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Differentiating Major and Incremental New Product Development: The Effects of Functional and Numerical Workforce Flexibility*

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This study seeks 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 innovation management literature, the authors distinguish two types of workforce flexibility, functional and numerical, and hypothesize differential effects on NPD outcomes. A large-scale sample of 284 Dutch firms across various manufacturing goods and business services industries serves to test these hypotheses. The results suggest that functional flexibility positively influences incremental NPD only, internal numerical flexibility negatively influences incremental NPD only, and external numerical flexibility positively influences major NPD only. Thus, differences between major and incremental NPD are grounded in the human resource flexibility of the firm. This complements research that found that such differences lie in critical development activities, learning processes, and capabilities. It also complements product innovation research on flexibility in NPD processes and on flexibility in organizational structures and routines. It extends the resource-based theory of the firm suggesting that human resource flexibility is part of the dynamic capabilities that allow firms to reconfigure existing competencies. The conclusions imply that managers of manufacturing and service firms may use training and education and create a functional flexible workforce that can progressively enhance incremental NPD outcomes. They may want to avoid paying overtime, because such internal numerical flexibility hampers incremental NPD, but use fixed-term contracts to expand external numerical flexibility to enhance major NPD.

Introduction

Firms increasingly must develop new products to respond to environmental change, develop competitive advantages, and increase their chances of survival (Brown and Eisenhardt, 1995; Meeus and Oerlemans, 2000). Environmental changes require firms to develop not just incremental innovations, but also major—radical and really new—innovations that they can commercialize (O'Connor, 2008). Major new product development (NPD) requires new knowledge based on new competencies and practices, whereas for incremental NPD, new knowledge is based on existing competencies and practices (Christensen, 1997; Levinthal and March, 1993; O'Connor, 2008). To pursue such knowledge, managers seek to adjust their organizations to achieve flexible structures and processes, as well as flexible personnel resources. The flexibility of the people employed, or workforce flexibility, is defined as the ability to change the jobs and tasks assigned to workers, their working hours, and their number (Atkinson, 1987).

About 90% of U.S. firms, especially those in high-tech settings, use some contingent workers, usually employing them as technical experts in core areas (Matusik and Hill, 1998). For example, ASML, a developer of high-tech lithography systems for the semiconductor industry, encourages its regular workers to develop multiple skills and also increasingly employs contingent workers. In 2010, a significant proportion of its workforce (22%) consisted of people on fixed-term contracts, whether identified by specialized detachment agencies or self-employed. ASML also stimulated education and training facilities, and allowed employees to save up to eight months of days of leave. According to Peter Wennink, executive vice president and chief financial officer of ASML, it could not have survived the global financial

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crisis without flexibility in its costs and labor; flexibility combined with continuous research and development (R&D) investments also were critical to maintaining its commitment to innovation. Flexibility thus enabled ASML to protect its technological leadership and benefit from growth in the chip industry that supplies electronic innovations such as tablets and smartphones.

Research on flexible organizational structures and routines describes the conditions for their use and their effects on NPD outcomes (Benner, 2009; Buganza and Verganti, 2006; Buganza, Dell'Era, and Verganti, 2009). The way firms create flexibility in their NPD processes to develop major new products and these influences on NPD outcomes also appear extensively studied (Biazzo, 2009; Iansiti, 1995; MacCormack, Verganti, and Iansiti, 2001; Sanchez and Mahoney, 1996; Thomke, 1998). Most studies conclude that rather than traditional stage gate processes, flexible development processes employed in formal cross-functional teams in flat organization structures more effectively develop major new products and adapt to changing conditions in turbulent environments. To date though, little research in the field of product innovation has addressed the effect of workforce flexibility on NPD outcomes, including both major and incremental NPD. Using a case study approach, O'Connor and McDermott (2004) discovered that major NPD requires flexible people, such as multifunctional individuals rather than cross-functional teams. O'Connor (2008) also signals the importance of a flexible workforce for major innovations by hypothesizing about their requisite skills and talents in her conceptual article. To the best of our knowledge though, no prior investigation has answered our focal research question, about how workforce flexibility affects NPD outcomes, distinguishing major from incremental new products.

Because answers to this question help managers understand how human resource practices may benefit major and incremental NPD, a large-scale, cross-industry analysis was conducted in the Netherlands. This study makes several contributions to the product innovation literature. It analyzes the human resource aspects for determining the flexibility in NPD, moving beyond NPD process aspects and organizational structures and routines. Moreover, this study demonstrates that the differences between major and incremental NPD outcomes are grounded not only in critical development activities, such as strategic planning and business and market opportunity analysis (Song and Montoya-Weiss, 1998), but also in firms' human resource characteristics. In so doing, the findings confirm that the development of new competencies for major NPD is likely to be determined by workforce skills and resulting flexibility (O'Connor, 2008; O'Connor and McDermott, 2004). Furthermore, this study contributes to the literature on human resource management by building on work that includes product innovation as a homogeneous construct but ignores the distinction between major and incremental NPD (see, e.g., Arvanitis, 2005; Michie and Sheehan, 2003), combines product and process innovation elements into a single construct (see, e.g., Martínez-Sánchez, Vela-Jiménez, Pérez-Pérez, and De-Luis-Carnicer, 2008, 2011), or excludes some aspects of external numerical flexibility (Beugelsdijk, 2008; Martínez-Sánchez et al., 2008). Thus, this study seeks to explain some conflicting findings in prior studies regarding whether flexible contracts have positive or negative effects on innovation.

