work practices are positively correlated with investment in R&D and new technology as compared to traditional work practices. Laursen and Foss (2003) investigated the relationship between systems of HRM and the probability of introducing innovations for a sample of Danish firms. The HRM systems that are identified and used in the econometric analysis are combinations of HRM practices that emerge out of a principal component factor analysis and are strongly significant in explaining innovation performance, whereas only two individual practices were found to be strongly significant ("integration of functions" and "firm-internal training"). They interpret this result as evidence that supports their hypothesis of complementarities between HRM practices. In another study also based on data for Danish firms, Foss and Laursen (2005) examined the relationship between work practices and innovation the other way round, namely the association of a firm's ability to produce innovations with increasing degree of novelty with the likelihood of adopting delegation of responsibility and pay-for-performance schemes. Vinding (2006) showed for another sample of Danish firms that the application of HRM practices is positively correlated with the ability to innovate. Shipton et al. (2005, 2006) found that training, induction, team working, appraisal and focus on exploratory learning are predictors of innovation and that innovation is enhanced if there is a supportive learning climate.

Acemoglu et al. (2007) examined the relationship between diffusion of innovations and the decentralization of British and French manufacturing firms. They showed that firms closer to the technological frontier, firms in more heterogeneous environments and younger firms are more likely to choose decentralization. Hempell and Zwick (2008) investigated the effects of two organizational practices, employee participation and outsourcing, on the likelihood of the introduction of products and/or process innovations. The results, based on data for 900 German

firms in the years 2002 and 2004, showed that employee participation is positively associated with product and process innovations, while outsourcing favors innovations in the short run, but reduces innovation performance in the long run. Zoghi et al. (2010) analyzed the relationship between decentralization, information-sharing, incentive pay schemes and innovation for a large sample of Canadian firms and three cross-sections. Although they found correlations between these factors, they show that the correlation is weaker for decentralized decision-making or incentive pay programs compared to the correlation between information-sharing and innovation. Exploiting the panel structure gives no clear evidence on the proposed relationships.

Using four waves of a survey of firms from the Netherlands, Zhou et al. (2011) found that high functional flexibility is positively associated with sales of new products. In contrast, they did not find any impact of external labor turnover on innovation since innovation leaders who need to continuously accumulate tacit knowledge favored longer commitments of workers to their firms. For a sample of UK firms, Cosh et al. (2012) found that decentralized decision-making generally supports the ability to innovate in small and medium-sized enterprises and that young firms in high technology sectors with informal structures have a greater tendency to be innovative, whereas firms in other sectors are better suited with formal structures. In a study with Taiwanese firms, Chang et al. (2012) show that there is a positive relationship between organizational capabilities and radical innovation. Jiang et al. (2012) show for Chinese firms that hiring and selection, reward, job design, and teamwork are positively related to employee creativity that influences innovation, whereas training and performance appraisal are not. Using data on Finnish manufacturing firms, large firms (in contrast to small firms) with more decentralized decision-making are not found to perform better in terms of innovation than those with a more bureaucratic decision-making structure (Koski et al. 2012). Performance-based wages are found to relate positively to innovation if they are combined with a systematic monitoring of the firm's performance. Arvanitis et al. (2013) investigated the relationship between indicators for the intensity of use of ICT, several forms of workplace organization, and human capital and innovation performance for Swiss and Greek firms. The

organizational variables for new work design (teamwork, job rotation, reduction of managerial levels) and employee voice (decentralization and delegation) have been found to show significant positive marginal effects for all innovation indicators in the Swiss sample.

In sum, all studies find a stable positive relationship between decentralization of decision-making, delegation of responsibility, information-sharing and innovation and – when examined – a positive relationship of teamwork and training with innovation. These basic relationships seem to hold irrespective of the cultural background of the surveys, the sample size, the definition of the variables of interest, and other measurement issues. A general limitation of all these studies, however, is that they analyze the impact of certain HRM practices and do not control for others. Accordingly, it is hardly possible to make a statement about the relative impact of a certain practice and their complementarities with each other. In contrast, our study is based on a unique dataset that allows to control simultaneously for different aspects of innovative HRM practices and thus to discuss their relative importance.

2.3 Research hypotheses

Based on existing studies, we investigate the relationship of a broad spectrum of factors of workplace organization and employment conditions (HRM practices) on the propensity to innovate and innovation success as represented by the sales of innovative products.[1] The practices taken into consideration can be grouped into four categories. Practices that are related to (a) workplace organization (e.g., number of hierarchical levels, extent of decentralization), (b) working time management (e.g., flexibility of the work schedule, extent of part-time employment), (c) incentive pay (e.g., individual performance salary, group performance salary) and (d) training intensity. Based on the literature discussed above we expect the following effects:

Hypothesis 1: The redesign of workplace organization as reflected in practices such as teamwork and job rotation, the reduction of hierarchical levels and the extent of

[1] However, we do not cover organizational changes such as vertical integration, mergers, outsourcing, and offshoring within multinational firms (see Bloom et al. 2010 on this point).

decentralization of decision-making has a positive association with (a) the propensity to innovate and (b) innovation success.

Hypothesis 2: Flexible practices of working time management have a positive association with (a) the propensity to innovate and (b) innovation success.

Hypothesis 3: Payment schemes that increase incentives through incentive payment have a positive association with (a) the propensity to innovate and (b) innovation success.

Hypothesis 4: The intensity of further training provided to a firm's employees has a positive association with (a) the propensity to innovate and (b) innovation success.

3 Description of the data

The firm level data used in this study were collected in the course of three surveys among Swiss companies conducted in 2005, 2008 and 2011, respectively. All surveys were based on a sample which covers manufacturing industry, construction and the commercial area of the service sector and is (with respect to firm size and two-digit industry affiliation) disproportionately stratified. The three surveys yielded data for 2555, 2172 and 2363 firms, respectively, representing response rates of 38.7%, 33.8% and 35.9%, respectively. The data were pooled to a dataset of a total of 7090 observations. The final sample used for model estimation was significantly smaller (about 4500 observations), primarily due to the fact that the questions on organizational practices were answered only by firms with more than 20 employees. As there is a large time lag between the surveys (three years), only about 50% of the firms replied to two successive surveys, meaning that the panel is highly unbalanced (what, as shown in the next section, is not without consequences for the choice of the econometric method used for model estimation).

The three questionnaires, downloadable from www.kof.ethz.ch, contain questions about the firms' innovation activities, the adoption of several ICT technologies (internet, intranet, extranet, etc.) and the intra-firm diffusion of some of these elements, the use of new organizational practices (team-work, job rotation, employees' involvement in decision-making, etc.) and the employees'

educational level. The three surveys also collected information on some financial variables and basic structural characteristics of firms.

4 Econometric framework

4.1 Model specification

As mentioned in the introductory section, our dependent variables are (a) a firm's innovation propensity (indicating whether a firm has introduced innovations in a certain period or not) and (b) innovation success as measured by firm's innovative sales of innovative (new and considerably modified existing) products. As theory does not offer specific explanations for innovation propensity and innovation intensity, we use the same set of independent variables in the two empirical models. To capture different effects on innovation activities, we include the variables describing the HRM practices in an extensive basic model (for a detailed definition of the variables and respective descriptive statistics see Table 1, Table A.1 and Table A.2 in the appendix, respectively). Following the theoretical literature and in accordance with empirical studies (see Cohen 2010 for an excellent review of research on innovation determinants; see also Acemoglu et al. 2007), we control in detail for the firms' human capital endowment, ICT usage, market conditions and general firm characteristics such as firm age and firm size. To capture industry specific effects, we further include industry specific time-fixed effects.

Innovation propensity is proxied by a variable that measures whether a firm has product and/or process innovation or no innovation.[2] The quantitative dependent variable measuring innovation success (sales of innovative products) is measured only for firms which actually have innovation activities.

