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# Cross-functional integration in the sustainable new product development process: The role of the environmental specialist

Ebru Genç [a], C. Anthony Di Benedetto [b,*]

[a] Department of Business Administration, Faculty of Management Sciences, Abdullah Gül University, Kayseri, Turkey
[b] Department of Marketing and Supply Chain Management, Fox School of Business, Temple University, Philadelphia, PA 19122, United States

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ABSTRACT

Companies in the twenty-first century are exposed to a variety of pressures to respond to environmental issues, and responding to these pressures affects several aspects of business such as purchasing, marketing and logistics. Managers increasingly view sustainability as a complement to their corporate agendas, or even as an opportunity. It is important to understand how firms integrate environmental issues into their businesses and how these integration strategies affect performance. The process of sustainable new product development (SNPD) is a key strategic focus to achieve economic and environmental sustainability. This paper examines the integration of environmental specialists into new product development teams that are composed of other functional specialists including marketing, manufacturing, and R&D personnel, and its impact on SNPD project performance across three stages: concept development, product development, and product commercialization. We empirically test our theoretical model using a sample of 219 firms from a range of business-to-business industries. We present evidence that integrating an environmental specialist into a new product team has a positive influence on SNPD project performance beyond what the traditional members of such a team would accomplish. We analyze this relationship across the stages of SNPD to obtain a clearer picture of the effects of this integration. In particular, the integration of the environmental specialist was more effective on SNPD project performance in the final stage of the SNPD process when the product was being launched; this effect is even greater for high-innovative projects.

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## 1. Introduction

The degradation of the natural environment is an important current issue for governments and societies throughout the world (Stern Report, 2006). After governments and societies awakened to the urgency of this problem, they began pressuring companies in various ways: regulators are increasing legislation such as Clean Air Act, United Nations Environment Program, North American Agreement on Environmental Cooperation (NAAEC), community groups and activists are protesting against firms that have unsustainable business practices, and consumers are demanding "environmentally-friendly" or "sustainable" products. Responding to this change, an increasing number of firms are committing to including the natural environment in their corporate agendas and have adopted sustainable business practices (Kolk, 2008; Madsen, 2009; Marcus & Fremeth, 2009). In tandem with the shift in the business world, several research studies have been conducted about distinct aspects of sustainability. Impressive progress has been made in understanding the importance of sustainable business practices in marketing and many other fields (Varadarajan, 2010). Several studies have found that the expenses incurred by sustainability initiatives can be compensated for gains made elsewhere; namely, it does "pay to be green" (Ambec & Lanoie, 2008; Clemens, 2006; Hart & Ahuja, 1996).

Nevertheless, these studies on sustainability are conducted typically in the context of pollution reduction, emissions of toxic chemicals, spills and other plant accidents, rather than adopting a more holistic, strategic point of view. In fact, little research has been done regarding the incorporation of sustainability issues and considerations directly into the conventional NPD process, which we refer to here as *sustainable new product development* (SNPD) (Huang & Wu, 2010; Pujari, Wright, & Peattie, 2003). In this study, SNPD is defined as "an organization-wide process of NPD into which sustainability concerns are explicitly integrated to minimize impacts on the natural environment, and on animal and human health". Incorporating sustainability issues into conventional NPD is important because it will bring several benefits to the firms such as reducing inefficiencies during the production process, and creating differentiation and cost advantages (Siegel, 2009).

Cross-functional integration has been identified as one of the most important factors for explaining new product success (Berchicci & Bodewes, 2005; Gemser & Leenders, 2011; Leenders & Wierenga,

* Corresponding author.
*E-mail addresses:* ebru.genc@agu.edu.tr (E. Genc), tonyd@temple.edu (C.A. Di Benedetto).

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2008; Nakata & Im, 2010; Pujari, 2006; Troy, Hirunyawipada, & Paswan, 2008). Studies found that organizational factors, as opposed to technical/process factors, are more likely to hamper the success of SNPD (Lenox & Ehrenfeld, 1997) which points to the additional importance of cross-functional integration in the context of SNPD. This study focuses on cross-functional integration in the SNPD process with specific attention to the role of the environmental specialist in the process. We expect that the integration of environmental specialists with the team will lead to a smooth and efficient transition from the conventional NPD process to the SNPD process, and, in turn, that will result in sustainable new products that can achieve better results in the market (Boks, 2006; Cordano & Frieze, 2000; Petala, Wever, Dutilh, & Brezet, 2010; Russo & Harrison, 2005).

However, the literature does not give a clear picture of how the integration of the environmental specialist into conventional NPD teams might influence the market performance of new products. The objective of this research study is to increase our theoretical understanding of the role of the environmental specialist on the NPD team and the impact on the success of sustainable new products. We make a theoretical contribution to the literature by showing the stage-wise impact on NPD performance of the integration of the environmental specialist to the NPD team. We develop a theoretical model that is based both on the NPD literature stream and on the sustainable management literature. In our model, we place particular attention on the integration of the environmental specialist on the NPD team across three stages of the NPD process: concept development, product development, and product commercialization. We empirically test our theoretical model using a sample of 216 business-to-business firms representing a wide variety of industries. We conclude with theoretical implications and managerial recommendations.

## 2. Theoretical framework

### 2.1. Sustainable new product development

Although today many large companies are producing sustainable products, relatively few studies to date have empirically examined the impact of sustainable products on a firm's performance (e.g.,Pujari & Wright, 1999; Pujari et al., 2003; Huang & Wu, 2010; Kesidou & Demirel, 2012). This relatively new notion is at the center of two streams of research: work on conventional NPD and work on sustainable management (Seebode, Jeanrenaud, & Bessant, 2012). The conventional NPD literature is replete with variables and models that have been proposed and empirically tested. As stated above, however, the question of how sustainability concerns should be integrated has not yet been resolved. Likewise, the sustainable management literature has not adequately addressed the direct impact of sustainability concerns on the market success of new products.

Successful new product development is a requirement for any firm's long run competitiveness (Cooper, 1983; Ulrich & Eppinger, 1995; Wheelwright & Clark, 1992), but the firm that incorporates sustainability and environmental concerns can extract additional advantage. For example, reducing inefficiencies during the production process, recycling manufacturing by-products, or innovating to meet strict environmental regulations may bring cost advantages for companies (Porter & van der Linde, 1995), and redesigned packaging, sustainable products, and promotion of environmental benefits can yield differentiation advantages (Siegel, 2009). Therefore, integrating sustainable management into the conventional NPD process would help firms achieve long-run competitiveness and sustainability goals, leading to a win–win situation for the firm and society (Chen, Lai, & Wen, 2006).

Furthermore, Pujari et al. (2003) conclude that a paradigm shift is underway, in which sustainability is more explicitly incorporated into product development by manufacturing firms. The greater responsiveness to sustainability at the corporate level has necessitated more substantive changes at the product development level. Based on the definition used by Huang and Wu (2010), this study defines SNPD[1]as "an organization-wide process of new product development into which sustainability concerns are explicitly integrated to minimize impacts on the natural environment, and on animal and human health." SNPD is not a radically different process than conventional NPD, but it involves sustainability concerns in addition to the other factors required for market success.