The next section describes the theoretical framework and hypotheses. After, the method is presented and the study findings are detailed. This paper concludes with a discussion of its theoretical contribution, some limitations and further research suggestions, and managerial implications.

Theoretical Framework

Different streams of research note the role of flexibility in adapting to environmental changes. In product innovation

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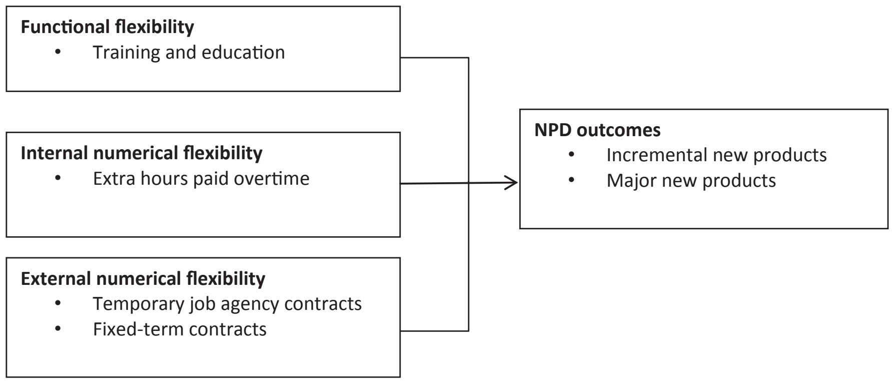

Figure 1. Conceptual Model

management literature, flexibility is a characteristic of the product, product development process, structure, or team rather than of the organization or R&D workforce. Various mechanisms might 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 and Verganti, 2006; Buganza et al., 2009). In addition to these NPD mechanisms, flexibility also may accrue from the human resources (O'Connor, 2008; O'Connor and McDermott, 2004).

In the management and HRM literature, flexibility is an organizational characteristic (Cordery, Sevastos, Mueller, and Parker, 1993; Ketkar and Sett, 2009; Wright and Snell, 1998), considered from the perspective of the resource-based view of the firm. In this view, flexibility represents the "firm's ability to quickly reconfigure resources and activities in response to environmental demands" (Wright and Snell, 1998, p. 758), such that it constitutes a dynamic capability. According to capability theory, dynamic capabilities imply the ability to build and reconfigure competencies and drive innovativeness in response to environmental changes (Eisenhardt and Martin, 2000; Teece, Pisano, and Shuen, 1997).

The flexibility of human resources may well be the heart of firms' dynamic capabilities. Human resources include workforce skills (knowledge and know-how) and behavior (Ketkar and Sett, 2009; Wright and Snell, 1998) and provide a basis for competitive advantages (Matusik and Hill, 1998; Wright, McMahan, and McWilliams, 1994). Human resource flexibility in turn likely resides in individual skills and behavior and their development (O'Connor, 2008; O'Connor and McDermott, 2004). Conceptually, O'Connor (2008) suggests that such skills and talents include courage, intellect, different ways of thinking, and being capable of dealing with complex information. She proposes identifying and nurturing appropriate skills and talents, as part of a dynamic capability conducive to the development of major innovations. Identification and nurturing take the shape of mentoring, coaching, or apprenticeships, because there are few other known ways to develop new capabilities. For example, routinization of capabilities and procedures for knowledge generation and accumulation are inappropriate in the context of major innovations (O'Connor, 2008).

Flexibility in workforce skills and behavior can be categorized as functional flexibility, which involves the diversity of tasks and jobs, and numerical flexibility, or the quantity of human resources (Atkinson, 1987). The meanings of these terms largely correspond with the meanings of the labels resource flexibility and coordination flexibility, respectively, as used by Sanchez (1995) and Wright and Snell (1998). From these sources, the conceptual model for our study was derived, as depicted in Figure 1. It is detailed further in the following sections.

Functional Flexibility

Functional flexibility involves adjusting the deployment of workers and job contents so that each worker can "deploy his or her skills across a broader range of tasks" (Atkinson, 1987, p. 90). In many studies, functional flexibility also is defined to include both skill and behavior flexibility (Blyton and Morris, 1992; Sparrow and Marchington, 1998), in reference to "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 more diverse tasks and jobs are more flexible (Atkinson, 1987; Macduffie, 1995; Snell and Dean, 1992). By referring to adaptable, internally mobile employees, these studies also include the willingness (i.e., the behavioral component). If employees are internally mobile, they are willing to work on different tasks too. Our understanding of functional flexibility is restricted to skill flexibility, with the assumption that skills are largely consistent with behavior (Carvalho and Cabral-Cardoso, 2008). A functionally flexible workforce means that employees possess a broad range of skills and can be flexibly reassigned to different jobs and tasks in the organization (Atkinson, 1987).

