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Combining knowledge stock and knowledge flow to generate superior incremental innovation performance – Evidence from Swiss manufacturing

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Abstract

Firms generate new knowledge that leads to innovations by recombining existing knowledge sources. A successful recombination depends on the availability of a knowledge stock (human capital pool) and the flow of knowledge within the firm (induced by HRM systems). While human resource theory expects complementarities between human capital pools and HRM systems, it does not explicitly address how knowledge exchange may be guaranteed or fostered. Moreover, empirical approaches neglect the complexity of such complementarities. In this study we develop a model that integrates a firm's knowledge stock and flow into a knowledge creation (KC) system comprising four ideal types. This system explains the occurrence of superior incremental innovation performance. We empirically analyze the KC system by applying fuzzy set qualitative comparative analysis (fsQCA) and identify configurations concurring with our ideal types. The results show that the use of human capital and HRM practices depends on firm size and industry dynamism.

Keywords: Human resource management; Human capital; Innovation; Fuzzy set qualitative comparative analysis (fsQCA)

1. Introduction

Firms generate innovations through recombinations of existing knowledge sources (Kogut & Zander, 1992). The quality and quantity of these recombinations depend on a firm's stock and flow of knowledge. As the human capital of employees contains knowledge and skills relevant for innovation, this capital is an important part of a firm's knowledge stock (Wright, McMahan, & McWilliams, 1994; Wright, Dunfold, & Snell, 2001). The human resource management (HRM) system comprises human resource practices that affect both the organization of work and workers' behavior, thereby initiating and regulating the knowledge flow between workers (Wright et al., 1994; Wright et al., 2001). Both human capital pools and HRM systems build on the notion that complementarities exist between different types and levels of skills and different HRM practices, respectively. Wright et al. (1994) and Wright et al. (2001) point out that complementarities also occur between a firm's human capital pool and HRM system, and argue for an integrated perspective.

Although the theoretical HR literature combines human capital pools and HRM systems,[1] the empirical innovation literature neglects these approaches. Empirical studies tend to explain innovation from either the HRM or human capital perspective. Those taking the HRM perspective analyze the relationship between single HRM practices (e.g., Laursen, 2002; Laursen & Foss, 2003) or HRM systems (e.g., Delery & Doty, 1996; Guest, Conway, & Dewe, 2004) and innovation. Studies taking the human capital perspective focus on either average human capital (e.g., Galunic & Rodan, 1998; Subramaniam & Youndt, 2005) or

[1] Miles and Snow's (1984) typology contains management practices and practices that affect workforce skills. Lepak and Snell (1999) distinguish between the value and uniqueness of human capital, arguing that the applicability of certain management practices depends on workers' skills. Kerr and Slocum, Jr (1987); Osterman (1994) and Sonnenfeld and Peiperl (1988) propose typologies with a similar approach (i.e., using practices that affect workforces skills instead of dealing with them directly). Wright et al. (2001) identify knowledge stocks (human capital) and knowledge flows (workers' behavior resulting from a firm's HRM system) as parts of what they call an "HR system."

firms' diversity in human capital (e.g., Østergaard, Timmermans, & Kristinsson, 2011). Although a recent literature stream links human capital and HRM (e.g., Cabello-Medina, Lopez-Cabrales, & Valle-Cabrera, 2011; De Winne & Sels, 2010), this stream focuses on single or moderating effects, thereby neglecting multiple complex complementarities between human capital and HRM. Thus, for the joint influence of a firm's human capital pool and HRM system on innovation, a large gap remains between theorizing (i.e., using a configurational approach) and analyzing (i.e., generally using contingency approaches).

This study contributes to the HRM literature in two ways: First, following Wright et al. (2001), we build a model that integrates the knowledge stock and the knowledge flow in a firm. This model explains how combinations of the knowledge stock, the knowledge flow, and external factors such as industry dynamism and firms size create knowledge that leads to incremental innovations. Our model contains several complex complementarities and underlies configurational theory. We therefore call it a "knowledge creation (KC) system." Within the KC system we identify four ideal types and explain how these ideal types generate incremental innovations.

Second, we analyze the KC system by applying fuzzy set qualitative comparative analysis (fsQCA) (Ragin, 2008). This method helps us to overcome some of the drawbacks of other methods (e.g., regression analysis, cluster analysis, or deviation score analysis) used for analyzing complex systems (Fiss, 2007). For example, researchers using regression analysis use interaction terms for analyzing configurations. However, the higher the order of the interaction, the increasingly complicated the interpretation of the interaction terms becomes (Fiss, 2007; for a comparison of fsQCA with standard statistical methods see Fiss, 2011). In contrast to some standard statistical methods, fsQCA can deal with both equifinality and causal complexity (Fiss, 2007; Wagemann, Buche, & Siewert, 2016), two major properties of configurational theory (Doty, Glick, & Huber, 1993). Thus fsQCA is an excellent method for testing or building configurational theory (Woodside, 2013). By applying fsQCA to an analysis of a firm's KC system, we can identify multiple configurations and test whether our theoretically derived ideal types exist.

For our analysis, we use data from the Swiss manufacturing sector. This data set contains measures for a firm's incremental innovation performance (i.e., the sales percentage of highly improved products), human capital pool (i.e., different percentages of workers with similar educational degrees), a firm's HRM system (i.e., teamwork, job rotation, and empowerment), firm size, and industry dynamism. The results of our analysis reveal multiple configurations of the KC system. These configurations are in line with our theoretically derived ideal types. We find that the KC systems of firms operating in a highly dynamic environment have both knowledge stock and knowledge flow at the core of their operations, whereas the KC systems of firms operating in a low dynamic environment have only knowledge stock at the core of their operations.

Our analysis of the KC system contributes to the HR and innovation literature in several ways. We show the existence of multiple strategies for superior incremental innovation performance. The design of a KC system highly depends on a firm's environment and its organizational size. The more dynamic the environment is, the more important are HRM practices that initiate a knowledge flow. Moreover, the larger firms are, the more they require HRM practices to overcome disadvantages from a complex and often bureaucratic organization. Our results also show that a human capital pool and HRM practices that induce knowledge flow are connected by complex complementarities, a finding that should be considered in HRM theories.

2. Literature review

Only a few studies that investigate the influence of human capital or HRM practices on innovation both theorize *and* empirically test complementarities between these two concepts. HRM theories consider complementarities between human capital and HRM practices and model human capital as a knowledge stock, and view HRM practices as means of inducing knowledge flow (Boxall, 1996; Schuler & Jackson, 1987; Wright et al., 2001). Knowledge stock and knowledge flow are also key determinants of innovation. Thus these HRM theories have implications for innovation in firms. Despite existing theoretical foundations, empirical studies that investigate such complementarities are scarce.

One reason for the scarcity of empirical studies incorporating both human capital and HRM practices lies in the complexity of both concepts. The human capital available in a firm (the human capital pool) covers diverse skills and abilities. Grant and Hayton (2011) argue that complementarities occur between differently skilled individuals. Because education can differ in terms of level, type, or field, complementarities within a firm's human capital pool can be highly complex. Similarly, complementarities occur between different HRM practices. The configurational approach in HRM theory expects these complementarities to occur in multiple and non-linear interactions between HRM practices (Delery & Doty, 1996). As such HRM systems comprise multiple HRM practices, these practices must be both internally consistent and externally aligned with the firms' strategy (Becker & Huselid, 1998). Thus an analysis of complementarities between human capital and HRM practices requires models that are capable of dealing with complexity.

Some empirical studies approach the complementarity between human capital and HRM practices in the context of innovation. De Winne and Sels (2010) investigate the influence of human capital and HRM on innovation by taking a contingency approach.

Arguing that the level of the workers' human capital moderates the impact of HRM practices on innovation, they expect the impact of HRM practices to increase with the level of human capital. For their empirical analysis, they use the percentage of workers who have completed a bachelor's degree or higher as a measure of human capital. They measure HRM practices by counting the practices applied. After applying path analysis, they show that workers' human capital moderates the impact of HRM practices on innovation.