[2] We alternatively estimated our model separately for product and process innovation. However, results differ only marginally between the two types of innovation (see Table A.5 in the appendix).

4.2 Selectivity bias

In case of the binary dependent variable measuring a firm's innovation propensity estimating probit regressions is an adequate procedure. To take into consideration firm heterogeneity we use random-effects models. As already mentioned, the variable for innovation success refers only to firms with innovation activities. Consequently, selectivity bias may be a problem. We estimate a two-stage Heckman selection model to detect a potential bias (see Heckman 1979). We use the same set of explanatory variables in the selection equation (innovation yes/no) as in the intensity equation (sales of innovative products) with the exception of the additional identifying variable "regulated_access_Swiss_market" (for definition see Table 1) that is used to make sure that the estimated coefficients are reliable (see Wooldridge 2002). This instrument is a 3-digit industry average[3] of a variable that measures whether a firm's innovation activities are hampered by limited access to strongly regulated markets in Switzerland. In line with Cassiman and Veugelers (2002, p. 1174), we assume that this industry variable picks up the effect of unobserved industry-specific attributes that contribute to the potential endogenous firm-specific variables. Accordingly, it can be assumed that the instrument is uncorrelated with the error term. Furthermore, this variable should be a good instrument as the large amount of the regulation-related costs are expected to be fixed and should thus affect selection (innovation yes/no) but not innovation intensity. The effective relationship can also be observed in the data. The effect of the variable "regulated_access_Swiss_market" is statistically significant in the innovation propensity equation but insignificant in the innovation intensity model (see Table A.3 in the appendix). As the inverse mills ratio is statistically insignificant at the 10%-level, there is no evidence for a selection bias (see Table 2). To take firm heterogeneity into consideration we estimate random-effects GLS models for innovation success.

[3] The industries are defined according to the NACE classification. We excluded the value of the observation itself in order to ensure the exogeneity of these variables. If the number of observations of a specific 3-digit industry is lower than five, we used the average score at the NACE two-digit level.

4.3 Further econometric issues: omitted variable bias and causality

A further potential problem is the possibility of omitted variable bias that would imply inconsistent estimates. A possible way to reduce this problem – run a fixed effects model – can be ruled out in this case. Firstly, as our panel is highly unbalanced (see Section 3) the number of observations that may be used for estimating fixed-effects models is by much lower than in case of random-effects models. Hence, we would lose the representativeness of our sample. Secondly, as the variance of our model variable across time is rather low, it would hardly be possible to identify within effects. However, since a broad set of observables that generally affect innovation is included in the estimation equations besides the HRM variables, we expect that there is no omitted variable bias and that the estimated parameters measure firm-specific effects only.

Causality is another potential problem that we cannot directly deal with. As a consequence, we refrain from making causal claims. Instead, our estimation results are interpreted as partial correlations. Nevertheless, some robust regularities come out, which, if interpreted in view of our hypotheses presented in Section 2.3 and their theoretical and empirical support outlined in Section 2.2, could possibly indicate the direction of causal links.

5 Estimation results

The results for the basic model are presented in Table 2. Columns (1) and (2) show the random-effects probit estimates for the innovation propensity, columns (3) and (4) the random-effects GLS estimates for the innovation intensity.

The columns with uneven numbers show the estimation results for the variables as defined in Table 2. As we are interested in the relative impact of the different variables, the columns with even numbers show the results for the same estimations based on standardized variables (average 0; standard deviation 1) that allow for the comparison of the relative strength of different independent variables (see Agresti 1996; Menard 2011).

The coefficients of the control variables show the expected positive signs in the innovation propensity equation and are all statistically significant except for firm age. For the sales of innovative products, the coefficient of firm age is negative and statistically significant meaning that younger firms are more successful with their innovations on the market than older ones, which is in line with the finding of previous studies (see, e.g., Huergo and Jaumandreu 2004). The results for the HRM variables are discussed in detail in the next two sub-sections.

5.1 Innovation propensity

We comment on the results for the standardized variables in column (2). The practices that characterize the redesign of workplace organization show positive associations with innovation propensity. The coefficients of the respective variables are strongly statistically significant except for the variable that measures the decrease of the number of hierarchical levels that has the expected positive sign but is not statistically significant at the 10% test level.

Of the three practices referring to working time management only the variable that measures the importance of work schedule flexibility shows a positive but weakly significant association with innovation propensity.

The extent of temporary and part-time employment does not appear to have an effect on innovation.

All three incentive payment schemes do not show any significant association with innovation propensity in our estimation.

Among the considered HRM practices, variables referring to workplace organization have the largest coefficients of the standardized variables in the innovation propensity equation. The difference between the coefficients of each of the (standardized) workplace organization variables and the (standardized) variable for work schedule flexibility is statistically significant. This means that a change by one standard deviation in the extent of use of teamwork, the share of employees that switched function, the extent of use of job rotation or the extent of decentralization is associated with a significantly larger change of the innovation probability than a change by one

standard deviation in the extent of work schedule flexibility. Furthermore, the coefficients of the workplace organization variables have significantly larger magnitudes than all control variables with the exception of firm size. The coefficients of the variables for workplace organization do not differ significantly from each other.

It seems plausible that innovative firms that use human capital and information technologies to a large degree would also apply workplace organization practices that are related to more flexible forms of work and cooperation as well as to stronger employee participation in decision-making more intensively than non-innovators. It also appears sensible that working time flexibility is a further characteristic that is in line with more innovative environments. Obviously, the use of incentive payment schemes does not make the difference between innovative and non-innovative firms at the first place. However, it does make a difference as to innovation success (see below), as production and marketing get interlocked between research and development and the market.

5.2 Innovation success

The effect of HRM practices on innovation success seems to be more limited. We also comment on the results for the standardized variables in column (4). Of the practices belonging to workplace organization only the share of employees that switched function or department (functional flexibility) and the variable that measures the extent of decentralization of decision-making show statistically significant positive associations with the sales of innovative products. Further, the variable based on firm performance pay shows a significantly positive but weak association with innovation success. Interestingly, further training is positively associated with innovation success, but not with innovation propensity. For the propensity to innovate only the stock of human capital (as measured by the share of employees with tertiary-level education) seems to be important, whereas further training is rather needed for market success that is mostly conditioned on additional marketing and managerial skills.

For innovation success, the coefficients of the two statistically significant workplace organization variables for the share of employees that have switched function or department and the extent of decentralization are also not statistically different from each other. The coefficient of further training is slightly smaller in magnitude compared with the workplace organization variables, but the difference is not significant. A comparison of the size of the coefficients of the HRM variables with the control variables indicates that the impact of HRM practices is much smaller with respect to innovation success than with respect to innovation propensity. Firm size has the largest relative importance for innovation success, followed by the share of employees with tertiary-level education and firm age.

With respect to our hypotheses we thus conclude that hypothesis 1 receives empirical support, as there is a positive linkage between workplace organization practices and both innovation propensity and success. However, the relationship between workplace organization practices and innovation propensity seems to be stronger than the linkage between workplace organization practices and innovation success. The extent of use of teamwork and job rotation is positively correlated only with innovation propensity but not innovation intensity. Hypotheses 2 and 3 are only weakly confirmed. Work schedule flexibility, one out of three variables reflecting a firm's working time management, is slightly positively correlated with innovation propensity. Salary based on firm performance, one out of three variables reflecting a firm's incentive pay schemes, is positively correlated with innovation success. Accordingly, the correlation of working time management and incentive pay schemes with innovation performance seems to be rather weak. Finally, hypothesis 4 is confirmed only with respect to innovation success but not with respect to innovation propensity.