To generate and develop new ideas, employees require such flexibility in their functional tasks. Yet the mechanism underlying the relationship between functional flexibility and innovation remains poorly understood. 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 multi-skilling, team working and the involvement of employees in job design and the organization of work" (p. 650). These aspects of functional flexibility correspond with Van de Ven's (1986) requirements for innovation, according to which employees should not only possess knowledge within their own functional area, but also have an understanding of what occurs beyond their functional department because "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). "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 required functional flexibility might appear at the interface between R&D and marketing (Moenaert and Souder, 1990). If an R&D employee does not have insight into customer demands, newly developed technologies are unlikely to increase customer value, and if a marketing employee does not know what possibilities are available through technology, he or she cannot identify new potential product features that might increase customer value. The more closely related to a breakthrough technology—and thus the more radical the new product—the stronger the impact of this lack of knowledge and the greater any employee's dependence on other functional specialists. Furthermore, radical and really new product innovation require a broader set of skills, because multiple roles are required, together with high connectivity (O'Connor and McDermott, 2004). These roles include idea generation, project leadership, gate keeping, sponsoring or coaching, and championing. Such numerous and varied tasks cannot be fulfilled by one person, and it is unlikely there is one person for every role, so radical innovation teams must be composed of highly multifunctional individuals rather than just individuals with specific functional (i.e., departmental) backgrounds (O'Connor and McDermott, 2004). Part of a dynamic capability system for radical innovation involves the development of requisite skills and talent (O'Connor, 2008). Therefore, the following hypothesis is proposed:

> *H1: Functional flexibility relates positively to product innovation outcomes with a stronger effect on major compared with 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, that is "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 further consists of internal and external forms (Martínez-Sánchez et al., 2008).

Internal numerical flexibility refers to the ability to adjust the quantity of human resources by changing the hours that the existing workforce works. Working overtime, part-time, and flexible working hours all fall within this category. Internal numerical flexibility allows organizations to adjust their amount of human resources quickly to meet their human resource demand (Martínez-Sánchez et al., 2008). It also provides flexibility to the workforce, giving individuals or organizational units a means to anticipate problems and opportunities as they occur, and then working extra or decreasing the number of hours when necessary. It is the fastest way to ensure that the workforce hours match an increase in workload, even as the individual workload per hour, the number of workers, and the breadth and depth of knowledge offered during the NPD process remain stable. It also invokes lower coordination costs than hiring or firing employees. However, the size and duration of the changes in workforce hours may be restricted by labor laws and regulations (Blanpain and Grant, 2009; Chung, 2009, p. 170).

The short-term, low-level uncertainties that mark NPD processes, as well as manufacturing processes in general, can benefit from this flexibility. For example, competitive or customer pressures to speed up a delayed prototype to meet a deadline or introduce the final product onto the market may benefit from the use of (paid) overtime. The effect on major new products is likely stronger, because more market and technological uncertainty surround the nature and timeframe of tasks that must be undertaken (O'Connor, 2008; Song and Montoya-Weiss, 1998). On the other side, a (temporary) decrease in hours worked (to prevent layoffs) during severe cost cutback programs may slow down the development of major projects, especially because these projects are generally more risky. But if a decrease in working hours prevents layoffs, the firm can retain the knowledge and skills of its workers for future projects. Cuts to R&D programs may be the exception: During economic crises, cutbacks may help keep the R&D budget intact if applied to people outside R&D. In this case, internal numerical flexibility as a result of extra hours of paid overtime may enhance NPD outcomes. Therefore, the following hypothesis is proposed:

H2: Internal numerical flexibility as a result of extra hours of paid overtime positively affects NPD outcomes, with a stronger effect on major compared with incremental new products.

External numerical flexibility means adjusting the number of workers by changing the existing workforce (Atkinson, 1987; Kochan, Smith, Wells, and Rebitzer, 1994; Martínez-Sánchez et al., 2008). Such changes include temporary workers from job agencies on day labor or on-call basis. These changes also include temporary workers on fixed-term contracts who are hired due to their specialized skills through in-house application procedures, detachment organizations, or partner firms, or who are self-employed individual subcontractors. The inclusion of individual contractors distinguishes this form of flexibility from the practice of outsourcing tasks to other firms (Martínez-Sánchez et al., 2008). Compared with internal numerical flexibility, its access to human resources is slower and the coordination costs are higher, but it also supports a more substantial change in the size and duration of workforce hours. Furthermore, it is not aimed solely at achieving optimal usage of the human resource capacity, but also may 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 alters the knowledge range (Kochan et al., 1994). Again, changes in the number of workers may be restricted by labor laws and regulations.

Empirical results regarding the effects of external numerical flexibility are mixed. Martínez-Sánchez et al. (2008) and Beugelsdijk (2008) found significant negative effects of external numerical flexibility on innovation, whereas others suggest a significant positive effect (Arvanitis, 2005) or no significant effect (Michie and Sheehan, 2003) of external numerical flexibility on product innovation. Arguments in support of some effects stem from the discrepancy between available and required skills (including knowledge and know-how) within a workforce, as well as the differences in the commitment of the various types of temporary workers who deploy those skills for specified purposes, that is, major or incremental NPD. However, theoretical explanations in previous studies provide only part of the picture and exclude relevant numerical flexibility practices (e.g., Beugelsdijk, 2008), combine various human resource practices in one construct and bundle product and process innovation (e.g., Martínez-Sánchez et al., 2008, 2011), or abstract away from a distinction between major and incremental NPD (e.g., Arvanitis, 2005; Michie and Sheehan, 2003).

