GREEN PRODUCT INNOVATION IN MANUFACTURING FIRMS:
A SUSTAINABILITY-ORIENTED DYNAMIC CAPABILITIES PERSPECTIVE

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Abstract

Despite environmental sustainability being identified as one of the key drivers of innovation, extant literature lacks a theoretically-sound and empirically-testable framework that can provide specific insights into green product innovation from a capabilities perspective. This study develops a theoretical framework from a sustainability-oriented dynamic capabilities (SODCs) perspective. We conceive SODCs as consisting of three underlying processes (external resource integration, internal resource integration, and resource building and reconfiguration) that influence the change/renewal of sustainability-oriented ordinary capabilities (SOOCs) (green innovation capability and eco-design capability). This study answers two key questions: which SODCs are needed to develop green innovation and eco-design capabilities? Which of these capabilities lead to better market performance of green products? We test a structural model linking SODCs to market performance in 189 Italian manufacturing firms. First, we find that the nature of the SODCs-performance link (direct or indirect) depends on the SODC type. Specifically, resource building and reconfiguration is the only SODC with a direct effect on market performance. Second, all three types of SODCs affect the eco-design capability, which mediates the link between SODCs and market performance. Third, we find that external resource integration is the only SODC affecting the green innovation capability, which mediates the link between external resource integration and market performance. Resource building and reconfiguration is the SODC with the overall (direct and indirect) highest impact on market performance. This study, among the first ones to consider capabilities for green product innovation under a dynamic capabilities perspective, provides implications for scholars, managers, and policy makers.

KEYWORDS: dynamic capabilities, green innovation, eco-design, manufacturing firms, environmental sustainability, sustainable development

1. INTRODUCTION

As environmental concerns among the businesses become commonplace, green product innovation (GPI) has grown in importance among manufacturing firms worldwide. Several firms invest in sustainability initiatives not just for cost savings and risk mitigation but also for revenue generation. For example, 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]. Global companies, such as Tesla, Ikea, Unilever, Nike, Toyota, Whole Foods, generated at least 1 billion dollars of revenue from products or services that have sustainability at their core (Williams, 2015). All these indications suggest that green product innovation is one of the big shifts of our times that requires scholars' attention and significant ongoing research to support managers and firms interested in the marketing of green products (Kotler, 2011; Slotegraaf, 2012).

Our review of current literature reveals that scholars have focused so far on ad hoc green product development activities mainly at *project* level (e.g., Chen and Chang, 2013; Dangelico and Pujari, 2010; Dangelico *et al.*, 2013; Pujari, 2006; Shu *et al.*, 2016). We argue that it is crucial to investigate GPI at *program* level, since this represents a more constant and stable firm endeavor for GPI. Further, few GPI studies explicitly rely on established organizational and managerial theories (Dangelico, 2015). We believe that the dynamic capabilities theory could be particularly suitable to study GPI (Dangelico, 2015), as firms need to transform their capabilities or to create new ones to engage in a sustainability-oriented change (Chang, 2016; Chen and Chang, 2013; Nidumolu *et al.*, 2009). Further, Luchs *et al.* (2016) highlight sustainability as a key issue for product design and suggest that building knowledge on product design within the theoretical lens of dynamic capabilities

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

would be an influential contribution, as it will explain how design capabilities build and sustain competitive advantage

This paper addresses calls to fill these gaps and makes an important contribution by developing a theoretical framework for GPI and performance from a sustainability-oriented dynamic capabilities (SODCs) perspective.

Based on extant literature on environmental sustainability, innovation as well as dynamic capabilities (DCs), and relying on the definition by Teece, Pisano and Shuen (1997), we define SODCs 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 identify three types of SODCs in this research: external resource integration, internal resource integration, and resource building and reconfiguration. We posit that firm's processes, that we call SODCs, exist at a higher order as suggested by many scholars (e.g. 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 (SOOCs) 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 , we argue that SODCs operate "to extend, modify or create" SOOCs (Winter, 2003 , p. 991), governing their rate of change (Collis, 1994).