5.3 Overall effects of the groups of HRM practices

In a further step we conducted a principal component factor analysis of all 12 HRM practices that are taken into consideration in this study in order to get an idea of the overall effect of each of the four categories of HRM practices in which we have already grouped the 12 individual practices. We

could identify three groups of HRM practices (see Table 3 for detailed information on the factor pattern matrix) that correspond quite well to the a priori categories we have constructed. Factor 1 contains primarily the three practices related to incentive payment. Factor 2 corresponds to the four components of workplace organization (rather small loadings for job rotation and decrease of the number of hierarchical levels, large loadings for the share of employees that switched function, teamwork and decentralization). Further training also belongs to this factor, which is quite plausible in the light of empirical literature that finds a close positive relationship between human capital and new workplace organizational measures (see, e.g., Arvanitis 2005). Factor 3 covers the three working time management practices.

The factor values of the three-factor solution were inserted as independent variables in the estimation equations for innovation propensity and innovation success. The estimates are found in Table 4. We find positive coefficients for all three factors but only factor 2 (workplace organization) is statistically significant for both innovation variables. Factor 1 (incentive payment schemes) is only statistically significant in the innovation success equation, factor 3 (working time management) only in the propensity equation.

The coefficient of factor 2 is significantly larger than the coefficient of factor 3 (working time management) in the propensity equation as well as the coefficient of factor 1 (incentive payment schemes) in the innovation success equation.

On the whole, these results are quite in accordance with those for the individual practices in Table 2. Moreover, they demonstrate more clearly the relative overall importance of the three categories of HRM practices (training is included in factor 2) with respect to innovation performance: workplace organization has the highest importance, working time management the second-highest, and incentive payment schemes have the lowest importance.

5.4 Effects of combinations of individual HRM practices

Complementarities between and/or cumulative effects of the use of HRM practices is a major concern in economic literature (see Section 2.1). Because the results of existing empirical studies are heterogeneous and the methods not always consistent to each other, it is difficult to make a generalizing statement on how the HRM practices are exactly interconnected and which HRM practices influence other ones that might mediate the relationship with (innovation) performance.

We used a method based on Ichniowski et al. (1995, 1997) to examine which combinations of HRM practices show larger associations with innovation than others. This is not a test on complementarity, but it contributes to a better understanding of the interdependence of such practices.

First, we created a dummy for each HRM practice variable that takes the value 1 when the firm ranks "high" for this practice and 0 when the firm ranks "low". As the variables are scaled quite differently, we use the median of the underlying distributions of the original variables (i.e., not the logarithms of them) as cut-off value ("low" versus "high") except for the variable *Δ_hierarchical_levels* that is already 0/1 coded.[4] These twelve dummy variables are summed into a 0-to-12 HRM index. Based on the frequencies of the individual practices in this index, we defined four HRM systems that roughly involve the same number of firms: HRM index=0-2 practices (HRM system 1), HRM index=3-4 practices (HRM system 2), HRM index=5-6 practices (HRM system 3), HRM index=7-11 practices (HRM system 4). In this way, to each of the 12 single practices is assigned the same weight. There are no firms in our sample that have adopted all twelve practices to a sufficient degree so that all twelve dummies would take the value 1. Only a small

[4] In Table A.4 results are shown from a regression using the dummy variables (same names as the original variables in Table 2 only adding the suffix _d) instead of the original variables as regressors. The coefficient of further training intensity becomes strongly significant in the innovation propensity equation when using a dummy variable. Otherwise the results are quite similar to those in Table 2.

number of firms have adopted more than nine practices (1.05%) or – conversely – no practice at all (0.84%). The bulk of firms have adopted three to six HRM practices (66.85%).[5]

Table 5 shows estimation results after inserting the HRM systems using HRM system 1 as reference group. The coefficients of the HRM systems are all positive and strongly statistically significant in the innovation propensity equation. The general impression is that the coefficients are the larger the more HRM practices are combined within an HRM system. Chi-squared-tests on the equality of coefficients show that the coefficient of HRM system 2 is significantly different from that of HRM systems 3 and 4. Thus, our first finding is that firms that use more than 2 HRM practices show a significantly higher innovation propensity than firms with less than 2 practices. Further, the use of 5 and more of the 12 HRM practices is associated with a larger probability of innovation than the use of less than 5 practices. Both findings can be interpreted as hints for some kind of *cumulative effect* of the combined use of HRM practices on the propensity of innovation. In the estimates for the sales of innovative products only the coefficient of HRM system 4 is positively statistically significant. The threshold for the cumulative effect of the combined use of HRM practices is in this case higher (from 7 HRM practices on).

A complementarity test would imply that the magnitude of the innovation effects of the HRM systems is larger than the sum of the effects from adopting each individual practice. Although we do not explicitly test for complementarities in this way and we thus cannot say anything about the sum of the coefficients of the individual practices as compared to the coefficients of the HRM systems, a simple inspection of the magnitude of the coefficients of the individual practices in Table 2 or Table A.4 and the HRM systems in Table 5 shows that no coefficient of the individual HRM practices is larger than the coefficient of HRM system 3 or 4.

[5] HRM system 1:16.26%; HRM system 2: 36.40%; HRM system 3: 30.44%; HRM system 4: 16.90%.

5.5 Effects of combinations of groups of HRM practices

In a further step, we wanted to investigate the effect of a firm adopting practices from different categories of HRM practices as defined before,[6] for example, one practice of the category workplace organization and one of the category "working time management". To this end, we constructed four dummy variables based on the number of categories of HRM practices in which a firm has adopted practices and uses them at "high" level (for the construction of the underlying dummies, see Section 5.4): practices from only 1 category (bloc_1); practices from 2 categories (bloc_2); practices from 3 categories (bloc_3); practices from 4 categories (bloc_4). A regression on these four variables (reference group: firms without any practice at "high level) clearly shows that adopting practices in all four categories has the highest statistically significant association with innovation propensity, followed by adopting practices in three categories (see Table 6). Only adopting practices in one or two categories does not have a significant association with innovation. These findings are a further hint for a cumulative effect of the use of HRM practices from different groups of HRM practices.

5.6 Robustness checks

We performed two robustness checks with respect to the basic results in Table 2. First, our innovation measure includes both process and product innovation. We checked whether the results differ between product and process innovations by estimating the innovation propensity separately for product and process innovations (see Table A.5). For the variables of interest we do not find any difference between product and process innovations except for the coefficient of the variable for the flexibility of the work schedule that is highly significant for process innovations but not for product innovations. Other differences are limited to the control variables, e.g., share of employees with

[6] Category 1: workplace organization; category 2: working time management; category 3: incentive payment schemes; category 4: training intensity.

tertiary-level education, the share of ICT investments, and demand development are only significantly associated with product innovations but not with process innovations.

Second, we conducted a robustness test of our estimates with respect to possible multicollinearity between the variables of the same group of practices. We inserted the single practices for each of the three main groups (working time management, incentive payment schemes and workplace organization) separately in both innovation equations and estimated once more the respective models. The results of these additional estimates seem to confirm the findings in Table 2. Table A.6 in the appendix shows the results for working time management practices. Except for the part-time employment intensity whose coefficient becomes weakly significant when inserted separately into the innovation propensity equation, the results do not change. Results do not change at all when inserting the incentive pay variables separately (see Table A.7). Inserting the workplace variables separately, the only thing that changes is the coefficient for the number of hierarchical levels that becomes slightly significant for innovation propensity (see Table A.8).

6 Summary and conclusions

Our investigation refers to the effects of 12 HRM practices on innovation performance that are grouped in four categories (workplace organization, working time management, incentive payment schemes and training). We find that variables representing workplace organization (with the exception of the variable for the decrease of the number of hierarchical levels) show highly significantly positive associations with innovation propensity. Some of them seem to be more important than other "standard" determinants of innovation such as demand development, competition conditions or human capital endowment. New workplace organization practices are also important for innovation success, however, their effects on innovation success are more limited than for the propensity of innovation. A further finding is that the intensity of further training is significantly positively associated with innovation success, but not with innovation propensity. Working time management practices and incentive payment schemes appear to have only a small

impact on both innovation propensity and innovation success. Overall, we find stronger linkages between innovative HRM practices and innovation propensity than with innovation success. The main reason for these differences might be the fact that the two innovation variables measure different things. HRM practices seem to be directly positively associated with the firm being innovative or not. Given that a firm is innovative, differences as to the magnitude of innovative sales might be influenced to a higher degree by a series of further factors such production and marketing skills as it is indicated by the effect of the variable intensity of further training.

