Making a difference between major and incremental new product development: The effects of functional and numerical workforce flexibility

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Abstract

The purpose of this study is to explain the differential effects of workforce flexibility on incremental and major new product development (NPD). Drawing on the resource-based theory of the firm, human resource management research and the innovation management literature, we distinguish two types of workforce flexibility, i.e. functional and numerical flexibility of the workforce and hypothesized their differential effects on NPD outcomes. A large-scale sample of 407 Dutch firms across various manufacturing goods and business services industries was used to test these hypotheses. The results show that functional flexibility influences major NPD, where external numerical flexibility influences both incremental and major NPD. 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 major NPD outcomes. Complementing functional flexibility, they may also use fixed-term contracts as part of the external numerical flexibility to increase major NPD and to a lesser extent incremental NPD. The paper contributes to the product innovation literature suggesting that the differences between major and incremental NPD are also grounded in the human resource flexibility of the firm.

Introduction

Firms are increasingly challenged to develop new products in order to respond to environmental change, to develop competitive advantages and to increase their chances of survival (Meeus and Oerlemans, 2000). Environmental changes not only require firms to decrease the time-to-market (Brown and Eisenhardt, 1995), but also challenge firms to develop and commercialize major new products – radical and really new innovation – in addition to incremental new products (O'Connor, 2008). Major new product development (NPD) requires new knowledge based on new competencies and practices that is different from incremental NPD where new knowledge is based on existing competencies and practices (Christensen, 1997, Levinthal and March, 1993, O'Connor, 2008). Consequently, it is not surprising that managers not only change their organizations to have flexible structures and processes, they also change their organizations to have flexible people. The flexibility of the people employed, or workforce flexibility, is defined as the ability to change the jobs and tasks of workers, the working hours, and the number of workers (Atkinson, 1987).

About 90 percent of the US firms, especially high-technology firms, use contingent workers of which almost half employs them as technical experts in core areas (Matusik and Hill, 1998). ASML – that develops high-tech lithography systems for the semiconductor industry – is an example of a high-technology firm that not only increasingly employs contingent workers, but also stimulates workers to develop multiple skills. In 2010, ASML’s workforce flexibility is characterized by having a large share (22%) of people on fixed-term contracts via specialized detachment agencies and self-employed people, allowing employees to save up to 8 months of days of leave, and stimulating education and training facilities. According to Peter Wennink, executive vice president and CFO of ASML, it would not have survived the crisis in 2008 without flexibility in costs and labor. Flexibility together with continuous R&D investments were critical for maintaining commitment to innovation. Such flexibility seems to allow ASML to protect its technological leadership and benefit from the steep growth in the chip industry driven by electronic gadget innovations such as table PCs and smartphones.

Research on flexible organizational structures and routines, conditions for their use, and their effect on NPD outcomes is readily available (Benner, 2009, Buganza *et al.*, 2009, Buganza and Verganti, 2006). Also the way firms create flexibility in their NPD processes to develop major new products and how it affects NPD outcomes has already extensively been studied (Biazzo, 2009, Iansiti, 1995, MacCormack *et al.*, 2001, Sanchez and Mahoney, 1996, Thomke, 1998). These studies conclude that rather than traditional stage gate processes, flexible development processes employed through formal cross-functional teams in flat organization structures work better to develop major new products and to adapt to changing conditions in turbulent environments. To date, however, hardly any research in the field of product innovation has been conducted on the effect of workforce flexibility on NPD outcomes, distinguishing major from incremental NPD. Using a case study approach, O'Connor and McDermot (2004) discovered that major NPD requires flexible people, for instance highly multifunctional individuals rather than cross-functional teams. Also O'Connor (2008) signals the importance of a flexible workforce for major innovation hypothesizing about requisite skills and talents in her conceptual paper. Therefore, this research answers the question how workforce flexibility affects NPD outcomes, distinguishing major from incremental new products. We conducted a large-scale cross-industry analysis in The Netherlands.

