Green Product Innovation in Manufacturing Firms: A Sustainability-Oriented Dynamic Capability Perspective

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ABSTRACT

In spite of environmental sustainability being identified as one of the mega trends that pose a challenge to innovation management, extant literature lacks a theoretically-sound and empirically testable framework that can provide specific insights into green product innovation from a capabilities perspective. Responding to scholars' calls, this study develops a theoretical framework from a sustainability-oriented dynamic capabilities (DCs) perspective. We conceive sustainability-oriented DCs as a higher-order construct consisting of three underlying processes, such as external resource integration, internal resource integration and, resource building and reconfiguration, that influence the change in or renewal of sustainability-oriented ordinary capabilities (OCs), such as green innovation capability and eco-design capability. This study answers two key questions. First, which sustainability-oriented DCs are needed to develop green innovation and eco-design capabilities in manufacturing firms? Second, which of these capabilities lead to better market performance of green products? We propose and test a structural model linking sustainability-oriented DCs to market performance of green products, both directly and indirectly, in 189 Italian manufacturing firms. First, we find that the nature of the DCs-performance link (direct or indirect) depends on the type of sustainability-oriented DCs. Specifically, resource building and reconfiguration has a significant direct link with market performance of green products. Second, the link between all three types of sustainability-oriented DCs and market performance of green products is mediated by the development of the eco-design capability.

Third, we find that the link between external resource integration and market performance of green products is also mediated by the green innovation capability.

KEYWORDS: sustainability-oriented dynamic capabilities, eco-design capability, green innovation capability, Italian manufacturing firms, market performance, environmental sustainability

1. INTRODUCTION

As environmental concerns among the businesses become commonplace, green product innovation (GPI) has grown in importance among manufacturing firms worldwide. Business press has reported that several firms invest in sustainability initiatives not just for cost savings and risk mitigation but also for revenue generation. For example, business magazine Fortune reports that GE's Ecomagination line of products and services has generated more than $200 billion in revenues since GE started the program 10 years ago. In 2014 alone, revenue from Ecomagination products totaled $34 billion, representing about 30 percent of total GE sales[1]. Very encouraging results are also shown by Enel Green Power, the Enel Group company dedicated to developing and managing energy generation from renewable sources, that showed a 9-month 2015 EBITDA of €1.470 million, with a 12% growth compared to 2014[2]. Williams (2015) reports that global companies, such as Tesla, Chipotle, Ikea, Unilever, Nike, Toyota, Whole Foods and a Brazilian beauty company Natura, generated at least 1 billion dollars of revenue from products or services that have sustainability or social good at their core. Target's Made to Matter line of "better-for-you and better-for-the-world" products have also been similarly successful. Toyota Prius family became the world's third best-selling car in 2013. Toyota also saw world-wide sales of its hybrid cars go from 6 million vehicles in 2013 to more than 8 million in 2015[3]. Nike Flyknit product line (among one of Nike's most expensive offerings in the women's footwear category) uses a technology that allows athletic shoes to be woven rather than pieced together, resulting in a high performance shoe that creates up to 80% less waste than conventional athletics shoes during the manufacturing process. Bloomberg reports that this product has been one of the main contributors to the

[1] http://fortune.com/2015/08/27/green-giants-freya-williams/

[2] http://www.enelgreenpower.com/en-GB-static/media_investor/presentations/doc/2015_07/EGP_9M_2015_consolidated_results_13Nov15.pdf

[3] http://www.greencarreports.com/news/1076525_toyota-prius-becomes-worlds-third-best-selling-car-line; http://www.toyota-global.com/innovation/environmental_technology/hv-record/

brand's steady sales increases and progress on the stock market[4]. Emerging interest in GPI also manifests in explicit goals set by leading manufacturing firms in developing innovative green products across the world. For example, a stated aim of the Ariston Thermo Group, an Italian firm and one of the world's leading companies in thermic comfort, is to achieve 80% of their revenues from high-energy efficient products using renewable energy sources by 2020, by leveraging their capabilities on energy efficiency, innovation, and design (Ariston Thermo Group, 2014). All these indications suggest that green product development and innovation is one of the big shifts of our times that requires scholars' attention (Barczak, 2012; Kotler, 2011; Slotegraaf, 2012) and significant ongoing research to support managers and firms interested in the marketing of sustainable products (Dangelico, 2015; Luchs *et al.*, 2012). Scholars' attention towards green products is growing (Dangelico, 2015), encompassing almost all industries, ranging from food (e.g. Chkanikova, 2015) to air travel (e.g. Hinnen *et al.*, 2015).

Our review of current literature reveals that scholars have identified several green product development activities, emphasizing the roles of environmental sustainability specialists in the product development teams and eco-design tools (such as life cycle analysis), and their relationships with market and environmental performance of products (Pujari et. al., 2003; Pujari, 2006; Dangelico and Pujari, 2010). These are important insights but are limited to ad hoc green product development activities mainly at *project* level. We argue that in order to achieve a stable and constant endeavor for green product innovation, it is crucial to investigate firm level sustainability competences that are geared towards creating GPI at *program* level in the firm rather than limited random NPD activities in ad hoc green product development projects. Scholars recommend that successful GPI requires re-configuration of multiple new elements, knowledge and technologies, process transformation, capabilities

[4] http://www.businessoffashion.com/articles/news-analysis/nike-profit-tops-analysts-estimates-as-new-products-help-sales; http://www.bloomberg.com/news/articles/2012-03-07/nike-sock-like-flyknit-transforming-shoes-as-shares-rise-retail

development, as well as effective management of stakeholders and complexities (Dangelico, 2015; Lenox and Ehrenfeld, 1997; Seebode *et al.*, 2012). However, in spite of environmental sustainability being identified as one of the mega trends that pose a challenge to innovation management, research offering a theoretical framework or specific insights into environmentally sustainable innovation is currently inadequate (Dangelico, 2015; Slotegraaf, 2012). This paper addresses calls to fill these gaps and makes an important contribution by developing a theoretical framework for green product innovation and performance from a sustainability-oriented dynamic capabilities (DCs) perspective.

There has been a significant interest among scholars over the years to understand, develop and refine the concept of DCs and to apply this concept in various disciplines, including marketing and innovation (e.g. Drnevich and Kriauciunas, 2011; Helfat and Peteraf, 2009; Menguc and Auh, 2006; O'Connor, 2008; Pablo *et al.*, 2007; Peteraf *et al.*, 2013; Piening and Salge, 2015; Teece, 2007; 2012; Teece *et al.*, 1997). The general theory of DCs essentially argues that organizations need to review existing routines and adapting, editing and adding to them in order to deal with a changing context (Teece and Pisano, 1994). DCs are defined as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece *et al.* 1997 , p. 516). As GPI faces conditions of dynamism (e.g. changing market needs and market uncertainty), requiring new knowledge creation and new capabilities, it seems relevant to investigate GPI from the perspective of sustainability-oriented DCs. Seebode et. al. (2012) point out that for established firms that are gearing towards sustainability-led change, but are facing inertia, DCs generally force these firms to learn new approaches and let go of old ones around the "core search, select and implement questions" (p. 197).

Based on extant literature on environmental sustainability, innovation as well as DCs, and relying on the definition by Teece, Pisano and Shuen (1997), we define sustainability-oriented DCs as the firm's ability to integrate, build and reconfigure competences and resources to embed environmental sustainability into new product development to respond to changes in the market. We stress that sustainability-oriented DCs, as conceptualized in our definition, meet the standard to be called as acceptable DCs, as literature on a general theory of DCs implies and even advocates for. First, sustainability-oriented DCs are triggered by factors, such as market opportunities and regulatory uncertainty, but these are developed in the firm (Ambrosini and Bowman, 2009); and are intentional, deliberate and the result of managerial commitment (Adner and Helfat, 2003; Helfat *et al.*, 2007; Zollo and Winter, 2002), making these capabilities idiosyncratic to the firm and inimitable for competitors. Second, sustainability-oriented DCs are a set of stable and repeated underlying processes (e.g. integrating, building and reconfiguration of sustainability resources and competences) embedded in the firm's new product program (Zollo and Winter, 2002) that can be measured (Pavlou and El Sawy, 2011; Teece, 2007). Further, these underlying processes (micro-foundations) can impact other resources, capabilities and routines (Ambrosini and Bowman, 2009; Winter, 2003; Zollo and Winter, 2002), such as green innovation and eco-design capabilities. Finally, sustainability domain has a strong influence on this conceptualisation (Bruni and Verona, 2009). We argue that the sustainability-oriented DCs theoretical framework is particularly relevant in investigating the nature and characteristics of sustainability capabilities of firms as it helps to understand how manufacturing companies develop innovative green products through deliberate efforts in resource building, integration and reconfiguring, and what impact they have on market performance. We identify three types of sustainability-oriented DCs in this research: external resource integration, internal resource integration, and resource building and reconfiguration. We posit that firm's processes, that we call sustainability-oriented DCs, exist at a higher order as suggested by many scholars (see for instance, (King and Tucci, 2002; Winter, 2000). On the other hand, we consider ordinary capabilities (OCs) as the "set of abilities and resources that go into solving a problem or achieving an outcome" (Zahra *et al.*, 2006 , p. 921) and that "permit a firm to 'make a living' in the short term" (Winter, 2003 , p. 991). Following, these studies, we conceptualize sustainability-oriented OCs as the set of abilities and resources that allow a firm to develop green products that meet market needs and identify two types: eco-design capability and green innovation capability. To make these capabilities tuned with the external environment over time, based on the general theory of DCs and OCs (Collis, 1994; Winter, 2003), we argue that sustainability-oriented DCs operate "to extend, modify or create" them (Winter, 2003 , p. 991), governing their rate of change (Collis, 1994).