### 2.2. Cross-functional integration in SNPD

Cross-functional integration is a critical driver of new product success (Berchicci & Bodewes, 2005; Gemser & Leenders, 2011; Leenders & Wierenga, 2008; Nakata & Im, 2010; Pujari, 2006; Troy et al., 2008). Creating new products requires multidisciplinary viewpoints and the involvement of different functional units (Dougherty, 1992; Olson, Walker, Ruekert, & Bonner, 2001). Cross-functional integration provides significant benefits for the NPD process including stimulating creativity, encouraging open communication, achieving a common understanding of the product and enhancing consistency among decisions (Han, Kim, & Srivastava, 1998; Sethi, 2000).

To our knowledge, there is little research on cross-functional integration in the context of SNPD (e.g., Huang & Wu, 2010; Pujari et al., 2003) and the role of the environmental specialist as one of the functions on the team. Nonetheless, organizational factors have been shown to significantly affect the success of SNPD (Lenox & Ehrenfield, 1997). Since cross-functional integration is a major organizational component, we propose that cross-functional integration is an important success factor of SNPD and may even be more critical than conventional NPD.

### 2.3. The role of the environmental specialist

Product developing firms must comply with newly-implemented, rigorous environmental regulations, and as consumer interest in the subject grows, the environmental aspects of a product are becoming more valuable to consumers (EPA, 2009). Due to these concerns, many firms meet consumer demand by launching sustainable products through sustainable management practices that go above and beyond existing regulations. Given these conditions in the market, there should be experts in the company who are dedicated to supervising the application of new environmental requirements, identifying sustainability procedures for the new product development process, complying with applicable laws, regulations and other sustainability-oriented requirements, performing environmental audits, spotting significant areas for reducing energy use and waste, and proposing modifications to the whole process by going above and beyond what is required by law. These experts are referred to as "environmental specialists" in this study.

The literature suggests that improving cross-functional teamwork between environmental specialists, engineers and production personnel leads to the successful incorporation of sustainable management strategies into corporate strategic planning (Boks, 2006; Cordano & Frieze, 2000; Petala et al., 2010; Russo & Harrison, 2005) and results in improved financial and environmental performance (Judge & Douglas, 1998). Nevertheless, the interaction between marketing and environmental specialists is often weak and marked by a limited understanding of each other's roles and challenges (Charter & Clark, 2007). Pujari et al. (2003) emphasized the importance of including an environmental specialist in the SNPD process, and the positive effect of this specialist on sustainable new product performance, but did not elaborate on how the specialist would interact with other team members. Our

[1] There is small but growing literature on SNPD, which is alternatively named *environmental NPD* (Pujari et al., 2003) or *green NPD* (Huang & Wu, 2010). We consistently used "sustainable" instead of "environmental" or "green" in this study as it is a more comprehensive and clear term encompassing many sustainable new product development objectives.

study extends this literature in this respect, since these studies indicate the need for more research in this relatively neglected but important area of study.

### 2.4. The role of the environmental specialist across the NPD stages

In line with prior work on related topics (Ernst, Hoyer, & Rübsaamen, 2010; Song & Parry, 1997; Song & Swink, 2009; Song, Thieme, & Xie, 1998), we view the SNPD process as being composed of three distinct stages: (1) concept development (CD), (2) product development (PD), and (3) product commercialization (PC). The NPD literature suggests that firms should follow a stage-like process, to keep investment low while uncertainties are high, to reduce uncertainties progressively with evaluative steps after each stage, and ultimately to increase the chances of new product success (Crawford & Di Benedetto, 2010).

In addition to the importance of the stages, it is also important to consider the roles of each function on the NPD team and how these are likely to change from one stage to the next. Success with new products will "be more likely when a firm employs function-specific and stage-specific patterns of cross-functional integration than it is when the firm attempts to integrate all functions during all NPD stages" (Song et al., 1998). In their meta-analysis of cross-functional integration, Troy et al. (2008) recommended that future research attempt a stage-by-stage analysis to better understand the relationship between cross-functional integration and new product success. Thus far, only limited research has studied the effects of stage-by-stage integration (Olson et al., 2001; Song & Swink, 2009; Song et al., 1998), and none has specifically examined the integration of the environmental specialist on the new product team.

The correct mix of cross-functional involvement depends on the stage in the NPD (Song et al., 1998), and a fluid organizational structure is recommended so that team members can enter and exit the NPD process as the team moves from one stage to the next (Troy et al., 2008). We propose that the environmental specialist is an important team member throughout the SNPD process, but his/her role will change as the team moves through the stages.

In the first stage, concept development, ideas are generated and the most promising of these are developed into product concepts, then refined and selected for further development (Kim & Wilemon, 2003). The environmental specialist can play an important role at this earliest stage of SNPD, by being involved early in product development decisions that have environmental consequences, which might be costly and time-consuming to fix later in the process. As an example, one of these decisions would be the selection of environmentally safe materials, and recommending against the use of environmentally harmful ones. The environmental specialist will in fact be highly trained in the selection and use of appropriate materials, and participation in materials selection at this early stage in the process ensures that the developed product is in line with the firm's sustainability objectives (Hart, 1995; Sharma & Vredenburg, 1998), and minimizes the possibility that extensive redesign and rework will need to be done later in the process to fix incorrect materials decisions.

The second stage in the process is product development, in which prototypes are developed, tested, and further refined. The environmental specialist will carry out a different task during this stage, by identifying cost and/or differentiation advantages for the product in development (Siegel, 2009). For example, using sustainable resources, finding efficiency improvements in the production process, or changing manufacturing methods to lessen waste or pollution in product manufacture, choosing less polluting inputs, or recycling by-products can all result in cost advantages; product redesign for low environmental impact or higher sustainability can add differentiation advantages (Hart, 2005; Marcus & Fremeth, 2009).

The third stage, product commercialization, includes the product launch and all related activities, such as product training, after-sales support, and competitive monitoring and other benchmarking (Song & Parry, 1992). Here again, the environmental specialist can play an important specialized role, for example in the selection of environmentally-friendly (biodegradable or recyclable) packaging, elimination of excessive packaging, less waste disposal, or environmentally efficient logistic activities and channels of distribution (Boks, 2006; Petala et al., 2010).

### 2.5. Development of hypotheses

Based on our theoretical framework, we develop several testable hypotheses regarding cross-functional integration, and the role of the environmental specialist, at various stages in the SNPD process (see Fig. 1 for the conceptual model). To be precise, we state two hypotheses for each of the three stages. The first concerns the integration of the traditional functions (marketing, R&D, and/or manufacturing) depending on the requirements and needs at each stage. The second concerns the integration of the environmental specialist into the product team at that stage, and what his/her role specifically would be at that stage. Thus, we have a total of six hypotheses, which are further explained below.

The concept development stage involves the generation and evaluation of new product ideas and then the refinement of the most promising ideas into actual new product concepts before they pass to the development stage (Kim & Wilemon, 2003). In line with the previous literature, we argue that marketing–R&D integration is important in the concept development stage (Gupta, Raj, & Wilemon, 1986) because effective collaboration on the front end of the SNPD process would be highly beneficial for product success, combining what is desired by the current and potential customers with what is technologically feasible (Rouziès et al., 2005). Such an exchange should produce a superior value proposition that is both acceptable to the target markets and deliverable by the firm. We hypothesize the following:

**H1.** Integration between Marketing and R&D in the concept development (CD) stage of SNPD will be positively associated with SNPD project performance.