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

The study has been conducted through a survey of Italian manufacturing firms. Italy has been chosen as a setting for this study, since it can be considered an excellent choice in the context of green economy. The Greenitaly Report 2015[2] highlights that 24.5% of Italian companies have invested in green products or technologies during 2008-2014 (or planned to do so by 2015) and this percentage raises to 32% considering only the manufacturing sector. Further, Italy is the first country in Europe for the number of EU ecolabel products and services[3].

This article is structured as follows. First, we provide additional conceptualization of SODCs and SOOCs and identify their different types. Second, we develop a model linking SODCs to market performance of green products, both directly and through the development of SOOCs. Third, we present methodological details. Fourth, we report on the testing of our model using structural equation modelling. Finally, we discuss theoretical, managerial, and public policy implications of our results.

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). We present a theoretical framework of SODCs, adapting from a general theory of DCs and a review of the literature in sustainability management, innovation & NPD and marketing. In general, empirical research on GPI has been done from resource-based and capabilities perspectives (Chang, 2016; 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

[2] www.unioncamere.gov.it/download/5615.html
[3] http://ec.europa.eu/environment/ecolabel/facts-and-figures.html

Fouts, 1997; Sharma and Vredenburg, 1998). Lenox and Ehrenfeld (1997) show that integrating diverse resources plays an important role into building eco-design capability, while Mariadoss *et al.* (2011) 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. Chen and Chang (2013 ; p.109) highlight that green dynamic capabilities - the ability of a company to exploit its existing resources and knowledge to renew and develop its green organizational capabilities to react to the dynamic market - are positively linked to green creativity and green product development performance.

While the extant literature advances our knowledge on capabilities development in the context of environmental sustainability at broad corporate level, an analysis of the extant literature in the main academic journals' databases reveals that research on dynamic capabilities for GPI is quite limited. This prompts a need to identify nature and characteristics of SODCs that allow firms to develop/improve sustainability capabilities leading to GPI.

2.1. Sustainability-oriented Dynamic Capabilities

Based on an integration of the evidences from studies on DCs and on GPI, as well as on a deep authors' knowledge of the GPI domain, we identify and describe the characteristics of SODCs 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 (Albino *et al.*, 2012; Dangelico *et al.*, 2013; Foster and Green, 2000; Guoyou *et al.*, 2013; Lee and Kim, 2011; Lenox and Ehrenfeld, 1997; Polonsky and Ottman, 1998). The relevance of integrating external environmental knowledge and competencies to address environmental sustainability challenges also 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[4]. 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.

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

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. 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).

2.2. Sustainability-oriented Ordinary Capabilities

SODCs, which are conceived as higher-order capabilities, have the ability to impact, shape or transform SOOCs, 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 GPIs 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 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; 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.

2.3. Market Performance

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

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

FIGURE 1

2.4. Outcomes of SODCs: Direct Paths towards Market Performance

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. Drnevich and Kriauciunas (2011) find that DCs positively affect the relative firm performance under the conditions of environmental dynamism, while 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 GPIs that are likely to achieve market success.

Thus, we propose that SODCs will bring market success for green products.

Hypothesis 1: SODCs (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. SODCs and Market Performance: the Mediating Role of SOOCs

The literature on general theory of DCs also 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 SODCs lead to development of SOOCs, such as green innovation 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 SODCs will focus the firm's efforts towards improvement or development of SOOCs, such as eco-design capability and green innovation capability. Accordingly, we hypothesize that:

Hypothesis 2: SODCs (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.

Hypothesis 3: SODCs (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.

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 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 (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 4: The eco-design capability has a positive impact on the market performance of green products for 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 the greater their financial value, in terms of success rate and return on investment (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.

In the environmental sustainability context, there are many examples of innovative green products achieving high market success, such as Green Works (a natural household cleaning product line that Clorox launched in 2008) which achieved a market share of 50% within the first year, and Ford Fusion that received reputational awards such as Green Car of the Year for 2012. We argue that the ability to develop truly innovative green products results 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, as part of a larger multi-country study. We report here findings from the data collected in Italy. A questionnaire was sent via e-mail (as an attachment and providing a link to answer on-line, so as to offer a double option to respondents) to 1,500 contacts of companies belonging to SIC codes 20 to 39 (excluding SIC code 21 for tobacco industries). A first reminder was sent after three weeks and a final reminder was sent after two weeks (Dillman, 2007). The data collection process took place in 2009 and lasted three months.