The relative dominance of the workplace organization practices is confirmed by the overall effects of the groups of practices as measured by the three factors that were extracted from the data by factor analysis.

Finally, we find cumulative effects of the use of HRM practices on innovation. First, from a certain threshold on, the effect on innovation is larger, the larger the number of *individual practices* a firm has introduced and used intensively. Second, also from a certain threshold on, the effect on innovation is larger, the larger the number of *groups of practices* a firm has introduced and used intensively. These cumulative effects demonstrate the potential of such practices that can be exploited by firms in order to increase their performance.

On the whole, our study contributes to literature in three ways, first, through the use of detailed information on a broad spectrum of HRM practices; second, by focusing on the effects on innovation, which is a rather under-researched topic; and third, through the identification of cumulative effects of the use of such practices on innovation. Of course, there are also drawbacks, the most important one being, as already mentioned, that we cannot identify causal links, thus, letting open the possibility that the reverse causality holds, namely that innovative firms are more likely to adopt an innovative workplace organization and not the other way around.

References

Acemoglu, D., P. Aghion, C. Lelarge, J. Van Reenen, and F. Zilibotti (2007), Technology, information, and the decentralization of the firm, *Quarterly Journal of Economics*, 122(4), 1759–99.

Agresti, A. (1996), An introduction to categorical data analysis. Wiley, London.

Arvanitis, S. (2005), Modes of labour flexibility at firm level: Are there any implications for performance and innovation? Evidence for the Swiss economy, *Industrial and Corporate Change*, 14(6), 1-24.

Arvanitis, S., E.N. Loukis, and V. Diamantopoulou (2013), Are ICT, Workplace Organization and Human Capital Relevant for Innovation? A Comparative Study Based on Swiss and Greek Micro Data, *KOF Working Papers No. 333*, Zurich.

Azoulay, P. and J. Lerner (2013), Technological innovation and organizations, in: Gibbons, R. and J. Roberts (ed.): Handbook of Organizational Economics, Princeton University Press, pp. 575-603.

Black, S.E. and L.M. Lynch (2001), How to compete: The impact of workplace practices and information technology on productivity, *The Review of Economics and Statistics*, 83(3), 434-445.

Bloom, N. and J. Van Reenen (2007), Measuring and explaining management practices across firms and countries, *Quarterly Journal of Economics*, 122(4), 1351-1408.

Bloom, N. and J. Van Reenen (2010), Why do management practices differ across firms and countries?, *Journal of Economic Perspectives*, 24(1), 203-224.

Bloom, N., R. Sadun, and J. Van Reenen (2010), Recent advances in the empirics of organizational economics, *CEP Discussion Paper No 970,* London.

Boning, B., C. Ichniowski, and K. Shaw (2001), Opportunity counts: Teams and the effectiveness of production incentives, *NBER Working Paper Series 8306*, Cambridge, Mass.

Bresnahan, T.F., E. Brynjolfsson, and L.M. Hitt (2002), Information technology, workplace organization, and the demand for skilled labor: firm-level evidence, *Quarterly Journal of Economics*, 117(1), 339-376.

Briody, B. (2012), The new workplace trend: goof off to get ahead, *The Fiscal Times*, April 25.

Cassiman, B. and R. Veugelers (2002), R&D cooperation and spillovers: Some empirical evidence from Belgium, *American Economic Review*, 92(4), 1169–1184.

Chang, Y.-C., H.-T. Chang, H.-R Chi, M.-H. Chen, and L.-L. Deng (2012), How do established firms improve radical innovation performance? The organizational capabilities view, *Technovation*, 32, 441-451.

Cohen, W. M. (2010), Fifty years of empirical studies of innovative activity and performance, in: B.H. Hall and N. Rosenberg (Eds.), Handbook of the economics of innovation, volume 1, Elsevier B.V., Amsterdam, pp. 129-213.

Cosh, A., X. Fu, and A. Hughes (2012), Organization structure and innovation performance in different environments, *Small Business Economics*, 39, 301-317.

Foss, N.F. and K. Laursen (2005), Performance pay, delegation and multitasking under uncertainty and innovativeness: An empirical investigation, *Journal of Economic Behavior & Organization*, 58, 246-276.

Gibbons, R. (1998), Incentives in organizations, *Journal of Economic Perspectives*, 12(4), 115-132.

Heckman, J.J. (1979), Sample selection bias as a specification error, *Econometrica*, 47, 153–161.

Hempel, T. and T. Zwick (2008), New technology, work organization, and innovation, *Economics of Innovation and New Technology*, 17(4), 331-354.

Holmström, B. (1989), Agency costs and innovation, *Journal of Economic Behavior and Organization*, 12, 305-327.

Huergo, E. and J. Jaumandreu (2004), How does probability of innovation change with firm age?, *Small Business Economics*, 22, 193-207.

Huselid, M.A. (1995), The impact of human resource management practices on turnover, productivity, and corporate financial performance, *Academy of Management Journal*, 38(3), 635-872.

Ichniowski, C., K. Shaw, G. Prennushi (1995), The effects of human resource management practices on productivity, *NBER Working Paper Series 5333,* Cambridge, Mass.

Ichniowski, C., K. Shaw, G. Prennushi (1997), The effects of human resource management practices on productivity: A study of steel finishing lines, *The American Economic Review*, 87(3), 291-313.

Ichniowski, C. and K. Shaw (2003), Beyond incentive pay: Insiders' estimates of the value of complementary human resource management practices, *Journal of Economic Perspectives*, 17(1), 155-180.

Jiang, J., S. Wang, S. Zhao (2013), Does HRM facilitate employee creativity and organizational innovation? A study of Chinese firms, *The International Journal of Human Resource Management*, 23(19), 4025-4047.

Jensen, M.C. and W.H. Meckling (1995), Specific and general knowledge, and organizational structure, *Journal of Applied Corporate Finance*, 8, 4-18.

Koski, H., L. Marengo, and I. Mäkinen (2012), Firm size, managerial practices and innovativeness: some evidence from Finnish manufacturing, *International Journal of Technology Management*, 59(1/2), 92-115.

Laursen, K. and N.F. Foss (2003), New human resource management practices, complementarities and the impact on innovation performance, *Cambridge Journal of Economics*, 27, 243-263.

Menard, S. (2011), Standards for standardized logistic regression coefficients, *Social Forces,* 89(4): 1409-1428.

Michie, J. and M. Sheehan (1999), HRM practices, R&D expenditure and innovative investment: Evidence from the UK's 1990 Workplace Industrial Relations Survey, *Industrial and Corporate Change*, 8, 211-234.

Mookherjee, D. (2006), Decentralization, hierarchies, and incentives: A mechanism design perspective, *Journal of Economic Literature*, 44(2), 367-390.

Murphy, K.J. (1999), Executive compensation, in: O. Ashenfelter and D.E. Card (eds.), Handbook of Labor Economics, Ch. 38, Vol. 3b, Elsevier Science, North-Holland, New York and Oxford, pp. 2485-2563.

Shipton, H., D. Fay, M. West, M. Patterson, and K. Birdi (2005), Managing people to promote innovation, *Creativity and Innovation Management*, 14(2), 118-128.

Shipton, H., M. West, J. Dawson, K. Birdi, and M. Patterson (2006), HRM as a predictor of innovation, *Human Resource Management Journal*, 16(1), 3-27.

Vinding, A.L. (2006): Absorptive capacity and innovative performance: A human capital approach, *Economics of Innovation and New Technology*, 15(4-5), 507-517.