Cabello-Medina et al. (2011) take a different approach by arguing (a) that HRM practices affect human and social capital and (b) that both types of capital affect innovation. In contrast to De Winne and Sels (2010), Cabello-Medina et al. (2011) do not include moderating effects in their model; instead, they distinguish between different functions of human capital (i.e., uniqueness and value). They operationalize the value of human capital with a 5-item scale and operationalize the uniqueness of human capital with a single variable. To measure HRM practices, they distinguish between practices related to development, selection, incentives, and empowerment (all scales). The results of their structural equation model show three positive effects: that of (1) human capital on innovation, (2) developmental HRM practices on the value of human capital, and (3) empowerment on the uniqueness of human capital.

Two additional studies are located in the context of the influence of human capital and HRM on innovation. Bornay-Barrachina, De la Rosa-Navarro, López-Cabrales, and Valle-Cabrera (2012) expect human capital to mediate the relationship of employment relations and innovation. Their analyses support their hypothesis. Lopez-Cabrales, Pérez-Luno, and Valle Cabrera (2009) hypothesize that knowledge is a moderator between HRM practices and firms' innovation output. Distinguishing between the uniqueness and the value of knowledge, they show that unique knowledge mediates the relationship between both collaborative HRM practices and innovation, and that knowledge-based HRM practices positively influence innovation.

However, all of these empirical studies investigate the influence of human capital and HRM on innovation from either a universalistic or a contingency perspective. Although Bornay-Barrachina et al. (2012) also consider moderating effects, they focus on employment relations but do not deal directly with HRM practices. In sum, a configurational approach that combines a firm's human capital pool and HRM system still remains under-investigated in the empirical literature.

According to Doty et al. (1993) and Doty and Glick (1994), all analyses that consider the configurational approach must take equifinality and complex synergies into account. These properties of configurational theory challenge current empirical approaches (e.g., regression analysis, cluster analysis or deviation score analysis), because most of them cannot handle either equifinality or complex synergies (Fiss, 2007). A viable alternative for analyzing complex configuration is fsQCA, a set-theoretic method that facilitates the analysis of complex causal relationships and takes equifinality into account (Ragin, 2008).

FsQCA has been used for the analysis of well-established configurational theories such as organizational configurations (Fiss, 2011) or innovation systems (Meuer, Rupietta, & Backes-Gellner, 2015). Researchers also apply fsQCA for building complex causal theories such as Mysangyi and Acharya (2014). Recent applications of fsQCA also analyze complex complementarities in high performance work systems (e.g., Meuer, 2016), and configurational pathways to innovation (e.g., Poorkavoos, Duan, Edwards, & Ramanathan, 2016). Thus fsQCA is a suitable method for analyzing complex complementarities within a human capital pool, within an HRM system, and between a human capital pool and an HRM system.

3. Theory

In the following section, we develop a theory of a knowledge creation (KC) system that combines two important components of a firm: knowledge stock and knowledge flow. Our theoretical model builds on Wright et al.'s (2001) conceptualization of knowledge stock and knowledge flow. We develop a KC system that both comprises four ideal types and explains superior incremental innovation. For the development of the ideal types, we take innovation-relevant context factors into account and link them to the ideal types. These context factors are industry dynamism and the size of the firm. The KC system, based on configurational theory, contains complementarities between knowledge stock, knowledge flow, firm size, and industry dynamism.

3.1. Constructs

3.1.1. Incremental innovation performance

With our KC system, we explain a specific type of innovation: incremental innovation. Incremental innovations are refinements of existing processes, products, services, or technologies (Ettlie, 1983). They build on knowledge that exists in a firm and reinforce its applicability (Abernathy & Clark, 1985; Gatignon, Tushman, Smith, & Anderson, 2004). The KC system describes specifically how the use and diffusion of existing knowledge leads to incremental innovation, rather than dealing with other forms of innovation outcomes.

3.1.2. Knowledge stock

The knowledge stock, which comprises the pool of human capital that employees of a firm possess (Wright et al., 2001), consists of the knowledge, skills, and abilities of employees. As firms hire employees with different types and levels of education and training, the knowledge in a firm’s human capital pool is typically diverse. Such a diverse stock of knowledge is a requirement for generating innovation. According to Subramaniam and Youndt (2005), modern innovations require the integration of different types of knowledge.

For knowledge to be integrated within a firm, it must be communicated and shared among the employees. Therefore, differences in knowledge can impede knowledge sharing. If the individual knowledge stock of two or more employees share hardly any overlap, the establishment of a common ground for knowledge sharing becomes necessary. Grant (1996) argues that “sophisticated common knowledge” enhances the communication of specialized knowledge. If the difference between specialized knowledge and common knowledge is large, workers must reduce their specialized knowledge to common knowledge, thereby losing information during the simplification process (Grant, 1996). As the knowledge stock of a firm contains several types of knowledge, complementarities between these types will necessarily exist. Such complementarities occur when employees have little need to simplify their knowledge when sharing it with colleagues.

3.1.3. Knowledge flow

Specific HRM practices induce a knowledge flow among employees. Such practices can affect the organization of work (e.g., team work or job rotation) (Collins & Smith, 2006; Smith, Collins, & Clark, 2005) or induce a certain behavior (e.g., empowerment) (Schuler & Jackson, 1987). Teamwork facilitates the integration of existing knowledge by inducing interactions among team members. A higher quality and intensity of interaction can increase the utilization and recombination of existing knowledge and result in incremental innovation (Subramaniam & Youndt, 2005). Knowledge sharing in a team may likely not only—and importantly—determine incremental innovation but also contribute to it. Collins and Smith (2006) argue that job rotation enhances the cross-functional and cross-divisional diffusion of knowledge. By implementing job rotation, firms increase the likelihood that workers will share knowledge and learn to comprehend different terminologies. These workers can adopt an integrating role in their teams (Crawford & Lepine, 2013) and align the knowledge of different teams.

The configurational approach in HRM theory expects complementarities to exist between HRM practices (Delery & Doty, 1996). We also expect such complementarities for knowledge flow. For example, a combined application of team work and job rotation will lead to a variety of knowledge flows that would not occur where work is carried out independently. This combined application of teamwork and job rotation entails an employee's strong reliance on existing knowledge in a specific functional area and subsequently diffuses that knowledge across the firm. Thus it induces a richer knowledge exchange (Subramaniam & Venkatraman, 2001; Subramaniam & Youndt, 2005), which in turn results in the generation of incremental innovation.

3.1.4. External factors

A firm's KC system depends not only on the stock and the flow of existing knowledge but also on external factors such as environmental velocity (McCarthy, Lawrence, Wixted, & Gordon, 2010) and firm size (Forés & Camisón, 2016). "Environmental velocity" refers to factors related to industry dynamism, turbulence, and hyper-turbulence (McCarthy et al., 2010), factors also known to influence the configuration of the KC system. Datta, Guthrie, and Wright (2005) argue that a firm's industrial environment influences skill requirements and information processing needs, and expect, for example, that a dynamic environment will increase both factors. We therefore consider a firm's industrial environment in our empirical approach.

The size of a firm is another factor that has an impact on its innovation output. According to Arias-Aranda, Minguela-Rata, and Rodrìguez-Duarte (2001), large firms have more human resources. Having more human resources allows large firms to generate more recombinations of existing knowledge and therefore create knowledge for the improvement of existing products and processes. However, larger firms face greater organizational complexity and less flexibility than small- and medium-sized enterprises (SMEs) (Forés & Camisón, 2016). Thus their internal knowledge flow might be slower and less effective than that of SMEs.

3.2. Ideal types

From these four concepts, we generate a KC system that comprises four ideal types. These ideal types are based on configurational theory in the sense that we expect complex complementarities between the four concepts. Fig. 1 lists the four ideal types. In this subsection, we explain the internal mechanisms of these ideal types and the way in which they generate incremental innovation.

The first ideal type of a KC system applies to a small firm that operates in a weak dynamic environment. The core component of this ideal type is the knowledge stock, which contains the knowledge and skills necessary for both improving existing products and following an existing technological trajectory (Gatignon et al., 2004). The knowledge stock will therefore include a small set of knowledge and skills. In such an environment, as innovations do not have to appear frequently, no need for a strong knowledge flow exists. Given the small size of the firm, the application of formal HRM practices to inducing such a knowledge flow is unnecessary. Thus such firms generate innovations from the skills and the human capital of their employees and have an organizational structure that allows both flexibility and sharing of knowledge (Forés & Camisón, 2016).

