EFFECTS OF ORGANIZATIONAL WORKFORCE FLEXIBILITY ON PRODUCT INNOVATION OUTCOMES

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ABSTRACT

The purpose of this study is determine whether and how the flexibility of the workforce is affecting product innovation outcomes of firms responding to their changing environments. Drawing on the resource-based theory of the firm we contribute to the literature distinguishing human resource characteristics from human resource management practices and subdividing the characteristics into functional and numerical flexibility of the workforce. Accordingly, we hypothesized that both types of flexibility influence product innovation outcomes but in different ways. A large-scale sample of 407 Dutch firms across various manufacturing goods and business services industries was used to test the hypotheses. The results show that functional flexibility influences radical product innovation, where external numerical flexibility influences both incremental and radical product innovation. This implies that managers of manufacturing goods as well as service firms may use training and education as part of the functional flexibility to create a workforce deployed to increase radical product innovation outcomes. Similarly, fixed-term contracts as part of the external numerical flexibility of the workforce increase both radical and incremental product innovation. This study contributes to the production innovation literature with taking this human resource perspective on flexibility in product innovation that is complementary to the new product or new product development perspective on product innovation.

INTRODUCTION

How firms respond to changing environments is a central theme in organization and management research (Hannan and Freeman, 1984; Levinthal and March, 1993; Tushman and Anderson, 1986). Firms are increasingly challenged to develop new products in order to respond to environmental change, develop competitive advantages and increase their chances of survival (Meeus and Oerlemans, 2000). Major environmental changes not only requires firms to decrease the time to get the products onto the market (Brown and Eisenhardt, 1995). They also demand firms to develop and commercialize new products beyond incremental new products (O'Connor, 2008). Recent environmental shocks, for example due to a financial crisis, makes managers even more aware of the need to develop new products, though innovation budgets are under pressure to be cut. Consequently managers change their organizations to have flexible structures, systems and people.

How firms create flexibility in their new product innovation processes and how it affects new product outcomes has already extensively been studied (Biazzo, 2009; Iansiti, 1995; MacCormack, Verganti, and Iansiti, 2001; Sanchez and Mahoney, 1996; Thomke, 1998). Also research on organizational structures and routines and their new product innovation outcomes is readily available (Benner, 2009; Buganza, Dell'Era, and Verganti, 2009; Buganza and Verganti, 2006). Surprisingly, little research has been done on the flexibility of human resource systems on new product innovation outcomes. Human resource systems include HRM-practices, workforce skills and behavior (Wright and Snell, 1998). Some researchers did investigate human resource practices and found that they have effects on new product development activities (Arvanitis, 2005; Beugelsdijk, 2008; Keld and Foss, 2003). However in essence, not the human resource (management) practices, but the human resources themselves account for new product development activities and their outcomes, though these human resources are likely to be affected by these practices. Ultimately, these human resources can lead to a competitive advantage, if they are valuable, rare, inimitable and non-substitutable (Wright, McMahan, and McWilliams, 1994).

It is this flexibility of the underlying human resource skills represented in numerical and functional flexibility of the workforce that is hardly investigated in the context of product innovation. The numerical flexibility involves the numbers workers and working hours employed, for example contingent workers hired for their specialized skills to carry out a temporary project (Atkinson, 1987; Kochan, Smith, Wells, and Rebitzer, 1994). The functional flexibility of the workforce refers to employees who can accomplish a large number of diverse tasks (Atkinson, 1987; Macduffie, 1995; Snell and Dean, 1992). Taking it all together, the numerical and functional flexibility of the set of employees are expected to have a direct effect on activity outcomes. Therefore, the following research question is answered in this research. What is the effect of workforce flexibility on new product innovation outcomes? The rest of the paper is structured as follows. The next section describes the theoretical framework that embeds the hypotheses. Thereafter the method and the findings of the study are presented. The paper ends with a conclusion, a discussion of its theoretical contribution and limitations, and with the managerial implications.