Wooldridge, J.M. (2002), Econometric Analysis of Cross Section and Panel Data, MIT Press, Cambridge, Massachusetts, London, England.

Zhou, H., R. Dekker, and A. Kleinknecht (2011), Flexible labor and innovation performance: evidence from longitudinal firm-level data, *Industrial and Corporate Change*, 20(3), 941-968.

Zoghi, C., R.D. Mohr, and P.B. Meyer (2010), Workplace organization and innovation, *Canadian Journal of Economics*, 43(2), 622-639.

Table 1: Definition and measurement of model variables

Variable	Definition/ measurement
Dependent variables	
Innovation yes/no	Firm has product and/or process innovation yes/no
Sales of innovative products	Sales of new or significantly improved products, ln (only firms having innovation activities)
Independent variables	
Workplace organization	
functional_flexibility	Share of employees that switched function or department, ln
team_work_extent	Incidence of teamwork (six-level ordinal variable, ranging from 'very high' (value 5) to 'does not exist' (value 0))
job_rotation_extent	Incidence of job rotation (six-level ordinal variable, ranging from 'very high' (value 5) to 'does not exist' (value 0))
decentralization_extent	Degree of decentralization of competencies (mean of *seven* ordinal variables ranging from 'line manager decides alone' up to 'employee decides alone'; 5-point scale: 1) speed of work, 2) procedures of work, 3) distribution of tasks, 4) modality of the execution of tasks, 5) problems in production, 6) regular contact with clients, 7) complaints of clients)
Δ_hierarchical_levels	Change of the number of hierarchical levels in the preceding five years (decrease (value 1); otherwise (value 0))
Working time management	
work_schedule_flexibility	Incidence of work schedule flexibility (mean of *three* ordinal variables ranging from 'low importance' up to 'high importance'; 5-point scale: flexibility on 1) monthly basis, 2) yearly basis, 3) between years)
part_time_employment_extent	Incidence of part-time work (five-level ordinal variable, ranging from 'high importance' (value 5) to 'low importance' (value 0))
temporary_employment_extent	Incidence of temporary work (five-level ordinal variable, ranging from 'high importance' (value 5) to 'low importance' (value 0))
Incentive payment schemes	
individual_performance_salary	Dependency of the wage level on individual performance (five-level ordinal variable, ranging from 'high importance' (value 5) to 'low importance' (value 0))
group_performance_salary	Dependency of the wage level on workgroup performance (five-level ordinal variable, ranging from 'high importance' (value 5) to 'low importance' (value 0))
firm_performance_salary	Dependency of the wage level on firm performance (five-level ordinal variable, ranging from 'high importance' (value 5) to 'low importance' (value 0))
Training intensity	
further_training_intensity	Share of employees taking part in continued training, ln
Control variables	

tertiary_share	Share of employees with a tertiary-level degree, ln
ict_share	Share of ICT related investments in total investments, ln
demand_development	Expected development of a firm's specific demand in the next three years (five-level ordinal variable (level 1: 'strong decrease'; 5; 'strong increase'); referring to survey year)
price_competition_intensity	Intensity of price competition (five-level ordinal variable, ranging from 'very weak' (value 1) to 'very strong' (value 5))
nonprice_competition_intensity	Intensity of non-price competition (five-level ordinal variable, ranging from 'very weak' (value 1) to 'very strong' (value 5))
firm_age	Firm age, ln
firm_size	Number of employees, ln
regulated_access_Swiss_market	Average industry (3-digit-level) score of the relevance of limited access to strongly regulated markets in Switzerland for a firms' innovation activities (original variable is defined as a five-level ordinal variable (level 1: 'very weak'; level 5: 'very strong')
Industry specific time fixed effects	Industry-time dummies for 31 industries and 3 cross-sections

Note: ln: natural logarithm.

Table 2: Estimates of the innovations equations (random-effects models)

	Innovation yes/no		Sales of innovative products	
	normal	standardized	Normal	standardized
	(1)	(2)	(3)	(4)
Workplace organization				
functional_flexibility	0.227***	0.204***	0.123***	0.110***
	(0.037)	(0.033)	(0.035)	(0.031)
team_work_extent	0.095***	0.162***	0.018	0.031
	(0.020)	(0.033)	(0.017)	(0.029)
job_rotation_extent	0.129***	0.147***	0.010	0.012
	(0.030)	(0.034)	(0.020)	(0.023)
decentralization_extent	0.267***	0.150***	0.143***	0.080***
	(0.059)	(0.033)	(0.048)	(0.027)
Δ_hierarchical_levels	0.081	0.021	0.041	0.011
	(0.120)	(0.032)	(0.079)	(0.021)
Working time management				
work_schedule_flexibility	0.052*	0.058*	-0.026	-0.029
	(0.029)	(0.033)	(0.022)	(0.025)
part_time_employment_extent	0.036	0.041	-0.021	-0.024
	(0.031)	(0.035)	(0.024)	(0.027)
temporary_employment_extent	0.010	0.012	-0.002	-0.002
	(0.028)	(0.034)	(0.021)	(0.026)
Incentive payment schemes				
individual_performance_salary	0.011	0.009	0.027	0.023
	(0.041)	(0.035)	(0.032)	(0.028)
group_performance_salary	-0.010	-0.012	-0.012	-0.014
	(0.031)	(0.036)	(0.023)	(0.027)
firm_performance_salary	-0.034	-0.037	0.046*	0.050*
	(0.032)	(0.035)	(0.024)	(0.026)
Training intensity				
further_training_intensity	0.049	0.057	0.055**	0.063**
	(0.032)	(0.037)	(0.025)	(0.029)
Control variables				
tertiary_share	0.080**	0.091**	0.157***	0.179***
	(0.039)	(0.045)	(0.033)	(0.038)
ict_share	0.096***	0.103***	0.056**	0.060**
	(0.032)	(0.035)	(0.027)	(0.029)
demand_development	0.122***	0.105***	0.024	0.021
	(0.037)	(0.032)	(0.028)	(0.024)
price_competition_intensity	0.067**	0.069**	0.044*	0.046*
	(0.032)	(0.033)	(0.027)	(0.027)
nonprice_competition_intensity	0.109***	0.101***	0.086***	0.080***
	(0.032)	(0.030)	(0.026)	(0.024)
firm_age	0.017	0.014	-0.143***	-0.124***
	(0.040)	(0.035)	(0.031)	(0.027)
firm_size	0.176***	0.260***	1.055***	1.556***
	(0.032)	(0.047)	(0.026)	(0.039)
inverse_mills_ratio			0.132	0.132
			(0.194)	(0.194)
_cons	-4.017***	0.053	10.463***	16.142***
	(1.030)	(0.956)	(1.198)	(1.095)
Industry specific time fixed effects	yes	yes	yes	yes
N	4480	4480	2311	2311
Number of groups	2810	2810	1640	1640
Wald chi2	427.52***	427.52***	3232.51***	3232.51***
Log Likelihood	-2265.30	-2265.30		
r2_within			0.1228	0.1228
r2_between			0.6603	0.6603
r2_overall			0.6472	0.6472

Notes: random effects estimates; all models include industry-time fixed effects.