The second ideal type of a KC system applies to a large firm that operates in a weak dynamic environment. As with the first ideal type, a clearly-defined—although not necessarily specialized—stock of knowledge is its core component. While large firms have a large knowledge stock, their size might impede them from using it effectively. Compared to small firms, large ones have higher coordination costs, are less flexible (Nooteboom, Van Haverbeke, Duysters, Gilsing, & Van den Ord; 2007), and face difficulties in connecting the various resources that the innovation process requires (Forés & Camisón, 2016). These problems hamper their ability to generate innovations. By implementing HRM practices that promote connections between sources of relevant knowledge, a large firm can induce a knowledge flow that will help it overcome its size-related disadvantages. We therefore expect HRM practices—which are not part of the KC system's core components—to play an auxiliary role in that system.

The third ideal type of a KC system applies to a small firm that operates in a highly dynamic environment. The KC system for such a firm strongly differs from that of the previous two. A dynamic environment requires both a strong knowledge flow and a fast reaction to changes in the market. Thus HRM practices with the capacity to induce a strong knowledge flow are core components of this system. The knowledge stock is also part of the core of this system, because firms need sufficient knowledge to generate knowledge recombinations. Without such a knowledge stock, firms can still apply HRM practices, thereby inducing a knowledge flow. In this situation, however, the knowledge flow contains either insufficient knowledge or very similar knowledge and will thus not generate knowledge recombinations.

The fourth ideal type of a KC system applies to a large firm in a dynamic environment. As with the third ideal type, the core of this KC system is the knowledge flow. Human capital is likewise part of the core, because it builds the knowledge stock, and the firm applies HRM practices to diffuse knowledge from that stock. The HRM practices in this system fulfill two roles. First, they help the firm overcome the high degree of organizational complexity that characterizes large firms. Second, they both connect the different divisions of the firm and induce a knowledge flow that is aligned with the firm's highly dynamic environment.

Insert Fig. 1 about here

Fig. 1 summarizes our theoretical considerations and presents the four ideal types of a KC system. Although we do not develop specific hypotheses in this paper, we nonetheless expect these four ideal types to appear in our analyses.

4. Empirical analysis

Our theoretical model of a KC system is based on configurational theory. We therefore use fsQCA, a method that takes several properties of configurational theory (e.g., equifinality and causal complexity) into account (Fiss, 2007, 2011; Seny Kan, Adegbite, El Omari, & Abdellatif, 2016). This method allows us to identify several complex KC system configurations that explain innovativeness.

To measure innovation, we focus on incremental innovation. Compared to other innovation types, incremental innovation has the highest alignment with the KC system that we have described. To generate innovation, the KC system builds upon the use of a given knowledge stock. Because incremental innovation relies more on the existing knowledge sources of a firm than on new knowledge entering it (Henderson & Clark, 1990; Subramaniam & Youndt, 2005), our KC system is consistent with the determinants of incremental innovation.

4.1. Data

For our empirical analysis we use the 2005 wave of the Innovation Survey collected by the Swiss Economic Institute (KOF). This data set is representative for the Swiss firm populations in the manufacturing, construction, and service sectors. In its raw version, the data set contains about 2000 observations. It provides detailed information on a firm's innovativeness, the educational composition of its workforce, and the HRM practices that it applies.

We restrict our sample to the manufacturing sector for the following two reasons: First, Arvanitis and Hollenstein (2001) and Hollenstein (1996, 2003) show that the Swiss manufacturing sector is based primarily on incremental innovations. Thus the Swiss manufacturing sector is an ideal setting in which to test a theory that explains the occurrence of superior incremental innovation performance. In addition, the Swiss education system covers a wide range of formal qualifications of different types and levels (e.g., practical vs. theoretical and secondary vs. tertiary). Second, innovation processes tend to differ in the manufacturing and service sectors (Ettlie & Rosenthal, 2011; Hollenstein, 2003), and we therefore analyze them separately.

Given the high market orientation of incremental innovation in Swiss manufacturing (Hollenstein, 1996), we select a measure that captures this pattern. Market-oriented innovation measures relate innovation output to financial performance measures such as sales or revenue (Arnold, Fang, & Palmatier, 2011; Hollenstein, 1996). To obtain a measure for firms' incremental innovation performance, we use the sales percentage of highly improved products (Atuahene-Gima, 2005; Henard & McFadyen, 2012).

4.2. Measures

As measures for human capital pool and HRM system, we select both the educational composition of the workforce and the HRM practices that regulate knowledge flow. The KOF collects information on the educational composition of the workforce by categorizing workers into five groups and calculating their percentage of the total workforce. This categorization distinguishes among workers with university degrees, workers with degrees from professional education and training (PET), workers with degrees from dual-track vocational education and training (VET), workers with degrees from lower-secondary schooling, and apprentices.[2] For our analysis we focus on educational degrees either higher than or equal to dual-track VET. As workers with completed lower-secondary schooling do not have additional occupation-specific knowledge, they cannot contribute to a firm's knowledge stock. Moreover, apprentices are a source of external knowledge inflow from the VET system (Rupietta & Backes-Gellner, 2012), not an internal source of knowledge. We therefore exclude these two groups from our analysis.

We gather information on HRM practices from the items measuring the application of teamwork, job rotation, and empowerment (the distribution of decision-making responsibilities between worker and supervisor). The items on teamwork and job rotation are measured by two binary items. The KOF uses seven items to measure empowerment. For each item, the KOF uses a five-point Likert type scale ranging from one (the worker has all the decision-making responsibilities) to five (the supervisor has all the decision-making responsibilities). The seven items cover information such as the sequencing of work,

[2]Dual-track VET constitutes 3-to-4-year training programs at the upper secondary level. These programs combine intense workplace training with vocational schooling. About two thirds of a cohort continues with dual-track VET after having completed lower secondary education. PET constitutes a variety of programs at the tertiary level. A large majority of students starting a PET program have already completed VET. Like VET, PET combines practical and theoretical education.

customer relations, and customer complaints (see table 1 for the full list). We also include firm size, measured by the number of employees.

Insert Table 1 about here

To measure environmental velocity, we draw upon the conceptualizations of McCarthy et al. (2010): The rate of change in demand is a standard measure for environmental velocity (Bourgeois & Eisenhardt, 1988; Smith, Smith, Olian, Sims, O'Bannon, & Scully, 1994) and is still in use (e.g., Nadkarni & Barr, 2008). We combine two items that measure the changes in demand in the main product market of the past and the future three years (measured on a five-point Likert scale). We subtract the future demand change from the past one and calculate the absolute value from this difference. We purposely omit the direction of change, because the high values of our dynamism measure automatically result in changing conditions at the firm level (e.g., firms accustomed to a growing demand might more easily adapt to a further increase than to a decrease).

Table 1 shows the descriptive statistics for the sample we use for our analysis, a sample generated from a representative data set. As this data set contains missing values (predominantly in the HRM measures), we exclude all observations with at least one missing value in the variables relevant to our analysis. The resulting sample is thus no longer representative. Therefore, to compare the firms before and after the exclusion of missing values, we calculate the average firm size in the representative sample and use the survey weights in our calculation. Our final sample constitutes a selection of large firms.

4.3. Calibration

fsQCA applies Boolean algebra for the calculation of causally complex configurations of causal conditions (Ragin, 2008). To identify causal configurations, fsQCA follows a three-step process (Fiss, 2011). The first step consists of the transformation of all measures to sets that range from 0 to 1. We will explain this procedure in detail for each measure below. These sets are organized in a truth table that contains all logically possible combinations of the sets. The second step reduces the truth table by applying both the frequency cutoff and the consistency cutoff to the data. The frequency cutoff determines the minimum number of cases that are required for a solution, and the consistency cutoff determines "to which cases correspond to the set-theoretic relationships expressed in a solution" (Fiss, 2011: 402). For the current study we use a frequency cutoff of 3 and a consistency cutoff of 0.84. In the third step, the Boolean minimization, an algorithm identifies complex configurations. The algorithm performs a counterfactual analysis of causal conditions and allows the identification of core and peripheral conditions.