THEORETICAL FRAMEWORK

Different streams of research discuss the role of flexibility in adapting to environmental changes. In the new product development literature flexibility is treated as a characteristic of the product, the product development process, structure or team. Various mechanisms in the context of new product development (NPD) have been studied that create flexibility in NPD projects (Biazzo, 2009), i.e. 1) rapid and early experimentation around concepts (Iansiti, 1995; MacCormack et al., 2001; Thomke, 1998), 2) exploitation of people's generational experience (MacCormack et al., 2001), 3) the search for modular product architectures (MacCormack et al., 2001; Sanchez and Mahoney, 1996), and 4) organization structures and teams (Buganza et al., 2009). While these NPD mechanisms have been found to resort effects, this does not exclude the effects of flexibility mechanisms at the organizational level for example in workforce skills. This is the domain of management and HRM studies.

In the management and HRM literature flexibility is regarded as an organizational trait. From a resource-based view of the firm, it represents the "firm's ability to quickly reconfigure resources and activities in response to environmental demands" (Wright and Snell, 1998: p. 758). Amongst others human resources determine this flexibility. The human resources are often broadly subdivided into two types: employee skills and employee behavior (Wright and Snell, 1998). Skills and behaviors of the workforce are related, as skills to experiment allow behaving in an experimental way too. But behavior also differs from skills because of personal conditions such as motivation and because of organizational conditions such as routines (Wright and Snell, 1998). Employees could be reluctant to generate new ideas for innovation even if they possess the skills to do so. At the organizational level, if employees are used to act in a particular (e.g., standardized working processes), they are unlikely to experiment although they might have the skills to do so. Here our main focus is on the flexibility residing in the workforce skills, assuming that these are largely consistent with workforce behavior (see e.g. Carvalho and Cabral-Cardoso, 2008).

Flexibility in workforce skills may be found in the quantity of human resources and the functional tasks and jobs. The quantity of human resources involves the number of workers and the number of working hours (Atkinson, 1987). This type is often labeled numerical flexibility. This flexibility in turn falls apart in internal (extra hours, flexible part-time work) and external flexibility (temporary contracts, freelancers). For example, contingent workers may be hired for their specialized skills to carry out a temporary project (Kochan et al., 1994). Flexibility in workforce skills may also be found in functional tasks and jobs. Employees who can accomplish a large number of diverse tasks and jobs are thought to be more flexible (Atkinson, 1987; Macduffie, 1995; Snell and Dean, 1992). This is labeled functional flexibility. Others use a similar typology but with other less unambiguous labels. For example Wright and Snell (1998) follow Sanchez (1995) who distinguishes between resource flexibility and coordination flexibility. This largely corresponds with the terms functional and numerical flexibility, respectively.

Numerical flexibility

Numerical flexibility is defined as "the ability of firms to adjust the number of workers, or the level of worked hours, in line with changes in the level of demand for them" (Atkinson, 1987: p. 90). Numerical flexibility can be divided into internal numerical flexibility and external numerical flexibility (Martínez-Sánchez, Vela-Jiménez, Pérez-Pérez, and De-Luis-Carnicer, 2008). Internal numerical flexibility refers to the ability to adjust the quantity of human resources by changing the hours the existing workforce makes. For example, working overtime, part-time or in flexible hours falls within this category.

Internal numerical flexibility allows organizations to adjust its amount of human resources to its demand for human resources in a quickly manner (Martínez-Sánchez et al., 2008; Van der Steenen, Sels, Van Hootegem, Forrier, and De Witte, 2002). It is the fastest way to ensure that the workforce hours match an increase in workload, while the individual workload per hour, the number of workers, and the breadth and depth of knowledge need in the product development process remain stable. Also, coordination costs are low. The size and duration of the changes in workforce hours, however, is limited, as it may be restricted by labor laws and regulations, and employee motivation. It provides flexibility to the workforce, giving individuals or organizational units the possibility to anticipate problems and opportunities when they occur, by working extra hours when necessary. Short-term low-level uncertainties present in new product development processes, but also production processes, can benefit from this flexibility. For example, competitive or customer pressure to speed up a delayed prototyping process to meet a fairs deadline or to introduce the final product onto the market may stand to benefit from (paid) overtime. On the other side, costs cutback programs may require a (temporary) decrease in hours worked slowing down the number of new products developed. Generally, with cutback programs being an exception, internal numerical flexibility may positively affect new product innovation outcomes.