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[5].

[5] 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).

We 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 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). 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 SODCs and the scale for the eco-design capability, we interviewed managers of eight Italian companies that developed GPIs. 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. Consistent with previous studies on capabilities (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 SODCs 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. 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. 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). 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 (scores 1 to 4). Firm's industry environmental risk category was identified according to Case's (1999) list of high environmental risk activities (companies were coded as 1 if their industry was in the list 0 otherwise).

4. RESULTS

4.1. Preliminary Analysis

A logarithm transformation was performed on the variables (firm's size and age) showing significant departure from normality (Hair *et al.*, 2006). The characteristics of all constructs, their means, standard deviations, reliability measures, variance extracted, and correlations with the other constructs in the model are provided in Table I. Results show that the most developed capabilities by companies in the sample are external resource integration and eco-design capability. Scale reliabilities exceeded the recommended cut-off criteria: Cronbach's alpha >=.70 (Nunally and Bernstein, 1978), composite reliability >=.70 (Fornell and Larcker, 1981), and the variance of each construct exceeded the recommended threshold of 50% for all constructs (Hair *et al.*, 2006). Thus, the measures are reliable and cover at least one-half of a construct's domain.

TABLE I

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, suggesting 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 (SODCs on one hand and their outcomes on the other hand). With regard to SODCs 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 SODCs 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). Item loadings on the constructs are reported in Table II.

TABLE II

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.

TABLE III

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

We tested our hypotheses using SEM. As shown by the goodness-of-fit statistics (χ^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. In Figure 2 the causal path is depicted.

FIGURE 2

Direct path between SODCs and market performance. Hypotheses predicting that SODCs have a direct link with market performance are only partially confirmed. In fact, the only type of SODCs showing a significant direct link with performance is resource building and reconfiguration (β=0.263, $p<0.05$), leading us to accept Hypothesis 1c.

However, the direct links between external resource integration and market performance (β=0.042, $p>0.10$), and between internal resource integration and market performance (B=0.048, $p>0.10$) are both insignificant, leading us to reject Hypotheses 1a and 1b.

Indirect path between SODCs and market performance mediated by the eco-design capability. Hypotheses predicting that SODCs have a positive impact on the eco-design capability receive full support. More specifically, the positive and significant effect of external resource integration (β=0.381, $p<0.01$) supports Hypothesis 2a, the positive and significant effect of internal resource integration (β=0.270, p=0.01) provides support to Hypothesis 2b, and the positive and significant effect of resource building and reconfiguration (β=0.263, $p<0.05$) supports Hypothesis 2c. Hypothesis 4, 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 (β=0.232, $p<0.10$). Thus, the link between SODCs and market performance is mediated by the development/improvement of the eco-design capability, as suggested by Hypotheses 2 and 4.

Indirect path between SODCs and market performance mediated by the green innovation capability. Our hypotheses predicting that SODCs 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 (β=0.306,

$p<0.05$), thus providing support to Hypothesis 3a. Resource building and reconfiguration shows a positive, even though non-significant, effect on the green innovation capability ($\beta=0.122$, $p>0.10$), leading us to reject Hypothesis 3c. Finally, internal resource integration does not show a significant influence on the green innovation capability ($\beta=0.012$, $p>0.10$), leading us to reject Hypothesis 3b.

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 ($\beta=0.163$, $p<0.10$).

Hypotheses 3 and 5, jointly considered, suggest that the link between SODCs 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. With regards to the effect of control variables on the green innovation capability, the industry technological intensity shows a significant and positive link ($\beta=0.147$, $p<0.05$). We also found a negative effect of the firm's size on the green innovation capability ($\beta=-0.279$, $p<0.01$). Industry environmental risk positively influences the green innovation capability ($\beta=0.187$, $p<0.01$).