4.3.1. Incremental innovation performance

To measure incremental innovation performance of firms we use firms' sales percentage of highly improved products. For any evaluation of firms' innovation performance, the choice of a meaningful benchmark is crucial. We relate firms' sales percentage of highly improved products to the accompanying subsector-specific (high tech or traditional manufacturing) mean. Table A.1 in the appendix shows the classification of the industries.

To be reliable, the benchmark value should represent the entire subsector, not merely a selective sample. Thus the calculation of the benchmark should be based on representative data. Before the exclusion of missing values, the data set is representative for the Swiss firm population in the manufacturing sector. To calculate the average innovation performance in each of the two subsectors, we use the raw data.

Relating firms' performance to the sector or subsector level is a standard procedure only when QCA is applied to multi-sector data (Greckhamer, Misangyi, Elms, & Lacey, 2008). As in our study, Greckhamer et al. (2008) use multi-sector data. For the definition of the cutoff of their outcome (superior business-unit performance), they calculate the overall sample mean of business-unit performance and assign a 1 to all business units that have a higher return on assets than the sample mean and a 0 to those below that mean.

We use a similar procedure for the calibration of superior incremental innovation performance, i.e., we relate a firm's innovation performance to its peer group. This benchmarking is necessary for the identification of configurations that allow firms to outperform their competitors. Greckhamer et al. (2008) use a very broad definition of a firm's peer group (i.e., all firms in the sample). We argue that narrowing the peer group to firms that share the same subsector gives the firm a better opportunity to both observe and react to its peers. As the performance of those peers determines a firm's survival in the market, the performance of this subgroup might be a benchmark in which a firm is interested.

We therefore deviate from Greckhamer et al. (2008) by using the subsector means for calibration instead of the overall means. We subtract the subsector mean from the sales percentage of highly improved products for every firm in a subsector. As we focus on explaining superior incremental innovation performance, we set 0 as the value for the crossover (Greckhamer et al., 2008). This point reflects a performance that is precisely in line with the average subsector performance, one that is therefore neither superior nor inferior. We calculate, by subsector, standard deviations of the mean-corrected innovation performance measure. As the standard deviations vary substantially across subsectors, we select subsector-specific standard deviation as the value for the “fully in” and “fully out” thresholds. The “fully in” threshold is the value that indicates full membership in a set, and the “fully out” threshold is the value that indicates full non-membership. We select a positive standard deviation for the “fully in” threshold and a negative one for the “fully out” threshold.

4.3.2. Explanatory conditions

We use four explanatory conditions that are crucial for a firm`s superior incremental innovation performance. The first set of conditions contains the educational composition of the workforce, thereby measuring a firm’s human capital pool. The second set of conditions contains the use of HRM practices. The third condition measures firm size, and the fourth measures industry dynamism.

For the three workforce composition measures and firm size, we apply the same method we used for the calibration of the outcome: Again, we subtract the subsector means from the workforce composition measure and firm size, respectively. The 0 serves as the crossover. We use the standard deviation for the “fully in” and “fully out” points. A positive standard deviation constitutes the “fully in” point; a negative, the “fully out” point.

For the measurement of HRM practices, we use teamwork, job rotation, and empowerment. As both teamwork and job rotation are binary conditions, we do not have to transform them into sets and can use them directly in our analysis. Given that we focus on overall empowerment, not on particular areas, we combine seven items—all measured on a five-point Likert-type scale—to obtain the empowerment condition. Before combining the items into scales, we perform a principal factor analysis (Fiss, 2011). The results appear in Table 2. One factor has an eigenvalue greater than 1, indicating a one-factor solution for each subsector. We combine all items into one scale that shows a Cronbachs-alpha of 0.77 for the entire sample.

Insert Table 2 about here

The resulting scale pictures the distribution of decision-making responsibilities between workers and supervisor. While the value 1 indicates that the employee has all the decision-making responsibilities, the value 5 indicates that the supervisor has them all. Entitling the scale “empowerment,” we follow Fiss (2011) for the coding procedure of scales constructed from items measured on a five-point Likert-type scale. Thus we set the “fully in” point at 1, the “fully out” point at 5, and the “crossover” point at 3.

To generate a measure for industry dynamism, we use information on the development of demand in a firm’s main product market. In the questionnaire the firms are asked to indicate the past demand in their main product market and to provide an estimate of the future demand in their main product market. To measure industry dynamism, we use the difference between the past and future demand. We calculate the mean of the resulting measure for each industry in every subsector. To obtain comparable measures across the two subsectors, we normalize all measures over the entire manufacturing sector. Thus a highly dynamic environment in high-tech manufacturing is comparable to a highly dynamic environment in traditional manufacturing.[3]

5. Results

We follow Greckhamer et al. (2008) and run the analyses separately for each of the two subsectors. We present the results of our analysis and explain the internal mechanisms of the KC systems that we have identified. We present the results of our fsQCA in a configuration chart, which constitutes one widespread way of presenting fsQCA results. Table 3 shows the

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[3] Table A.2 in the Appendix summarizes the cutoff points.

configuration of the fsQCA in both subsectors.[4] The first column lists the conditions that belong to the two main components of a KC system, the human capital pool and the HRM system, as well as two conditions that provide information on the context, firm size, and industry dynamism. A configuration chart lists all configurations vertically and uses symbols for the presence or the absence of a condition. A filled circle indicates the presence of a condition, and a crossed circle indicates the absence of a condition. Large circles indicate core conditions, and small circles indicate peripheral conditions. Empty cells indicate that the presence or absence of a condition does not matter for explaining superior incremental innovation performance.

At the bottom of Table 3, we present the overall consistency and coverage scores. As we analyze the traditional manufacturing sector and the high-tech manufacturing sector separately, we obtain these score for each analysis. For both analyses, we obtain overall consistency scores that are above the acceptance threshold of 0.8 (Fiss, 2011).[5] The overall coverage scores are 0.26 for the traditional manufacturing sector and 0.29 for the high-tech manufacturing sector, with both values in line with studies using similarly sized data sets and frequency cutoffs. Fiss (2011) reports overall coverage scores ranging from 0.27 to 0.36. More recent studies applying fsQCA in a large-N environment, such as Bell, Filatotchev, and Aguilera (2014), Misangyi and Acharya (2014), and Meuer, Rupietta, and Backes-Gellner (2015), report similar scores.

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[4] Table 3 contains sufficient conditions. A typical procedure in a fsQCA is also the analysis of necessary conditions. We present the analysis of necessary condition in Table A.3 in the Appendix.
[5] See Meuer (2016) for a recent large-N application of QCA in the context of high-performance work systems. He reports an overall solution consistency score of 0.84.

5.1. Superior incremental innovation performance

Configuration 1 in the traditional manufacturing sector contains the two following core components: the absence of a concentration of employees with VET degrees, and the absence of high level of industrial dynamism.[6] The peripheral components are the presence of a concentration of university graduates and teamwork, and the absence of job rotation and empowerment. The practical skills of employees with VET degrees appear less important in this configuration. University graduates have relatively more opportunities for participating in collaborative projects (teamwork), either together or with other members of the workforce. In these cases, innovation is generated not only from the collaboration but also from knowledge spillovers. The concentration of employees with university degrees increases the likelihood that the remaining workforce will interact with them, thereby increasing the probability of knowledge spillovers.

Configuration 2 describes small firms that operate in a highly dynamic environment. Such firms, due to their small size, require fewer formal HRM practices that foster knowledge exchange. With these firms, the human capital pool consists of a concentration of workers with PET degrees (e.g., master craftsmen) and VET degrees (e.g., journeymen). The completion of a VET degree is a prerequisite for the majority of PET programs. Thus workers with PET degrees and workers with VET degrees have what Grant (1996) calls "sophisticated common knowledge." Both groups use the same terminology and share a certain degree of knowledge, thus facilitating knowledge sharing among these workers. Thus the innovative potential in this configuration results from the collaboration of highly knowledgeable workers

[6] All conditions that constitute the firm's human capital pool must be interpreted relative to the subsector average, e.g., the absence of a concentration of employees with VET degrees means that firms employ fewer employees with VET degrees than the subsector average.

who can easily transfer their expertise to one another. This rapid knowledge exchange is particularly valuable in the highly dynamic environment in which these firms operate.