Answers to this question help managers understand how human resource practices may benefit major and incremental NPD. This paper contributes to the product innovation literature analyzing the human resource aspects in determining the flexibility in NPD, where above-mentioned prior research mainly investigated NPD process aspects and organizational structures and routines. Moreover, it demonstrates that differences between major and incremental NPD outcomes are not only grounded for example in critical development activities such as strategic planning and business and market opportunity analysis (Song and Montoya-Weiss, 1998), but also in human resource characteristics of firms. This paper confirms the suggestion that the development of new competencies for major NPD is likely to be determined by workforce skills and the flexibility therein (O'Connor, 2008, O'Connor and McDermott, 2004). Furthermore, this paper also contributes to the literature on the management of human resources. It builds on the human resource management work of researchers that included product innovation as a homogeneous construct but neglected the difference between major and incremental NPD (see e.g. Arvanitis, 2005, Michie and Sheehan, 2003) or that combined product and process innovation elements into one single construct (see e.g. Martínez-Sánchez *et al.*, 2011, Martínez-Sánchez *et al.*, 2008), or do not treat all aspects of external numerical flexibility (Beugelsdijk, 2008, Martínez-Sánchez, *et al.*, 2008). As such it may provide an explanation for the conflicting findings of these studies in determining whether flexible contracts have a positive or negative effect on innovation.

The rest of the paper is structured as follows. The next section describes the theoretical framework that includes hypotheses. Thereafter the method and the findings of the study are presented. The paper ends with a conclusion, a discussion of its theoretical contribution, the limitations and future research suggestions, and the managerial implications.

Theoretical framework

Different streams of research discuss the role of flexibility in adapting to environmental changes. In the product innovation management literature flexibility is treated as a characteristic of the product, the product development process, structure or team rather than as a characteristic of organizational or R&D workforce. Various mechanisms have been studied that create flexibility in NPD projects (Biazzo, 2009), such as 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, routines and teams (Benner, 2009, Benner and Tushman, 2003, Buganza, *et al.*, 2009, Buganza and Verganti, 2006). While these NPD mechanisms have been found to resort effects, flexibility in NPD activities may also come from the human resources (O'Connor, 2008, O'Connor and McDermott, 2004).

In the management and HRM literature, flexibility is regarded as an organizational characteristic. 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). Human resources are part of these resources and include workforce skills (knowledge and knowhow) and behavior (Wright and Snell, 1998). Human resources, especially the individual knowledge and skills involved are lying at the basis of competitive advantages (Matusik and Hill, 1998, Wright *et al.*, 1994). The flexibility of the human resources may well be at the heart of the dynamic capabilities of firms. According to capability theory, dynamic capabilities represent the ability to build and reconfigure competencies and drive innovativeness in response to environmental changes (Benner, 2009, Teece *et al.*, 1997). Human resource flexibility resides in requisite skills and talent development that are part of the management system viewed as a dynamic capability that is conducive to the development of major innovations (O'Connor, 2008).

Flexibility in workforce skills and behavior falls apart in functional flexibility that involves the diversity of tasks and jobs and numerical flexibility that involves the quantity of human resources (Atkinson, 1987). The meanings of these terms functional and numerical flexibility largely correspond with the meaning of the labels resource flexibility and coordination flexibility respectively, used by for example Sanchez (1995) and Wright and Snell (1998). In the following section the arguments are given for the hypotheses visualized in figure 1.

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Functional flexibility

Functional flexibility entails adjusting the deployment of the workers and the job contents so that the worker can "deploy his or her skills across a broader range of tasks" (Atkinson, 1987: p. 90). In many studies functional flexibility is defined to include both skill and behavior flexibility (Blyton and Morris, 1992, Sparrow and Marchington, 1998), as "the ability to respond to changes in business needs by having multi-skilled, adaptable and internally mobile employees" (Carvalho and Cabral-

Cardoso, 2008: p. 333). 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). By referring to adaptable and internally mobile employees, these studies also include the willingness (thus the behavioral component) of employees. 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, assuming the skills are largely consistent with behavior (Carvalho and Cabral-Cardoso, 2008). 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).

For employees to generate and to develop new ideas, flexibility in functional tasks is necessary. This is agreed upon by many, however, most authors do not explain well the mechanism underlying the relationship between functional flexibility and innovation. Martínez-Sánchez *et al*. (2008) define functional flexibility 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” (p. 650). These aspects of functional flexibility highly correspond with Van de Ven’s requirements for innovation (Van de Ven, 1986). He 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). For NPD, 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, the new technologies developed are not likely to increase 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. The more it concerns a breakthrough technology – thus the more radical the new product – the stronger the impact of this lack of knowledge is and the greater the dependence on other functional specialists. Furthermore, radical and really new product innovation require a broader set of skills as multiple roles are required as well as a high connectivity between them (O'Connor and McDermott, 2004). This includes roles such as idea generation, project leading, gate keeping, sponsoring or coaching, and championing. Because these various roles cannot be fulfilled by one person, while at same time it is unlikely there is one person for every role (but even in that case), the radical innovation teams are to be composed of highly multifunctional individuals rather than only individuals with different functional (i.e. departmental) backgrounds (O'Connor and McDermott, 2004). As part of a dynamic capability system for radical innovation it involves the development of requisite skills and talent (O'Connor, 2008). Therefore, we propose the following hypothesis.