As noted above, the environmental specialist's role at this stage will center on the need to build in environmental concerns early in the SNPD process to avoid costly fix-ups later in the process. Indeed, the effectiveness of sustainable initiatives requires cooperation among environmental specialists, engineers, and production personnel (Cordano & Frieze, 2000; Russo & Harrison, 2005). Environmental specialists at this stage, for example, can design in environmentally-benign materials and design out environmentally-harmful materials. In this way, concepts that are pushed forward into development will be in line with the firm's sustainability objectives (Hart, 1995; Sharma & Vredenburg, 1998). We hypothesize the following:

**H2.** The integration of an environmental specialist into the cross-functional team in the concept development (CD) stage of SNPD will be positively associated with SNPD project performance.

The product development stage involves actual technical product development, the execution of prototype tests, and test marketing. Marketing can help R&D obtain feedback from customers on technical product design by testing the prototype with selected customers (Song & Parry, 1997). Furthermore, marketing carries out test-marketing activities to assess the overall market acceptance of the new product before actually launching it (Crawford & Di Benedetto, 2010).

It is at this stage when the differences between the viewpoints of manufacturing and the other functions become most pronounced. For example, manufacturing's emphasis on product standardization for the sake of lower manufacturing costs may result in unsatisfied customers (Kotabe, 1992). Close integration of manufacturing into the product team will provide the opportunity for team members to better understand each other's viewpoint and engage in joint-decision making (Song et al., 1998). We hypothesize the following:

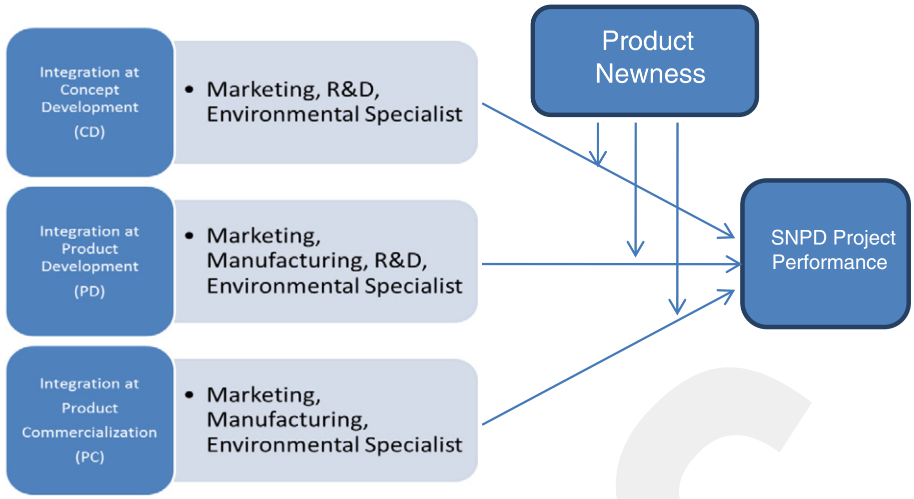


**Fig. 1.** Conceptual framework of cross-functional integration in the sustainable new product development process.

**H3.** The integration of Marketing, R&D and Manufacturing in the product development (PD) stage of SNPD will be positively associated with SNPD project performance.

Effective integration of an environmental specialist into the team at the PD stage can lead to both cost and differentiation advantages (Siegel, 2009). Cost advantages can stem from promoting the sustainable use of resources, improving inefficiencies in the production process, minimizing waste by suggesting new, innovative methods, redesigning and innovating for less polluting production processes, using inputs that generate less pollution, and recycling the by-products of processes (Hart, 2005; Marcus & Fremeth, 2009). Differentiation advantages may arise from redesigning the products for greater sustainability (for example, many modern cars are designed to be almost completely separated into component parts and recycled after the end of the car's useful life). We hypothesize the following:

**H4.** The integration of an environmental specialist into a cross-functional team in the product development (PD) stage of SNPD will be positively associated with SNPD project performance.

The product commercialization stage involves activities such as market launches, product training, after-sales support, and the monitoring of competitors' reactions (Song & Parry, 1992). During the PC stage, marketing possesses information that is critical to SNPD performance, such as identifying and contacting certain customers who are crucial for the diffusion of new products in the market (Gordon & Schoenbachler, 1997; Hultink & Atuahene-Gima, 2000; Rochford & Wotruba, 1996). In the absence of integration, marketing personnel may push for heavy inventories and flexible production capacities in order to provide fast and fluid adaptations to changes in customer demands. Manufacturing personnel would be more likely to seek to reduce costs by attempting to keep inventory levels and production disruptions at a minimum by forecasting sales as accurately as possible. Variations in objectives prompt a need for the joint involvement of marketing and manufacturing in production planning and demand management activities during the commercialization stage. We hypothesize the following:

**H5.** Integration between Marketing and Manufacturing in the product commercialization (PC) stage of SNPD will be positively associated with SNPD project performance.

The activities in the commercialization stage involve last-step decisions regarding packaging, waste disposal and the selection of appropriate channels of distribution. The role of the environmental specialist at this stage would include pointing out the benefits of recyclable and biodegradable packaging and minimizing excessive packaging. The environmental specialist may also suggest technologies to better handle production waste, which can benefit both the environment and company profitability. In addition, environmental specialists can suggest new technologies or methods regarding the commercialization of the product including logistic activities (Boks, 2006; Petala et al., 2010). We hypothesize the following:

**H6.** The integration of an environmental specialist into the cross-functional team in the product commercialization (PC) stage of SNPD will be positively associated with SNPD project performance.

### *2.6. Moderating the effect of product newness*

The literature highlights the importance of considering the degree of product newness (e.g., Shenhar, 1998; Tatikonda & Rosenthal, 2000). We build on resource dependency theory to explain the possible moderating effect of product newness. Given that a higher level of product newness implies a higher level of external and internal uncertainty, resource-dependency theory suggests that as the degree of product newness increases, so do functional interdependence and cross-functional information and resource exchanges among the functional areas in NPD activities (Olson, Walker, & Ruekert, 1995; Ruekert & Walker, 1987). Therefore, as the degree of newness increases (i.e., the breakthrough or radical projects), it is generally necessary to improve integration among the various functions of the SNPD teams. Accordingly, we presume that some of the relationships between cross-functional integration and new product success are probably moderated by the degree of product newness. We hypothesize the following:

**H7a–c.** Cross-functional integration during the (a) CD (b) PD and (c) PC stages of SNPD will be more positively associated with SNPD project performance on high-product-newness SNPD projects than on low-product-newness SNPD projects.

## 3. Methodology

### *3.1. Sample*

To test the hypotheses, we collected data describing completed SNPD projects via an online survey. In the following sections, we will describe the sample, data collection procedures and the survey instrument. Since this study focused on processes and outcomes associated with individual SNPD projects rather than on aggregate SNPD performance at the firm level, we collected data on the cooperation among functional areas over the course of a specific SNPD project. We worked with a market research company (Research Now) to reach product/project managers in various U.S. companies. The respondents were selected randomly from the pool of managers available from the market research company. Screening questions were created to ensure that the final sample consisted only of respondents who had worked actively on new product development projects for which performance data were available. The respondents who participated in the study worked in companies that operate across several industries. To increase the diversity of projects involved in the study, we maintained the anonymity of the respondents. We specifically sought projects that differed in terms of product newness and which had been completed within the past five years. We used key informants, specifically the "product/project managers" of the SNPD projects, as these are the people with the most direct responsibility for the projects. Since these are the people that act as the leader of the team so they have the information about the activities of each team member throughout the NPD process. Since we used key informants as our sample, we obtained only one questionnaire per firm.