External numerical flexibility means that the number of workers is adjusted, i.e. changing the existing workforce (Martínez-Sánchez et al., 2008), for instance hiring fixed-term specialized workers, or hiring/firing of temporary agency workers from job agencies. With including individual contractors, it is distinguished from outsourcing tasks to other firms (Martínez-Sánchez et al., 2008). Compared to internal numerical flexibility its access to human resources is less fast, but with a larger change in size and duration of workforce hours as well as at higher coordination costs. Furthermore, it is not solely aimed at achieving an optimal usage of the human resources capacity, but may also change the breadth or depth of the knowledge corresponding with needs in the development process. It can include hiring specialists temporarily; these employees are needed for specific knowledge for a short period of time (Kochan et al., 1994; Van der Steenen et al., 2002). Similar to changes in workers hours, the change in number of workers may be restricted by labor laws and regulations, labor markets, and employee motivation.

External numerical flexibility is likely to be related to innovation through the knowledge and skills availability within a workforce. External employees hired on a fixed-term or temporary agency basis are likely to have different knowledge and skills than permanent employees. On one hand, these employees lack organization specific-knowledge. On the other hand, they may bring knowledge and skills into the organization that are not available among permanent workers. Thus, arguments exist both for a positive and negative effect of numerical flexibility on innovation. Empirical results offer evidence for both of these contrasting arguments too. For instance, Martínez-Sánchez *et al*. (2008) and Beugelsdrijk (2004) found negative effects of external numerical flexibility of innovation. In contrast, Arvanitis (2005) found a positive effect of external numerical flexibility on product innovation, which he explains by the possibility for organizations to hire temporarily highly skilled R&D workers that are needed for an NPD process. However, in this current research, the focus lies on entire workforce, not merely the R&D department. Therefore, we stress the importance of organization specific-knowledge among the workforce, as Van De Ven puts it: “People will pay attention to new ideas the more they experience personal confrontations with sources of problems, opportunities, and threats which trigger peoples' action thresholds to pay attention and recognize the need for innovation” (Van De Ven, 1986: p. 604). Thus, organization-specific knowledge is essential in the creation of ideas and engaging in innovation and therefore we hypothesize a negative effect of external numerical flexibility on product innovation.

Hypothesis 1: Internal numerical flexibility positively affects product innovation.
Hypothesis 2: External numerical flexibility negatively affects product innovation.

Functional flexibility

In many studies functional flexibility is defined to include both skill and behavior flexibility, as “the ability to respond to changes in business needs by having multi-skilled, adaptable and internally mobile employees” (Blyton and Morris, 1992; Carvalho and Cabral-Cardoso, 2008: p. 333, based on Atkinson, 1987; Sparrow and Marchington, 1998). By referring to adaptable and internally mobile employees, these studies include also the willingness (thus the behavioral component) of human resources. If employees are internally mobile, it indicates that they are willing to work on different tasks too. In our study, we restrict functional flexibility to skill flexibility. Functional flexibility permits organizations to flexibly use human resources according to tasks and jobs (Van der Steenen et al., 2002: p. 6). A functional flexible workforce means that employees possess a broad range of skills and therefore they can be flexibly reassigned to different jobs and tasks in the organization (Atkinson, 1987). Skills address knowledge and know-how.

For employees to generate and to develop new ideas, flexibility in functional tasks is necessary. This is agreed upon by many authors, however, many do not well explain the mechanism between functional flexibility and innovation (e.g. Martínez-Sánchez et al., 2008). It is assumed to be logical that functional flexibility is required for innovation. An exception is Van De Ven (1986), who explains that employees should not only possess knowledge within their own functional area, they also need to have an understanding of what occurs beyond their functional department. “People develop an understanding of the essential considerations and constraints of all aspects of the innovation in addition to those immediately needed to perform their individual assignments” (Van de Ven, 1986: p. 600). As a result, “The more specialized, insulated, and stable an individual's job, the less likely the individual will recognize a need for change or pay attention to innovative ideas” (Van de Ven, 1986: p. 604).