Hypothesis 1: Functional flexibility is positively related to product innovation outcomes with a stronger effect on major compared to incremental new products.

Numerical flexibility

When increasing functional flexibility by adjusting the deployment of workers and job contents is insufficient, firms may complement it with 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, *et al.*, 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 and flexible working hours fall within this category. Internal numerical flexibility allows organizations to quickly adjust its amount of human resources to its demand for human resources (Martínez-Sánchez, *et al.*, 2008). 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 or decrease the number of hours when necessary. 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 offered in the product development process remain stable. Also, coordination costs are low compared to hiring or firing employees. The size and duration of the changes in workforce hours, however, is limited, as it may be restricted by labor laws and regulations (Blanpain and Grant, 2009, Chung, 2009: p. 170).

Short-term low-level uncertainties present in new product development processes but also manufacturing 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. Here the effect on major new products is likely to be stronger as more market uncertainty as well as technological uncertainty is involved with respect to the nature as well as the timeframe of tasks to be carried out (O'Connor, 2008, Song and Montoya-Weiss, 1998). On the other side, a (temporary) decrease in hours worked (to prevent people from being dismissed) as a result of severe costs cutback programs may slow down development activities of major projects in particular as these projects are generally more risky. But at the same time if a decrease in working hours prevents to lay off workers, the knowledge and skills of these workers may be retained for future projects. Generally, cutback programs are an exception for R&D-people or may in times of economic crises even help keeping the R&D-budget intact when applied to other than R&D-people. Thus, internal numerical flexibility as a result of extra hours paid overtime may positively affect NPD outcomes. Therefore, we propose the following hypothesis.

Hypothesis 2: Internal numerical flexibility as a result of extra hours paid overtime positively affects NPD outcomes, with a stronger effect on major compared to incremental new products.

External numerical flexibility means that the number of workers is adjusted by changing the existing workforce (Atkinson, 1987, Kochan *et al.*, 1994, Martínez-Sánchez, *et al.*, 2008). This includes temporary workers from job agencies on day labor or on-call basis, temporary workers on fixed-term contracts (i.e. hired through in-house application procedures, detachment organizations or partner firms for their specialized skills to carry out a temporary project), or temporary workers that are self-employed individual subcontractors. 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. For example, hiring specialists for their specific knowledge for a short period of time provides change in knowledge range (Kochan, *et al.*, 1994). Similar to changes in workers hours, the change in number of workers may be restricted by labor laws and regulations.

Empirical results on the effects of external numerical flexibility are mixed. For instance, Martínez-Sánchez *et al*. (2008) and Beugelsdijk (2004) found significant negative effects of external numerical flexibility of innovation. In contrast, others found a significant positive effect (Arvanitis, 2005) or no significant effect (Michie and Sheehan, 2003) of external numerical flexibility on product innovation. Arguments for the effects of external numerical flexibility on innovation are found in the discrepancy between the available and required skills (including knowledge and knowhow) within a workforce, in the difference in commitment between the types of temporary workers to deploy those skills, and in the area where the skills are deployed – major or incremental NPD. However, the theoretical explanations of previous studies provide only part of the picture excluding relevant numerical flexibility practices (e.g. Beugelsdijk, 2008), including various human resource practices in one construct and unbundling product and process innovation (e.g. Martínez-Sánchez, *et al.*, 2011, Martínez-Sánchez, *et al.*, 2008), and/or abstracting from a distinction between major and incremental NPD (e.g. Arvanitis, 2005, Michie and Sheehan, 2003). Here we aim at combining these insights.

External employees hired on a fixed-term or temporary agency basis are likely to have different skills than permanent employees. While employees on fixed-term contracts or on temporary job agency contracts lack organization-specific knowledge, they may bring new skills into the organization that are not available among permanent workers (Matusik and Hill, 1998). However, the nature of skills of fixed-term workers is likely to be far more advanced than that of job agency workers hired on day labor or on-call basis, as the former are on average higher educated than the latter (Cörvers *et al.*, 2011: 59). Similarly, fixed-term workers hired for their specialized skills are likely to be more committed to their tasks and to the organization than job agency workers on an on-call or day labor basis. Posthuma et al. (2005) find differences in productivity between the two types of non-permanent workers that can be explained by differences in commitment to the organization. Note that while Pearce (1993) found no support for the hypothesized difference between non-permanent and permanent workers, he did not control for above-mentioned types of non-permanent workers.