Although the use of multiple respondents would reduce concerns about potential response biases, there are several problems attached to this method. First, it has been acknowledged that identifying and obtaining responses from multiple well-informed respondents is extremely difficult (Lilien & Grewal, 2012; Poutziouris, Smyrnios, & Klein, 2006). Second, it can compromise the anonymity of the questionnaire (Kearns & Sabherwal, 2006). Third, matched pairs may result in subjectivity and measurement error (Tallon, 2007). Finally, there is a potential negative effect of multiple respondents on usable response rates, and difficulties in survey administration (Felekoglu & Moultrie, 2014; Lai, Lee, & Hsu, 2009). There is often limited availability of organizations or respondents who are willing to participate. Using key informants is an alternative strategy to address these concerns, and is still heavily used in management and NPD fields, even in recent studies (Ingenbleek, Frambach, & Verhallen, 2013; Smets, Langerak, & Rijsdijk, 2013) and also in recent psychology literature (Kim-Spoon, Farley, Holmes, & Longo, 2014; Wong, Tjosfold, & Zi-you, 2005). Moreover, as suggested by Montoya-Weiss and Calantone (1994), for appropriate use of key informants, the hierarchical level of key informants needs to be consistent since different levels of respondents would have very different perceptions. In our work, we controlled these concerns by insisting that the respondents be knowledgeable. We obtained data not from a random sample, but from a purposefully selected sample of individuals likely to possess the most relevant information due to their key positions, experience, or expertise in the process that we were researching, and by collecting the data from the same level of respondents.

Additionally, we used different scale endpoints and formats for the predictor and criterion measures in order to diminish method biases caused by commonalities in scale endpoints and anchoring effects as suggested by Podsakoff and Organ (1986). For example, while we used strongly agree and strongly disagree format for the predictor variables, we used 1 = "a great financial failure," and 7 = "a great financial success", 1 = "far less than our other new products," and 7 = "far greater than our other new products", 1 = "far less than our other new products," and 7 = "far greater than our other new products", 1 = "far less than our objectives," and 7 = "far exceeded our objectives" type of formats for the questions that measure our criterion variable.

To encourage participation, we established a confidential agreement with each company and promised to give it an executive summary of results upon request. Respondents received a hyperlink to an internet-based questionnaire by e-mail. They were asked to fill out the survey for the most recently introduced product for which the respondent was knowledgeable and performance data were available. Each participant was asked to complete the questionnaire, which assessed his or her perceptions regarding the hypothesized constructs, and asked for performance measures and company demographic information (e.g., the industry, the number of employees). A total of 1200 respondents were contacted. Most of them were eliminated with the screening questions. Overall, 282 questionnaires were returned, which represented a response rate of 23%. Finally, the elimination of sixty-three surveys because of incomplete responses left 219 usable questionnaires. The sample covered a range of business-to-business industries, including electrical and electronic devices and equipment, chemicals, hospital and medical devices, agriculture and processed food products, machinery, pharmaceuticals, automotive and spare parts, and steel products. T-tests were applied between early and late responses, and the results did not show significant differences on all of the variables, treated separately (Armstrong & Overton, 1977). We also performed a multivariate analysis of variance (MANOVA) to compare early respondents with late respondents on all of the variables. Similarly, the results were not significant at the 95% confidence level, suggesting that there were no significant differences between early and late respondents.

### 3.2. Measures

We reviewed the literature to identify scales to measure each construct. All of the measures were adopted by the appropriate research studies. In the following section, we explain in detail how we measured each construct. The questionnaire instrument was composed of three parts, starting with a cover letter describing the purpose of our survey. The first part consisted of items for measuring the hypothesized constructs. The second part contained items measuring the performance of the SNPD projects, and the third part contained items measuring company descriptive data, including the number of employees, the year founded, the industry sector, etc. All of the constructs were measured using seven-point Likert-type scales from 1 to 7, ranging from strong disagreement (1) to strong agreement (7). Firm size (a control variable) was measured by the number of employees. The definitions and measurements of the constructs are further defined in the following discussion (for a detailed description of the measures).

*SNPD project performance*. This refers to the ability of a sustainable new product or innovation to compete in the marketplace and to the degree to which firms are more profitable than their competitors (Clemens, 2006; Judge & Douglas, 1998). Overall, SNPD project performance captures the success of the completed SNPD project. We followed previous NPD research and used a commonly applied subjective measure of new product success (Ernst et al., 2010; Song & Parry, 1997). Subjective measures have the advantage of facilitating comparisons across the SNPD projects of firms from different industries (Atuahene-Gima, 1995).

*Cross-functional integration*. We divided the NPD process into three stages, so as to capture the key steps in the SNPD process without making the model too complicated (Ernst et al., 2010). Following Song and Parry (1992) and Ernst et al. (2010), we identified 18 key activities along the entire SNPD process that could potentially require the integration of an environmental specialist with marketing, R&D, and manufacturing personnel (please see Table 1). Specifically, out of these 18 key activities, 7 of them belong to the concept development stage, another 7 of the activities belong to the product development stage, and the remaining 4 activities belong to the product commercialization stage.

For each stage, we asked product/project managers for their perceptions of the level of integration for two types of integration (one for the traditional team members and one for the integration of environmental specialist with the team) for a particular SNPD project. *Level of integration* refers to the level of involvement and information sharing with the other department(s) with regard to each of the 18 SNPD activities (see Table 1). All items were measured on a seven-point scale, ranging from "strongly disagree" (1) to "strongly agree" (7).

*Product newness*. In order to measure product newness, we adapted items from previously validated, high-reliability scales in the literature. The scale for product newness includes four items assessing the

**Table 1**
The 18 key NPD activities.

| Stage 1. Concept development | Stage 2. Product development | Stage 3. Product commercialization |
|---|---|---|
| •Planning and formulating of the new product goal and strategy.<br>•Idea generation.<br>•Analysis of trends, market changes, and potentials.<br>•Assessment and selection of new product ideas.<br>•Assessment of needed funds, times, and risk related to the new product development project.<br>•Preparation of the written product concept.<br>•Determination of desired product features. | •Actual development of the prototype.<br>•Preparation of the commercialization concept.<br>•Execution of prototype tests with customers.<br>•Selection of customers for test-marketing reasons.<br>•Execution of test-marketing measures before market introduction of the new product.<br>•Final evaluation of market acceptance before market introduction of the new product.<br>•Determination of the overall strategy before introducing the new product into the market. | •Market introduction of the new product (selling, advertising, distribution).<br>•Product training for customers.<br>•Customer enquiries/after-sales support.<br>•Monitoring competitors' reactions and their strategies. |

newness to the industry of the product and its associated technologies (Song & Swink, 2009; Song & Xie, 2000). All items were measured on a seven-point scale, ranging from "strongly disagree" (1) to "strongly agree" (7).

We also included two control variables in the analyses, the industry type and the company size. By including the industry type as an overall control variable, we were able to adjust for significant differences between industries with regard to new product performance. By including company size, we were able to control for any differences that might have been caused by the firm's size. All questions were pre-coded and pretested with managers and academics to ensure that our questions were clearly understood and easily answerable by the respondents. At this stage, no particular problems with the wording or response format were found.