Firms need to transform their capabilities or to create new ones to engage in a sustainability-oriented change (Nidumolu *et al.*, 2009). We argue that sustainability-oriented DCs could be particularly important to implement such a capabilities' renewal. Recent years have seen many companies, large and small, committing to sustainability-oriented changes in their practices and setting ambitious green product launch goals, which are likely to require changes in both sustainability-oriented DCs and OCs. Despite this, as highlighted by Dangelico (2015), the general theory of DCs has only been marginally used to study green product innovation (Lenox and Ehrenfeld, 1997). Though academic research has come a long way in understanding corporate sustainability broadly (primarily in the strategic management discipline), rarely do we see any detailed analysis on the nature and characteristics of sustainability competencies or capabilities employed by manufacturing companies to achieve green product innovation. Thus, it is less clear how innovation processes are transformed while responding to significant changes in its market arising from the environmental sustainability imperative (Seebode *et al.*, 2012) and very little is known about the characteristics of firm's sustainability-oriented capabilities and their impact on market performance of green products. Building on and adapting from a general theory of DCs

(Teece and Pisano, 1994), this article's focus is to (i) develop a theoretical framework of sustainability-oriented DCs; (ii) operationalize and measure sustainability-oriented DCs; and (iii) assess their impact on green innovation capability, eco-design capability and market performance of green products.

To this aim, this study will answer the following research questions:

i. Which sustainability-oriented DCs are needed to develop green innovation and eco-design capabilities?

ii. Which of these capabilities lead to better market performance of green products?

We theorize and examine these research questions through five hypotheses. We first examine the direct relationships between sustainability-oriented DCs and market performance of green products. Then, we examine the mediating role of sustainability-oriented OCs.

This article is structured as follows. Following the definitions on sustainability-oriented DCs and OCs given earlier, we provide additional conceptualization of these constructs and identify their different types. Second, we develop a model linking sustainability-oriented DCs to market performance of green products both directly and through the development of sustainability-oriented OCs. Third, we present methodological details. Fourth, we report on the testing of our model using structural equation modelling. Finally, we discuss the implications of our results for scholars and practitioners interested in developing and deploying sustainability-oriented DCs for better GPI performance.

2. THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

Firms' quest to develop innovative green products and to seek revenues from them motivates the firms to develop specific competencies (Nidumolu *et al.*, 2009). Hilke (2010) states that firms with sustainability orientation and innovation processes show evidence of value creation, such as development of new to the market products. We present a theoretical framework of sustainability-oriented DCs, adapting from a general theory of DCs and an extensive review of the literature in sustainability management, innovation & NPD and marketing. In general, limited empirical research on GPI has been done from resource-based and capabilities perspectives (Dangelico, 2015; Lai *et al.*, 2015; Lenox and Ehrenfeld, 1997; Mariadoss *et al.*, 2011; Seebode *et al.*, 2012) which are built or adapted from literature in strategic management (e.g. (Berchicci *et al.*, 2012; Hart, 1995; Lee and Klassen, 2008; Russo and Fouts, 1997; Sharma and Vredenburg, 1998). Lenox and Ehrenfeld (1997) in their case studies find how integration of diverse resources into building eco-design capability played an important role, while Mariadoss *et al.* (2011) in their case studies among 47 B2B firms find key marketing capabilities, including product development capability, that tie to innovation-based sustainability strategies and firm performance. Lai *et al.* (2015) show that knowledge sharing external to enterprises improved the interoperability of innovation capability and corporate sustainability. While the extant literature advances our knowledge on capabilities development in the context of environmental sustainability, research on capabilities for GPI remains a neglected area (e.g. see Dangelico, 2015) for a systematic review), though significant work has been done at a broad corporate level in the strategic management discipline.

Marcus and Anderson (2006) adopt a general theory of DCs to investigate whether a general dynamic capability could lead to business competencies (such as supply chain management) as well as to social competencies (such as environmental management). Their study shows that, while a general dynamic capability may lead to the development of business competencies, it is not enough to determine environmental management competencies. This prompts a need to identify nature and characteristics of sustainability-oriented DCs that allow firms to develop/improve sustainability competences leading to GPI.

2.1. Sustainability-oriented Dynamic Capabilities

Based on an extensive review of the relevant literature, we describe characteristics of sustainability-oriented DCs by way of explaining three sub-sets of underlying processes.

External resource integration. Due to the complexity of sustainability issues, firms embracing environmental sustainability in the innovation process need to develop links with a wide range of external actors (Foster and Green, 2000; Lenox and Ehrenfeld, 1997; Polonsky and Ottman, 1998). The relevance of integrating external environmental knowledge and competencies to address environmental sustainability challenges clearly emerges in practice. For example, McDonald's collaborated with HAVI Global Solutions, its primary packaging supplier, to minimize the environmental footprint of consumer packaging. External resource integration is the sustainability-oriented DC referred to as the exchange and integration of sustainability knowledge and competencies between the firm and external actors. This includes integration of knowledge on environmental impact of products during customers' use, integration of suppliers' knowledge and competencies on environmental impact of components, materials or production processes, and collaborations with channel members to reduce the environmental impact of products.

Internal resource integration. It is advocated in the literature that significant cross-disciplinary coordination and integration is required if firms are to integrate sustainability issues into their strategies and operations (Shrivastava, 1995). Integration of the natural environment into strategic decision indeed adds complexity to organizational processes (e.g. Hart, 1995), requiring that all functions (e.g. design, marketing, research & development [R&D]) are involved and integrated in the development of green products. Several companies have recognized the relevance of cross-functional integration between specialized environmental functions and other functions within the firm. For example, Hewlett-Packard has an energy supply chain function, which acts as a cross-functional bridge between traditional procurement and environmental responsibility teams[5]. Internal resource integration is, thus, the sustainability-oriented dynamic capability referred to as the exchange and integration of environmental knowledge and competencies within the firm. This includes cross-functional collaboration between specialized environmental and other units (such as manufacturing, marketing, and design) and the integration of sustainability knowledge and competencies in functions/departments within the firm.

Resource building and reconfiguration. Responding to environmental sustainability challenges may also require building new sustainability knowledge and competencies and reconfiguring firm resources. For example, GE expanded its investments in cleaner and more energy efficient technologies and was among the first companies to create a new division, Ecomagination, devoted solely to greener products in the fields of hybrid locomotives, lower-emission aircraft engines, fuel cells, solar energy, efficient lighting, lighter and stronger durable materials, and water purification technology. Similarly, Panasonic created a new business unit (Eco Solutions North America) that focuses on the design, implementation, and financing of renewable energy and energy efficiency projects in the USA and Canada. Resource building and reconfiguration is, thus, the sustainability-oriented dynamic capability related to the creation of environmental knowledge and competencies within the firm and the reconfiguration of firm resources in order to address environmental sustainability challenges. This includes i) creating/acquiring new resources by means of hiring people with specific environmental expertise, training product development team members and R&D staff, investing in environmental R&D, and ii) reconfiguring existing resources, such as creating a new green division, including environmental specialists in product development teams, and reconfiguring relationships along the supply chain (e.g. conducting suppliers' environmental audits).

5 http://www.greenbiz.com/blog/2008/07/23/b-c-design-engaging-whole-company-developing-sustainable-products

2.2.Sustainability-oriented Ordinary Capabilities

Sustainability-oriented DCs, which are conceived as higher-order capabilities, have the ability to impact, shape or transform OCs, such as eco-design and green innovation capabilities that we discuss in the following.

Eco-design capability. Literature suggests that eco-design capability can be particularly relevant for green product innovations as firms develop products that minimize the environmental impacts of a product through product design (Ehrenfeld, 2008; Fuller and Ottman, 2004; Hwang *et al.*, 2013; Lee and Klassen, 2008; Lenox and Ehrenfeld, 1997; Luttropp and Lagerstedt, 2006). The importance of eco-design capability in business has grown over time with an increased understanding that environmental impacts are generated not just by manufacturing process of the products but also by their use and disposal (Roy, 1994). In simple terms, eco-design capability refers to a firm's "capability to incorporate environmental concerns into product development" (Lenox and Ehrenfeld, 1997): 189), that enables it to "reverse ecosystem degradation while providing benefits to customer and financial incentives to firms" (Fuller and Ottman, 2004 , p. 1237). More specifically, as firms attempt to develop products with minimum environmental impact, it is critical for firms to develop capabilities to create designs which minimize manufacturing emissions or energy and resource consumption during consumer use, increase the recyclability and re-manufacturability of products, help achieve compliance, meet customer demands for environmentally benign products, and respond to major shifts in public policy. It is also argued that eco-design capability not only minimizes the environmental impact through product design, but also avoids compromising the desirable traditional product attributes such as functionality, look, and feel (Hwang *et al.*, 2013).

Following the literature, in our study, eco-design capability is modelled as an ordinary or operational capability, which is critical for developing green products and includes the abilities to reduce materials used into products and processes, use environmentally friendly materials, design products to be easily disassembled and recycled, and improve production processes (energy efficiency, pollution prevention, etc.) (Luttropp and Lagerstedt, 2006).