Configuration 3 describes large firms that operate in a highly dynamic environment. Given the concentration of workers with PET degrees, more advanced practical knowledge is available in these firms than in the average firm in the sector. By applying teamwork and job rotation, firms belonging to configuration 3 implement an HRM system that leads to organizational learning and ensures the diffusion of advanced practical knowledge throughout the entire firm. Workers with PET degrees diffuse their knowledge either by directly participating in teamwork or job rotation, or by interacting with workers in different jobs or functions. Innovativeness therefore results from the combination of organizational learning and the availability of advanced practical knowledge.

Configurations 4-7 show KC systems in the high-tech manufacturing sector. Configurations 4 and 5 consist of small firms that operate in a highly dynamic environment. Firms that belong to configuration 4 focus on knowledge transfers from university graduates and on a combined application of teamwork and job rotation. In these firms scientists and engineers exchange knowledge among one another more frequently than do other employees, and, given the application of teamwork and job rotation practices, other members of the workforce will more likely interact. The relative importance of theoretical knowledge in these firms, as opposed to practical knowledge, might be due to the differences in knowledge requirements between the traditional and the high-tech manufacturing subsectors.

In contrast to configuration 4, configuration 5 contains firms with both an overall high degree of employee empowerment and a large percentage of workers with PET degrees. Firms that belong to this configuration combine two types of expert knowledge: theoretical and advanced practical knowledge (i.e., that of university graduates and employees with PET degrees). As the high degree of empowerment helps engineers and master craftsmen to directly implement their ideas, one can reasonably assume that they jointly generate improvements in products and processes.

Insert Table 3 about here

Configurations 6 and 7 constitute firms in a weak competitive environment. Firms that belong to configuration 6 lack a concentration of employees with university degrees and VET degrees, nor do they apply any of the HRM practices that we selected in our study. Given the small firm size, formal HRM practices that induce knowledge-sharing might not be necessary for innovation in these firms. Knowledge spillover from workers with PET degrees to the remaining workforce is one channel that may explain the innovative potential of the firms in configuration 6. A different channel for innovation might be master craftsmen, who use their expertise to generate innovations independently.

By concentrating on all skill types and skill levels, firms that belong to configuration 7 have a strong human capital pool. However, they only apply teamwork to diffuse this knowledge. Given that these are large firms that do not operate in a highly dynamic environment, they might not need to diffuse knowledge rapidly. Instead, they might augment their strong human capital pool and form project teams that have the capacity to work independently and improve existing products.

5.2. Robustness of the fsQCA results

We analyze the robustness of the fsQCA results by changing the consistency and the frequency cutoffs. Therefore, we always keep one cutoff constant and change the other cutoff. We perform these robustness checks separately for the traditional manufacturing sector and for the high-tech manufacturing sector. The entire robustness test generates four additional configuration charts per sample. For the sake of brevity, we summarize the main results of the robustness tests in Tables A.5 and A.6 in the Appendix.

In Table A.5, we summarize the robustness tests for our analysis of the traditional manufacturing sector. Configurations 1 and 3 are robust against changes in the consistency cutoff. Only configuration 3 changes after we lower the consistency cutoff by -0.04. While Configuration 2 does not appear if we increase the consistency cutoff to 0.90, it remains stable when we reduce it. Configurations 1 and 3 are less robust to changes in the frequency cutoff. When we increase the frequency cutoff from 3 to 4, these configurations do not appear. Configuration 2, however, is quite robust against this change. All configurations are robust against a decrease in the frequency cutoff from 3 to 2. In sum, we obtain robust results for the traditional manufacturing sector.

Table A.6 contains our results from the robustness tests in the high-tech manufacturing sector. Only one configuration, configuration 5, disappears after an increase in the consistency cutoff of 0.01. The remaining configurations remain stable or change only slightly. Our results are less robust against changes in the frequency cutoff. Configurations 4 to 6 disappear after an increase from 3 to 4 in the frequency cutoff. A reduction in the frequency cutoff has little effect on the results. The results of the robustness test in the high-tech manufacturing sector are comparable to those in the traditional manufacturing sector. In general, the results are robust. Changes mainly occur due to an increase in the frequency cutoff.

6. Discussion

Studies that analyze the combined effect of HRM practices and human capital on the incremental innovation performance of firms are scarce. Although theoretical models recommend that researchers apply an integrated view (e.g., Wright et al. 2001), only little empirical research has been undertaken thus far on this topic. One reason for this lack of empirical research might be the complexity of the constructs. Complementarities between HRM practices lead to the emergence of HRM systems, a set of HRM practices. Similarly, a firm's human capital pool contains several types of knowledge in which complementarities can be exploited. Thus the analysis of the combined effect of HRM practices and human capital on the incremental innovation performance requires an empirical approach that is capable of dealing with high levels of causal complexity.

In this study, we develop a KC system that we conceptualize as consisting of (types of) knowledge stock (i.e., human capital) and knowledge flows (induced by HRM practices). We derive four ideal types that depend on firm size and industry dynamism. We empirically analyze the KC system using fsQCA, a method well suited for analyzing complex causal relationships. Our empirical analysis identifies seven configurations of the KC system. We compare the empirical results with our theoretically derived ideal types as follows.

The first ideal type that we identify covers small firms in an environment with a low level of dynamism. For such firms, we expect that the knowledge stock is the core component of the KC system and that these firms do not require a strong knowledge flow, because they do not need to innovate at a rapid rate. We find that configuration 6, depicting the high-tech manufacturing sector, corresponds to this ideal type. We define the knowledge stock, which contains the core conditions, as a narrow set of knowledge and skills that such firms need if they are to follow their technological trajectory and generate incremental innovations.

The second ideal type covers large firms in a weakly dynamic environment. We expect the knowledge stock of these firms to be the core component of their KC system. We also expect them to use HRM practices to induce a knowledge flow because of their complex and often bureaucratic organizational structure. Our results show that the configurations of both manufacturing sectors correspond to this type. These configurations are configuration 1 and configuration 7. In both configurations, the core conditions appear in the knowledge stock. While configuration 1 has a narrowly defined knowledge stock, configuration 7 has a diversified knowledge stock. In both configurations, although HRM practices are present, they are only peripheral conditions.

The third ideal type consists of small firms that operate in a highly dynamic environment. The KC system of these firms has the core components of knowledge stock and knowledge flow, because these firms need to rapidly recombine existing knowledge if they are to remain innovative. We identify configurations in both sectors that correspond to this ideal type: configurations 2, 4, and 5. In all configurations, core conditions appear among the HRM practices. Only configurations 4 and 5 also have a core condition in the human capital component of the configuration. Thus our results only partly agree with the theoretically derived ideal type.

The fourth ideal type consists of large firms that operate in a highly dynamic environment. We expect that their KC system has two core components: a knowledge stock and a knowledge flow. Configuration 3 in the traditional manufacturing sector corresponds to this ideal type.

In sum, we obtain empirical results that are much in line with our theoretically derived ideal types. This finding also has theoretical implications. Both our model and our results show the existence of different ways for firms to generate incremental innovations. We show that incremental innovation results from a complex combination of conditions. Moreover, we show that a knowledge stock contains several complementarities, such as an HRM system.

These findings refine the model presented by Wright et al. (2001) and provide first insights into how knowledge stock and flow depend on one another.[7]

Our theoretical reasoning is related to innovation as an outcome of the KC system. Nonetheless, in the same way that an HRM system has the capacity to influence not only firms' financial performance but also their innovation output, the ideal types of a KC system might also influence firms' financial performance. More theory is required for determining which system is beneficial for both financial performance and innovation.

Our study also has several empirical implications. By applying fsQCA, we use an emerging method that is capable of identifying complex configurations of causal conditions. This method has potential for further applications to configurational innovation theory. This field of theory is not new. For example, Burns and Stalker (1961) use an established configurational theory to identify two different ideal types of firms. Such theories provide an ideal setup for the application of fsQCA.