### 3.3. Psychometric properties of the scales

Before starting the main analyses, several tests were conducted in order to validate the psychometric properties of the scales used. First, potential common method bias was discarded using the Harman test, which revealed that five different factors emerged from a factor analysis that explained more than 74% of the extracted variance (Podsakoff & Organ, 1986). The unrotated principal component factor analysis, the principal component analysis with varimax rotation, and the principal axis analysis with varimax rotation all revealed the presence of five distinct factors with eigenvalues greater than 1.0, rather than a single factor. Thus, no general factor was apparent. To support the Harman test, we also conducted a confirmatory factor analysis which showed that the single-factor model did not fit the data well: $\chi^2 = 4746.165$, $p = .000$, GFI = .381; CFI = .629; RMSEA = .140. All of these tests show that common method bias is not a big concern in the extent that it will affect the validity of our data. Table 2 reports the means, standard deviations, skewness and kurtosis for all of the variables. Examination of the skewness and kurtosis values for all of the variables (see Table 2) indicated that the number of employees (firm size) was skewed. We transformed this variable by taking its logarithm to ensure normal distribution.

We tested constructs for multicollinearity by calculating variance inflation factors on the item level (Im, Nakata, Park, & Ha, 2003; Micheal, Rochford, & Wotruba, 2003). The results show no significant parameter distortion due to multicollinearity problems (variance inflation factor < 10). To assess the scale's reliability, the value of Cronbach's alpha value was studied. Cronbach's alpha for all the scales far exceeded the critical limit of 70% (Nunnally, 1978).

An exploratory factor analysis was performed on independent variables for each stage, using principal component analysis (the varimax method). Each model produced two factors with eigenvalues greater than 1 and factor loadings of 0.60 as the cutoff points, accounting for 74%, 75%, and 78% of the variance, respectively, for each stage: concept development, product development, product commercialization (K–M–O statistic .936, Bartlett statistic 91 for stage 1 with significance .000; K–M–O statistic .932, Bartlett statistic 91 for stage 2 with significance .000; K–M–O statistic .889, Bartlett statistic 28 with a significance .000 for stage 3). An analysis of the scree plot also shows a two-factor solution for each stage. These results confirm the hypothesized two construct variables for each stage. The first refers to the marketing and R&D integration (MRCoop) and the second refers to the integration of the environmental specialist to the team (E1Coop) for the first stage. For the second stage, there are also two construct variables of which one is marketing, R&D and manufacturing integration (MMRCoop) and the other is the integration of the environmental specialist to the team (E2Coop). Finally the two construct variables for stage 3 are marketing and manufacturing integration (MMCoop) and the integration of the environmental specialist to the team (E3Coop).

Next, a series of confirmatory factor analyses (CFAs) was performed to test the scales for unidimensionality. Instead of examining all of the variables in a seven-construct model, three models were fitted for two groups of theoretically interrelated variables, to avoid a violation of the five-to-one ratio of sample size to parameter estimates (Bentler & Chou, 1987). Model 1 contained marketing and R&D cooperation at stage 1 and the integration of the environmental specialist with the team at stage 1 constructs ($\chi^2 = 71.858$, $p = .104$; GFI = .955; CFI = .995; RMSEA = .033; see Table 3). Model 2 contained marketing, manufacturing and R&D cooperation at stage 2, and the integration of

**Table 2**
Descriptive statistics.

| | Mean | Std. deviation | Skewness | | Kurtosis | |
|---|---|---|---|---|---|---|
| | Statistic | Statistic | Statistic | Std. error | Statistic | Std. error |
| Marketing–R&D—stage 1 | 5.6249 | 0.99959 | −0.835 | 0.164 | 0.47 | 0.327 |
| EnvSpecialist with team—stage 1 | 5.2551 | 1.34461 | −0.909 | 0.164 | 0.633 | 0.327 |
| Marketing–manufacturing–R&D—stage 2 | 5.529 | 1.07549 | −0.855 | 0.164 | 0.801 | 0.327 |
| EnvSpecialist with team—stage 2 | 5.2485 | 1.40025 | −0.975 | 0.164 | 0.701 | 0.327 |
| Marketing–manufacturing—stage 3 | 5.6393 | 1.06579 | −0.746 | 0.164 | 0.091 | 0.327 |
| EnvSpecialist with team—stage 3 | 5.2169 | 1.40395 | −0.834 | 0.164 | 0.298 | 0.327 |
| PERF | 5.524 | 0.90154 | −0.449 | 0.164 | 0.742 | 0.327 |
| NEWNESS | 4.9886 | 1.47548 | −0.646 | 0.164 | −0.168 | 0.327 |
| EMP | 15,880.6 | 43,019.4 | 3.522 | 0.164 | 12.21 | 0.327 |
| logEMP | 2.9598 | 1.1167 | 0.288 | 0.164 | −0.483 | 0.327 |

**Table 3**
Confirmatory factor analysis—model 1 (standardized estimates).

| | | | Estimate | S.E. |
|---|---|---|---|---|
| MRCoop7 | <--- | F1 | 0.814* | |
| MRCoop6 | <--- | F1 | 0.768* | 0.077 |
| MRCoop5 | <--- | F1 | 0.804* | 0.074 |
| MRCoop4 | <--- | F1 | 0.839* | 0.068 |
| MRCoop3 | <--- | F1 | 0.723* | 0.068 |
| MRCoop2 | <--- | F1 | 0.835* | 0.075 |
| MRCoop1 | <--- | F1 | 0.736* | 0.082 |
| E1Coop7 | <--- | F2 | 0.892* | |
| E1Coop6 | <--- | F2 | 0.875* | 0.053 |
| E1Coop5 | <--- | F2 | 0.881* | 0.053 |
| E1Coop4 | <--- | F2 | 0.899* | 0.051 |
| E1Coop3 | <--- | F2 | 0.818* | 0.056 |
| E1Coop2 | <--- | F2 | 0.870* | 0.054 |
| E1Coop1 | <--- | F2 | 0.892* | 0.058 |

* $p < 0.001$.

the environmental specialist with the team at stage 2 constructs ($\chi^2 =$ 67.569, $p = .263$; GFI = .959; CFI = .998; RMSEA = .022; see Table 4). Model 3 contained marketing and manufacturing cooperation at stage 3, and the integration of the environmental specialist with the team at stage 3 constructs ($\chi^2 = 15.897$, $p = .320$; GFI = .982; CFI = .999; RMSEA = .025; see Table 5). All three of the CFA models showed good fits. The significant factor loadings demonstrated convergent validity for all scales.

We also tested convergent validity by calculating the average variance extracted. Since they are all bigger than .5, the scales are good in terms of convergent validity (Hair, Black, Babin, Anderson, & Tatham, 2010; see Table 6). Composite reliabilities also show good reliability of the scales since they are all larger than .7. However, we have discriminant validity issues between E1Coop and E2Coop and between E2Coop and E3Coop and also between MRCoop and MMRCoop. These are because of high correlations between stage 1 and stage 2 variables (see Table 6). We handle this issue by dropping stage 2 variables in the main analysis since we also had multicollinearity issues in the case of including all the parameters which we will discuss later in the paper. So the scales that were used in the main analysis are good in terms of discriminant validity as well.