Green innovation capability. Innovation capability has been widely studied in the innovation and new product development literature which suggests that a firm's innovation capability (or innovativeness) represents the extent to which the firm has developed its ability to explore new ideas and possibilities that are crucial for survival and success (Danneels, 2011; De Luca and Atuahene-Gima, 2007; Hauser *et al.*, 2006; Ngo and O'Cass, 2012; Rubera and Kirca, 2012; Slater *et al.*, 2014). In the context of sustainability, we define green innovation capability as a firm's ability to produce radically new or significantly improved green products, create new green product categories, identify and respond to new (environmentally-related) customer needs and new green markets. Given the dynamic nature of the environments the businesses operate in, it is widely accepted that a firm's innovation capability will improve the prospects of better market performance than competitors and enhance the value of the firm itself. Though innovation capability has been described in the literature (Kochhar and David, 1996; Rubera and Kirca, 2012; Tellis *et al.*, 2009) in terms of both inputs (i.e. sources of capability, such as talent, skills, knowledge, training, R&D) and outputs (i.e. product innovations, patents, etc.), in this study, we focus on outputs as they, in our view, more appropriately capture the underlying meaning of innovation capability. Most firms have some capability to innovate, and most product development efforts are likely to result in at least incremental innovations (Griffin, 1997). However, as meta-analysis by Rubera and Kirca (2012) shows, radical innovations consistently generate more positive performance outcomes than incremental innovations. We argue that the deployment of DCs transforms the green innovation capability through the process of external integration, internal integration and resource building and reconfiguration. This change in green innovation capability is reflected and manifested in developing radically new or significantly improved green products, creating new markets and serving new customers. Following Helfat and Winter (2011) and Malik and Kotabe (2009), we further argue that, because of the deployment of DCs relating to new product development, green innovation capability as ordinary capability undergoes changes and produces particular type of products (e.g. radically new green products) and charts a specific trajectory into new green markets.

2.3.Market Performance

Market performance in this study is characterised by the market success of specific programs involving green product innovation. Consistent with previous studies (e.g.(Atuahene-Gima *et al.*, 2005; Calantone *et al.*, 2003), we chose this performance measure as appropriate to the focus of this study.

This study proposes a model in which three different types of DCs (external resource integration, internal resource integration, and resource building and reconfiguration) are linked to the green product innovation performance both directly and indirectly through the development/improvement of the above discussed ordinary capabilities: eco-design capability and green innovation capability (Figure 1).

INSERT FIGURE 1 ABOUT HERE

2.4.Outcomes of Sustainability-oriented DCs: Direct Paths towards Market Performance of Green Products

The existing literature on general theory of DCs is divided about the links between DCs and competitive advantage (Ambrosini and Bowman, 2009). Some studies, among them the work by Teece *et al.* (1997), indicate a direct link between DCs and competitive advantage (e.g. Li and Liu, 2014). Similarly, Lee *et al.* (2002) maintain that sustainable advantage is attributed to DCs in Shumpeterian eras of rapid change. More recently, in their study of Chilean firms, Drnevich and Kriauciunas (2011) find that DCs positively affect the relative firm performance under the conditions of environmental dynamism. In another empirical study of Taiwanese firms, Wu (2010) finds that a significant relationship exists between DCs and competitive advantage. We argue that the firms that continuously integrate external and internal knowledge are better equipped to address environmental sustainability issues. For example, integrating specialized in-house knowledge on life cycle impacts or integrating innovative materials that suppliers bring into the product development process provide companies competitive advantage. Similarly, we posit that companies that regularly build new knowledge and reconfigure their competencies are in a better position than their competitors to bring out green product innovations that are likely to achieve market success.

Thus, we propose that sustainability-oriented DCs will bring market success for green products.

Hypothesis 1: Sustainability-oriented DCs (external resource integration [a], internal resource integration [b], resource building and reconfiguration [c]) have a positive impact on the market performance of green products for manufacturing firms

2.5. Sustainability-oriented Dynamic Capabilities and Market Performance of Green Products: the Mediating Role of Ordinary Capabilities

The literature on general theory of DCs suggests that DCs' value for competitive advantage is in the resource configuration they create, rather than in the DCs themselves, and thus proposes that the relationship between DCs and performance is an indirect one, mediated by ordinary capabilities' development (e.g. Eisenhardt and Martin, 2000; Protogerou *et al.*, 2012; Wang and Ahmed, 2007; Zahra *et al.*, 2006).

Considering the above discussion, we posit that sustainability-oriented DCs lead to development of OCs, such as GPI capability and eco-design capability (Wang and Ahmed, 2007; Zahra *et al.*, 2006). While OCs allow a firm to produce a desired output and survive in the short term, DCs "operate to extend, modify or create ordinary capabilities" (Winter, 2003 , p. 991). DCs are "future oriented", whereas OCs are about "competing today" (Ambrosini and Bowman, 2009). Collis (1994) explicitly and formally states that DCs govern the rate of change of OCs. More recently, Wang and Ahmed (2007 , p. 41) contend that "the higher the DCs a firm demonstrates, the more likely it is to build particular capabilities over time". The authors also suggest that the focus on developing particular capabilities is dependent upon the firm's overall business strategy. Therefore, we argue that for firms that embrace and integrate environmental sustainability into their product strategy, the deployment of sustainability-oriented DCs will focus the firm's efforts towards improvement or development of OCs, such as eco-design capability. Accordingly, we hypothesize that:

Hypothesis 2: Sustainability-oriented DCs (external resource integration [a], internal resource integration [b], resource building and reconfiguration [c]) have a positive impact on the eco-design capability of manufacturing firms.

The general theory of DCs also suggests that firm performance depends upon the particular resource configuration that DCs create (Eisenhardt and Martin, 2000; Wang and Ahmed, 2007; Zahra *et al.*, 2006). In the literature, there is some evidence that eco-design activities are positively related to market performance of new green product development (Pujari, 2006). Eco-design in products is one of the sources of product differentiation (Holdway *et al.*, 2002), which in turn is positively linked to competitive advantage or above-average returns (Mosakowski, 1993; Porter, 1985). Thus, we hypothesize that the differences in performance of green products among competing firms can be explained through varying degrees of eco-design capabilities.

Hypothesis 3: The eco-design capability has a positive impact on the market performance of green products for manufacturing firms.

Leonard-Barton (1992) highlights that a firm's core capabilities have a down side that inhibits innovation, and introduces the concept of core rigidities. Thus, new product development managers face the so-called capabilities-rigidities paradox: taking advantage of core capabilities without being hampered by the rigidity they create. Following Leonard-Barton's study, Teece and Pisano (1994) suggested a possible explanation of why radical innovations are often introduced by new entrants. Incumbent firms develop distinctive organizational processes that are not able to support the new technology. Therefore, the frequent failure of incumbents to develop radical innovations can be seen as a result of the mismatch that may exist between organizational processes needed to support the conventional products and those needed by the new products. Radical innovations would require an organizational re-engineering to support the new products. We argue that such a renewal that is characterised by the development of innovation capability can be provided by the deployment of sustainability-oriented DCs.

Since environmental sustainability issues are not generally addressed by core activities for most firms, green product innovations often require capabilities that are different from a firm's core ones. Thus, when firms decide to embrace and integrate environmental sustainability into their product strategy, they need a renewal of their core capabilities (Nidumolu *et al.*, 2009), which could be provided by sustainability-oriented DCs (e.g. Collis, 1994; Winter, 2003). The greater the deployment of these sustainability-oriented DCs the more radical green product innovation will be when compared to conventional products or green products previously developed by the firm. Therefore, we argue that firms with higher sustainability-oriented DCs will be more capable to develop radical green products that are new to the firm, industry, or markets:

Hypothesis 4: Sustainability-oriented DCs (external resource integration [a], internal resource integration [b], resource building and reconfiguration [c]) have a positive impact on the green innovation capability of manufacturing firms.

Literature suggests that product innovation has a positive impact on the market value and profitability of firms (e.g. Blundell *et al.*, 1999) and that the more innovative the new products are the greater their financial value will be, in terms of success rate and return on investment for example (Chaney *et al.*, 1991; Kleinschmidt and Cooper, 1991). Ngo and O'Cass (2012) highlight that innovation capability positively affects market and innovation-related performance outcomes. Green Works, a natural household cleaning product line that Clorox launched in 2008, illustrates this well. Green Works identified a new target market and achieved a market share of 50 percent (leap frogging its closest competitor at 33 percent) within the first year. This very innovative product line was also noted under EPA's DfE (Design for the Environment) Formulator Program (Cate *et al.*, 2009). In a different industry, other than Toyota (that created and achieved market leadership in the hybrid vehicles product category), Ford has also received reputational awards such as Green Car of the Year for 2012 (for its 2013 Fusion model). We argue that developing, extending or modifying the ability to innovate green products enhances the ability of firms to truly integrate environmental sustainability into product development process, resulting in green products with solid credentials and better market performance. Accordingly, we propose that:

> *Hypothesis 5: The green innovation capability has a positive impact on the market performance of green products for manufacturing firms.*

3. METHODOLOGY

3.1.Sample and Data collection

We collected primary data for testing hypotheses through a survey of manufacturing firms operating in Italy. We utilize the setting of Italian firms because i) environmental issues are becoming increasingly relevant in Europe and Italy, and ii) the small to medium size dimension of the large majority of Italian companies makes them particularly flexible, allowing us to have a better evidence of the deployment of sustainability-oriented DCs. A database containing contact information as well as size and inception date of 3,800 companies belonging to SIC codes 20 to 39 (excluding SIC code 21 for tobacco industries) was purchased. Each company in the sample was contacted by telephone to obtain names and contact information of potential respondents knowledgeable about the phenomena to be measured. 1,500 out of 3,800 firms provided the name and contact information of the potential respondents. The questionnaire was sent via e-mail together with a cover letter in which the aim of the study was stated, confidentiality of information provided was ensured, and a report of research results was promised to participants. A first reminder was sent after three weeks and a final reminder was sent after two weeks (Dillman, 2007).