Martínez-Sánchez *et al.* (2008) conducted an uncommon study on the role of functional flexibility on innovation. Martínez-Sánchez *et al.* (2008) define it as “a process through which firms adjust to changes in the demand for their output by an internal reorganization of workplaces based on multiskilling, teamworking and the involvement of employees in job design and the organization of work" (Martínez-Sánchez et al., 2008: p. 650). The findings of this study indicate that functional flexibility is positively related to innovation. For product innovation, the functional flexibility required lies for instance in the interface between R&D and marketing (Moenaert and Souder, 1990); if an R&D employee does not have any insight in customer demands, new technologies that may be developed do not lead to increased customer value. Vice versa, if a marketing employee does not know what possibilities are available in technology, he or she does not know about new potential product features that increase customer value.

Hypothesis 3: Functional flexibility is positively related to product innovation.

METHOD

Sample

The hypotheses were tested by using a regression analysis of secondary data. These data were obtained from DANS[1] and provided by a labor market research institute (Organisatie voor Strategisch Arbeidsmarktonderzoek) affiliated with two Dutch universities in the Netherlands. This institute gathered the data using a Labor Survey Panel in 2005/2006 with partly self-reporting survey and partly telephone interviews based on a standardized questionnaire. The sample contained Dutch organizations or its main subsidiaries with at least 5 employees. In total 407 observations were used including the sectors: agriculture and industry; construction; trade (whole and retail), hotel and catering, and repair industry; transport; and professional services.

Measures

Dependent variables

Product innovation was measured by the percentage of products or services that were changed compared two years ago, which is the sum of the percentages of incremental and radical product innovation. Incremental product innovation entails the percentage of new products and services that was renewed on some aspects. Radical product innovation entails the percentage that was substantially changed or even entirely renewed.

Independent variables

Internal numerical flexibility referring to the ability to adjust the number of hours was measured by the variable share extra hours worked as paid overtime of the total number of hours. For this variable the above median and below median categories were compared with no paid overtime as the reference category.

External numerical flexibility referring to the ability to adjust the number of workers was measured by four variables. Share of employees with a fixed-term contract in the total workforce. For this variable the above median and below median categories were compared with no fixed-term workers as the reference category. Temporary agency workers is a nominal variable. The question was asked: Does this organization have temporary agency workers in the total workforce: yes/no? In addition, two variables were chosen that reflect numerical bottlenecks. Keeping existing employees bottleneck: Is

[1] Data Archiving and Networked Services in the Netherlands, dataset title: OSA-Arbeidsvraagpanel 2005-2006, Creator: M.A.M. de Voogd. Data collection period: April 2005-May 2006.

keeping existing employees a bottleneck at this moment? Controlling work pressure bottleneck: Is controlling the work pressure a bottleneck at this moment?

Functional flexibility reflecting a broad range of skills was measured by three variables. Training and education: Percentage of employees that participated in external and/or internal education/training. In addition, two categorical variables were used to identify two functional bottlenecks. Inadequate qualifications bottleneck: Are inadequate qualifications of the workforce a bottleneck at this moment? Insufficient broad employability: Is the insufficiently broad employability of the workforce a bottleneck at this moment?

Control variables

The main control variables including in the models are the following.

Organizational size was included to control for effects on innovation (Camisón-Zornoza, Lapiedra-Alcamí, Segarra-Ciprés, and Boronat-Navarro, 2004; Laursen and Foss, 2003). Two dummy variables measuring the number of employees were used: Medium-size (20-99 employees) and Large-size (100 + employees) were compared to the reference category Small-size (5-19 employees).

R&D investments were measured as the percentage of turnover spent on R&D, with the above-median share, and below-median share, with no R&D investments as the reference category.

Organizational change with consequences for the workforce was measured reflecting the consequences of organizational changes (cutbacks/takeover) on the existing workforce. It consists of summated scale score of 5 items with respect to the workforce: expansion, reduction with enforced dismissals, reduction without enforced dismissals, reappointments, and extra/re-education/training.

Industry type was measured to control for technological opportunity differences (Geroski, 1990) by comparing the effect of the services (trade, catering, repair industry, transport, and professional services) with manufactured goods (agriculture, manufacturing and construction industry).

In addition, one other control variable was included in an earlier stage of analysis. To control for a difference in effect between the total workforce size and the workforce deployed in product innovation or R&D, the functional mutations in product innovation or R&D workforce was measured. This appeared not to have a significant effect on product innovation.