Organization-specific skills (or knowledge) are likely to be important for developing incremental new products. As Van De Ven (1986) 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” (p. 604). The lack of organization-specific skills is likely to hinder the improvement of existing products, building on the existing competencies of the organization. As temporary on-call or day labor job agency workers lack organization-specific skills and at the same time hardly bring advanced-level new skills to the organization or are not involved in major NPD, we expect that they negatively influence incremental NPD only. On the other hand, new skills brought in by outsiders and not tied to the organization may provide a fertile ground for breakthrough ideas for example on new technologies and the corresponding new competencies needed for the development of major new products. Similarly, Arvanitis (2005), finding a positive effect of external numerical flexibility on NPD (without distinguishing major from incremental innovation), explains this effect by the opportunity organizations have to hire temporarily highly skilled R&D workers that are needed in the NPD process.

Commitment of individuals to the organization has a positive effect on NPD, in particular major innovation as it increases the productivity on tasks with high uncertainty and on the reciprocity involved tasks of multifunctional NPD teams. The knowledge dissemination and risk taking behavior inherent in these tasks are positively affected by individual commitment (van der Bij *et al.*, 2003). Temporary job agency workers who are hired on-call to replace employees in the manufacturing process on a day by day or weekly basis exhibit lower organizational commitment (de Ruyter *et al.*, 2008, Posthuma, *et al.*, 2005). As such this lack of commitment may to contribute to a negative effect on incremental new products as improvements in new products may also be based on changes for the better in the manufacturing process and may suffer from lack of commitment. Using a similar theoretical explanation with respect to the lack of organization-specific skills, Beugelsdijk (2004) who only included temporary workers from job agencies on standby-contracts, found a negative effect of external numerical flexibility of innovation. In addition, specialized fixed-term workers hired for a specific project are expected to be highly committed to their projects or jobs as it increases their chances on a permanent contract or – in the case they like to remain self-employed contractor – on obtaining future projects. Consequently, commitment of fixed-term workers that are more likely to work on major innovation projects may contribute to a positive effect on NPD, in particular on major new products. Therefore, we hypothesize the following.

Hypothesis 3a: External numerical flexibility as a result of temporary job agency contracts on on-call or day labor basis negatively affects NPD outcomes with a stronger effect on incremental compared to major new products.

Hypothesis 3b. External numerical flexibility as result of fixed-term contracts positively affects NPD with a stronger effect on major compared to incremental new products.

Method

Sample

The hypotheses were tested by using a regression analysis of data obtained from DANS. A labor market research institute affiliated with two Dutch universities in the Netherlands 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. This dataset is used because of its a semi-longitudinal setup in which an elaborate list of independent variables were measured prior to the dependent variables decreasing common method bias. The sample contained Dutch organizations or its main subsidiaries with at least 5 employees. In total 407 observations were used that are representative of the following sectors in the population: agriculture and manufacturing; construction; trade (whole and retail), hotel and catering, and repair industry; transport; and professional services.

Measures

Dependent variables. The variable *NPD outcome* is measured in 2006 by the percentage of products or services that were changed compared two years ago. This is the sum of the percentages of incremental and major new products. The variable *incremental new products* is measured as the percentage of new products and services that was renewed on some aspects, whereas the variable *major new products* is measured as the percentage of new products that was substantially changed or even entirely renewed. These measures are similar to the measures used by Song and Montoya-Weiss (1998) and do not distinguish between degrees of technological newness in order to include new services where technology may not play a (large) role. As these new products or services may or may not be new to the customers or industry, this category of major new products includes the radical and 'really new' product categories proposed by Garcia and Calantone (2002).

Independent variables. The independent variables were measured in 2005. Functional flexibility defined as deploying workers on a broad range of tasks is measured by the variable *training and education* as the percentage of employees that participated in external and/or internal education/training.

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

External numerical flexibility defined as the ability to adjust the number of workers was measured by two variables: fixed-term workers and temporary agency workers.

Fixed-term workers is calculated as the share of employees with a fixed-term contract in the total workforce. For this variable the above and below median categories were compared with no fixed-term workers as the reference category. *Temporary agency workers* is a nominal variable indicating whether or not the organization has temporary agency workers in the total workforce.