Respondents belonged to the following categories: head of R&D, chief technology officer, head of environmental management, head of health, safety and environment management, head of quality, safety and environment management, managing director, chief executive officer, president, head of strategic business unit, head of marketing, marketing director, head of sales, head of quality management, product manager, product designer, and director of operations. The average respondents' years of experience in the firm and in the industry to which their firm belonged was 10 and 14 respectively. In total, we received 195 completed questionnaires. After eliminating questionnaires filled by respondents who rated their relevant knowledge as below six in a ten-point scale (to ensure the competence of the key informant) and the ones with missing data, we retained 189, with an effective response rate of 22.6 percent[6]. The average size of the respondent firms is 250 employees; the average age of the firms is 32 years; and the average volume of sales is 77 million Euros. Around 35

[6] The effective response rate is obtained as the ratio of the number of retained questionnaires over the number of sent questionnaires minus the number of respondents stating that they did not want to take part to the survey and the number of respondents that stated they did not develop any green product: 189/(1500-155-507).

percent of the sample companies are in medium-high to high-tech industries, while 63 percent of them are in medium-low to low-tech industries. 64 percent of the sample firms operate in high environmental risk industries, while 36 percent of them operate in medium-low environmental risk industry. Finally, 77 percent of the sample companies are located in Northern Italy, while 23 percent of them are located in Central/Southern Italy (including islands), reflecting the distribution of Italian manufacturing firms across the national territory.

Common method variance may represent a problem in survey research. However, as stated by Chang and van Witteloostuijn (2010), the likelihood of common method variance is reduced by complicated models as this makes it difficult for respondents to visualize cause-effect relationships. Our dataset is unlikely to be affected by common method bias, since our model presents many constructs as well as both direct and mediated links among them. We also conducted two *post hoc* tests to detect any possible common method variance. Following Podsakoff and Organ's (1986) suggestions, Harman's one-factor test was conducted to test for the presence of the common method effect. Neither a single factor emerged from the factor analysis nor did one general factor account for the majority of the covariance among variables, indicating that common method bias is unlikely to affect our dataset. To further confirm these results, we followed Podsakoff *et al.* (2003) and Chang and van Witteloostuijn (2010) and performed an additional analysis. Specifically, we controlled for the effects of a single unmeasured latent method factor. Results indicated that the common factor accounted for only a small portion of the variance (27%). We also checked for differences between early respondents (who returned the questionnaire within three weeks) and late respondents and no significant differences on any survey constructs were found. Finally, we checked for non-response bias, testing for differences in a firm's size and age between the group of respondents and non-respondents, finding no differences. This suggests that non-response bias is unlikely to affect our dataset (Armstrong and Overton, 1977).

3.2.Measures

As suggested by Rouse and Daellenbach (1999) for studies focusing on resources and capabilities, the selected unit of analysis of this study is the Strategic Business Unit (SBU), considered as a profit center within the firm, with distinct products and markets. The operationalization of constructs in the questionnaire was done by adapting existing scales in the extant literature to the context of green product development as well as developing new scales where these did not exist in the currently available literature. There are between three and eight items measuring each construct, all of which use seven-point scales. The questionnaire was pretested on a convenience sample of managers and academics and was modified before the survey was mailed out to the sample.

Independent and dependent variables. In order to develop the new scales for the three types of sustainability-oriented DCs and the scale for the eco-design capability, we interviewed managers of eight Italian companies that developed green product innovations. Interviews were semi-structured, focused on organizational issues and challenges related to the development of green products, and lasted on average one hour. Comparing insights deriving from different interviews, relevant aspects related to the three categories of DCs were determined. Combining insights from the interviews and from existing studies (Lenox and Ehrenfeld, 1997), the new scale on eco-design capability was developed. As per the conceptualization of capabilities as organizational processes that perform well compared to competitors (Bingham *et al.*, 2007; Ethiraj *et al.*, 2005) and whose manifestations are visible to rivals (Moorman and Slotegraaf, 1999) and consistent with similar previous studies (Morgan *et al.*, 2009), we used seven-point scales with ‘much worse than major competitors’ and ‘much better than major competitors’ as anchors for both the sustainability-oriented DCs and the eco-design capability scales. Green innovation capability was measured adapting De

Luca and Atuahene-Gima's (2007) scale to the context of green products[7]. A standard Likert-type seven-point scale was used, with anchors 'strongly disagree' and 'strongly agree'. Market performance was measured using items from Atuahene-Gima et al. (2005) scale and adapting them to the context of green products[8]. Consistent with the anchors of capabilities' scales, a seven-point scale was used, with 'much worse than major competitors' and 'much better than major competitors' anchors.

Control variables. To control for industry and firm heterogeneity, five control variables were included in the model– age, size, geographic location, industry technological intensity, and industry environmental risk category. Firm's age was measured as the number of years since inception. Firm's size was measured as the number of employees, as usual in similar studies (e.g., Dangelico and Pontrandolfo, 2015; Dangelico *et al.*, 2013; Kim and Atuahene-Gima, 2010). For firm's geographic location, two categories were considered: Northern Italy and Central-Southern Italy (including islands). For firm's industry technological intensity, four categories of industries were identified on the basis of their R&D investments levels based on the OECD (2003) classification: low-tech, medium low-tech, medium high-tech, and high-tech. A score of 1 to 4 was assigned to each company based on its technological intensity (1 for low-tech, 2 for medium low-tech, 3 for medium high-tech, and 4 for high-tech). Firm's industry environmental risk category was identified according to Case's (1999) list of high environmental risk activities. Companies whose industry was included in the list were identified as having a high environmental risk and were coded as 1. The remaining companies were identified as having a medium to low environmental risk and were coded as 0.

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[7] We adapted the scale of De Luca and Atuahene-Gima to green products by specifically referring to green products, rather than generally referring to products. Further, due to the focus of our study, we referred to the SBU rather than to the firm.

[8] We focused on the items of Atuahene-Gima et al.'s referred to growth (growth in revenues, sales, and profitability from/of new products) and referred them to green products (growth in revenues, sales, profitability from /of green products). We referred to major competitors performance rather than to business unit objectives.

4. RESULTS AND DISCUSSION

4.1.Preliminary Analysis

A preliminary examination of variables found no significant outliers, skewness, or kurtosis for any variables, except for firm's size and age, which showed higher levels of skewness and kurtosis indicating non-normality; this was corrected by performing a logarithm transformation on both variables (Hair *et al.*, 2006). The characteristics of all model constructs, their means, standard deviations, reliability measures, variance extracted, and correlations with the other constructs in the model are provided in Table I.

INSERT TABLE I ABOUT HERE

4.2.Measures Validation

Convergent validity of constructs was assessed by computing i) standardized loadings estimates for each item, ii) Cronbach's Alpha, iii) composite reliability, and iv) average variance extracted (Hair *et al.*, 2006). An exploratory factor analysis (EFA) was performed on the DCs measurement model, using unrotated principal components factor analysis and principal component analysis with varimax rotation to determine the number of factors that are necessary to account for the variance in the variables. The EFA results suggest the existence of three constructs as they were hypothesized: three distinct factors emerged with eigenvalue greater than 1, accounting for the 63% of the total variance. Then, a series of confirmatory factor analysis (CFA) using structural equation modelling (SEM) - AMOS software - was conducted to test constructs and estimate the loadings of each item on the corresponding factor. To ensure adequate sample size-to-parameter ratios, we divided our measures into two subsets of theoretically related variables (sustainability-oriented DCs on one hand and their outcomes on the other hand). With regard to sustainability-oriented DCs variables, first, a measurement model where all items loaded on only one first-order construct was assessed. This model displays a poor fit with data (χ^2 = 854.69, df = 135, p< 0.000; CFI = 0.684; TLI = 0.642; NFI = 0.648; RMSEA = 0.168; PCLOSE = 0.000). Then, a sustainability-oriented DCs measurement model made of three first-order constructs, as suggested by the EFA, was tested. Results of CFA show a much better fit with the data (χ^2 = 202.84, df = 123, p< 0.000; CFI = 0.965; TLI = 0.956; NFI = 0.917; RMSEA = 0.059; PCLOSE = 0.156). After deleting items showing some evidence of cross-loadings or low-loadings on the constructs, the goodness-of-fit significantly increased, highlighting a very good fit with data (χ^2 = 64.24, df = 56, p< 0.210; CFI = 0.994; TLI = 0.992; NFI = 0.959; RMSEA = 0.028; PCLOSE = 0.897). The previously conducted EFA clearly showed that there are only three factors (corresponding to the three sustainability-oriented DCs) with eigenvalue greater than 1, suggesting that the dropped items did not form separate dimensions relevant for investigation. A content analysis of the dropped items confirmed that, compared to other items of the same construct, they do not add to the construct any further value, thus deserving no special attention in this study. Item loadings on the constructs are reported in Table II.

INSERT TABLE II ABOUT HERE

A three factor CFA was performed on the other constructs' measurement models (eco-design capability, green innovation capability, and market performance) to test for convergence of the items on their expected construct. Results of the CFA indicate that the model well fits the data (χ^2 = 67.38, df = 39, p< 0.003; CFI = 0.974; TLI = 0.963; NFI = 0.941; RMSEA = 0.062; PCLOSE = 0.200) and that the items converged on their expected constructs (Table III) with no evidence of any cross-loading.