External employees hired on a fixed-term or job agency basis likely have different skills than permanent employees. Temporary workers may lack organization-specific knowledge, but bring new skills into the organization that are not available among permanent workers (Matusik and Hill, 1998). Furthermore, the nature of the skills possessed by fixed-term workers is likely to be more advanced than that of job agency workers hired on a day labor or on-call basis; on average, the former are more educated than the latter (Cörvers, Euwals, and de Grip, 2011, p. 59). Similarly, fixed-term workers hired for their specialized skills tend to be more committed to their tasks and to the organization than on-call job agency workers or day laborers. Posthuma, Campion, and Vargas (2005) thus found differences in productivity between the two types of non-permanent workers that can be explained by differences in their commitment to the organization. Pearce (1993) found no such support for a hypothesized difference between non-permanent and permanent workers, but he also did not control for the specific types of non-permanent workers.

Organization-specific skills (or knowledge) likely are important for developing incremental new products. As Van de Ven (1986, p. 604) puts it, "People will pay attention to new ideas the more they experience personal confrontations with sources of problems, opportunities, and threats which trigger people's action thresholds to pay attention and recognize the need for innovation." A lack of organization-specific skills may hinder improvements to existing products that result from the existing competencies of the organization. Because temporary on-call and day labor job agency workers lack organization-specific skills and rarely bring advanced-level new skills to the organization or are not involved in major NPD, it is expected that they only influence incremental NPD and do so negatively. In contrast, new skills brought in by outsiders who are not tied to the organization may provide a fertile ground for breakthrough ideas about, for example, new technologies and also offer the corresponding new competencies needed to develop major new products. Arvanitis (2005), finding a positive effect of external numerical flexibility on NPD (without distinguishing major from incremental innovation), explains this effect by citing that the opportunity organizations have to hire highly skilled R&D workers temporarily to advance their NPD processes.

The commitment of workers to the organization also should have a positive effect on NPD, in particular major innovation, by increasing productivity on tasks that are marked by high uncertainty and reciprocity in multifunctional NPD teams. The knowledge dissemination and risk-taking behavior inherent in such tasks can be enhanced by individual commitment (van der Bij, Song, and Weggeman, 2003). However, temporary job agency workers hired on a day-by-day or weekly basis exhibit lower organizational commitment (de Ruyter, Kirkpatrick, Hoque, Lonsdale, and Malan, 2008; Posthuma et al., 2005). Their resultant lack of commitment may exert a negative effect on incremental new products, in that such improvements generally are based on changes in the manufacturing process, which are unlikely without commitment. Using a similar theoretical explanation, Beugelsdijk (2008) found a negative effect of external numerical flexibility—including only temporary job agency workers on standby contracts—on innovation. Specialized, fixed-term workers hired for a specific project instead should be highly committed to their projects or jobs that increases their chances for a permanent position or to obtain future contracts. The greater the commitment of these fixed-term workers, who also are more likely to work on major innovation projects, therefore may have a positive effect on NPD, especially for major new products. The following hypotheses are proposed:

> *H3a: External numerical flexibility as a result of temporary job agency contracts, on an on-call or day labor basis, negatively affects NPD outcomes, with a stronger effect on incremental than on major new products.*

> *H3b: External numerical flexibility as a result of fixed-term contracts positively affects NPD, with a stronger effect on major than on incremental new products.*

Method

Sample

To test these hypotheses, a regression analysis of data obtained from Data Archiving and Networked Services (DANS) (see note on page 1) was used. A labor market research institute affiliated with two Dutch universities in the Netherlands gathered the data using a Labor Survey Panel in 2005–2006, including both self-reported surveys and telephone interviews based on a standardized questionnaire. The target sample consisted of Dutch organizations or their main subsidiaries with at least five employees. In total, 284 observations enter the data set, 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.

This data set offers a semi-longitudinal setup: An elaborate list of independent variables was measured in 2005, and then the dependent variables were measured in 2006. Thus, the analysis accounts for a natural time lag effect between the development of new products/ services, in which workforce flexibility plays a role, and NPD outcomes, while also minimizing the potential for common method bias (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003). A one-year lag effect may lead to underestimations of the effects of workforce flexibility on radical innovations though, because radical innovations generally demand a longer time-to-market than incremental innovations (Griffin, 1997). Similar to Martínez-Sánchez et al. (2011), this one-year lag effect was retained, because our investigation includes not only major—radical and "really new"—but also incremental innovations. Furthermore, across the wide variety of manufacturing and business service industries included in our data set, the time-to-market varies for radical new products (Sternitzke, 2010). Finally, this timeframe is appropriate if human resource practices associated with workforce flexibility are assumed to be relatively stable and part of longer term strategies, changes to which are restricted by labor laws and regulations.