Analysis

We used a hierarchical regression analysis, with the first step specifying the control model, then in the second step adding the functional flexibility variables and in the third step adding the numerical flexibility variables. In addition, taking an exploratory angle in order to better explain our results of the main analysis of the product innovation model, we specified the model for incremental and radical innovation as these innovation practices largely differ (Garcia and Calantone, 2002).

RESULTS

Table 1 Descriptive statistics of dependent variables (n=407)

	Mean	Std. dev.	I	II
I Share product innovation	12.53	21.11	1	
II Share incremental product innovation	6.71	13.00	.746**	
III Share radical product innovation	5.82	14.33	.796**	.191**

Note: * = p<.05; ** = p<.01; *** = p<.001

Table 2 Descriptive statistics of independent variables (n=407)

		Mean	Std. dev.	% of n	Ref.cat.
Organizational size	Small-size (5-19 employees):			52.3	Ref.cat.
	Medium-size (20-99 employees)			24.1	
	Large-size (100+ employees)			23.6	
R&D investments	No R&D-investments			68.1	Ref.cat.
	R&D-investments below median			16.2	
	R&D-investments above median			6.6	
	R&D-investments missing			9.1	
Organizational Changes	Number of organizational change consequences for workforce	0.49	0.91		
Industry type	Products (agriculture, industry, construction)			43.0	Ref.cat.
	Business Services (trade, catering, repair, prof)			57.0	
Extra hours paid overtime	No Overtime			35.9	Ref.cat.
	Overtime below median			31.0	
	Overtime above median			16.2	
	Overtime missing			17.0	
Fixed-term workers	No fixed-term workers			42.8	Ref.cat.
	Percentage fixed-term workers below median			29.5	
	Percentage fixed-term workers above median			27.8	
Temporary agency workers	Nominal variable (yes/no)			52.6	
Keeping existing employees	Bottleneck: nominal variable (yes/no)			7.9	
Controlling work pressure	Bottleneck: nominal variable (yes/no)			19.2	
Training and education	No training and education			19.2	Ref.cat.
	Training and education below median			34.6	
	Training and education above median			32.7	
	Training and education missing			13.5	
Inadequate qualifications	Bottleneck: nominal variable (yes/no)			27.5	
Insufficient broad employability	Bottleneck: nominal variable (yes/no)			25.1	

Note: Ref.cat. = reference category; not present if not indicated.

Table 3 Regression analysis results (n=407)

			Product Innovation		Incremental Product Innovation		Radical Product Innovation	
			Beta	Sig	Beta	Sig	Beta	Sig
Control variables	Organizational size	Medium-size (20-99 employees)	-0.074	ns	-0.093	ns	-0.024	ns
		Large-size (100+ employees)	0.070	ns	0.079	ns	0.031	ns
	R&D investments	R&D investments below median	0.133	**	0.174	***	0.038	ns
		R&D-investments above median	0.323	***	0.259	***	0.241	***
		R&D-investments missing	0.241	***	0.131	*	0,236	***
	Organizational Changes	Number of organizational change consequences	0.035	ns	-0.104	*	0.147	**
	Industry type	Business Services (trade, catering, repair, prof.)	-0.010	ns	0.042	ns	-0.053	ns
Internal Numerical Flexibility	Extra hours paid overtime	Overtime below median	-0.011	ns	-0.015	ns	-0.004	ns
		Overtime above median	-0.007	ns	-0.056	ns	0.040	ns
External Numerical Flexibility	Fixed-term workers	Percentage fixed-term workers below median	0.045	ns	0.133	*	-0.054	ns
		Percentage fixed-term workers above median	0.156	**	0.118	*	0.123	*
	Temporary agency workers	Nominal variable (yes/no)	-0.016	ns	-0.023	ns	-0.002	ns
	Keeping existing employees	Bottleneck: nominal variable (yes/no)	0.087	ns	0.135	**	0.005	ns
	Controlling work pressure	Bottleneck: nominal variable (yes/no)	0.041	ns	-0.034	ns	0.092	ns
Functional Flexibility	Training and education	Training and education below median	0.026	ns	-0.010	ns	0.047	ns
		Training and education above median	0.156	*	0.064	ns	0.172	**
		Training and education missing	0.009	ns	0.016	ns	-0.002	ns
	Inadequate qualifications	Bottleneck: nominal variable (yes/no)	-0.030	ns	-0.012	ns	-0.033	ns
	Insufficient broad employability	Bottleneck: nominal variable (yes/no)	-0.062	ns	-0.021	ns	-0.072	ns
Model Statistics:	**Compound effects**							
	Controls only	R^2 change	0.202	***	0.139	***	0.143	***
	Functional Flexibility	R^2 change	0.02	ns	0.005	ns	0.023	ns
	Numerical Flexibility	R^2 change	0.033	*	0.036	*	0.033	*
	Full model	R^2	0.255		0.180		0.199	
	F-value (degrees of freedom)		6.62 (20, 386)	***	4.23 (20, 386)	***	4.79 (20, 386)	***