INSERT TABLE III ABOUT HERE

All of the item loadings exceeded 0.63 and were significant at $p < 0.001$, providing evidence of convergent validity among the measures for each construct (Hair *et al.*, 2006). Scale reliabilities exceeded the recommended cut off criteria, 0.70 for Cronbach's alpha (Nunally and Bernstein, 1978), 0.70 for composite reliability (Fornell and Larcker, 1981), and the variance of each construct exceeded the recommended threshold of 50 percent for all constructs (Hair *et al.*, 2006). Thus, the measures are reliable and cover at least one-half of a construct's domain. Item loadings, reliability measures, and variance extracted all provide evidence of good convergent validity of constructs. Discriminant validity was assessed in two different ways. First, the percentages of average variance extracted for any two constructs were compared with the square of the correlation estimate between the two constructs. For each pair of constructs, variance extracted estimate is greater than the squared correlation estimate, meaning that each latent construct explains its item measures better than it explains another construct. This provides good evidence of discriminant validity (Fornell and Larcker, 1981). We then conducted a series of two-factor CFA models involving each pair of constructs, in which the correlation among the constructs was constrained to unit and then freed. In all cases the χ^2 value of the unconstrained model was significantly lower than that of the constrained model. A Chi-difference test was also performed, showing that the unconstrained model was always superior, indicating discriminant validity between all of the constructs (Bagozzi *et al.*, 1991). Therefore, all constructs display good discriminant validity. Overall, considering convergent and discriminant validity, the constructs exhibit good measurement properties.

4.3.Findings and Discussion of Results

We tested our hypotheses using SEM. As shown by the goodness-of-fit statistics ($\chi^2 = 485.35$, df = 330, $p < 0.01$; CFI = 0.947; TLI = 0.935; NFI = 0.855; RMSEA = 0.050; PCLOSE = 0.488), the fit of the overall model to the data appears to be good. The results of our SEM analysis are reported in Table IV, which presents the standardized parameter estimates (β) for the causal paths and associated t-values for all relationships in the structural model. In Figure 2 the causal path is depicted.

INSERT TABLE IV ABOUT HERE

INSERT FIGURE 2 ABOUT HERE

Direct path between sustainability-oriented DCs and market performance. Hypotheses predicting that sustainability-oriented DCs have a direct link with market performance are only partially confirmed. In fact, the only type of sustainability-oriented DCs showing a significant direct link with performance is resource building and reconfiguration ($\beta = 0.285$, $p < 0.05$), leading us to accept Hypothesis 1c. This finding empirically shows that DCs, commonly understood as the firm's higher-level capabilities, such as resource building and reconfiguration, lead to higher market performance of green products.

However, the direct links between external resource integration and market performance ($\beta = 0.058$, $p > 0.10$), and between internal resource integration and market performance ($\beta = 0.048$, $p > 0.10$) are both insignificant, leading us to reject Hypotheses 1a and 1b. Overall, the results highlight the relevance of reconfiguration for performance improvement. Similar results were reported by an earlier study by Wu (2010) that investigates the relationships between three types of sustainability-oriented DCs (integration, learning, and reconfiguration) and several dimensions of performance (speed of responding to market, production efficiency, product quality, and speed of innovation), finding that the most significant and strongest direct links are those involving the reconfiguration capability.

Indirect path between sustainability-oriented DCs and market performance mediated by the eco-design capability. Hypotheses predicting that sustainability-oriented DCs have a positive impact on the eco-design capability receive full support. More specifically, the positive and significant effect of external resource integration ($\beta = 0.413$, $p < 0.01$) supports Hypothesis 2a, the positive and significant effect of internal resource integration ($\beta = 0.214$, $p = 0.01$) provides support to Hypothesis 2b, and the positive and significant effect of resource building and reconfiguration ($\beta = 0.202$, $p < 0.05$) supports Hypothesis 2c. In particular, external resource integration seems to have the strongest link with the development/improvement of the eco-design capability, followed by internal resource integration and resource building and reconfiguration. This means that a higher level of sustainability-oriented DCs integrating external knowledge and competencies is the most effective way by which firms develop or improve their eco-design capability. This result builds on the existing knowledge in the literature that has suggested the relevance of building an external network of information exchange and collaborations to develop green products (e.g. Lenox and Ehrenfeld, 1997; Seuring, 2004). It also reflects the need to adopt a life cycle perspective in green product development and to involve actors upstream and downstream in the supply chain. It is likely that one of the key factors that lead to greater external resource integration is closer relationships with suppliers as green products have a lot to do with materialization or "materials problem" (Eppinger, 2011 , p. 400). All the "materials" issue must be addressed as early as possible in a new product's physical life cycle which is possible if there is a closer relationship with key suppliers, facilitated by frequent interaction and knowledge exchange on materials' impact on the environment.

A relevant role is also played by internal resource integration in improving eco-design capability. This means that collaboration among specialized environmental units and design, production, or marketing functions/departments is key to design and develop innovative green products. It is likely that key factors that help make internal resource integration successful in our sample could be an increased degree of interaction, communication, co-ordination and shared value among employees for achieving environmental sustainability that is encouraged by a visible top management commitment (Berchicci and Tucci, 2010). Greater complexity about sustainability issues may also have brought various functions much closer, so leading to a greater resource integration within the SBU. This result and the previous one on external resource integration provide support to what was suggested by a qualitative study by Lenox and Ehrenfeld (1997), highlighting that firms with higher eco-design capabilities own dense information networks linking external and internal resources with the product development team.

More importantly, these set of findings provide clear empirical evidence of creating OCs, such as eco-design capability, through the development of higher-level capabilities of internal resource integration, external resource integration, and resource building and reconfiguration as suggested by extant, though mostly conceptual, literature. Hypothesis 3, suggesting that the higher the development of the eco-design capability the better the market performance of green products, is supported, as shown by the positive and significant link between the two constructs ($\beta = 0.293$, $p < 0.10$). This result shows that products, which are designed with natural environment being a critical part of the design process, also have a higher potential for successful innovations at the marketplace in terms of sales, revenues, and profitability. This result is in line with previous studies. For example, Pujari (2006) finds that design for environment and life cycle assessment activities have a positive impact on market performance of green products. Thus, the link between sustainability-oriented DCs and market performance is mediated by the development/improvement of the eco-design capability, as suggested by Hypotheses 2 and 3.

Indirect path between sustainability-oriented DCs and market performance mediated by the green innovation capability. Our hypotheses predicting that sustainability-oriented DCs have a positive influence on the green innovation capability are only partially supported. Results show that only external resource integration has a positive and significant link with green innovation capability ($\beta = 0.390$, $p < 0.10$), thus providing support to Hypothesis 4a. This result is consistent with previous studies in product innovation literature, highlighting that external linkages play a critical role for technological and market innovativeness of new products (e.g. Shu *et al.*, 2005). Resource building and reconfiguration shows a positive, even though non-significant, effect on the green innovation capability ($\beta = 0.123$, $p > 0.10$), leading us to reject Hypothesis 4c. According to previous studies, a significant and stronger relationship between resource building and reconfiguration and the ability to innovate for green products would have been expected. In fact, several studies suggest a positive link between new knowledge creation and the development of radical innovations, highlighting a positive effect of R&D intensity on radicalness of innovation (e.g.(Laursen and Salter, 2006). Finally, internal resource integration does not show a significant influence on the green innovation capability ($\beta = 0.011$, $p > 0.10$), leading us to reject Hypothesis 4b. The findings show that investing in resource building and reconfiguration (e.g. through environmental R&D) or in internal resource integration (e.g. enhancing cross-functional collaboration among specialized environmental units and other functional units within the firm) is not enough to successfully develop radical green product innovations. Rather, firms need to explore new solutions related to the integration of environmental knowledge and competencies different from those owned by specialized areas of the firm, which are often possessed by external actors, such as suppliers and customers. For example, suppliers' involvement and integration in the development process is particularly important for radical green product innovations as new, alternate or sustainable materials and components are critical for success. The relevance of external actors' involvement may reflect the fact that green product innovations present distinctive challenges. In fact, radical green innovations are likely to require systemic changes at a higher level than radical innovations in conventional products, meaning that they often simultaneously involve societal changes in consumers' behaviour, public policy incentives, and higher integration along the supply chain. In this sense, electric cars represent a good example: they require infrastructure development, a change in consumers' behaviour and mindset, and may need public policy incentives for manufacturers as well as for customers to take into account positive externalities for the natural environment and for the society.

Hypothesis 5 suggests that the green innovation capability positively affects market performance. Results provide support to this hypothesis, as shown by the positive and significant link between the green innovation capability (as manifested by radicalness of green products) and market performance ($\beta = 0.175$, $p < 0.10$). Previous studies in the innovation literature show that the innovativeness of new products is positively linked to their financial value, for example in terms of success rate and return on investment (Chaney *et al.*, 1991; Kleinschmidt and Cooper, 1991). Other studies, however, highlight that radicalness of product innovation does not have a significant effect on product innovation performance (e.g. De Luca and Atuahene-Gima, 2007). The issues about radicalness of green product innovation and its impact on performance have not been investigated in current literature. This result shows that radical green product innovations, besides being the ones with the greatest potential to benefit the natural environment, are also the most beneficial for a firm's success.

Hypotheses 4 and 5, jointly considered, suggest that the link between sustainability-oriented DCs and market performance is mediated by the green innovation capability. This mediation hypothesis receives partial support, being confirmed only for external resource integration.

Effect of control variables. None of the control variables show a significant effect on the eco-design capability, suggesting that differences in firms' size, firms' age, technological intensity of the firms' industry, industry environmental risk, and geographic location do not influence the development/improvement of the eco-design capability. With regards to the effect of control variables on the green innovation capability, the industry technological intensity shows a significant and positive link ($\beta = 0.205$, $p < 0.05$). This was expected, since firms in high-tech industries are likely to have higher levels of investments in R&D, and by extension in environmental R&D too, which leads to a higher level of innovation capability. We also found a negative effect of the firm's size on the green innovation capability ($\beta = -0.567$, $p < 0.01$) that shows that small rather than large firms develop most of radical green product innovations. In the literature, there are contrasting views about the influence of the firm's size on innovation (Chandy and Tellis, 2000). As suggested by Hockerts and Wüstenhagen (2010), one way to solve this controversy is to move from a static to a dynamic perspective, wherein large and small firms play different roles in different phases of industry evolution. In particular, when there is the emergence of a new technological paradigm, a creative destruction of existing competencies takes place, modifying the selection environment in favour of small firms that are more flexible, agile and less bureaucratic to pursue new opportunities. Hockerts and Wüstenhagen (2010) highlight that new start-ups are initially more likely to engage in developing sustainable innovations than incumbents. At the same time, incumbents often respond to early stages of an industry's sustainability transformation primarily with incremental green innovations. Consistent with these considerations, the results of our study, suggesting that smaller firms develop more innovative green products, can be explained by the fact that responding to environmental sustainability challenge has only become mainstream more recently for most manufacturing industries. Firm's age and geographic location do not affect the green innovation capability. Finally, industry environmental risk positively influences the green innovation capability, showing that firms operating in industries characterized by higher environmental risks tend to have a higher capability to develop green innovations. This may be due to the fact that they are highly motivated to develop green innovations, due to higher stakeholders' pressure compared to firms operating in medium-low environmental risk industries.