Measures

Dependent variables. The *NPD outcome* variable is measured as the percentage of products or services that were changed, compared with two years ago. This sum includes the percentages of both incremental and major new products. The *incremental new products* variable is the percentage of new products and services that have been renewed in some aspects, whereas the *major new products* variable is measured as the percentage of new products that changed substantially or were entirely renewed. These measures are similar to those used by Song and Montoya-Weiss (1998) and do not refer to degrees of technological newness, so that new services are included even if technology does not play a (large) role. Because these new products or services may or may not be new to customers or industry, the category of major new products includes both radical and "really new" product categories, as defined by Garcia and Calantone (2002).

Independent variables. To measure functional and numerical flexibility, variables that reflect human resource practices (e.g., Martínez-Sánchez et al., 2008, 2011; Michie and Sheehan, 2003) are used, because these practices generally are tied to flexibility, and organizational and cultural factors align with such practices. Functional flexibility entails deploying workers on a broad range of tasks, measured by a *training and education* variable that indicates the percentage of employees who participated in external and/or internal education or training. For internal numerical flexibility defined as the ability to adjust the number of hours, the variable *extra hours paid overtime* is assessed as the share of extra hours worked as paid overtime to the total number of hours worked. Finally, to measure external numerical flexibility defined as the ability to adjust the number of workers, we relied on two variables. *Fixed-term workers* is the share of employees with a fixed-term contract in the total workforce (excluding temporary job agency workers) and *temporary job agency workers* is a nominal variable indicating whether or not the organization has temporary job agency workers (on-call or day labor basis) in the total workforce.

Control variables. Not all changes in workforce skills and hours are part of workforce flexibility. Some changes may result from external necessities rather than the firm's choice. Therefore, the study includes several controls pertaining to 2003–2004 but measured in 2005. Four of them refer to potential bottlenecks in the NPD process: (1) *Inadequate qualifications*: Are inadequate qualifications of the workforce a bottleneck? (2) *Insufficient broad employability*: Is the insufficiently broad employability of the workforce a bottleneck? (3) *Keeping existing employees*: Is keeping existing employees a bottleneck? (4) *Controlling work pressure*: Is controlling the work pressure a bottleneck? In addition, the *organizational change consequences* variable is measured as the consequences of organizational changes (cutbacks/acquisitions) on the existing workforce. Not all changes result from deliberate flexibility policy choices, so this variable may explain part of the variance in NPD outcomes. It consists of the summated score of five items pertaining 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 its possible effects on innovation (Camisón-Zornoza, Lapiedra-Alcamí, Segarra-Ciprés, and Boronat-Navarro, 2004; Laursen and Foss, 2003). The measure of *R&D investments* indicates the percentage of turnover spent on R&D. Such investments positively affect learning and innovation (Cohen and Levinthal, 1990).

Industry type is included to control for technological opportunity differences (Geroski, 1990), by comparing the effects of the services (trade, catering, repair industry, transport, professional services) with those of manufactured goods (agriculture, manufacturing, construction industry).

For the incremental and major new product models, *major product innovation* and *incremental product innovation* are included to test for their effects and get more accurate estimates of flexibility parameters.

Finally, to control for the different effects of total workforce size and the workforce deployed in NPD or R&D, functional changes in the NPD or R&D workforce were measured at an earlier stage of analysis. However, these distinctions did not have significant effects on NPD.

Results

Table 1 provides the descriptive statistics and correlation coefficients. On average, firms show a share of more than 10% new products introduced in the preceding two years, including several more incremental new products than major new products (5.55% versus 4.79%). The moderate correlation between incremental and major innovation (.49, $p < .001$) suggests that a substantial part of the firms that practice incremental NPD are developing major new products.

In the hierarchical regression analysis of NPD, first, the control model (including the innovation controls and the flexibility controls) was specified, then the functional flexibility variables were added, and the final step added the numerical flexibility variables. Polynomial controls were included to test for non-linear effects and were kept in the model when they were significant.

Table 1. Descriptive Statistics and Correlation Coefficients

	Variables	Percent	Mean	Mean (log)	SD (log)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	New products (log)		10.34	1.20	1.55														
2	Incremental new products as percentage (log)		5.55	.87	1.32	.86													
3	Major new products as percentage (log)		4.79	.71	1.25	.79	.49												
4	Size: number of employees (log)		78.89	3.11	1.42	.17	.15	.14											
5	Industry type: Business services	60.2%				.06	.10	.03	−.09										
6	R&D investments percentage (log)		1.30	.39	.77	.43	.39	.32	.19	−.14									
7	Organizational changes consequences in numbers (log)		.43	.24	.44	.05	.01	.08	.22	−.07	.06								
8	Inadequate qualifications (yes/no)	25.7%				.03	.05	−.03	.17	−.13	.06	.16							
9	Insufficient broad employability (yes/no)	21.8%				.11	.07	.10	.19	−.08	.21	.08	.12						
10	Keeping existing employees (yes/no)	8.1%				.17	.17	.20	.11	−.08	.16	.10	.06	.06					
11	Controlling work pressure (yes/no)	15.1%				.11	.10	.12	.14	.04	.16	.17	.07	.06	.20				
12	Training and education as percentage (log)		31.53	2.63	1.65	.17	.15	.12	.11	.01	.12	−.06	−.01	.13	.04	.12			
13	Fixed–term workers as percentage (log)		7.71	1.22	1.38	.20	.17	.20	.24	.12	.02	.03	.14	.01	.03	.15	−.05		
14	Temporary job agency workers (yes/no)	45.4%				.10	.07	.10	.39	−.21	.14	.06	.11	.08	.17	.15	.08	.11	
15	Extra hours paid overtime as percentage (log)		3.32	.89	1.00	.05	.00	.07	.42	−.03	.07	.13	.06	.11	.01	.01	.05	.19	.26