Control variables. Not all changes in workforce skills and hours are part of workforce flexibility. Some changes may be the result of external necessities rather than a choice with respect workforce flexibility. Therefore the following controls pertaining to 2003-2004 but measured in 2005 were included. *Inadequate qualifications bottleneck*: Are inadequate qualifications of the workforce a bottleneck? *Insufficient broad employability*: Is the insufficiently broad employability of the workforce a bottleneck? *Keeping existing employees bottleneck*: Is keeping existing employees a bottleneck? *Controlling work pressure bottleneck*: Is controlling the work pressure a bottleneck? *Organizational change consequences* is a variable that measures the consequences of organizational changes (cutbacks/acquisitions) on the existing workforce. As not all changes are the result of deliberate policy choices with respect to functional and numerical flexibility, this variable may explain part of the variance in NPD outcomes. It consists of summated scale score of 5 items with respect to organizational changes with the following consequences: expansion, reduction with enforced dismissals, reduction without enforced dismissals, reappointments, and re-education/re-training.

Organizational size is included to control for effects on innovation (Camisón-Zornoza *et al.*, 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. R&D investments positively affect learning and innovation (Cohen and Levinthal, 1990).

Industry type is 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, to control for a difference in effect between the total workforce size and the workforce deployed in NPD or R&D, the functional mutations in NPD or R&D workforce were measured in an earlier stage of analysis. This appeared not to have a significant effect on NPD.

Results

We performed a hierarchical regression analysis of NPD, 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.

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In Table 1 the descriptive statistics of the dependent variables are presented. On average firms show a share of almost 13 new products introduced in the preceding two years. The share of incremental new products was somewhat higher than major new products (6.76 versus 5.82). Correlation between incremental and major innovation is moderate (0.382, p<0.001), suggesting that firms that practice incremental NPD are generally not developing major new products. The statistics in Table 2 give an overview of the operationalization, coding and missing values of the controls and independent variables used.

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Table 3 shows the results of the regression analysis. As *R&D investments* and *training and education* had a considerable number of missing values, these values were included as a separate category in the analysis to avoid an unacceptable low number of valid cases. Only missing values of *R&D investments* had a significant effect on NPD outcomes and major new products suggesting that the effect of R&D investments may be underestimated. The more new major products developed, the larger the number of respondents that did not fill in the level of R&D investments.

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The results show that the full model that includes functional as well as numerical flexibility in addition to the control variables, is statistically significant with a R-square of 22%. Across different outcomes of NPD, numerical flexibility appears to have a larger impact than functional flexibility. Both functional and numerical flexibility thus seem to matter, though a considerable part of the variance in NPD outcomes might be explained by other factors not included in our analysis, for example in the area of development process flexibility and organizational routines and structures.

Our first hypothesis (H1) predicted a positive effect of functional flexibility on major new products, which would be larger than for incremental new products. Findings regarding *training and education* confirmed the positive effect of functional flexibility on NPD outcomes overall (above median *training and education* ß = 0.181, $p<0.01$). Differentiating between major and incremental new products showed, however, that functional flexibility appeared to be significant positive only for major new products (ß = 0.166, $p<0.001$). Workforces that enjoyed substantial internal and external training and education developed more major new products. The functional flexibility effect appeared to be absent for incremental new products (ß = 0.117, $p=0.073$ ns).

With respect to internal numerical flexibility we did not find support for the hypothesized (H2) positive effect of *extra hours paid as overtime* on undifferentiated NPD nor incremental and major new products.

With respect to external numerical flexibility, we found no support for the hypothesized (H3a) negative effect of temporary job agency workers on NPD outcomes, nor on incremental and major new products. However, findings showed a significant positive effect of deploying fixed-term workers (H3b) on NPD outcomes, with a stronger effect on major new products (above median, ß = 0.139, $p<0.01$) compared to incremental new products (below median, ß = 0.125, $p<0.05$). So workforces with a shell of fixed-term contracts develop more incremental new products, whereas a larger flexible shell of fixed-term contracts stimulates developing more major new products.