With respect to the influence of control variables on market performance, there are contrasting results about firm's age and firm's size. There is a positive effect of firm's size on market performance ($\beta = 0.289$, $p < 0.10$) and there is a negative effect of firm's age on market performance ($\beta = -0.565$, $p < 0.05$). The positive link between firm's size and market performance means that larger firms are more capable to turn green product innovations into market success. If we consider this result combined with the result that larger firms develop less radical green product innovations, this is consistent with previous studies' results, showing that larger firms are often less ambitious than smaller ones in their environmental goals, but they have a broader reach due to their greater marketing resources, e.g. an established market presence (Hockerts and Wüstenhagen, 2010). On the other hand, firm's age seems to have a negative effect on market performance, indicating that younger firms achieve higher success in green product innovation possibly due to a significantly greater sustainability value in their product offering compared to incumbents' product offerings. This result is consistent with previous studies on the effect of aging on innovation performance

(Sorensen and Stuart, 2000). Industry technological intensity as well as industry environmental risk do not influence market performance. Finally, geographic location of firms seems to affect market performance. Specifically, firms located in the North of Italy have higher market performance than those located in the Centre and in the South. This may be because of the productive industrial fabric that is much more developed in the Northern area and this allows firms to benefit from network externalities, closeness to suppliers and customers, better infrastructure, which make these companies more capable to fully capture the benefits deriving from green product innovation.

In order to check for endogenous co-determination of sustainability-oriented DCs and OCs, we tested another SEM model, in which there are sustainability-oriented DCs, OCs, and control variables. In this model there are causal links between sustainability-oriented DCs and OCs as well as between control variables and both sustainability-oriented DCs and OCs. Model fits data well (χ^2 =365.943, df = 248, p< 0.000; CFI = 0.951; TLI = 0.936; NFI = 0.866; RMSEA = 0.050; PCLOSE = 0.472). Results show: geographic location negatively affects external resource integration; industry environmental risk negatively affects external resource integration and internal resource integration, while positively affects green innovation capability; industry technological intensity positively affects resource building and reconfiguration and green innovation capability; firm's size negatively affects both resource building and reconfiguration and green innovation capability; firm's age does not show any significant link with either sustainability-oriented DCs or OCs. These results highlight that there should not be any problems of endogenous co-determination between sustainability-oriented DCs and eco-design capability, since none of the control variables significantly affects eco-design capability. A more in-depth discussion is needed with regard to the links between sustainability-oriented DCs and green innovation capability. In particular, specific attention should be devoted on the effects of control variables on external resource integration and green innovation capability, since this is the only significant link between sustainability-oriented DCs and green innovation capability. In particular, industry environmental risk negatively affects external resource integration and positively affects green innovation capability. However, the opposite signs of the links between industry environmental risk and external resource integration and green innovation capability suggest that the two variables are not endogenously co-determined.

Supplementary analysis on constructs' means across sub-samples. Since companies in the sample are located in different Italian regions and belong to different manufacturing industries and it could be expected that the relevance of green innovations may vary across regions and/or industries, we have performed a series of analysis to check if there were differences in constructs' means due to company location and/or industrial background. Specifically, we ran two t-tests for equality of means related to the constructs external resource integration, internal resource integration, resource building and reconfiguration, eco-design capability, green innovation capability, and green product innovation performance. The first test was run between the two samples of companies located in the Northern Italy and in the Central-Southern Italy, respectively. The second test was run between the two samples of companies operating in high environmental risk industries and in medium-low environmental risk industries, respectively. Results of both tests, show that differences in means on any construct is not significant at $p < 0.05$. These results show that the geographic location and the different industrial background of companies in the sample do not affect data analysis results.

5. THEORETICAL IMPLICATIONS

As GPI is increasingly given strategic importance by companies, this article responds to the calls in the literature for developing a theoretical framework from a sustainability-oriented DCs perspective that investigates GPI and market performance, especially in manufacturing firms. This study has several theoretical implications. First, this study shows that sustainability-oriented DCs perspective is an appropriate theoretical framework to study GPI and performance. Second, responding to calls in the literature on DCs (Ambrosini and Bowman, 2009; Drnevich and Kriauciunas, 2011; Wang and Ahmed, 2007), this study provides evidence that the sustainability-oriented DCs, conceived as a higher-order construct and validated by a multidimensional scale, is a robust construct to study GPI and performance. Third, while most of the empirical studies on DCs focused on a firm level, we addressed the need to analyse DCs at a more granular level (Helfat and Winter, 2011) to have a more contextual and situation specific analysis by focusing on sustainability-oriented DCs and on their impact on GPI market performance. Fourth, there are also broader theoretical implications that can be drawn from this study. The general theory of DCs has acquired increasing relevance in strategic management, innovation and marketing disciplines during the past decade. However, research in DCs is still in its infancy and constantly evolving (O'Connor, 2008; Teece, 2012; Zahra *et al.*, 2006) and exact mechanism of how DCs impact performance is not fully understood (Zott, 2003). This study's results, though limited to GPI performance rather than firm performance, contributes to the broader DCs literature by shedding some light on the debate over 'DCs - performance link' (i.e. direct vs indirect link) seen in several studies (e.g. Drnevich and Kriauciunas, 2011; Eisenhardt and Martin, 2000; Lee *et al.*, 2002; Protogerou *et al.*, 2012; Teece *et al.*, 1997; Wang and Ahmed, 2007; Wu, 2010; Zahra *et al.*, 2006). Our study empirically shows that the apparent inconsistency of previous studies' results may possibly be resolved by looking in depth at the different types of DCs and their effects on performance. In our study on manufacturing firms that measured GPI performance rather than firm performance, we found that two types of sustainability-oriented DCs (internal resource integration and external resource integration) only have an indirect effect on GPI market performance, mediated by sustainability-oriented OCs (only eco-design capability for internal resource integration and both eco-design capability and green innovation capability for external resource integration), whereas resource building and reconfiguration has both a direct link and an indirect one, mediated by the eco-design capability. Our study also shows that only external resource integration leads to superior green innovation capability, as manifested by the radicalness of green products.

As such, our study makes contribution in the areas of innovation and sustainability and has broader theoretical implications for literature on firm capabilities. An innovating firm needing to pioneer a market or create a new product category requires strong DCs (Teece, 2012). Our study has empirically shown that creating green new product category or achieving greater market performance from GPI will require higher-level capabilities, such as external resource integration, internal resource integration, and resource building and reconfiguration. These capabilities sit on top of OCs, such as green innovation capability and eco-design capability. Our study has also shown evidence that the value of sustainability-oriented DCs is in the new configurations or changes they bring in sustainability-oriented OCs. Sustainability-oriented DCs indirectly influence GPI performance by reconfiguring sustainability-oriented OCs, such as green innovation capability and eco-design capability. Even though these sustainability-oriented OCs will have impact on the GPI performance at any given time, sustainability-oriented DCs, such as external resource integration, internal resource integration, and resource building and reconfiguration, will supersede green innovation capability and eco-design capability in the long run, which is consistent with the arguments made by Teece *et al.* (1997).

6. MANAGERIAL IMPLICATIONS

This study provides directions to the growing number of firms that are embracing environmental sustainability as part of their strategy and have started or are planning to give impetus to GPI. In fact, our present research identifies key sustainability-oriented DCs to effectively integrate environmental sustainability into product innovation processes. In particular, the role of each of these sustainability-oriented DCs on development/improvement of eco-design capability, green innovation capability, and market performance of green products has been investigated. Results have several managerial implications. Senior management, product development and sustainability executives should note that all the three types of sustainability-oriented DCs are important to enhance eco-design capability, which suggests that in order to develop this capability, firms should invest in one or more of the sustainability-oriented DCs, prioritizing investments in external resource integration, which is the one with the strongest impact on eco-design capability. This DC also emerged to be key to the development of green innovation capability, thus suggesting that firms aiming at developing radical green product innovations should invest in creating a strong knowledge network with external actors, such as suppliers and customers. Knowledge related to environmental impact of materials, processes, and product during use can indeed be exchanged through such a network. Resource building and reconfiguration is the only sustainability-oriented DCs with a significant direct effect on green products' market performance and the sustainability-oriented DCs with the overall (direct and indirect) highest impact on performance. This result suggests that, in order to make GPI successful, the most effective way for managers is to: (i) create new environmental knowledge and competencies through increasing the scope of and the investments in environmental R&D, providing environmental training to product development team members and R&D staff, or hiring environmental specialists (such as experts in life cycle assessment and design for environment); and (ii) reconfigure the organizational structure (e.g. by creating a new division for green products or reconfiguring product lines) and the product development teams (e.g. by including environmental specialists).