Notes: $n = 284$. Correlations > .099 are two-tailed significant ($p < .05$). For industry type: the reference category is products (agriculture, industry, construction). Business services include trade, catering, repair, and professional services. Metric variables are log transformed. The yes category of the nominal variables is shown. The correlations are all Spearman's coefficients.

Table 2 contains the results of the regression analysis, which indicate that all three full models, including functional and numerical flexibility, are statistically significant. The full NPD outcomes model (including both incremental and major innovation) has an R^2 value of 26.2% that is comparable to the R^2 reported in similar cross-industry studies (e.g., Martínez-Sánchez et al., 2008; Michie and Sheehan, 2005). Much of the unexplained variance in NPD outcomes could possibly be explained by other factors not included in our analysis, such as development process flexibility or organizational routines and structures. While controlling for a mixture of effects in all three models, various functional and numerical flexibility variables have regression coefficients that differ statistically significantly from zero, though the controls are responsible for the largest part of the variance.

H1 that predicts a stronger positive effect of functional flexibility on major new products than on incremental new products is not supported. Although the analysis shows a significant linear, positive effect of *training and education* (linear $\beta = .121$, $p < .05$) on undifferentiated NPD outcomes, and a quadratic, positive effect on incremental innovation (quadratic $\beta = .437$, $p < .05$), the effect of *training and education* on major new products is not significant (linear $\beta = .061$, $p > .05$). Graphic representations lead us to conclude that workforces that enjoy more internal and external training and education develop mostly and with an increasing rate incremental new products.

With respect to internal numerical flexibility, support for the hypothesized (H2) positive effect of *extra hours paid as overtime* was not found. Working (paid) overtime has no effect on undifferentiated NPD outcomes and major new product; however, it has a negative effect on incremental new products ($\beta = -.107$, $p < .05$) suggesting that working overtime hinders developing incremental new products.

Table 2. Regression Analysis Results

Constructs	Variables	Hypothesis	NPD Outcomes (log)	Incremental New Products (log)	Major New Products (log)
Controls	Size		.086	.115*	−.022
	Industry type: business services		.096*	.139***	−.027
	R&D investments		.398***	.725***	−.308*
	R&D investments (squared)			−.519***	.493***
	Organizational change consequences		.017	−.087*	.094
Innovation controls	Major product innovation			.405***	
	Incremental product innovation				.410***
Functional flexibility controls	Inadequate qualifications (yes/no)		−.039	.070	−.121**
	Insufficient broad employability (yes/no)		−.011	−.021	.013
Numerical flexibility controls	Keeping existing employees (yes/no)		.083	.046	.082
	Controlling work pressure (yes/no)		−.010	−.022	.015
Functional flexibility	Training and education as percentage	H1	.121**	−.373**	.061
	Training and education (squared)			.437**	
Numerical flexibility	Fixed-term workers as percentage	H3b	.175***	.085	.118**
	Temporary job agency workers (yes/no)	H3a	.003	.007	.017
	Extra hours paid overtime as percentage	H2	−.052	−.107**	.052
Model statistics					
R^2 Controls only			.223***	.341***	.318***
ΔR^2 Functional flexibility			.011**	.014*	.003*
ΔR^2 Numerical flexibility			.028**	.014**	.016*
R^2 full model			.262	.369	.337
F full model (degrees of freedom)			F(12, 271): 11.69****	F(15, 268): 11.34****	F(14, 269): 12.34****

Notes: $n = 284$. The metric variables are log transformed. Polynomial parameters are centered and included if significant. Standardized regression coefficients are reported. The VIFs of the main parameters range from 1.1 to 1.6 and the VIFs of the polynomial parameters range from 10.7 to 14.4. The variable NPD outcomes is the accumulation of incremental new products and major new products. Two-tailed significance using robust standard errors: **** $p < .001$; *** $p < .01$; ** $p < .05$; * $p < .1$.

Similarly, with respect to external numerical flexibility, no support for the hypothesized (H3a) negative effect of temporary job agency workers on undifferentiated NPD nor on incremental versus major new products was found. However, the analysis shows partial support for hypothesis H3b: There is a significant, positive effect of deploying fixed-term workers on NPD outcomes ($\beta = .175$, $p < .01$) and on major new products ($\beta = .118$, $p < .05$). There is no significant effect on incremental new products. That is, workforces containing more people with fixed-term contracts stimulate the development of more major new products, while they do not appear to influence incremental innovations.