Table 3: Factor analysis: rotated factor loadings and unique variance

	Factor1	Factor2	Factor3	Uniqueness
functional_flexibility	0.118	**0.635**	0.111	0.570
team_work_extent	0.253	**0.564**	0.080	0.612
job_rotation_extent	0.235	**0.216**	0.068	0.893
decentralization_extent	-0.188	**0.586**	-0.058	0.618
Δ_hierarchical_levels	0.086	**0.173**	0.037	0.961
work_schedule_flexibility	0.214	0.061	**0.657**	0.519
part_time_employment_extent	-0.008	0.202	**0.645**	0.544
temporary_employment_extent	0.027	-0.084	**0.772**	0.397
individual_performance_salary	**0.673**	0.022	0.063	0.543
group_performance_salary	**0.760**	0.090	0.109	0.402
firm_performance_salary	**0.774**	-0.003	0.017	0.402
further_training_intensity	0.030	**0.680**	0.001	0.536
Statistics:				
Kaiser-Meyer-Olkin measure of sampling adequacy:	0.69			
Variance explained by each factor:	0.15	0.14	0.12	
Eigenvalue:	2.28	1.46	1.26	

Table 4: Estimates of the innovation equations with factors obtained from factor analysis (random-effects models)

	Innovation yes/no	Sales of innovative products
	(1)	(2)
Factors		
factor1 (incentive payment schemes)	0.051	0.042*
	(0.031)	(0.024)
factor2 (workplace organization)	0.403***	0.160***
	(0.038)	(0.040)
factor3 (working time management)	0.109***	-0.027
	(0.032)	(0.025)
Control variables		
tertiary_share	0.077*	0.160***
	(0.039)	(0.033)
ict_share	0.092***	0.057**
	(0.032)	(0.026)
demand_development	0.121***	0.020
	(0.037)	(0.028)
price_competition_intensity	0.067**	0.046*
	(0.032)	(0.026)
nonprice_competition_intensity	0.108***	0.087***
	(0.032)	(0.026)
firm_age	0.015	-0.148***
	(0.040)	(0.031)
firm_size	0.181***	1.051***
	(0.032)	(0.026)
inverse mills ratio		0.076
		(0.196)
_cons	-2.143**	11.442***
	(0.979)	(1.148)
Industry specific time-fixed effects	yes	yes
N	4480	2311
Number of groups	2810	1640
Wald chi2	417.26***	3211.03***
Log Likelihood	-2276.98	
r2_within		0.1208
r2_between		0.6582
r2_overall		0.6455

Table 5: Estimates of the innovation equations with HRM systems (random-effects models)

	Innovation yes/no	Sales of innovative products
	(1)	(2)
HRM systems		
hrm_system_2	0.326***	0.046
	(0.086)	(0.080)
hrm_system_3	0.631***	0.127
	(0.094)	(0.093)
hrm_system_4	0.766***	0.215**
	(0.111)	(0.104)
Control variables		
tertiary_share	0.138***	0.188***
	(0.039)	(0.034)
ict_share	0.117***	0.069**
	(0.032)	(0.027)
demand_development	0.131***	0.026
	(0.037)	(0.029)
price_competition_intensity	0.067**	0.046*
	(0.032)	(0.027)
nonprice_competition_intensity	0.113***	0.092***
	(0.032)	(0.026)
firm_age	0.005	-0.149***
	(0.041)	(0.031)
firm_size	0.227***	1.060***
	(0.031)	(0.029)
imr_inno		0.145
		(0.222)
_cons	-3.059***	11.047***
	(0.983)	(1.192)
Industry specific time-fixed effects	yes	yes
N	4480	2311
Number of groups	2810	1640
Wald chi2	399.48***	3132.72***
Log Likelihood	-2314.48	
r2_within		0.1260
r2_between		0.6519
r2_overall		0.6394

Tabelle 6: Estimates of the innovation equations with HRM blocs (random-effects models)

	Innovation yes/no	Sales of innovative products
	(1)	(2)
Blocs		
bloc_1	0.206	-0.232
	(0.333)	(0.350)
bloc_2	0.514	-0.024
	(0.317)	(0.334)
bloc_3	0.755**	-0.035
	(0.315)	(0.338)
bloc_4	0.929***	0.125
	(0.317)	(0.342)
Control variables		
tertiary_share	0.127***	0.176***
	(0.037)	(0.034)
ict_share	0.122***	0.048*
	(0.031)	(0.028)
demand_development	0.116***	0.029
	(0.036)	(0.028)
price_competition_intensity	0.064**	0.039
	(0.031)	(0.026)
nonprice_competition_intensity	0.122***	0.091***
	(0.032)	(0.026)
firm_age	0.009	-0.124***
	(0.039)	(0.030)
firm_size	0.236***	1.049***
	(0.031)	(0.030)
inverse mills ratio		0.019
		(0.239)
_cons	-3.302***	11.256***
	(1.023)	(1.273)
Industry specific time-fixed effects	yes	yes
N	4739	2431
Number of groups	2928	1702
Wald chi2	418.85***	3256.99***
Log Likelihood	-2476.83	
		0.1244
		0.6493
		0.6416

Appendix

Table A.1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.
Innovation variables			
innovation yes/no	4480	0.640625	0.479871
sales of innovative products	2313	16.04637	1.77314
Workplace organization			
functional_flexibility	4480	1.956402	0.902226
team_work_extent	4480	3.253571	1.697742
job_rotation_extent	4480	1.503348	1.148686
decentralization_extent	4480	2.391295	0.565046
Δ_hierarchical_levels	4480	0.073438	0.260882
Working time management			
work_schedule_flexibility	4480	2.564583	1.123954
part_time_employment_extent	4480	2.808482	1.111116
temporary_employment_extent	4480	2.452679	1.237031
Incentive payment schemes			
individual_performance_salary	4480	4.252076	0.804939
group_performance_salary	4480	2.822522	1.139801
firm_performance_salary	4480	3.501473	1.074878
Training intensity			
further_training_intensity	4480	2.933298	1.078648
Control variables			
tertiary_share	4480	2.758506	0.919129
ict_share	4480	2.558463	1.027606
demand_development	4480	3.180134	0.843349
price_competition_intensity	4480	3.980804	0.992082
nonprice_competition_intensity	4480	3.091295	0.972686
firm_age	4480	3.873484	0.834696
firm_size	4480	4.715039	1.186865

Table A.2: Correlation matrix

	Innovation yes/no	func-tional_ flexibility	team_ work_ extent	job_rota-tion_ extent	Decentra-lization_ extent	Δ_hierar-chical_ levels	work_ schedule_ flexibility	part_time_ employ-ment_ extent	temporary_ employment_ extent	individual_ perfor-mance_ salary
functional_flexibility	0.2029									
team_work_extent	0.2064	0.2151								
job_rotation_extent	0.1367	0.1543	0.1547							
decentralization_extent+	0.1396	0.1353	0.147	-0.0542						
Δ_hierarchical_levels	0.0521	0.1005	0.0331	0.0606	0.051					
work_schedule_flexibility	0.0962	0.1234	0.1145	0.0971	-0.023	0.0499				
part_time_employment_ extent	0.0576	0.1086	0.0948	0.0479	0.1108	0.0285	0.2036			
temporary_employment_ extent	0.0579	0.0545	0.0783	0.0261	-0.0612	0.0208	0.2718	0.2304		
individual_performance_salary	0.0486	0.0796	0.0943	0.0608	-0.0328	0.0352	0.1282	0.0942	0.0756	
group_performance_salary	0.0594	0.136	0.2157	0.1013	-0.0128	0.0526	0.2047	0.1034	0.0976	0.3319
firm_performance_salary	0.036	0.0838	0.1316	0.0903	-0.0372	0.0596	0.1519	0.0702	0.0585	0.3271
further_training_intensity	0.0946	0.2742	0.2295	0.0588	0.1868	0.0202	0.0728	0.1001	-0.0114	0.1043
tertiary_share	0.1662	0.2169	0.2263	0.0027	0.2186	0.0102	0.0576	0.0161	0.0336	0.025
ict_share	0.0958	0.1507	0.1019	-0.0156	0.1593	0.0211	-0.0002	0.0654	-0.0438	0.0682
demand_development	0.101	0.0545	0.0819	0.0269	0.0499	-0.0064	-0.0085	0.0025	-0.0264	0.0067
price_competition_intensity	0.0483	0.0672	0.0395	0.0112	-0.0289	0.0287	0.0759	-0.0084	0.1097	0.1133
nonprice_competition_intensity	0.1449	0.1014	0.0933	0.013	0.0952	-0.0018	0.0234	0.1011	0.0111	0.0681
firm_age	-0.0019	-0.059	-0.0321	0.0133	-0.0037	0.0129	0.0333	0.0107	-0.0089	-0.0003
firm_size	0.1576	0.1528	0.2318	0.0094	0.1614	0.0156	0.1136	0.126	0.2212	-0.023