The effects on NPD outcomes do not differ with respect to the control variables for most bottlenecks. Whether or not *inadequately qualified personnel, insufficiently broad employability* of personnel, or *controlling work pressure* is a bottleneck did not appear to have a significant effect on undifferentiated NPD outcomes, nor on major and incremental new products. One bottleneck, severe problems with *keeping existing employees* appears to positively affect incremental innovation (ß = 0.095, $p<0.05$), while it did not significantly affect NPD outcomes nor major new products. This finding suggests that if it becomes a serious problem that people leave the firm because they can find a better job elsewhere, firms appear to focus on incremental innovations. Also *organizational change consequences* accounts for part of the variance in NPD. If the number of organizational change consequences for the workforce is larger, the number of incremental new products appears to be smaller at the benefit of a larger number of major new products. This suggests that cutbacks/reorganizations/takeovers may bring the dynamics, competences and/or budgets needed for major NPD.

The innovation results do not differ with respect to the controls *industry type* (manufactured products versus business services) as well as with respect to *organizational size*. *R&D-investments* positively affect the number of product innovations.

Conclusion and discussion

Based on a large scale survey across service and manufacturing industries, the findings lead to conclude that flexibility of the workforce impacts NPD in general and developing major new products or services in particular. With this conclusion the research contributes to product innovation research on the nature of the flexibility of the new product development process (see e.g. Benner, 2009, Biazzo, 2009, Buganza, *et al.*, 2009, Buganza and Verganti, 2006, MacCormack, *et al.*, 2001). It adds up to studies that advocate a different approach to major NPD compared to incremental NPD. However, our research suggests that the difference may not only lie for example in critical development activities such as scanning business and market opportunities and strategic planning (Song and Montoya-Weiss, 1998), market learning processes (O'Connor, 1998), or capabilities (O'Connor and DeMartino, 2006). Using a large scale setup, this research confirms that it may also be grounded in the human resources of the firm as suggested by recent theory-building work of O’Connor and McDermott (2004) and O’Connor (2008). Here the insight is that while the skills of employees determine the innovation work, the flexibility of the workforce generates the transformations needed for major innovation. This research also contributes to research on how to adapt to environmental change. The findings suggest that the development of major innovations in order to adapt to market and technological change occurs through the flexibility of the human resources. Prior research mainly investigated organizational structures and routines (e.g. Benner, 2009, Buganza, *et al.*, 2009, Buganza and Verganti, 2006).

In addition, our study contributes to the management literature on product innovation and human resources in two ways. First, it suggests that firms with a functional flexible workforce develop more major new products, whereas previous studies found a positive effect on innovation without distinguishing major from incremental NPD and did not control for functional bottlenecks (Carvalho and Cabral-Cardoso, 2008, Martínez-Sánchez, *et al.*, 2008). External and internal training and education create multi-skilled employees that make them deployable across a broad range of tasks and jobs, enable them to develop more major new products. This impact is still significant when controlling for functional bottlenecks such as inadequate qualifications of employees and insufficiently broad employable workforce.

Second, the research suggests that firms with workforces that are external numerically flexible with a larger share of fixed-term contracts appear to develop more product innovations. The ability to adjust the number of fixed-term workers appeared to generate more major innovations, but also – though to a lesser degree – more incremental innovations. However, while we hypothesized a negative effect based on recent research of Beugelsdijk (2008), our research shows in line with Mitchie and Sheehan (2003) and Martínez-Sánchez (2011) that using temporary workers from job agencies does not make a difference. This may be due to the fact that we only had access to a dichotomized variable (yes/no), whereas it may be the degree of temporary job agency contracts that matters. When controlling for numerical bottlenecks, only the keeping-existing-employees bottleneck plays a role, whereas the controlling-work-pressure bottleneck did not. Severe problems with keeping existing employees appear to affect incremental innovation in a positive way. An explanation may be that this bottleneck shows the practice of a hard working environment that in contrast to an environment of complacency and lack of discipline (see e.g. Nohria and Gulati, 1996) may yield more innovations in the relative short term, but possibly at the cost of unmotivated employees that leave the firm in the longer run.

Our findings explain the mixed results of previous studies on the effect of external numerical flexibility that do not distinguish incremental from major NPD (e.g. Arvanitis, 2005, Michie and Sheehan, 2003), treat NPD not any different from process innovation (e.g. Martínez-Sánchez, *et al.*, 2011, Martínez-Sánchez, *et al.*, 2008) or exclude relevant aspects of external numerical flexibility (e.g. Beugelsdijk, 2008, Martínez-Sánchez, *et al.*, 2008). 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). Using a composite score may hide effects of specific elements such as fixed term contracts. Martínez-Sánchez et al. (2011) found a negative effect of short-term hires, but do distinguish between product and process innovation. Beugelsdijk (2008) found a negative relationship measuring NPD, but included only temporary job agency such as standby contract practices. These studies explain the negative effects suggesting that temporary employees possess les firm-specific knowledge, which inhibits innovation. However, in line with Arvanitis (2005), we explain the positive relationship advocating that the temporary workers on a fixed term contract may be hired for their specialized skills that are lacking in the NPD process, while these workers may do the utmost in order to get a permanent position or to be contracted repeatedly as is typical in the Dutch labor market. Here, we do not claim that there is no limit on the number of fixed-term workers that has a positive effect on NPD. In the end, it is all about a balance between fixed-term and permanent workers. Fixed-term workers may be given a permanent position, whereas permanent workers may leave the firm enabling it to hire new workers on fixed-term contracts.