With regard to market performance, there are contrasting results about the influence of firm's age and firm's size. There is a positive effect of firm's size on market performance ($\beta=0.132$, $p<0.10$) and there is a negative effect of firm's age on market performance ($\beta=-0.126$, $p<0.05$).

5. DISCUSSION

This study highlights that SODCs are important for GPI, however, in different ways. Results show the relevance of reconfiguration of resource and capabilities for market performance improvement, in accordance with Wu (2010) that finds that the DC with the strongest direct links is reconfiguration. Our study highlights that all three SODCs positively affect the development of the eco-design capability, with external resource integration having the strongest link, followed by internal resource integration. These results provide clear empirical evidence that DCs modify/improve OCs and support existing knowledge on the need for firms with high eco-design capabilities to own dense information networks linking external and internal resources with the product development team (Lenox and Ehrenfeld, 1997).

The positive effect of eco-design capability on performance shows that products, which are designed with natural environment being a critical part of the design process, also have a higher potential for success at the marketplace, supporting previous studies (e.g., Pujari, 2006) which find that design for environment and life cycle assessment activities have a positive impact on market performance of green products. Among the three SODCs, only external resource integration shows a positive effect on green innovation capability. This result, on one hand, is consistent with previous studies in the 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); on the other hand, it is in contrast with other studies that suggest a positive link between new knowledge creation (a key result of resource building and reconfiguration) and radicalness of innovation (e.g. Laursen and Salter, 2006). Our findings show that investing in environmental R&D or enhancing cross-functional collaboration among specialized environmental units and other functional units may not be 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 their core ones, which are often owned by external actors. For example, suppliers' involvement and integration is particularly important as new, alternative or sustainable materials and components are critical for success. Further, 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.

This study also contributes to another neglected issue in the literature (Dangelico, 2015): the effect of radicalness of green products on market performance, showing 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.

Our results also show that, as expected, firms in high-tech industries develop a better green innovation capability due to their higher levels of investments in R&D. Small rather than large firms develop most of radical green product innovations, while larger firms are more capable of turning green product innovations into market success. This is consistent with previous studies' results, that show that larger firms are often less ambitious in their environmental goals, but they have a broader reach due to their established market presence (Hockerts and Wüstenhagen, 2010). Firm's age has a negative effect on market performance in our study indicates that younger firms achieve higher success in GPI, in accordance with previous studies (e.g. Sorensen and Stuart, 2000). Further, geographic location of firms affects market performance. Firms located in Northern Italy achieve better market performance, coherently with a more developed productive industrial fabric, allowing firms to benefit from network externalities, closeness to suppliers and customers, and better infrastructure. Finally, firms operating in industries characterized by higher environmental risks tend to have a higher capability to develop green innovations, probably due to higher stakeholders' pressure compared to firms operating in industries with medium-low environmental risks.

6. IMPLICATIONS, LIMITATIONS, AND DIRECTIONS FOR FUTURE RESEARCH

This study has important implications for scholars, managers, and policy makers.

In terms of theoretical contributions, first, this paper develops a testable theoretical framework for GPI, highlighting that the DCs theory is a suitable theory to study green innovation and that GPI requires specific capabilities, both ordinary and dynamic. Second, this study develops and validates a multidimensional scale to measure DCs, in the context of sustainability. Third, while most of the empirical studies on DCs focused on a firm level, we address the need to analyse DCs at a more granular level (Helfat and Winter, 2011) by focusing on SODCs and on their impact on GPI market performance. Further, though limited to GPI performance rather than firm performance, this study also sheds light on the debate over 'DCs - performance link' (i.e. direct vs indirect link) empirically showing 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. Finally, this study explicitly analyses radicalness of green product innovation and its impact on performance, issues not yet investigated in extant literature, showing that more radical green products have better market performance.

In terms of implications for strategy managers, this study provides directions to a 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. Due to several motivations, including market demand as well as society and government attention towards sustainability issues, companies can no longer ignore or delay the development of a green innovation strategy. As a key contribution, our research identifies key SODCs to effectively integrate environmental sustainability into product innovation processes. In particular, in order to make GPI successful, strategy managers should: (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); ii) foster exchange and integration of environmental knowledge and competencies within the firm, through cross-functional collaboration between specialized environmental and other units (such as manufacturing, marketing, and design); and (iii) 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).