Some control variables also explain part of the variance. The functional flexibility controls do not take away the effect of the main functional flexibility variables, though one has a negative influence, namely *inadequately qualified personnel*, which appears to reduce major innovation ($\beta = -.121$, $p < .05$) but not significantly affect NPD outcomes or incremental new products. This finding suggests that if the workforce is inadequately qualified, to such an extent that it becomes a bottleneck, it severely hampers the development of major new products. The other functional flexibility bottleneck, *insufficiently broad employability* of personnel, has no statistically significant effect. The effects of numerical flexibility do not appear influenced by their control variables. For example, whether or not the firm *keeps existing employees insufficiently* or *controls work pressure* has no statistically significant effect on undifferentiated NPD outcomes, nor on major versus incremental new products.

The innovation control variables are significantly, strongly associated with the incremental and major NPD outcomes (respectively, major product innovation $\beta = .405$, $p < .05$, incremental product innovation $\beta = .410$, $p < .05$) as expected, suggesting that in firms that do both the one stimulates the other and vice versa.

As expected, *industry type* positively affects incremental innovation, such that business service firms tend to develop more incremental innovations ($\beta = .139$, $p < .01$). In addition, *R&D investments* have a quadratic effect that is negative for incremental (linear $\beta = .725$, $p < .01$; quadratic $\beta = -.519$, $p < .01$) and positive (linear $\beta = -.308$, $p < .10$; quadratic $\beta = .493$, $p < .01$) for major new products. To increase the number of major new products, a dramatic increase in R&D investments thus appears needed, while such an increase in investments does not yield additional incremental new products. *Organizational size* and *organizational change consequences* do not display significant effects.

Discussion

Firms using training and education to get a functional flexible workforce develop increasingly incremental rather than major new products; previous empirical studies that indicate a positive effect on innovation did not distinguish major from incremental NPD or control for functional bottlenecks (e.g., Carvalho and Cabral-Cardoso, 2008; Martínez-Sánchez et al., 2008). External and internal training and education create multiskilled employees who can be deployed across a broad range of tasks and jobs. Contrary to our expectations, such employability positively impacts incremental instead of major innovations; its marginal effects on incremental innovations are increasing. This impact is significant even when controls for functional bottlenecks are included such as inadequate qualifications or an insufficiently broad employable workforce. Internal and external training or education seems to reinforce existing competencies, although its marginal effect is decreasing, rather than bring new competencies to the firm. However, firms for which inadequately qualified personnel represent a bottleneck may experience negative effects of training and education on their major NPD.

This study also suggests that firms with workforces that are externally numerically flexible, with a larger share of fixed-term contracts, develop more product innovations. In particular, the ability to adjust the number of fixed-term workers generates more major innovations, with no effect on incremental innovations. A negative effect of using temporary workers from job agencies was hypothesized, based on recent research of Beugelsdijk (2008), yet our research shows—in line with Michie and Sheehan (2003) and Martínez-Sánchez et al. (2011)—that it had no effect. This null effect may arise because temporary workers from job agencies were measured as a dichotomized variable (yes/no), and the degree of temporary job agency contracts could be the critical question. Even when numerical flexibility bottlenecks, keeping existing employees, and controlling work pressure are controlled for, the effects of numerical flexibility persisted.

The findings thus may explain the mixed results of previous studies pertaining to the effect of external numerical flexibility that fail to distinguish incremental from major NPD (e.g., Arvanitis, 2005; Michie and Sheehan, 2003), do not treat NPD any differently from process innovation (e.g., Martínez-Sánchez et al., 2008, 2011), 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, had negative effects on innovation performance (Martínez-Sánchez et al., 2008), but the composite score may have hidden the effects of specific elements, such as fixed-term contracts. Martínez-Sánchez et al. (2011) also find a negative effect of short-term hires but do distinguish between product and process innovation. Beugelsdijk (2008) note a negative relationship with NPD but include only temporary job agency workers, such as standby contract practices. These studies suggest that temporary employees possess less firm-specific knowledge, which inhibits innovation. In line with Arvanitis (2005), our study proposes instead that a positive relationship can emerge from hiring temporary workers on a fixed-term contract to obtain their specialized skills, which are lacking from the firm's existing NPD process. These workers likely devote significant effort to the task, in the hope of obtaining a permanent position or repeated contracts. Such does not imply that there is no limit on the number of fixed-term workers with positive effects on NPD. Rather, the crucial question is the balance between fixed-term and permanent workers. Fixed-term workers also may receive permanent contracts and permanent workers may leave the firm, enabling it to hire new workers on fixed-term contracts.

Internal numerical flexibility, measured by the extra hours worked as paid overtime, appears to affect incremental innovations only and does so negatively. Prior studies identify no statistically significant effects (Martínez-Sánchez et al., 2008), whereas a positive effect was expected. Paid overtime undoubtedly creates flexibility in the development process, but it does not seem to create the structural flexibility in a positive way. It only distinguishes the major from the incremental innovators, leading us to suggest that paid overtime has no or negative impact, respectively. Maybe paid overtime mainly is used in the operations and thus jeopardizes innovation.

The effects on major compared with incremental NPD can partly be attributed to workforce flexibility. These effects persisted when controls for innovation, the size of the organization, and the consequences of corporate-level organizational changes (e.g., acquisitions, cutbacks) for the workforce are included. Clearly, incremental and major NPD appear to be associated. Additionally, major NPD is the result of flexibility in the workforce, not of organizational size or the consequences of organizational changes for the workforce, such as re-education and re-training, expansion, reappointments, or (enforced) dismissals. However, as expected, firms that develop more major new products invest substantially more in R&D, whereas firms that develop more incremental new products are more likely to be active in the field of business services rather than manufacturing industries.