To test convergent validity, exploratory factor analysis was performed on the product newness and project performance scales. The results produced a single factor for each scale, specifying eigenvalues greater than 1. Then, confirmatory factor analysis was run separately on two of the scales. The results showed that one factor model fit the data well for each scale. (For the project performance scale: GFI = .995; CFI = .999; RMSEA = .026; thus, for this scale, the variables seem to converge, giving evidence of convergent validity. For the product newness scale: GFI = .993; CFI = .997; RMSEA = .095). Therefore,

**Table 4**
Confirmatory factor analysis—model 2 (standardized estimates).

| | | | Estimate | S.E. |
|---|---|---|---|---|
| MMRCoop7 | <--- | F1 | 0.832* | |
| MMRCoop6 | <--- | F1 | 0.851* | 0.072 |
| MMRCoop5 | <--- | F1 | 0.869* | 0.07 |
| MMRCoop4 | <--- | F1 | 0.875* | 0.068 |
| MMRCoop3 | <--- | F1 | 0.822* | 0.073 |
| MMRCoop2 | <--- | F1 | 0.700* | 0.068 |
| MMRCoop1 | <--- | F1 | 0.547* | |
| E2Coop7 | <--- | F2 | 0.896* | 0.041 |
| E2Coop6 | <--- | F2 | 0.912* | 0.054 |
| E2Coop5 | <--- | F2 | 0.898* | 0.05 |
| E2Coop4 | <--- | F2 | 0.901* | 0.051 |
| E2Coop3 | <--- | F2 | 0.880* | 0.059 |
| E2Coop2 | <--- | F2 | 0.867* | 0.048 |
| E2Coop1 | <--- | F2 | 0.783* | 0.072 |

* $p < 0.001$.

**Table 5**
Confirmatory factor analysis—model 3 (standardized estimates).

| | | | Estimate | S.E. |
|---|---|---|---|---|
| MMCoop4 | <--- | F1 | 0.756* | |
| MMCoop3 | <--- | F1 | 0.864* | 0.101 |
| MMCoop2 | <--- | F1 | 0.776* | 0.1 |
| MMCoop1 | <--- | F1 | 0.729* | 0.082 |
| E3Coop4 | <--- | F2 | 0.874* | |
| E3Coop3 | <--- | F2 | 0.933* | 0.051 |
| E3Coop2 | <--- | F2 | 0.891* | 0.054 |
| E3Coop1 | <--- | F2 | 0.814* | 0.05 |

* $p < 0.001$.

the results of both the exploratory and confirmatory factor analyses suggest that all of the scales exhibit unidimensionality. Given this evidence of satisfactory psychometric properties, the constructs were formed by averaging the responses to all the remaining items.

## 4. Results

### 4.1. Patterns of cross-functional integration

Here we present the results regarding the effect of cross-functional integration on SNPD project performance across three SNPD stages. First, we wanted to assess whether the impact of cross-functional integration varies throughout the stages of the SNPD process. By conducting a series of contrast analyses, we were able to compare the stages with each other as nested (blocked) variables. The results from the model comparison analyses revealed that the stage makes a significant difference in SNPD project performance. In particular, cross-functional integration at stage 3 becomes the most significant factor for explaining the variations in project performance. Table 7 shows how adding each variable affects the significance of the overall model. There was no effect of integration on stage 2 after controlling for the existence of cross-functional integration in stages 1 and 3 because of the high correlation between stage 2 and 3 variables ($p = .246 > .05$; see Table 7). Therefore, cross-functional integration at stage 2 does not contribute to project performance beyond the integrations at stages 1 and 3. The multiple-regression method (Cohen & Cohen, 1983) was applied to specify the regression models. We ran the full model for all stages, as shown in Table 8 (full model). We faced multicollinearity problems in the full model since VIF > 10 for some variables. As mentioned in the contrast analysis, this was a result of the high correlation between stage 1 and stage 2 variables. Given the results of the contrast analysis and the multicollinearity problems, we removed insignificant stage 2 variables and ran a second regression (reduced model). As the results show, the effects of stage 3 variables become significant, since the multicollinearity problem was resolved (see Table 8, reduced model).

Visual inspection of the plots of the histogram and the normal probability plots confirmed the multivariate normality of the data (Hair et al., 2010). The variance inflation factors in the reduced model were all below five, indicating that multicollinearity was not a serious problem. Then, we run the multiple regression with the interaction terms added. We excluded the stage 2 variables because of the multicollinearity problem explained before. The outcomes of the multiple regression analyses are presented in Table 9. The results show significant effects of firm size which was expected. Nevertheless, the results show that the industry effect (in particular, manufacturing versus service) does not make a difference on the effect of the team integration on performance (see Table 9). By including these variables in the model, we were able to control the effects stemming from the size of the firm and the industry in which firm operates. $H_1$ proposed that during concept development, marketing–R&D integration would have a significant, positive impact on SNPD project performance. This hypothesis is supported because the coefficient for marketing–R&D cooperation in the concept development stage is positive (.270) and

**Table 6**
Convergent and discriminant validity analysis report.

| | CR | AVE | MRCoop | E1Coop | MMRCoop | E2COOP | MMCoop | E3COOP |
|---|---|---|---|---|---|---|---|---|
| MRCoop | 0.92 | 0.623 | 0.789* | | | | | |
| E1Coop | 0.958 | 0.767 | 0.707 | 0.876* | | | | |
| MMRCoop | 0.921 | 0.629 | 0.842 | 0.702 | 0.793* | | | |
| E2COOP | 0.959 | 0.77 | 0.631 | 0.857 | 0.656 | 0.877* | | |
| MMCoop | 0.863 | 0.613 | 0.724 | 0.589 | 0.766 | 0.588 | 0.783* | |
| E3COOP | 0.931 | 0.773 | 0.655 | 0.827 | 0.677 | 0.892 | 0.616 | 0.879* |

CR: composite reliability.
AVE: average variance extracted.
* Denotes square root of AVE and other numbers are correlations between variables.

significant ($p \le .05$). $H_5$, which pertains to marketing–manufacturing integration in the commercialization stage, is also supported. The coefficient of .163 ($p \le .05$; see Table 9) reveals a significant, positive relationship between the level of marketing–manufacturing integration and SNPD project performance at this stage. These results are consistent with the literature.

### 4.2. The integration of environmental specialist

As predicted, the impact of the integration of the environmental specialist varies across stages. $H_2$ pertains to the impact of the integration of the environmental specialist on SNPD project performance during concept development. Counter to our prediction, integration of an environmental specialist at the concept development stage is proved to be negatively associated with SNPD project performance (significant coefficient of $-.223$, $p < .05$; see Table 9). More important, as $H_6$ predicted, the integration of the environmental specialist at the commercialization stage had a strong positive and significant impact on overall SNPD project performance (with a coefficient of .322 ($p \le .01$); see Table 9).

### 4.3. The moderating effects of product newness

While the integration of an environmental specialist at the concept development and commercialization stages were significantly related to project performance, the unanswered question is whether those relationships are moderated by an individual project's characteristics, in particular by the product newness. To answer this question, we tested for the interaction effects of integration and product newness on project performance. We regressed the project performance variable on integration variables and also on two interaction variables that were formed by multiplying the integration of an environmental specialist at the concept development and commercialization stages by the product newness variable. We mean-centered product newness before creating the interaction terms, in order to avoid multicollinearity (Aiken & West, 1991).

We argued that the increased uncertainty and functional interdependence associated with high innovative SNPD projects, where firms have little relevant prior experience to draw upon, will likely strengthen the impact of the integration of the environmental specialist during the SNPD stages. We predicted in $H_{7a}$ that the integration of the environmental specialist at the concept development stage would be more positively related to SNPD project performance in relatively high innovative projects than low. The result in Table 9 fails to support this prediction, since the interaction variable for the integration of an environmental specialist at the concept development stage was found to be insignificant. Therefore, the integration of an environmental specialist at the concept development stage is not more important in high product newness projects than low product newness projects. Nevertheless, we predicted in $H_{7c}$ that the integration of an environmental specialist at the commercialization stage would be more positively related to SNPD project performance in relatively high product newness projects than low. The result—a significant interaction effect for the integration of an environmental specialist at the commercialization stage—supported this hypothesis, with a coefficient of .22 ($p \le .05$; see Table 9). Therefore, the integration of environmental specialists at the commercialization stage is more important in high product newness projects than low product newness projects.