Note: * = p<.05; ** = p<.01; *** = p<.001. Product innovation (PI) is the accumulation of incremental product innovation and radical product innovation. Organizational size reference category: Small-size (5-19 employees). Industry type is reference category: Products (agriculture, industry and construction). For R&D-investments, Fixed-term workers, Training and education, Overtime, the above median and below median categories are compared with 0-category as reference category.

In Table 1 and Table 2 the descriptive statistics of the dependent and independent variables are presented respectively. Correlation between incremental and radical innovation is low, suggesting that firms that pursue incremental product innovation are mostly not developing radical new products. The statistics in Table 2 give an overview of the operationalization, coding and missing values of variables used.

Table 3 shows the results of the regression analysis. The missing values of the variables are included in our analysis to test for their effects. With respect to internal numerical flexibility we did not find support the hypothesized (H1) positive effect of extra hours paid as overtime on undifferentiated product innovation nor incremental and radical innovation.

With respect to the hypothesized (H2) negative effect of external numerical flexibility on product innovation there is no support. Nevertheless, we did find effects depending on the nature of the numerical flexibility. With respect to numerical flexibility in terms of hiring (or firing) fixed-term workers a significant positive effect was found on undifferentiated product innovation, incremental and radical innovation. Our results do not show an effect of the use of temporary agency workers on undifferentiated product innovation, radical nor incremental innovation. With respect to the numerical bottlenecks, problems with keeping existing employees did not appear to significantly affect undifferentiated product innovation nor radical innovation. However, when keeping existing employees is a bottleneck this did appear to positively affect incremental innovation. Furthermore, with respect to problems with controlling work pressure no effect was found on undifferentiated product innovation, on incremental and on radical innovation.

Some support was found for hypothesis 3 suggesting a positive effect of functional flexibility on product innovation. Participation of employees in internal and/or external education and training appears to affect the number of products or services developed. This effect seems to be present for radical innovation and absent for incremental innovation. The indicators of functional flexibility bottlenecks did not appear to have a significant effect on undifferentiated product innovation, nor radical and incremental innovation.

These innovation results do not differ with respect to industry type (manufactured products versus business services) as well as with respect to organizational size. However, other control variables, R&D-investments and organizational change consequences do largely account for the variance in product innovation. Also, R&D investments determine the number of product innovations. And if the number of organizational change consequences for the workforce is larger, the number of incremental product innovations appears to be smaller at the benefit of a larger number of radical product innovations.

CONCLUSION AND DISCUSSION

Using a large scale survey across different industries in The Netherlands, we find that human resource flexibility, in particular, the flexibility of the workforce is important for product innovation, but especially with respect to developing radical new products or services and for elements of flexibility only. These findings complement the progression in the product innovation research on the nature of the flexibility of the new product development process (see e.g. Biazzo, 2009; Buganza et al., 2009; Buganza and Verganti, 2006; MacCormack et al., 2001). In addition, our study is one of the very few studies in the field of human resource management that differentiates product innovation into incremental and radical innovation (c.f.Martínez-Sánchez et al., 2008). The findings also contribute to the debate with respect to the resource-based theory of the firm in arguing that the human resources rather than the human resource management practices demarcate the sources of competitive advantage (Wright et al., 1994).