Furthermore, internal numerical flexibility measured by the extra hours worked as paid overtime did not appear to affect NPD outcomes. This is in line with the findings of earlier studies who did not find statistical significant effects (Martínez-Sánchez*, et al.*, 2008), though we expected a positive effect. While paid overtime undoubtedly creates flexibility in the development process, it does not seem to create the structural flexibility that distinguishes innovators from non-innovators or major from incremental innovators. However, flexibility in terms of consequences of corporate level organizational changes – such acquisitions of other firms or cutbacks – for the workforce is related to the number of major new products. This suggests that major NPD is not only the result of policies to create a flexible workforce, but also of the size of the set of consequences for the workforce such as re-education and re-training, expansion, reappoints and (enforced) dismissals. Organizational change may bring new life.

This research also contributes to the organization and management literature in particular the resource-based view of the firm. While the human resources may be classified as among the resources that allow creating core competences that may lead to competitive advantages, the flexibility of the human resources – amongst which the workforce – may well be part of the dynamic capabilities that allow firms to fundamentally reconfigure the existing competencies. Our research suggests that the competencies needed for major innovation can be reconfigured driven by workforce flexibility that can be shaped by human resource management policies.

Finally, the findings of the study give rise to the thought that workforce flexibility may act as a double-edged sword. It may allow firms not only to cut operating costs in order to stay in business or even keep R&D budgets intact. It also allows firms to renew their knowledge base needed to develop major new products and services, not solely through training and education, but also through hiring new people on fixed-term contracts. Using fixed-term employees seems to offer the specialized knowledge in order to renew the workforce and develop new products and services, but in particular major new ones.

Limitations and future research

First, the DANS database allowed investigating a large 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, job-sharing, workload reduction, flextime as well as external factors such as the number of lay-offs (see e.g. Martínez-Sánchez, *et al.*, 2008). With respect to external numerical flexibility, we only had access to dichotomized variable of temporary job agency contracts. Researchers may want to include the share of temporary job agency contracts that might be more explanative. Also, our study analyzed the effects of fixed-term employees without taking into account related issues such as how many contracts were offered to the same employee and at what contract length in time. Next to this issue, future researchers may also want to investigate the optimal balance between permanent and fixed-term workers.

Second, while it is amongst the very few in the field of workforce flexibility that distinguish major from incremental NPD and a broad non-incremental category is needed to include service innovations, the data did not allow us to further disentangle major new products differentiating between product/technology newness for the firm and product/technology newness for the industry/customers (see e.g. Garcia and Calantone, 2002). Researchers may want to take up this issue, while also including a measure of NPD success.

Third, whereas we took industry type effects into account, the very different mechanisms underlying innovation practices in service and manufacturing firms (De Brentani, 2001) are likely to require a more detailed analysis of the workforce flexibility effects. Moreover, the sample included firms in Dutch industries only that are under control of industry-specific collective agreements, 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 in-depth across a broad range of industries and countries with differing institutional arrangements.

Implications for managers

R&D or NPD managers of business services and manufactured products may take away that developing new products, in particular, major 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 major new 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 major NPD outcomes. This may be complemented by using fixed-term contracts in order to facilitate workforce adjustments to the particular knowledge and skills required for incremental but especially major NPD projects. This is not to say managers should follow a full ‘hire and fire’ policy. Employees may be offered an additional fixed-term contract or permanent contract if they meet expectations. Discussing the human resource capacity for innovation projects with human resource managers, may also help R&D or NPD managers, in particular those of multinational companies, to be informed by differences in labor laws and governmental regulations across industries, countries, or international regions.