	group_per-formance_ salary	firm_per-formance_ salary	further_ training_ intensity	tertiary_ share	ict_share	demand_ develop-ment	price_compe-tition_ intensity	nonprice_ compe-tition_ intensity	firm_age
firm_performance_salary	0.4347								
further_training_intensity	0.0506	0.0262							
tertiary_share	0.0818	0.0898	0.2349						
ict_share	0.0649	0.0786	0.1486	0.2325					
demand_development	0.0181	-0.0068	0.0775	0.0788	0.0257				
price_competition_intensity	0.0617	0.0749	0.0134	-0.0236	0.0182	-0.101			
nonprice_competition_intensity	0.0775	0.0935	0.0431	0.1045	0.0844	0.0855	0.0349		
firm_age	-0.0209	-0.0294	-0.0237	-0.0353	-0.0428	-0.0602	0.0571	-0.0249	
firm_size	0.017	-0.0504	0.1271	0.1403	0.0336	0.0704	0.0287	0.0949	0.102

Table A.3: Appropriateness test of the instrument used in the Heckman selection model

	Sales of innovative products (1)	Innovation yes/no (2)
Workplace organization		
functional_flexibility	0.110***	0.231***
	(0.030)	(0.037)
team_work_extent	0.013	0.096***
	(0.015)	(0.020)
job_rotation_extent	0.005	0.128***
	(0.019)	(0.030)
decentralization_extent	0.130***	0.270***
	(0.046)	(0.059)
Δ_hierarchical_levels	0.037	0.084
	(0.079)	(0.120)
Working time management		
work_schedule_flexibility	-0.028	0.052*
	(0.022)	(0.030)
part_time_employment_extent	-0.022	0.032
	(0.024)	(0.031)
temporary_employment_extent	-0.002	0.014
	(0.021)	(0.028)
Incentive pay		
individual_performance_salary	0.027	0.011
	(0.032)	(0.041)
group_performance_salary	-0.011	-0.008
	(0.023)	(0.031)
firm_performance_salary	0.047*	-0.036
	(0.024)	(0.032)
Training intensity		
further_training_intensity	0.053**	0.051
	(0.025)	(0.032)
Control variables		
tertiary_share	0.153***	0.075*
	(0.032)	(0.039)
ict_share	0.050*	0.097***
	(0.026)	(0.032)
demand_development	0.020	0.122***
	(0.027)	(0.037)
price_competition_intensity	0.040	0.066**
	(0.026)	(0.032)
nonprice_competition_intensity	0.081***	0.108***
	(0.025)	(0.032)
firm_age	-0.142***	0.012
	(0.031)	(0.040)
firm_size	1.047***	0.176***
	(0.023)	(0.032)
regulated_access_Swiss_market	-0.078	0.312**
	(0.083)	(0.122)
_cons	10.840***	-4.406***
	(1.128)	(1.042)
Industry specific time fixed effects	yes	yes
N	2311	4477
Number of groups	1640	2807
Wald chi2	3228.25***	427.67***
Log Likelihood		-2257.69
r2_within	0.1255	
r2_between	0.6598	
r2_overall	0.6471	

Table A.4: Estimates of innovative activity with HRM dummy variables (random-effects models)

	Innovation yes/no	Sales of innovative products
	(1)	(2)
Workplace organization		
functional_flexibilit_d	0.424***	0.131**
	(0.065)	(0.054)
team_work_extent_d	0.178**	0.091*
	(0.075)	(0.051)
job_rotation_extent_d	0.432***	0.06
	(0.087)	(0.06)
decentralization_extent	0.195***	0.093*
	(0.065)	(0.049)
Δ_hierarchical_levels_d	0.087	0.061
	(0.120)	(0.079)
Working time management		
work_schedule_flexibility_d	0.019	-0.021
	(0.063)	(0.047)
part_time_employment_extent_d	0.101	-0.087
	(0.075)	(0.054)
temporary_employment_extent_d	0.064	0.013
	(0.067)	(0.048)
Incentive pay		
individual_performance_salary_d	-0.034	0.043
	(0.064)	(0.047)
group_performance_salary_d	0.062	0.002
	(0.069)	(0.05)
firm_performance_salary_d	-0.010	0.003
	(0.080)	(0.057)
Training intensity		
further_training_intensity_d	0.322***	0.229**
	(0.114)	(0.103)
Control variables		
tertiary_share	0.114***	0.177***
	(0.039)	(0.034)
ict_share	0.105***	0.064**
	(0.033)	(0.027)
demand_development	0.123***	0.024
	(0.037)	(0.028)
price_competition_intensity	0.073**	0.045*
	(0.033)	(0.027)
nonprice_competition_intensity	0.115***	0.089***
	(0.033)	(0.026)
firm_age	0.017	-0.145***
	(0.041)	(0.031)
firm_size	0.221***	1.055***
	(0.032)	(0.028)
inverse mills ratio		0.104
		(0.201)
_cons	-3.325***	10.857***
	(1.000)	(1.184)
Industry specific time fixed effects	yes	yes
N	4480	2311
Number of groups	2810	1640
Wald chi2	412.66***	3177.19***
Log Likelihood	-2284.18	
r2_within		0.1259
r2_between		0.656
r2_overall		0.6435

Table A.5: Separate estimates for the propensity of product and process innovation (random-effects models)

	Product innovation yes/no	Process innovation yes/no
	(1)	(2)
Workplace organization		
functional_flexibility	0.216***	0.250***
	(0.038)	(0.034)
team_work_extent	0.075***	0.106***
	(0.020)	(0.018)
job_rotation_extent	0.123***	0.119***
	(0.030)	(0.025)
decentralization_extent	0.316***	0.153***
	(0.062)	(0.054)
Δ_hierarchical_levels	-0.003	0.022
	(0.121)	(0.102)
Working time management		
work_schedule_flexibility	0.034	0.072***
	(0.030)	(0.026)
part_time_employment_extent	0.049	-0.007
	(0.033)	(0.028)
temporary_employment_extent	-0.012	0.010
	(0.029)	(0.025)
Incentive pay		
individual_performance_salary	-0.013	0.049
	(0.042)	(0.037)
group_performance_salary	0.024	0.021
	(0.032)	(0.027)
firm_performance_salary	-0.010	-0.035
	(0.033)	(0.029)
Training intensity		
further_training_intensity	0.034	0.024
	(0.033)	(0.029)
Control variables		
tertiary_share	0.129***	0.020
	(0.042)	(0.036)
ict_share	0.061*	0.029
	(0.034)	(0.029)
demand_development	0.121***	0.032
	(0.038)	(0.033)
price_competition_intensity	0.086**	0.051*
	(0.034)	(0.029)
nonprice_competition_intensity	0.174***	0.057**
	(0.034)	(0.029)
firm_age	-0.006	-0.035
	(0.042)	(0.036)
firm_size	0.170***	0.191***
	(0.033)	(0.028)
_cons	-5.265***	-3.090***
	(1.136)	(0.980)
Industry specific time fixed effects	yes	yes
N	4480	4480
Number of groups	2810	2810
Wald chi2	431.72***	407.66***
Log Likelihood	-2331.44	-2633.91