In addition to testing for interaction effects in detail, we performed the Aiken and Wet procedure to test the effects of integrating an environmental specialist on SNPD project performance at high and low levels of product newness (based on a median split), separately. The results of these two models are reported in Table 10. At high levels of product newness, the integration of an environmental specialist at the commercialization stage is positively associated with SNPD project performance ($\beta = .723$; $p < .01$), whereas at low levels, the integration of an environmental specialist at commercialization stage was not related to SNPD project performance. This result shows the importance of integrating an environmental specialist at the commercialization stage, especially when product newness is high.

## 5. Discussion

To the best of our knowledge, this study is the first empirical examination of the impact of the integration of an environmental specialist into a SNPD team. As mentioned earlier, most previous studies in this area have only examined this issue conceptually. In the first place, our study contributed to the NPD literature by responding to a call by a recent meta-analysis. In that analysis, Troy et al. (2008) called for future research involving a more in-depth examination of the process,

**Table 7**
Model comparison—the insignificance of stage 2.

| Model | R | R square | Adjusted R square | Std. error of the estimate | Change statistics | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | R square change | F change | df1 | df2 | Sig. F change |
| 1[i] | .196[a] | .039 | .030 | .88809 | .039 | 4.328 | 2 | 216 | .014 |
| 2[ii] | .559[b] | .312 | .299 | .75469 | .274 | 42.553 | 2 | 214 | .000 |
| 3[iii] | .593[c] | .351 | .333 | .73637 | .039 | 6.391 | 2 | 212 | .002 |
| 4[iv] | .600[d] | .360 | .335 | .73494 | .009 | 1.413 | 2 | 210 | .246 |

[i] Model 1: control variables.
[ii] Model 2: control variables and stage 3 variables.
[iii] Model 3: control variables, stage 3 and 1 variables.
[iv] Model 4: control variables, stage 1, 3 variables and stage 2 variables.

**Table 8**
Full-reduced models comparison (standardized estimates).

| Integration between | Full model | | Reduced model | |
|---|---|---|---|---|
| | Estimate | SE | Estimate | SE |
| Marketing and R&D—stage 1 | .284* | .100 | .337* | .083 |
| EnvSpecialist with team—stage 1 | −.294* | .081 | −.219* | .073 |
| Marketing–manufacturing–R&D—stage 2 | .122 | .098 | | |
| EnvSpecialist with team—stage 2 | .161 | .089 | | |
| Marketing–manufacturing—stage 3 | .152 | .076 | .193* | .071 |
| EnvSpecialist with team—stage 3 | .171 | .083 | .275* | .066 |

* $p < 0.05$.

specifically a stage-by-stage analysis that could provide significant insights into how integration can most positively affect new product success. We found that cross-functional integration had a significant impact on SNPD project performance in the early and late stages of the SNPD, the concept development and commercialization stages, respectively, but not in the middle stage of product development. Our findings are consistent with arguments from resource dependency theory that increased novelty in SNPD increases the need for cross-functional integration at the concept development stage because of greater interfunctional dependence (Clark, 1989; Gupta et al., 1986; Ruekert & Walker, 1987; Takeuchi & Nonaka, 1986). Similarly, high levels of novelty at the commercialization stage of the SNPD process increase the need for cross-functional integration.

Contrary to our prediction, integration at the middle stage of the SNPD process, where product development takes place, does not appear to be significant. This may, in fact, be explained by resource dependency theory, because mostly in this stage, standardized production is scheduled, in other words, a decrease in novelty is taking place for the job being done. According to resource dependency theory, this leads to less interfunctional dependence and so less need for cross-functional integration. In addition, this result can be explained by Mudambi's "smile curve," which explains how developed market firms make their decisions to concentrate on high value-added activities and relocate or outsource low value-added activities to firms in emerging economies (Mudambi, 2008). As high value items, he identified early activities such as R&D and design, and late activities such as commercialization, logistics and after-sale services, which resemble the activities that take place in the concept development and commercialization stages of the SNPD process. He also identified low-value items such as standardized manufacturing, which resembles the activities that take place in the product development stage. In relation to the smile curve, high-value items give rise to a strong need for cross-functional integration, whereas low-value items do not, which explains our finding of the significant impact of integration at the concept development and commercialization stages, but not at the product development stage.

**Table 9**
The influence of cross-functional integration on SNPD project performance (standardized estimates).

| | Estimate | Standard error |
|---|---|---|
| Constant | | 0.439 |
| Manufacturing vs Service industry | 0.081 | 0.109 |
| Firm size | 0.136* | 0.044 |
| Marketing–R&D—stage 1 | 0.270* | 0.081 |
| Environmental specialist—stage 1 | −0.223* | 0.072 |
| Marketing–manufacturing—stage 3 | 0.163* | 0.068 |
| Environmental specialist—stage 3 | 0.322* | 0.067 |
| Product newness | 0.156* | 0.058 |
| Product newness * Environmental specialist integration—stage 1 | 0.030 | 0.067 |
| Product newness * Environmental specialist integration—stage 3 | 0.220* | 0.064 |

* $p < 0.05$.

**Table 10**
Low–high product newness comparison (standardized estimates).

| | Low-newness projects | | High-newness projects | |
|---|---|---|---|---|
| | Estimate | SE | Estimate | SE |
| Environmental specialist—stage 3 | −0.08 | 0.104 | 0.723* | 0.14 |

* $p < 0.05$.

In addition to this contribution, this study also contributes to the literature by demonstrating the impact of the integration of an environmental specialist at each stage. Our results show that the integration of the environmental specialist into the team had a strong and positive impact on SNPD project performance at the commercialization stage, beyond the well-known effect of marketing and manufacturing cooperation on SNPD project performance. As discussed, the role of the environmental specialist at this stage includes suggesting new technologies or methods. For an auto manufacturer, these methods might include the installation of more efficient engines and tires, using hybrid drive systems to reduce a company's environmental footprint and increase efficiency, and indicating effective ways and technologies to deal with production waste. These methods help a company improve sustainability metrics and a higher return-to-landfill rate, while also saving cash. All of these activities lead to cost-efficiency and cash savings, which explains the significant positive impact of the integration of an environmental specialist on SNPD project performance.

On the other hand, the most surprising finding of this study is the observation that the integration of an environmental specialist into the SNPD team at the concept development stage had a significant negative impact on SNPD project performance. One possible explanation for this would be that the suggestions made by environmental specialists at the concept development stage may require costly investments or incur additional expenses, which impact project performance negatively in the short run.

Finally, the findings show that the degree of innovation of the product being developed influences the impact of the integration of an environmental specialist on project performance differently across stages. The results revealed that the integration of the environmental specialist with the SNPD team in the commercialization stage has a stronger positive impact on new product performance in high-innovative product development projects than in low-innovative ones. However, the integration of an environmental specialist at the concept development stage appears not to be impacted by the degree of innovation.