This study has conceptual and empirical limitations. In our KC system, we consider only two of the three components of the ability-motivation-opportunity (AMO) model, a widely used classification of HRM practices. The three components of the original model all affect employees' performance (Appelbaum, Bailey, Berg, and Kalleberg, 2000). In this context, Lepak, Liao, Ghung, and Harden (2006) distinguish among skill-enhancing, motivation-enhancing, and opportunity-enhancing HRM practices. Our KC model covers the outcome of skill-enhancing HRM practices, the human capital that is available in a firm, and opportunity-enhancing HRM practices, those practices giving employees the opportunity to use their skills. These opportunity-enhancing practices are in line with the practices that generate the knowledge flow in our KC system. Thus our KC system focuses only on a part of

[7] We also performed a fsQCA of the negated outcome. We obtain meaningful results only in the high-tech manufacturing sector. The results do not contradict any of the ideal types in Fig. 1.

an entire HRM system and on a part of Wright et al.'s (2001) model. Nevertheless, the KC system allows us to make an in-depth analysis of complex complementarities that are also part of an HRM system and Wright et al.'s (2001) model.

Another limitation is related to the sample that we selected for our analysis. Our sample consists of data from the Swiss manufacturing sector. Although we distinguish between traditional and high-tech manufacturing, the generalizability of the results remains limited. By applying our method in different sectors or countries, future studies could contribute to the identification of new configurations and to the refinement of the ideal types that we propose in this study.

References

Abernathy, W. J., & Clark, K. (1985). Innovation: Mapping the winds of creative destruction. *Research Policy*, 14(1), 3–22.

Appelbaum, E., Bailey, T., Berg, P., & Kalleberg, A. L. (Eds.), (2000). Manufacturing advantage: Why high performance work systems pay off. Ithaca, NY: Cornell University Press.

Arnold, T. J., Fang, E., & Palmatier, R. W. (2011). The effects of customer acquisition and retention orientations on a firm's radical and incremental innovation performance. *Journal of the Academy of Marketing Science*, 39(2), 234–251.

Arias-Aranda, D., Minguela-Rata, B. & Rodriguez-Duarte, A. (2001). Innovation and firm size: An empirical study for Spanish engineering consulting companies. *European Journal of Innovation Management*, 4(3), 133-142.

Arvanitis, S., & Hollenstein, H. (2001). *Innovative Activity and Firm Characteristics - A Cluster Analysis with Firm-level Data of Swiss Manufacturing.* ETH Zürich Konjunkturforschungsstelle.

Atuahene-Gima, K. (2005). Resolving the Capability: Rigidity Paradox in New Product Innovation. *Journal of Marketing*, 69(4), 61–83.

Becker, B. E., & Huselid, M. A. (1998). High Performance Work Systems and Firm Performance: A Synthesis of Research and Managerial Implications. *Research in Personnel and Human Resources Management*, 16, 53–101.

Bell, R. G., Filatotchev, I., & Aguilera, R. (2014). Corporate Governance and Investors' Perceptions of Foreign IPO Value: An Institutional Perspective. *Academy of Management Journal*, 57(1), 301-320.

Bornay-Barrachina, M., De la Rosa-Navarro, D., López-Cabrales, A., & Valle-Cabrera, R. (2012). Employment Relationships and Firm Innovation: The Double Role of Human Capital. *British Journal of Management*, 23(2), 223–240.

Bourgeois, L. J., & Eisenhardt, K. M. (1988). Strategic decision processes in high velocity environments: four cases in the microcomputer industry. *Management Science*, 34(7), 816–835.

Boxall, P. (1996). The strategic HRM debate and the resource-based view of the firm. *Human Resource Management Journal*, 6(3), 59–75.

Burns, T., & Stalker, G. M. (1961). *The Management of Innovation*. London: Tavistock.

Cabello-Medina, C., Lopez-Cabrales, A., & Valle-Cabrera, R. (2011). Leveraging the innovative performance of human capital through HRM and social capital in Spanish firms. *The International Journal of Human Resource Management*, 22(4), 807–828.

Collins, C. J., & Smith, K. G. (2006). Knowledge exchange and combination: the role of human resource practices in the performance of high-technology firms. *Academy of Management Journal*, 49(3), 544–560.

Crawford, E. R., & Lepine, J. A. (2013). A configural theory of team processes: accounting for the structure of taskwork and teamwork. *Academy of Management Review*, 38(1), 32–48.

Datta, D. K., Guthrie, J. P., & Wright, P. M. (2005). Human Resource Management and Labor Productivity: Does Industry Matter? *Academy of Management Journal*, 48(1), 135–145.

De Winne, S., & Sels, L. (2010). Interrelationships between human capital, HRM and innovation in Belgian start-ups aiming at an innovation strategy. *The International*

Journal of Human Resource Management, 21(11), 1863–1883.

Delery, J. E., & Doty, D. H. (1996). Modes of Theorizing in Strategic Human Resource Management: test of Universalistic, Contingency and Configurational Performance Prediction. *Academy of Management Journal*, 39(4), 802–835.

Doty, D. H., & Glick, W. H. (1994). Typologies as a unique form of theory building: Toward improved understanding and modeling. *Academy of Management Review*, 19(2), 230–251.

Doty, D. H., Glick, W. H., & Huber, G. P. (1993). Fit, equifinality, and organizational effectiveness: A test of two configurational theories. *Academy of Management Journal*, 36(6), 1196–1250.

Ettlie, J. E., & Rosenthal, S. R. (2011). Service versus Manufacturing Innovation. *Journal of Product Innovation Management*, 28(2), 285–299.

Ettlie, J. E. (1983). Organizational policy and innovation among suppliers to the food processing sector. *Academy of Management Journal*, 26, 27–44.

Fiss, P. (2007). A Set-Theoretic Approach to Organizational Configurations. *Academy of Management Review*, 32(4), 1180–1198.

Fiss, P. (2011). Building Better Causal Theories: A Fuzzy Set Approach to Typologies in Organization Research. *Academy of Management Journal*, 54(2), 393–420.

Forés, B. & Camisón, C. (2016). Does incremental and radical innovation performance depend on different types of knowledge accumulation capabilities and organizational size? *Journal of Business Research*, 69(2), 831-848.

Galunic, D. C., & Rodan, S. (1998). Resource recombinations in the firm: Knowledge structures and the potential for Schumpeterian innovation. Strategic Management Journal, 19(12), 1193-1201.

Gatignon, H., Tushman, M. L., Smith, W., & Anderson, P. (2004). A structural approach to assessing innovation: Construct development of innovation locus, type and characteristics. *Management Science*, 48(9), 1103–1123.

Grant, R. M. (1996). Prospering in Dynamically-competitive Environments: Organizational Capability as Knowledge Integration. *Organization Science*, 7(4), 375–387.

Grant, R. M., & Hayton, J. C. (2011). Interdependencies between people in organizations. *Bocconi University Working Paper No. 11/004, Milan*.

Greckhamer, T., Misangyi, V. F., Elms, H., & Lacey, R. (2008). Using Qualitative Comparative Analysis in Strategic Management Research: An Examination of Combinations of Industry, Corporate, and Business-Unit Effects. *Organizational Research Methods*, 11(4), 695–726.

Guest, D., Conway, N., & Dewe, P. (2004). Using sequential tree analysis to search for ´bundles´ of HR practices. *Human Resource Management Journal*, 14(1), 79–96.

Henard, D. H., & McFadyen, M. A. (2012). Resource Dedication and New Product Performance: A Resource-Based View. *Journal of Product Innovation Management*, 29(2), 193–204.

Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly*, 35(1), 9–30.

Hollenstein, H. (1996). A Composite Indicator of a Firm's Innovativeness. An Empirical Analysis Based on Survey Data for Swiss Manufacturing. *Research Policy*, 25(4), 633–645.

Hollenstein, H. (2003). Innovation Modes in the Swiss Service Sector. A Cluster Analysis Based on Firm-level Data. *Research Policy*, 32(5), 845–863.

Kerr, J., & Slocum, J. W., Jr (1987). Managing Corporate Culture Through Reward Systems. *Academy of Management Executive*, 1(2), 99–107.