In terms of implications for policy makers, this study suggests that public policy could stimulate GPI in several ways. For example, it could foster companies' resource building and reconfiguration through incentivizing investments in environmental R&D or the hiring of employees with environmental competencies, especially for smaller firms. On the other hand, public policy could enhance companies' external resource integration by financing collaborative projects among supply chain members, aiming at developing innovative green products.

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, 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 SODCs 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. Another limitation is a possibility of social desirability bias, despite the fact that complete self-administration, anonymity, and confidentiality (as ensured in this study) are considered to reduce social desirability bias (e.g. Leggett *et al.*, 2003). In fact, Roxas and Lindsay (2012) pointed out that, in the field of sustainability, respondents tend to provide higher scores to items related to knowledge, practices, commitment to environmental sustainability, and managerial attitudes towards the environment in self-administered questionnaires compared to enumerator assisted surveys, whereas this tendency turns around for items related to the external environment. This may have led to a general increase in the scores of our study items (all related to internal issues), though not affecting the results on the relationships among constructs. Future studies should focus on the antecedents of SODCs, investigating why some firms are better than others to deploy these DCs. It may also be interesting for future studies to examine SODCs 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 SODCs.

In conclusion, we believe that this study has advanced our knowledge by providing empirical evidence on the nature of SODCs and on the links between them and SOOCs 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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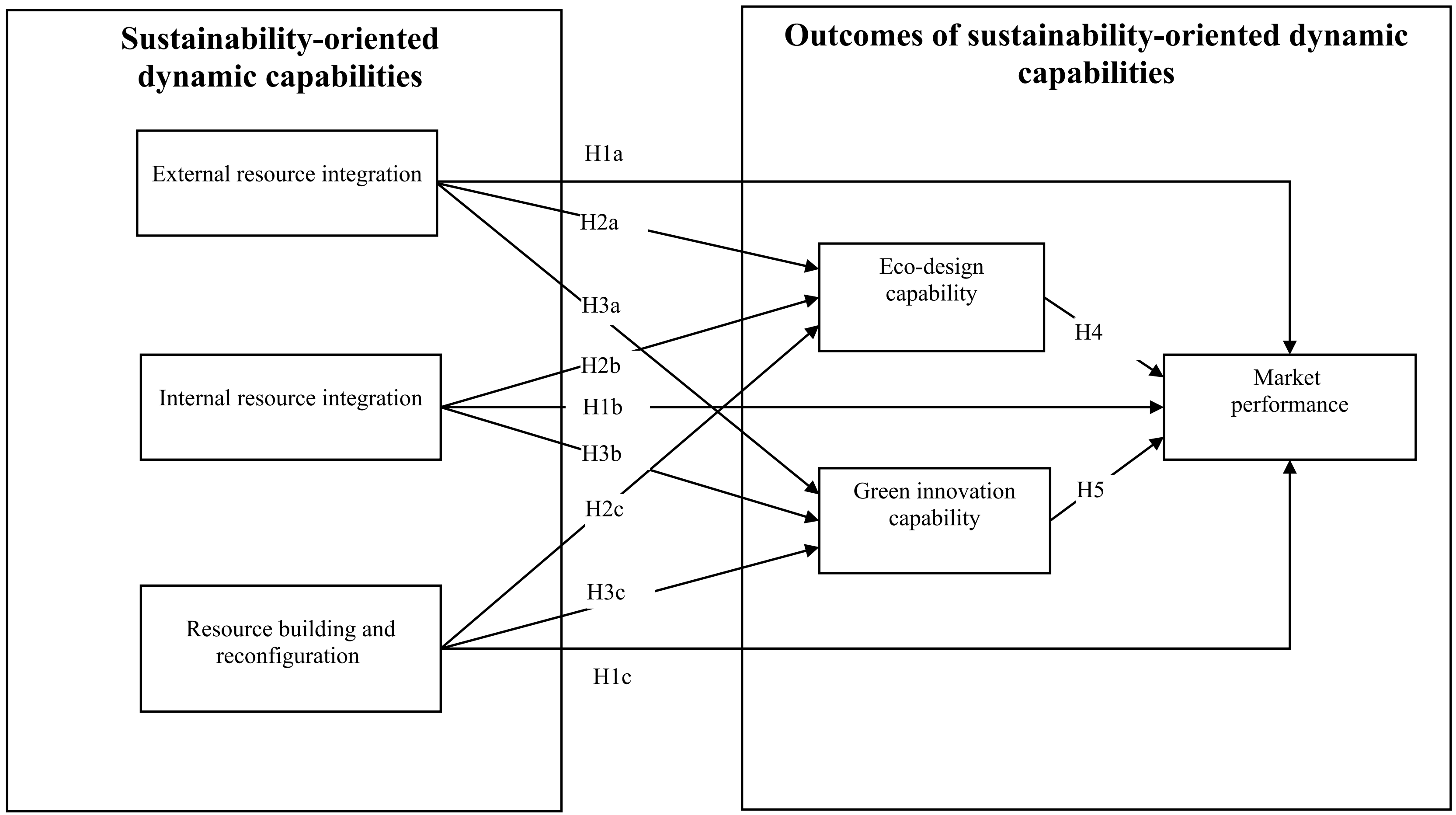
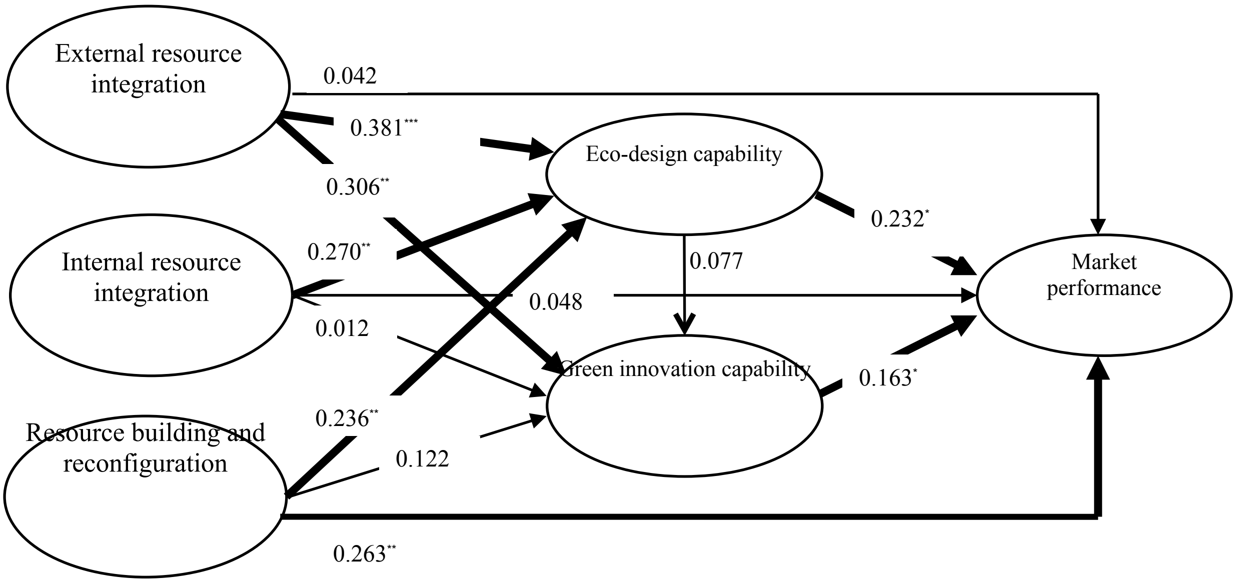


FIGURE 1
A Conceptual Framework



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

FIGURE 2
Path Diagram (standardized regression weights)

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. Log_firm_size	1.89	0.59	-	-	-	-0.21***	-0.08	-0.11	-0.32***	-0.14*	-0.07
8. Log_firm_age	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	0.6	0.4	-	-	-	-0.12	-0.13*	-0.07	0.11	-0.03	-0.05

environmental risk	4	8									
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