Based on our findings, we suggest to managers that as such all three sustainability-oriented DCs are important to develop green products and a balanced approach would be desirable. However, in order to focus the firm's investments, managers should prioritize investments in external resource integration to develop eco-design capability and radical green product innovations. On the other hand, they should prioritize investments in resource building and reconfiguration if they want to maximize market performance of green products.

7. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

We duly acknowledge potential limitations of this study. We used cross-sectional data to derive causation. Although this approach is quite common among academic studies, scholars have raised some concerns about its validity that relate to causal inference. To address these concerns, however, Rindfleisch *et al.* (2008) suggest that, under certain conditions, the results from cross-sectional data exhibit validity comparable to the results obtained from longitudinal data. In this study, we met key conditions suggested by Rindfleisch *et al.* (2008) by specifying a time period for the survey questions. Further, to ensure an adequate time lag between causes and effects, performance measures were referred to a time period shorter (past three years) than for other measures (past five years). Finally, since we believed that it would have been relevant to assess the effect of sustainability-oriented DCs and OCs on market performance of green products over time, so as to capture their effect on the improvement of market performance, we used a scale focused on the growth of this measure of performance. This has been the only option to get this kind of information, since extracting market performance data specifically from green products out of firm's overall market performance data is almost impossible from secondary data sources, as no company reports sales or revenue data just on green products on a regular basis. A second limitation could be raised about the recruitment of a single respondent per strategic business unit (SBU). In this regard, we attempted to obtain two respondents per SBU, but in most cases there was only one person available within the SBU sufficiently knowledgeable about environmental sustainability issues. Further, to ensure the validity of the key informant, we included a key informant test at the research design stage: the questionnaire had an item assessing the self-reported knowledge on the issues under investigation, and only questionnaires completed by knowledgeable respondents were included in the analyses. This allowed us to retain only the questionnaires answered by confident/competent informants. Wagner *et al.* (2010), based on van Bruggen *et al.* (2002), demonstrate that the use a single informant who is very competent/confident provides data that are as good or better than using multiple informants. Third, only managers' perceptions were measured and the only secondary data coming from external sources were firms' age, size, and industry type. Adding secondary data (for example on environmental R&D investments, firms' environmental performance, or sales and profitability of green products), which would have increased the robustness of this research, was not possible since databases with data on specific environmental activities and performance of firms are still lacking. On the other hand, these data could be found in companies' environmental or sustainability reports, but only a few companies have such reports and, most importantly, the data reported are not in a comparable format. While our sample includes companies belonging to different industrial sectors, we only implicitly controlled for industry effects through the levels of industry technological intensity and environmental risk. We chose this form of control as this is consistent with the focus of the study: product innovation in the context of environmental sustainability.

With regard to future research directions, given that most organizations now have sustainability managers with ever greater authority, responsibility and top management representation, it would be important and fruitful to investigate and understand the role these individuals and transformational managers and leaders (Teece, 2012) play in bringing in non-routine, strategic change in the firm's sustainability-oriented DCs to produce sustainability solutions. This line of research will contrast the dominant current thinking of firm-specific routines in the literature. Future researchers should also empirically investigate the antecedents of sustainability-oriented DCs, investigating why some firms are better than others to deploy these DCs. It may also be interesting for future studies to examine sustainability-oriented DCs in service sectors, such as tourism sector, or in the building sector, in which the interest toward environmental sustainability is rapidly growing. Another important and interesting future research avenue could be to test the developed framework in other countries, so as to understand whether and how the national context (e.g. in terms of culture) can influence sustainability-oriented DCs. Further, since this study highlights the key role of external and internal resource integration and previous studies show that DCs are generated as a result of collaboration between stakeholders (Agarwal and Selen, 2009) and that the firms with higher eco-design capabilities own dense information networks (Lenox and Ehrenfeld, 1997), future studies could deepen the understanding of sustainability-oriented DCs from a network-based view. Finally, more recently, some scholars in marketing and innovation fields call for empirical work on DCs from a systems perspective (O'Connor, 2008; Seebode *et al.*, 2012), and adaptive capabilities perspective (Day, 2011) as true extensions of DCs literature. Finally, a network-based analysis would also enhance the richness of analysis in future research on sustainability-oriented DCs, especially in the context of external resource integration wherein companies will likely develop a network of relationships with a variety of players external to the firm. These proposed perspectives should be of interest to future researchers interested in extending the knowledge base on sustainability-oriented DCs. Future researchers would need to operationalize these perspectives in situation specific context for empirical testing to compare and contrast with the results from the current study.

In conclusion, we believe that this study, has contributed to advance our knowledge by providing empirical evidence on the nature of sustainability-oriented DCs and on the links between them and sustainability-oriented OCs as well as market performance of green products. We hope that our work stimulates further theoretical refinement and empirical investigation in this important area of research.

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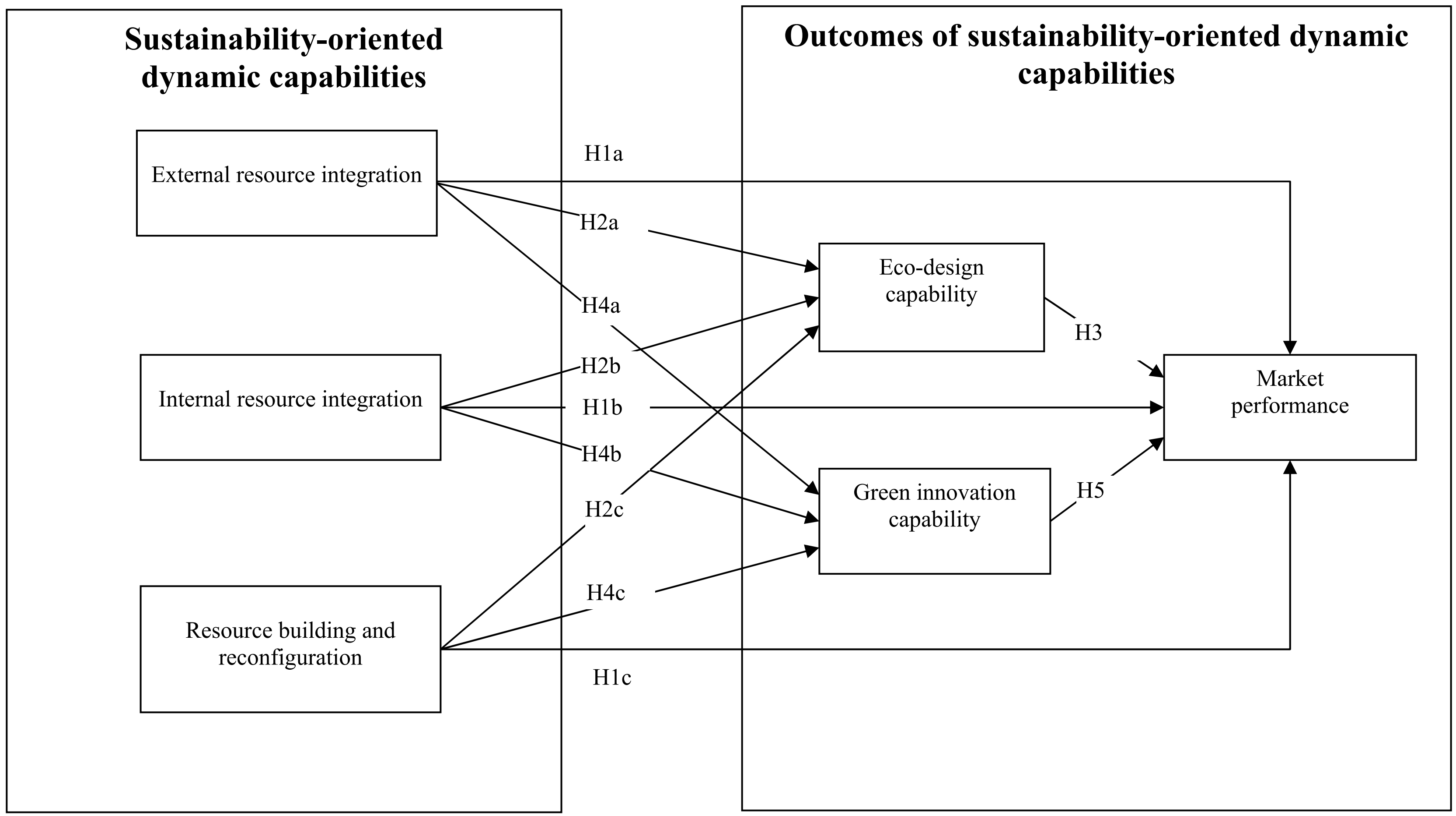
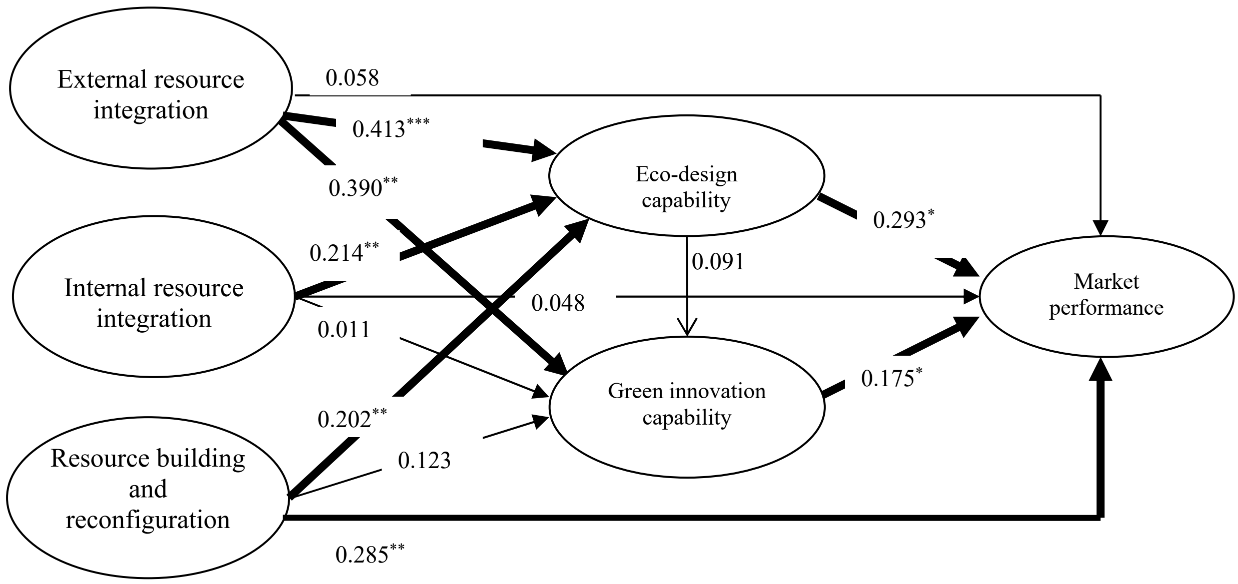