Kogut, B., & Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science*, 3(3), 383–397.

Laursen, K. (2002). The Importance of Sectoral Differences in the Application of Coplementary HRM Practices for Innovation Performance. *International Journal of the Economics of Business*, 9(1), 139–156.

Laursen, K., & Foss, N. J. (2003). New human resource management practices, complementarities and the impact on innovation performance. *Cambridge Journal of Economics*, 27(2), 243–263.

Lepak, D. P., & Snell, S. A. (1999). The Human Resource Architecture: Toward a Theory of Human Capital Allocation and Development. *Academy of Management Review*, 24(1), 31–48.

Lepak, D. P., Liao, H., Chung, Y., & Harden, E. E. (2006). A Conceptual Review of Human Resource Management Systems in Strategic Human Resource Management Research. In J. J. Martocchio (Ed.), *Research in Personnel and Human Resources Management* (pp.217 – 271). Emerald Group Publishing Limited.

Lopez-Cabrales, A., Pérez-Luno, A., & Valle Cabrera, R. (2009). Knowledge as a mediator between HRM practices and innovative activity. *Human Resource Management*, 48(4), 485–503.

McCarthy, I. P., Lawrence, T. B., Wixted, B., & Gordon, B. R. (2010). A multidimensional conceptualization of environmental velocity. *Academy of Management Review*, 35(4), 604–626.

Meuer, J., Rupietta, C., & Backes-Gellner, U. (2015). Layers of co-existing innovation systems. *Research Policy*, 44(4), 888–910.

Meuer, J. (2016). Exploring the complementarities within high-performance work systems: A set-theoretic analysis of UK firms. *Human Resource Management*, published ahead of print.

Miles, R. E., & Snow, C. C. (1984). Designing Strategic Human Resources Systems. *Organizational Dynamics*, 13(1), 36–52.

Mysangyi, V. F., & Acharya, A. G. (2014). Substitutes or complements? A configurational examination of corporate governance mechanisms. *Academy of Management Journal*, 57(6), 1681–1705.

Nadkarni, S., & Barr, P. S. (2008). Environmental context, managerial cognition, and strategic action: an integrated view. *Strategic Management Journal*, 29(13), 1395–1497.

Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V., & Van den Oord, A. (2007). Optimal cognitive distance and absorptive capacity. *Research Policy*, 36(7), 1016–1034.

Poorkavoos, M., Duan, Y., Edwards, J. S. & Ramanathan, R. (2016). Identifying the configurational paths to innovation in SMEs: A fuzzy-set qualitative comparative analysis. *Journal of Business Research*, 69(12), 5843-5854.

Østergaard, C. R., Timmermans, B., & Kristinsson, K. (2011). Does a different view create something new? The effect of employee diversity on innovation. *Research Policy*, 40(3), 500–509.

Osterman, P. (1994). How common is workplace transformation and who adopts it? *Industrial and Labor Relations Review*, 47(2), 173–188.

Ragin, C. C. (Ed.) (2008). *Redesigning Social Inquiry*: *Fuzzy Sets and Beyond*. Chicago: University of Chicago Press.

Rupietta, C., & Backes-Gellner, U. (2012). *High quality workplace training and innovation in highly developed countries.* Swiss Leading House Working Paper no. 74.

Seny Kan, A. K., Adegbite, E., El Omari, S. & Abdellatif, M. (2016). On the use of qualitative comparative analysis in management. *Journal of Business Research*, 69(4), 1458-1463.

Schuler, R. S., & Jackson, S. E. (1987). Linking Competitive Strategies with Human Resource Management Practices. *Academy of Management Executive*, 1(3), 207–219.

Smith, K. G., Collins, C. J., & Clark, K. D. (2005). Existing knowledge, knowledge creation capability, and the rate of new product introduction in high-technology firms. *Academy of Management Journal*, 48(2), 346–357.

Smith, K. G., Smith, K. A., Olian, J. D., Sims, H. P., O'Bannon, D. P., & Scully, J. A. (1994). Top Management Team Demography and Process: The Role of Social Integration and Communication. *Administrative Science Quarterly*, 39(3), 412–438.

Sonnenfeld, J. A., & Peiperl, M. A. (1988). Staffing Policy as a Strategic Response: A Typology of Career Systems. *Academy of Management Review*, 13(4), 588–600.

Subramaniam, M., & Venkatraman, N. (2001). Determinants of transnational new product development capability: Testing the influence of transferring and deploying tacit overseas knowledge. *Strategic Management Journal*, 22(4), 359–378.

Subramaniam, M., & Youndt, M. A. (2005). The influence of intellectual capital on the types of innovative capabilities. *Academy of Management Journal*, 48(3), 450–463.

Swiss Federal Statistical Office (2002). NOGA General classification of economic activities. Retrieved February 16, 2017 from: https://www.bfs.admin.ch/bfs/en/home/statistics/industry-services/nomenclatures/noga/publications-noga-2002-1995.assetdetail.341591.html

Wagemann, C., Buche, J., & Siewert, M. B. (2016). QCA and business research: Work in progress or a consolidated agenda? *Journal of Business Research*, 69(7), 2531-2540.

Woodside, A. (2013). Moving beyond multiple regression analysis to algorithms: Calling for adoption of a paradigm shift from symmetric to asymmetric thinking in data analysis and crafting theory. *Journal of Business Research*. 66(4), 463-472.

Wright, P. M., Dunfold, B. B., & Snell, S. A. (2001). Human resources and the resource-based view of the firm. *Journal of Management*, 27(6), 701–721.

Wright, P. M., McMahan, G. C., & McWilliams, A. (1994). Human resources and sustained competitive advantage: a resource-based perspective. *International Journal of Human Resource Management*, 5(2), 301–326.

Tables and figures

Fig. 1 Ideal types of a KC system

	1	2	3	4
Human capital pool	core component	core component	core component	core component
HRM system		peripheral component	core component	core component
Firm size	small	large	small	large
Industry dynamism	low	low	high	high

Table 1 Descriptive statistics

Variables	Traditional manufacturing Obs.	Mean	Std. dev.	Min.	Max.	High tech manufacturing Obs.	Mean	Std. dev.	Min.	Max.
Uncalibrated										
Sales share strongly improved products	213	14.827	18.010	0	100	248	23.613	20.564	0	100
Human capital pool (large share of workers with:)										
University degree	213	3.061	5.123	0	54	248	6.750	7.959	0	50
PET degree	213	10.291	8.311	0	50	248	17.403	12.179	0	76
VET degree	213	41.263	20.515	0	90	248	45.758	18.029	4	86
HRM system										
No teamwork applied	55					40				
Teamwork applied	158					208				
No job rotation	150					187				
Job rotation	63					61				
Work pace	213	3.282	0.737	1	5	248	3.206	0.775	1	5
Sequencing	213	3.526	0.872	1	5	248	3.350	0.922	1	5
Distribution	213	4.005	0.755	2	5	248	3.980	0.734	2	5
Workmanship	213	3.545	0.934	1	5	248	3.363	0.942	1	5
Production problems	213	3.925	0.785	2	5	248	3.810	0.800	1	5
Customer relations	213	3.535	1.168	1	5	248	3.282	1.106	1	5
Customer complaints	213	3.981	0.961	1	5	248	3.706	0.976	1	5
Industry dynamism	213	0.227	0.164	0.031	0.594	248	0.246	0.080	0.097	0.319
Firm size	213	184.056	259.594	17	2515	248	209.045	429.196	11	5445
Calibrated										
Incr. innovation performance	213	0.460	0.344	0.099	0.999	248	0.502	0.362	0.049	0.999
Human capital pool (large share of workers with:)										
University degree	213	0.471	0.289	0.169	0.999	248	0.464	0.340	0.099	0.999
PET degree	213	0.368	0.352	0.009	0.999	248	0.464	0.348	0.019	0.999
VET degree	213	0.383	0.375	0	0.999	248	0.459	0.371	0	0.999
HRM system										
Teamwork	213	0.742		0	1	248	0.839		0	1
Job rotation	213	0.296		0	1	248	0.246		0	1
Empowerment	213	0.284	0.140	0.049	0.779	248	0.332	0.161	0.059	0.849
High industry dynamism	213	0.763	0.347	0.009	0.999	248	0.699	0.244	0.429	0.999
Large firm	213	0.628	0.164	0.439	0.999	248	0.588	0.184	0.359	0.999

Table 2 Principal factor analysis for responsibility distribution

	Traditional manufacturing Factor 1	High tech manufacturing Factor 1
Survey item		
1. Work pace	0.234	0.423
2. Sequencing	0.475	0.540
3. Distribution	0.319	0.378
4. Workmanship	0.287	0.419
5. Production problems	0.361	0.470
6. Customer relations	0.669	0.724
7. Customer complaints	0.693	0.568
Eigenvalue	1.522	1.855

All items are measured on a scale ranging from 1 (the worker has all the decision-making responsibilities) to 5 (the supervisor has all the decision-making responsibilities).