## 6. Conclusion

The objective of this study was to increase our theoretical understanding of the role of the environmental specialist in NPD and new product success. Our results show the positive influence on new product performance of integrating an environmental specialist with the traditional members of an NPD team. By designing a framework to analyze this relationship across the stages of sustainable new product development (SNPD), we gained a clearer picture of the effectiveness of that integration. First, cross-functional integration becomes critical when the product is in the concept development and in the commercialization stage. Second, the integration of an environmental specialist is more effective for product performance in the final stage of the SNPD process, when the product is launched. This effect especially becomes apparent for high-innovative projects. These new and detailed insights will help academics better understand the nature and effects of cross-functional integration in SNPD and will help managers take appropriate and actionable measures to lower failure rates and boost SNPD performance. These findings have important theoretical and managerial implications.

### 6.1. Theoretical implications

Our first important finding suggests that the benefits, detriments and costs of the cross-functional integration of the SNPD process can vary considerably across SNPD stages and the levels of innovation attempted. Importantly, these effects appear to be more complex than a simple "direct" model might suggest (Song & Swink, 2009).

Second, several researchers (Charter & Clark, 2007; Hart & Ahuja, 1996; King & Lenox, 2001) have called for empirical evidence examining the effects of integrating an environmental specialist with other functional departments throughout the entire SNPD process. Nonetheless, few if any studies have explicitly studied the effects of sustainable product development on firm performance. In this regard, this study makes several important research contributions. We do conceptualize and empirically investigate the integration of the environmental specialist with other functional departments across the entire SNPD process. The stage-specific analyses show that the integration of the environmental specialist with the SNPD team has a significant, positive impact on new product project performance during the commercialization stage.

By considering a more complex set of effects, our results extend those of prior studies for traditional functional integration as well. The significant stage-to-stage effects revealed in this analysis provide a more complete picture than prior studies.

### 6.2. Managerial implications

Our findings suggest that organizations need to carefully manage cross-functional integration in the SNPD process, and that managers need to foster cross-functional integration among personnel from the marketing, R&D, and manufacturing departments and environmental specialists at specific stages of the SNPD process. Thus, managers are advised not to adhere to the popular view that integration of the same functions across all of the stages of SNPD is good for product success. Instead, they need to focus on facilitating cooperation, especially when the novelty of the job being done is high, as in the concept development and commercialization stages of the SNPD process. Our results show a strong positive impact on SNPD project performance when an environmental specialist is integrated into the team in the commercialization stage. A promising strategy would be to integrate environmental specialists into cross-functional teams at the commercialization stage, where decisions regarding product launches, logistics and transportation are made. Therefore, managers need to take strong, proactive initiatives to bring environmental specialists into the NPD process. Our results also suggest the surprising finding that the environmental specialist's involvement in the earliest SNPD process may be detrimental to the success of the new product. It is possible that the environmental specialist should be consulted as an expert on material selection and other issues that may come up at this early stage, purely on an ad hoc basis. But our results suggest that it is, interestingly, a good idea to keep the environmental specialist "out of the kitchen" during the concept development stage. Ad hoc membership of the environmental specialist on the team at the earliest stage is an intriguing possibility but was not explicitly examined in this study, and is a possible direction for future research.

In addition, the results make clear that the role of the environmental specialist varies as the team moves through the stage wise SNPD process. As with all other team members, different tasks need to be done at different stages, and members may take on a primary or secondary role throughout the process as the requirements change. For example, marketing plays a key role in obtaining the Voice of the Customer at the concept development stage, while R&D may have a more visible presence during product development. Nonetheless, all members are on the team at all times, and the results show that the contributions of the environmental specialist change through time. Managers should understand the complexities of team management and set reasonable expectations for each team member, including the environmental specialist, which vary from one stage to the next.

Finally, due to different experiences and mindsets of different team members, it is always challenging for managers to integrate team members, and incorporating the environmental specialist on the team is no exception. Specific training for the traditional team members (i.e., marketing, manufacturing, R&D) should concentrate on giving them a holistic view of the importance of integrating environmental sustainability into the SNPD process: how it provides benefits in terms of more sustainable or environmentally-friendly products and also fewer costly delays late in the process. Both of these benefits will potentially impact the new product's success level and profitability. Cross-training may serve to build cross-functional empathy and a collegial environment, which are needed to establish respect and trust across departments (Susman & Dean, 1992).

### 6.3. Limitations and future research

The primary limitation of this study is that we used key informants as our sample in this study; therefore we obtained only one questionnaire per firm. This limitation makes it impossible to statistically assess the validity and reliability of the responses we obtained.

Nevertheless, using key informants, especially those who are at a senior level within the organization, who possess high levels of knowledge, and are highly involved in decision making, results in reliable and valid data that is quite similar to secondary, objective data (Henard & Szymanski, 2001). Additionally, recent work on organizational theory and NPD concluded that single informant bias is not a problem because of high overall inter-rater agreement in an organization (Van Doorn, Jansen, Van den Bosch, & Volberda, 2013). Similarly, no difference was found between the mean responses of those most knowledgeable about each network and the mean responses of other network representatives (Wincent, Thorgren, & Anokhin, 2013).

Second, there are also limitations that are inherent in survey-based research. The data are self-reported and so are subject to bias, although we checked for common-method bias and found it not to be a significant issue in this study. Moreover, asking respondents to provide retrospective evaluations might lead to their simply forgetting relevant information. Finally, we used a cross-sectional methodology, which constrains the ability to infer causation, although it is useful for hypothesis testing. Our understanding of the results would clearly benefit from future research employing a larger sample and longitudinal methods. For example, a further study could determine whether the role of the environmental specialist in firms which produce mostly consumer products would differ from this sample, which was composed of business-to-business manufacturing firms.

Other avenues for further research can also be explored. In this study, we only looked at the effect on financial performance. One research direction would focus on including other performance measures specifically sustainability related performance measures. Another direction for future research would be to examine the way of employing environmental specialists, whether as another department in the firm, or outsourcing which was beyond the scope of this study.

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## Appendix A

Scales, measurement items, and response format

SNPD Project Performance (adapted from Song & Parry, 1997; Ernst et al., 2010).

Project performance will be assessed by the project leader of Project X. To what extent do you agree with the following statements related to the success of the new product (Project X):

- How successful was this new product from an overall profitability standpoint? (1 = "a great financial failure," and 7 = "a great financial success").
- Relative to your firm's other new products, how successful was this new product in terms of revenues? (1 = "far less than our other new products," and 7 = "far greater than our other new products").
- Relative to your firm's other new products, how successful was this new product in terms of profits? (1 = "far less than our other new products," and 7 = "far greater than our other new products").
- Relative to your firm's objectives, how successful was this new product in terms of profits? (1 = "far less than our objectives," and 7 = "far exceeded our objectives").

Cross-functional integration across stages of SNPD (adapted from Ernst et al., 2010)

The scales for the integration between marketing, R&D, manufacturing and environmental specialist were formative constructs and were rated on a seven-point Likert scale, anchored by 1 = "strongly disagree" and 7 = "strongly agree." Cooperation is defined and explained to respondents as the level of involvement and information sharing. Project leader/manager will assess the level of integration among the functions for the particular SNPD project. An example for a specific item is as follows: In the SNPD Project X, personnel from marketing cooperated with personnel from R&D during the following SNPD activities… (see Table 1)

Moderating variable: product newness (adapted from Song & Swink, 2009)

(0 = "strongly disagree" and 7 = "strongly agree).

- This product relied on technology that has never been used in the industry before.
- This product caused significant changes in the whole industry.
- This product was one of the first of its kind introduced into the market.
- This product was highly innovative—totally new to the market.

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