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Table 1 Descriptive statistics of dependent variables

	Mean	Mean log	Std. dev.	I	II
I Share product innovation outcomes	12.53	1.36	1.61		
II Share incremental new products	6.76	0.97	1.38	0.831**	
III Share major new products	5.82	0.76	1.31	0.760**	0.382**

Note: n=407. * = p<.05; ** = p<.01; *** = p<.001

Table 2 Descriptive statistics of control and independent variables

		Mean	Std. dev.	% of n	Ref.cat.
Controls:					
Organizational size	Small-size (5-19 employees):			52.3	Ref.cat.
	Medium-size (20-99 employees)			24.1	
	Large-size (100+ employees)			23.6	
Industry type	Products (agriculture, industry, construction)			43.0	Ref.cat.
	Business Services (trade, catering, repair, prof)			57.0	
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 change consequences	Number of organizational change consequences for workforce	0.49	0.91		
Inadequate qualifications	Bottleneck: nominal variable (yes/no)			27.5	
Insufficient broad employability	Bottleneck: nominal variable (yes/no)			25.1	
Keeping existing employees	Bottleneck: nominal variable (yes/no)			7.9	
Controlling work pressure	Bottleneck: nominal variable (yes/no)			19.2	
Functional flexibility:					
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	
Internal numerical flexibility:					
Extra hours paid overtime	No Overtime			35.9	Ref.cat.
	Overtime below median			31.0	
	Overtime above median			16.2	
	Overtime missing			17.0	
External numerical flexibility:					
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	

Note: n=407. Ref.cat. = reference category; not present if not indicated. For the nominal variables the percentage shows the yes-category.

Table 3 Regression analysis results

			NPD outcomes (log)		Incremental new products (log)		Major new products (log)	
			Beta	**Sig**	**Beta**	**Sig**	**Beta**	**Sig**
Control variables:	Organizational size	Medium-size (20-99 employees)	-0.055	ns	-0.043	ns	-0.024	ns
		Large-size (100+ employees)	0.073	ns	0.145	*	0.021	ns
	Industry type	Business Services (trade, catering, repair, prof.)	0.006	ns	0.046	ns	-0.014	ns
	R&D investments	R&D investments below median	0.223	***	0.230	***	0.098	*
		R&D-investments above median	0.308	***	0.233	***	0.311	***
		R&D-investments missing	0.222	***	0.089	ns	0.190	***
	Organizational change conseq.	Number of organizational change consequences	0.009	ns	-0.083	ns	0.116	*
	Inadequate qualifications	Functional bottleneck: nominal variable (yes/no)	0.000	ns	0.018	ns	-0.065	ns
	Insufficient broad employability	Functional bottleneck: nominal variable (yes/no)	-0.015	ns	-0.028	ns	0.018	ns
	Keeping existing employees	Numerical bottleneck: nominal variable (yes/no)	0.072	ns	0.095	*	0.061	ns
	Controlling work pressure	Numerical bottleneck: nominal variable (yes/no)	0.003	ns	-0.032	ns	0.067	ns
Functional flexibility	Training and education	Training and education below median	0.079	ns	0.027	ns	0.088	ns
		Training and education above median	0.181	**	0.117	ns	0.166	**
		Training and education missing	0.048	ns	0.009	ns	0.064	ns
Internal numerical flexibility	Extra hours paid overtime	Overtime below median	-0.002	ns	-0.053	ns	-0.040	ns
		Overtime above median	0.018	ns	-0.051	ns	0.080	ns
External numerical flexibility	Fixed-term workers	Percentage fixed-term workers below median	0.100	ns	0.125	*	-0.032	ns
		Percentage fixed-term workers above median	0.153	**	0.105	ns	0.139	**
	Temporary job agency workers	Nominal variable (yes/no)	-0.028	ns	-0.010	ns	-0.010	ns
Model statistics:	**Compound effects**							
	Controls only	R^2 change	0.213	***	0.149	***	0.166	***
	Functional Flexibility	R^2 change	0.018	ns	0.011	ns	0.016	ns
	Numerical Flexibility	R^2 change	0.024	ns	0.022	ns	0.036	*
	Full model	R^2	0.255		0.182		0.218	
	F-value (degrees of freedom)		6.6 (20, 386)	***	4.3 (20, 386)	***	5.4 (20, 386)	***

Note: n=407. * = p<.05; ** = p<.01; *** = p<.001. Standardized beta-coefficients are reported. The variable NPD outcomes is the accumulation of incremental new products and major new products. Organizational size reference category is: Small-size (5-19 employees). Industry type reference category is: 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 no-category as reference category.

Figure 1 Conceptual model