Table 3 Configurations explaining superior incremental innovation performance in manufacturing

Sector	**Traditional manufacturing**			**High tech manufacturing**			
KC system	1	2	3	4	5	6	7
HC pool (large percentage of workers with:)							
University degree	●			⬤	●	⨂	⬤
PET degree		●	⬤	⨂	⬤	●	⬤
VET degree	⨂	●				⨂	⬤
HRM system							
Teamwork	●	⬤	●	●	●	⊗	●
Job rotation	⊗	⨂	⬤	⬤	⊗	⊗	⊗
Empowerment	⊗	⊗	⊗	⊗	⬤	⊗	⊗
High industry dynamism	⨂	⬤	●	⬤	●	⨂	⊗
Large firm	●	⨂	●	⊗	⊗	⊗	⬤
Consistency	0.86	0.82	0.85	0.84	0.80	0.84	0.85
Raw coverage	0.17	0.11	0.08	0.06	0.16	0.03	0.12
Unique coverage	0.17	0.08	0.08	0.06	0.07	0.03	0.03
Overall solution consistency	0.81			0.83			
Overall solution coverage	0.26			0.29			

⬤ Core condition (present)

● Peripheral condition (present)

⨂ Core condition (absent)

⊗ Peripheral condition (absent)

Appendix

Table A.1 Industry and sector classification

Industry number	Industry title	Sector
Manufacturing		
1	Manufacture of food products, beverages and tobacco	Traditional manufacturing
2	Manufacture of textiles and textile products	Traditional manufacturing
3	Manufacture of wearing apparel; dressing and dyeing of fur and Manufacture of leather and leather products	Traditional manufacturing
4	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Traditional manufacturing
5	Manufacture of pulp, paper and paper products	Traditional manufacturing
6	Publishing, printing and reproduction of recorded media	Traditional manufacturing
7	Manufacture of coke, refined petroleum products and nuclear fuel and manufacture of chemicals and chemical products	High tech manufacturing
8	Manufacture of rubber and plastic products	High tech manufacturing
9	Manufacture of other non-metallic mineral products	Traditional manufacturing
10	Manufacture of basic metals	Traditional manufacturing
11	Manufacture of fabricated metal products, except machinery and equipment	Traditional manufacturing
12	Manufacture of machinery and equipment not classified elsewhere	High tech manufacturing
13	Manufacture of electrical machinery and apparatus not classified elsewhere	High tech manufacturing
14	Manufacture of office machinery, data processing devices, Manufacture of radio, television and communication equipment and apparatus, manufacture of medical and surgical equipment and orthopedic appliances, manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, manufacture of industrial process control equipment and manufacture of optical instruments and photographic equipment	High tech manufacturing
15	Manufacture of watches and clocks	Traditional manufacturing
16	Manufacture of transport equipment	High tech manufacturing
17	Manufacture of furniture, jewelry, musical instruments, sports goods, games and toys and other goods, recycling	Traditional manufacturing
18	Electricity, gas and water supply	Traditional manufacturing
Construction		
19	Construction	Construction
Services		
20	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel and wholesale trade and commission trade, except of motor vehicles and motorcycles	Traditional services
21	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	Traditional services
22	Hotels and restaurants	Traditional services
23	Land transport; transport via pipelines, Water transport, air transport and supporting transport activities; activities of travel agencies	Traditional services
24	Financial intermediation; insurance (excluding compulsory social security)	Modern services
25	Real estate activities and Renting of machinery and equipment without operator and of personal and household goods	Traditional services
26	Computer and related activities and research and development	Modern services
27	Other business activities	Modern services
28	Other service activities	Traditional services
29	Post and telecommunications	Modern services

Source of industry titles: Swiss Federal Statistical Office (2002)

Table A.2 Calibration

Conditions	Fully-in	Cut off	Fully-out
Human capital pool (large percentage of workers with:)			
University degree	+ industry-specific std. dev.	0	- industry-specific std. dev.
PET degree	+ industry-specific std. dev.	0	- industry-specific std. dev.
VET degree	+ industry-specific std. dev.	0	- industry-specific std. dev.
HRM system			
Teamwork (binary)			
Job rotation (binary)			
Empowerment	1	3	5
Industry dynamism	+ industry-specific std. dev.	0	- industry-specific std. dev.
Firm Size	+ industry-specific std. dev.	0	- industry-specific std. dev.

Table A.3 Analysis of necessary conditions

Conditions	Consistency	Coverage
Human capital pool (large percentage of workers with:)		
University degree	0.62	0.61
PET degree	0.51	0.64
VET degree	0.43	0.51
HRM system		
Teamwork	0.73	0.45
Job rotation	0.34	0.53
Empowerment	0.42	0.64
Industry dynamism	0.83	0.50
Firm Size	0.78	0.57

Table A.4 Analysis with negated outcome (high-tech manufacturing).

	1
HC pool (large percentage of workers with:)	
University degree	⨂
PET degree	⨂
VET degree	
HRM system	
Teamwork	⬤
Job rotation	⊗
Empowerment	⊗
High industry dynamism	⨂
Large firm	
Consistency	0.86
Raw coverage	0.17
Unique coverage	0.17
Overall solution consistency	0.86
Overall solution coverage	0.17

⬤	Core condition (present)
●	Peripheral condition (present)
⨂	Core condition (absent)
⊗	Peripheral condition (absent)

Table A.5 Summary of fsQCA robustness tests (Sector: Traditional manufacturing)

	1	2	3
Robustness tests			
Consistency cutoff = 0.90 (next case with higher consistency)	A: Identical	Does not appear	B: Identical
Consistency cutoff = 0.82 (-0.04)	A: Identical	B: Somewhat similar	C: Similar
Frequency cutoff = 4 (+1)	Does not appear	B: Somewhat similar	Does not appear
Frequency cutoff = 2 (-1)	A&F: Similar C: Somewhat similar	D: Somewhat similar	B: Similar

To compare the results reported in the paper with the robustness checks, we code a configuration as *identical* when there is no change in either core or peripheral condition; *very similar* if the core conditions remain stable and the majority of the peripheral conditions remains stable; *similar* if the majority of the core conditions remains stable and the majority of the peripheral condition remains stable; and *somewhat similar* if the core and peripheral conditions change but most of the conditions retain their direction.

Table A.6 Summary of fsQCA robustness tests (Sector: High tech manufacturing)

	4	5	6	7
Robustness tests				
Consistency cutoff = 0.84 (+0.01)	B: Identical	Does not appear	A: Somewhat similar	C: Identical
Consistency cutoff = 0.82 (-0.01)	C: Identical	E: Identical	A: Somewhat similar	B&D: Somewhat similar
Frequency cutoff = 4 (+1)	Does not appear	Does not appear	Does not appear	A: Somewhat similar
Frequency cutoff = 2 (-1)	C1: Identical C2: Very similar	D & E: Somewhat similar	A1 & A2: Somewhat similar	B: Similar

To compare the results reported in the paper with the robustness checks, we code a configuration as *identical* when there is no change in either core or peripheral condition; *very similar* if the core conditions remain stable and the majority of the peripheral conditions remains stable; *similar* if the majority of the core conditions remains stable and the majority of the peripheral condition remains stable; *somewhat similar* if core and peripheral conditions change but most of the conditions retain their direction.