Conclusion

This large-scale survey, across service and manufacturing industries, reveals that workforce flexibility affects NPD in general and the development of major new products or services in particular. The development of major innovations to adapt to market and technological change partly relies on the flexibility of human resources. With this conclusion, the study contributes to product innovation research pertaining to the nature of the flexibility in NPD processes (see, e.g., Biazzo, 2009; MacCormack et al., 2001) and research into how to adapt to environmental change, which previously has mainly investigated organizational structures, routines, and teams (e.g., Benner, 2009; Buganza et al., 2009; Buganza and Verganti, 2006).

Accordingly, a different approach to major versus incremental NPD may be used. Prior research suggests that the difference for example lies 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, semi-longitudinal setup, this study confirms that it may also be grounded in the human resources of the firm in accordance with the theory recently proposed by O'Connor and McDermott (2004) and O'Connor (2008). Although the skills of employees determine their innovation work, the flexibility of the workforce generates the transformations needed for major innovations. This insight also expands the resource-based view of the firm. Human resources can support the creation of core competences that may lead to competitive advantages, but the flexibility of these human resources, including the workforce, also may be part of the dynamic capabilities that allow firms to fundamentally reconfigure 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 give rise to the notion that workforce flexibility may act as a dual benefit. It allows firms to cut operating costs and stay in business or even keep R&D budgets intact. It also enables them to renew their knowledge bases to develop major new products and services, through hiring new people on fixed-term contracts. Using fixed-term employees offers specialized knowledge that can renew the workforce, encouraging the development of major new products. Training and education have no impact on major NPD, but progressively more enhance the employees' employability to improve products.

Limitations and Future Research

Although the DANS database allowed us to investigate a large array of variables at different points in time across a large, diverse representative set of firms, the number of variables included for functional and numerical flexibility is limited. Researchers should consider functional flexibility alongside other variables, beyond training and the bottlenecks, such as multiskilled teams, quality and problem-solving teams, and the involvement of employees in planning and job design (see, e.g., Martínez-Sánchez et al., 2008). They also should delve deeper into the functional flexibility effect of training and education on major new products, because our results give indications, though weak indications, that the linear effect might actually be quadratic. Such a quadratic effect implies that the impact of training and education on major new products comes to a hold; marginal effects are decreasing.

For numerical flexibility, internal factors also should be included, such as part-time contracts, job sharing, workload reduction, and flextime together with external factors such as the number of layoffs (see, e.g., Martínez-Sánchez et al., 2008). With respect to external numerical flexibility, only a dichotomized variable was accessible. Additional studies could include the share of temporary job agency contracts, which may offer more explanatory power. Also, the effects of fixed-term employees were analyzed, without taking into account related issues, such as how many contracts were offered to the same employee and at what contract length. In relation to this issue, ongoing researchers should seek to determine the optimal balance between permanent and fixed-term workers.

This study is among the first to distinguish major from incremental NPD and a broad non-incremental category was included to ensure the inclusion of service innovations. However, the data do not permit disentangling major new products further, such as by differentiating product versus technology newness for the firm or for the industry/customers (see, e.g., Garcia and Calantone, 2002). Nor do these data include time-to-market information, which would have allowed us to control for differences between radical and incremental innovations or across various industries. Such data also could confirm the appropriateness of the time lags that are used to determine the effects of workforce flexibility on major compared with incremental product innovation outcomes. Researchers who take up this issue might include a measure of NPD success and new product success.

Industry-type effects were taken into account, but the different mechanisms underlying innovation practices in service and manufacturing firms (De Brentani, 2001) likely require a more detailed analysis. Moreover, the sample of Dutch industry firms was under the 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 typical Dutch labor law practice. Additional research should investigate this topic in greater depth, across a broad range of industries and countries with unique institutional arrangements.

Implications for Managers

The R&D or NPD managers of business services and manufactured products should recognize that developing new products depends on the functional and external numerical flexibility of their workforce. In addition to taking a development process perspective on flexibility to adapt to changes in the environment, managers may need to adopt a human resource perspective. For example, R&D managers might confer about the firm's capacity for innovation projects and programs with human resource managers, in an attempt to determine the nature of required changes in the workforce. This study reconfirms the importance of training and education for developing a broad range of workforce skills, but concludes that they appear effective for incremental innovations only.

Complementary efforts might rely on fixed-term contracts to facilitate workforce adjustments and attain the particular knowledge and skills required for major NPD projects. This is not to say managers should follow an exclusive "hire and fire" policy; employees can be offered additional fixed-term or permanent contracts if they meet expectations. Complementary efforts, however, might not rely on asking employees to work extra hours paid overtime, because that only seems to hamper incremental innovation. By discussing the firm's human resource capacity for innovation projects with human resource managers, R&D or NPD managers, especially those in multinational companies, also can gain more information about differences in labor laws and governmental regulations across industries, countries, and international regions.

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