One element of a functional flexible workforce appears to affect radical innovation. Externally and internally training and educating employees to develop their skills is likely to represent the ability to use a broadly skilled workforce. Organizations that exhibit the ability to use a broadly skilled workforce with employees capable of executing various tasks and jobs appear to more radically new products. Support for the effects of other functional bottlenecks, an inadequately qualified and insufficiently broad employable workforce, that were thought to hinder product innovation was not found.

Moreover an external numerical flexible workforce appears to affect radical innovation, but also incremental innovation. While using temporary workers from job agencies does not appear to affect product innovation, the ability to adjust the number of fixed-term workers does appear to make a difference. Interestingly, we hypothesized a negative relationship, while we found a positive relationship. Using fixed-term employees seems to offer the specialized knowledge in order to renew the workforce and develop both incremental and radical products and services. In previous research, external numerical flexibility measured as a composite score of items was found to have a negative effect on innovation performance (Martínez-Sánchez et al., 2008). Part of the explanation is that such a composite score may hide effects of specific elements such as using fixed term contracts. Also Beugelsdijk (2008) found a negative relationship based on an analysis of some individual elements, but focussed on standby contract practices. Their explanation is that temporary employees possess les firm-specific knowledge, which inhibits innovation. An explanation for the positive relationship may be that these temporary workers may be hired for the specialized skills that are lacking in the NPD process (Arvanitis, 2005), while these workers may do the utmost in order to become a permanent position as is typical in the Dutch labor market.

Other interesting findings are that one numerical bottleneck, problems with keeping existing employees, appears to positively affect incremental innovation. Here explanations may be that this bottleneck shows the practice of a hard working environment in contrast to an environment of complacency and lack of discipline (see e.g. Nohria and Gulati, 1996) that may yield more innovations in the relative short term, but possible at the cost of a unmotivated employees that leave the firm in the longer run. In addition, internal numerical flexibility measured by the extra hours worked as paid overtime did not appear to have an effect.

The main limitations of the study and future research implications are the following. While the secondary database allowed investigating an array of variables in a large, diverse and representative set of firms, the number of variables included for functional and numerical flexibility is still limited. Future researchers may consider functional flexibility with other variables than training and the bottlenecks, such as job rotation, multi-skilled teams, quality and problem solving teams, and the involvement of employees in planning and job design (see e.g. Martínez-Sánchez et al., 2008). For numerical flexibility, internal factors may be included such as part-time contracts, jobsharing, workload reduction, flexitime as well as external factors such as the number of lay-offs (see e.g. Martínez-Sánchez et al., 2008). In addition, while the measure of product innovation distinguished incremental from radical new products or services and our study is amongst the very few on this particular topic of workforce flexibility that accounted for a distinction, it did not allow for differentiating between product/technology newness for the firm and product/technology newness for the industry/customers (see e.g. Garcia and Calantone, 2002). Future research may want to take up this issue.

In addition, while we took industry type effects into account by broadly distinguishing manufacturing products firms from services firms, the very different mechanisms underlying innovation practices in service and manufactured product innovation (De Brentani, 2001) are likely to require a more detailed analysis of the workforce flexibility effects. Moreover, the sample included Dutch firms only that are under control of Dutch labor laws and governmental regulations. For example, offering employees a fixed-term contract of one year is a very typical example of Dutch labor law practice. Future research needs to investigate this topic across a broad range of countries with different labor laws and governmental regulations.

IMPLICATIONS FOR MANAGERS

R&D or product innovation managers of business services and manufactured products may take away that developing new products, in particular, radical innovations is likely to be affected by functional as well as external numerical flexibility of the workforce. In addition to taking a new product or development process perspective on flexibility in order to adapt to changes in the environment, managers may need to take a human resource perspective on flexibility. Taking such a human resource perspective, R&D managers may want confer the capacity for innovation projects and programs, the radical ones in particular, with human resource managers in order to determine the nature and changes in the workforce. Especially, the importance of training and education is re-established for developing a broad range of workforce skills that are likely to increase radical product innovation outcomes. Also the use of fixed-term contracts can be used in order to facilitate workforce adjustments to the particular knowledge and skills required for incremental as well as radical new product development projects. Discussing the human resource capacity for innovation projects with human resource managers, may also help R&D or product innovation managers, in particular those of multinational companies, to be informed by differences in labor laws and governmental regulations across countries or international regions.

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