FIGURE 1
A Conceptual Framework



*= p<0.10; ** = p<0.05;*** = p<0.01

FIGURE 2
Path Diagram

TABLE I
Constructs'/Indicators' Means, Standard Deviations, Cronbach's Alpha (α), Composite Reliability (CR), Average Variance Extracted (AVE), and Intercorrelations

						Correlation Matrix					
Construct/ Indicator	M	SD	α	CR	AVE	*1*	*2*	*3*	*4*	*5*	*6*
1. External resource integration	5.09	1.02	0.81	0.80	0.51	1.00					
2. Internal resource integration	4.71	1.31	0.91	0.89	0.74	0.58***	1.00				
3. Resource building and reconfiguration	4.33	1.20	0.88	0.87	0.52	0.54***	0.59***	1.00			
4. Green innovation capability	4.20	1.30	0.80	0.83	0.55	0.40***	0.32***	0.37***	1.00		
5. Eco-design capability	5.43	1.12	0.85	0.84	0.57	0.61***	0.59***	0.55***	0.38***	1.00	
6. Market performance	4.50	1.32	0.92	0.92	0.80	0.37***	0.41***	0.46***	0.37***	0.45***	1.00
7. Firm size (log)	1.89	0.59	-	-	-	-0.21***	-0.08	-0.11	-0.32***	-0.14*	-0.07
8. Firm age (log)	1.42	0.28	-	-	-	0.03	0.03	0.00	-0.12	0.03	-0.09
9. Industry technological intensity	2.17	0.85	-	-	-	0.02	0.03	0.15**	0.14*	0.02	0.10
10. Industry environmental risk	0.64	0.48	-	-	-	-0.12	-0.13*	-0.07	0.11	-0.03	-0.05

11. Geographic location	0.77	0.42	-	-	-	-0.14*	-0.12	-0.06	-0.08	-0.06	-0.05

*p < 0.10 ** p < 0.05 ***p < 0.01

TABLE II
Sustainability-oriented Dynamic Capabilities Measurement Model

Construct	Measure *Relative to your major competitors, please evaluate how well or poorly, your SBU has done/performed in the following activities to integrate environmental sustainability in product development, during the past five years:*	Standardized loadings [a]
External resource integration	integrating customers' requirements about products' environmental performance	0.74[b]
	integrating knowledge on environmental impact of products during customers' use	0.79
	integrating suppliers' knowledge and competencies on environmental impact of components or materials	0.64
	integrating suppliers' knowledge and competencies on environmental impact of production processes	0.67
	collaborating with channel members (such as whole sellers, retailers, etc.) to reduce the environmental impact of products	*(D)*
Internal resource integration	collaborating among specialized environmental unit (e.g. environmental sustainability managers, environmental sustainability unit) and design function/department within the SBU	0.89 [b]
	collaborating among specialized environmental unit (e.g. environmental sustainability managers, environmental sustainability unit) and production function/ department within the SBU	0.77
	collaborating among specialized environmental unit (e.g. environmental sustainability managers, environmental sustainability unit) and marketing function/ department within the SBU	0.91
	integrating environmental knowledge and competencies in functions/departments (design, manufacturing, marketing,…) within the SBU	*(D)*
	facilitating cross-functional environmental knowledge exchange within the SBU	*(D)*
Resource building and reconfiguration	hiring environmental specialists (e.g. experts on Life Cycle Assessment (LCA) and Design for Environment (DfE))	0.68 [b]
	training (e.g. through attendance to conferences, workshops, courses) product development teams' members to upgrade their environmental knowledge and competencies	0.70
	training (e.g. through attendance to conferences, workshops, courses) R&D staff to upgrade their environmental knowledge and competencies upgrading environmental knowledge and competencies	0.70
	strengthening environmental R&D (e.g. increasing the scope, increasing investments)	0.75
	reconfiguring organizational structure to focus on environmental sustainability (e.g. creating a new division, reconfiguring product lines)	0.77
	reconfiguring product development teams to include environmental specialists	0.75
	reconfiguring relationships with suppliers (e.g. supplier environmental audit, changing suppliers) to reduce the environmental impact of products	*(D)*
	reconfiguring relationships with customers (e.g. lease instead of sale) to reduce the environmental impact of products	*(D)*

[a] All reported loadings significant at p < 0.001; [b] Fixed parameter; *(D)* indicates dropped items

TABLE III
Items' Loading on the Constructs Eco-Design Capability, Green Innovation Capability, and Market Performance

Construct	Measure	Standardized loadings [a]
Eco-design capability	*Relative to your major competitors, please rate the extent to which the following green product development abilities have been improved/developed in your SBU during the past five years:*	
	implementing environmental life cycle assessment (LCA) of products	*(D)*
	reducing materials used in products and processes (raw materials, chemicals, toxic substances)	0.70[b]
	using environmentally friendly materials (e.g. recycled, recyclable, biodegradable, renewable, certified as sustainable)	0.81
	improving product design (e.g. high durability, easily repairable, easily disassembled, easily recyclable)	0.82
	improving manufacturing processes (e.g. pollution prevention, waste reduction, energy/resource efficiency)	0.68
	reusing by-products, products, or components	*(D)*
	integrating green technologies or components within the product (such as hybrid engine within cars or energy efficient systems within products using energy)	*(D)*
Green innovation capability	*Please indicate the degree to which you agree or disagree with the following statements regarding the radicalness of green products developed by your SBU's during the past five years:*	
	most of our green products offered were new to the SBU	*(D)*
	most of our green products offered were new to the market	0.63[b]
	most of the green customer needs we served were new to the SBU	0.85
	most of the users of our green products were new to the SBU	0.77
	most of our new green products were based on revolutionary changes in technology	0.70
Market performance	*Relative to your major competitors, please rate the performance of your SBU green product innovation at the program level, over the past three years on:*	
	growth in revenues from green products	0.91[b]
	growth in profitability of green products	0.90
	growth in sales of green products	0.88

[a] All reported loadings significant at $p < 0.001$; [b] Fixed parameter; *(D)* indicates dropped items

TABLE IV
Parameter Estimates for the Causal Paths

Hypothesis	Path	Standardized estimate	t-value	Hypothesis supported/not supported
Hypothesis 1a	External resource integration → Market performance	0.058	0.315	*Not supported*
Hypothesis 1b	Internal resource integration → Market performance	0.048	0.421	*Not supported*
Hypothesis 1c	Resource building and reconfiguration → Market performance	0.285**	2.324	*Supported*
Hypothesis 2a	External resource integration → Eco-design capability	0.413***	3.326	*Supported*
Hypothesis 2b	Internal resource integration → Eco-design capability	0.214**	2.582	*Supported*
Hypothesis 2c	Resource building and reconfiguration → Eco-design capability	0.202**	2.328	*Supported*

Hypothesis 3	Eco-design capability → Market performance	0.293**	1.728	*Supported*
Hypothesis 4a	External resource integration → Green innovation capability	0.390**	2.265	*Supported*
Hypothesis 4b	Internal resource integration → Green innovation capability	0.011	0.101	*Not supported*
Hypothesis 4c	Resource building and reconfiguration → Green innovation capability	0.123	1.082	*Not supported*
Hypothesis 5	Green innovation capability→ Market performance	0.175*	1.844	*Supported*
	Eco-design capability → Green innovation capability	0.091	0.575	*Not supported*
Control variables	**Path**	**Standardized estimate**	**t-value**	**Significant/ not significant**
	Firm size → Green innovation capability	-0.567***	-3.988	*Significant*
	Firm size → Eco-design capability	-0.98	-0.750	*Not significant*
	Firm size → Market performance	0.289*	1.846	*Significant*
	Firm age → Green innovation capability	-0.152	-0.576	*Not significant*
	Firm age → Eco-design capability	0.180	0.861	*Not significant*
	Firm age → Market performance	-0.565**	-2.006	*Significant*
	Industry technological intensity → Green innovation capability	0.205**	2.318	*Significant*
	Industry technological intensity → Eco-design capability	0.066	0.931	*Not significant*
	Industry technological intensity → Market performance	0.032	0.339	*Not significant*
	Industry environmental risk → Green innovation capability	0.462***	2.917	*Significant*
	Industry environmental risk → Eco-design capability	0.138	1.153	*Not significant*
	Industry environmental risk → Market performance	-0.028	-0.165	*Not significant*
	Geographic location → Green innovation capability	-0.004	-0.024	*Not significant*
	Geographic location → Eco-design capability	0.061	0.448	*Not significant*
	Geographic location → Market performance	0.371**	1.997	*Significant*

* = p<0.10; ** = p<0.05; *** = p<0.01