Table A.6: Separate estimates for each single working time management practice

	Innovation yes/no			Sales of innovative products		
	(1)	(2)	(3)	(4)	(5)	(6)
Workplace organization						
functional_flexibility	0.229***	0.232***	0.233***	0.107***	0.105***	0.105***
	(0.037)	(0.037)	(0.037)	(0.030)	(0.029)	(0.029)
team_work_extent	0.096***	0.096***	0.097***	0.012	0.011	0.011
	(0.020)	(0.020)	(0.020)	(0.015)	(0.015)	(0.015)
job_rotation_extent	0.129***	0.132***	0.133***	0.004	0.003	0.003
	(0.030)	(0.030)	(0.030)	(0.019)	(0.019)	(0.019)
decentralization_extent	0.268***	0.262***	0.268***	0.129***	0.133***	0.130***
	(0.059)	(0.059)	(0.059)	(0.046)	(0.046)	(0.046)
Δ_hierarchical_levels	0.083	0.088	0.089	0.042	0.038	0.038
	(0.120)	(0.120)	(0.120)	(0.079)	(0.079)	(0.079)
Working time management						
work_schedule_flexibility	0.061**			-0.034		
	(0.028)			(0.021)		
part_time_employment_extent		0.050*			-0.025	
		(0.030)			(0.022)	
temporary_employment_extent			0.029			-0.014
			(0.026)			(0.020)
Incentive pay						
individual_performance_salary	0.014	0.013	0.015	0.022	0.021	0.021
	(0.041)	(0.041)	(0.041)	(0.032)	(0.032)	(0.032)
group_performance_salary	-0.009	-0.004	-0.002	-0.009	-0.013	-0.013
	(0.030)	(0.030)	(0.030)	(0.023)	(0.023)	(0.023)
firm_performance_salary	-0.034	-0.031	-0.032	0.045*	0.043*	0.043*
	(0.032)	(0.032)	(0.032)	(0.024)	(0.024)	(0.024)
Training intensity						
further_training_intensity	0.049	0.052	0.054*	0.055**	0.056**	0.054**
	(0.032)	(0.032)	(0.032)	(0.025)	(0.025)	(0.025)
Control variables						
tertiary_share	0.079**	0.082**	0.080**	0.155***	0.153***	0.153***
	(0.039)	(0.039)	(0.039)	(0.032)	(0.032)	(0.032)
ict_share	0.095***	0.095***	0.094***	0.050*	0.050**	0.050*
	(0.032)	(0.032)	(0.032)	(0.026)	(0.026)	(0.026)
demand_development	0.120***	0.123***	0.122***	0.020	0.021	0.020
	(0.037)	(0.037)	(0.037)	(0.027)	(0.027)	(0.027)
price_competition_intensity	0.067**	0.069**	0.067**	0.041	0.042	0.042
	(0.032)	(0.032)	(0.032)	(0.026)	(0.026)	(0.026)
nonprice_competition_intensity	0.111***	0.108***	0.111***	0.079***	0.080***	0.080***
	(0.032)	(0.032)	(0.032)	(0.025)	(0.025)	(0.025)
firm_age	0.017	0.017	0.020		-0.145***	-0.147***
	(0.040)	(0.040)	(0.040)	(0.031)	(0.031)	(0.031)
firm_size	0.181***	0.183***	0.180***	1.048***	1.046***	1.048***
	(0.031)	(0.031)	(0.032)	(0.023)	(0.022)	(0.023)
_cons	-3.979***	-3.977***	-3.973***	10.747***	10.689***	10.686***
	(1.031)	(1.022)	(1.023)	(1.125)	(1.124)	(1.125)
Industry specific time fixed effects	yes	yes	yes	yes	yes	yes
N	4480	4480	4480	2313	2313	2313
Number of groups	2810	2810	2810	1642	1642	1642
Wald chi2	427.12***	425.83***	423.87***	3212.89***	3207.73***	3203.57***
Log Likelihood	-2266.21	-2267.05	-2267.87			
r2_within				0.1257	0.1247	0.1259
r2_between				0.6577	0.6577	0.6573
r2_overall				0.6455	0.6452	0.6450

Table A.7: Separate estimates for each single incentive payment scheme

	Innovation yes/no			Sales of innovative products		
	(1)	(2)	(3)	(4)	(5)	(6)
Workplace organization						
functional_flexibility	0.226***	0.227***	0.227***	0.107***	0.107***	0.107***
	(0.037)	(0.037)	(0.037)	(0.029)	(0.030)	(0.029)
team_work_extent	0.092***	0.095***	0.094***	0.014	0.013	0.011
	(0.019)	(0.020)	(0.019)	(0.015)	(0.015)	(0.015)
job_rotation_extent	0.128***	0.128***	0.129***	0.005	0.006	0.004
	(0.030)	(0.030)	(0.030)	(0.019)	(0.019)	(0.019)
decentralization_extent	0.271***	0.270***	0.267***	0.129***	0.127***	0.130***
	(0.059)	(0.059)	(0.059)	(0.046)	(0.046)	(0.046)
Δ_hierarchical_levels	0.074	0.076	0.080	0.046	0.045	0.040
	(0.120)	(0.120)	(0.120)	(0.079)	(0.079)	(0.079)
Working time management						
work_schedule_flexibility	0.047	0.050*	0.051*	-0.027	-0.027	-0.030
	(0.029)	(0.029)	(0.029)	(0.022)	(0.022)	(0.022)
part_time_employment_extent	0.036	0.037	0.036	-0.017	-0.017	-0.017
	(0.031)	(0.031)	(0.031)	(0.024)	(0.024)	(0.024)
temporary_employment_extent	0.009	0.009	0.010	-0.003	-0.002	-0.003
	(0.028)	(0.028)	(0.028)	(0.021)	(0.021)	(0.021)
Incentive pay						
individual_performance_salary	-0.007			0.035		
	(0.038)			(0.030)		
group_performance_salary		-0.020			0.010	
		(0.028)			(0.021)	
firm_performance_salary			-0.036			0.046**
			(0.029)			(0.022)
Training intensity						
further_training_intensity	0.051	0.050	0.050	0.054**	0.057**	0.058**
	(0.032)	(0.031)	(0.031)	(0.025)	(0.025)	(0.025)
Control variables						
tertiary_share	0.078**	0.078**	0.080**	0.158***	0.157***	0.153***
	(0.039)	(0.039)	(0.039)	(0.032)	(0.032)	(0.032)
ict_share	0.094***	0.095***	0.096***	0.051**	0.052**	0.051**
	(0.032)	(0.032)	(0.032)	(0.026)	(0.026)	(0.026)
demand_development	0.121***	0.122***	0.122***	0.022	0.021	0.021
	(0.037)	(0.037)	(0.037)	(0.027)	(0.027)	(0.027)
price_competition_intensity	0.066**	0.066**	0.067**	0.042	0.043*	0.043*
	(0.032)	(0.032)	(0.032)	(0.026)	(0.026)	(0.026)
nonprice_competition_intensity	0.107***	0.108***	0.109***	0.082***	0.082***	0.080***
	(0.032)	(0.032)	(0.032)	(0.025)	(0.025)	(0.025)
firm_age	0.018	0.017	0.017	-0.145***	-0.145***	-0.143***
	(0.040)	(0.040)	(0.040)	(0.031)	(0.031)	(0.031)
firm_size	0.179***	0.178***	0.176***	1.043***	1.042***	1.046***
	(0.032)	(0.032)	(0.032)	(0.023)	(0.023)	(0.023)
_cons	-4.091***	-4.060***	-3.999***	10.850***	10.960***	10.826***
	(1.028)	(1.021)	(1.023)	(1.125)	(1.121)	(1.121)
Industry specific time fixed effects	yes	yes	yes	yes	yes	yes
N	4480	4480	4480	2313	2313	2313
Number of groups	2810	2810	2810	1642	1642	1642
Wald chi2	426.47***	426.59***	427.58***	3203.27***	3199.25***	3210.66***
Log Likelihood	-2266.11	-2265.86	-2265.38			
r2_within				0.1228	0.1235	0.1249
r2_between				0.6576	0.6573	0.6580
r2_overall				0.6453	0.6450	0.6455