J Bus Ethics (2013) 116:107–119
DOI 10.1007/s10551-012-1452-x

The Determinants of Green Product Development Performance: Green Dynamic Capabilities, Green Transformational Leadership, and Green Creativity

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Received: 30 April 2012 / Accepted: 10 August 2012 / Published online: 26 August 2012

Abstract Because no previous literature discusses the determinants of green product development performance, this study develops an original framework to fill the research gap. This study explores the influences of green dynamic capabilities and green transformational leadership on green product development performance and investigates the mediation role of green creativity. The results demonstrate that green dynamic capabilities and green transformational leadership positively influence green creativity and green product development performance. Besides, this study indicates that the positive relationships between green product development performance and their two antecedents—green dynamic capabilities and green transformational leadership—are partially mediated by green creativity. It means that green dynamic capabilities and green transformational leadership can not only directly affect green product development performance positively but also indirectly affect it positively via green creativity. Hence, companies have to increase their green dynamic capabilities, green transformational leadership, and green creativity to enhance their green product development performance.

Keywords Green product development · Green dynamic capabilities · Green transformational leadership · Green creativity · Environmental management

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Introduction

The success of product development lies in creating products whose core attributes can satisfy the needs of customers and other internal and external stakeholders. Product stewardship efforts encompass all aspects of products' functionalities and their impacts through the analysis of product life cycle. Since environmental protection has quickly become a mainstream issue due to the impact of disastrous environmental pollution and global warming nowadays, more companies are willing to develop green products (Chen 2011). The successful green product development can help companies and economies move towards environmental sustainability. Green products become a powerful competitive weapon in the market because more consumers become concerned about the environment and more people are willing to pay more for green products (Bhat 1993). Perceiving the devastating environmental toxic wastes of industrial manufacturing activities around the world, consumers increasingly take notice of environmental issues (Ginsberg and Bloom 2004). Environmental consideration has rapidly emerged as a widely accepted concept because of global climate change, so more consumers would like to pay more attention to green products (Chen and Chang 2012). Consumers pay more attention to the prevalence of environmental protection activities such that consumer environmentalism is more popular in the world (Chang 2011). Hence, consumers are prone to purchase green products in the environmental era (Makower 2009; Kalafatis and Pollard 1999). As a result, more and more companies are redesigning and redeveloping their products into green products. In the environmental era, it is necessary for companies to integrate environmental management philosophy with new product development (Pujari et al. 2003).

Green product development plays an important role for companies to respond effectively to the environmental challenge (Albino et al. 2009). A lot of consumers are aware of environmental issues and they would not hesitate to take action against companies that are considered to be environmentally irresponsible. Besides, consumers notice the importance of environmental protection such that consumer environmentalism is more prevalent and environmental regulations are stricter in the world (Jain and Kaur 2004). Eventually, the public is eager to purchase green products which are not harmful to the environment (Chen 2010). For example, 93 % of Thai people, 83 % of Brazilians, and 53 % of Americans are willing to pay higher price to purchase green products (Makower 2009). Besides, 56 % of Americans are keen to pay for the reductions of carbon emissions in US (Roe et al. 2001). Hence, firms have to correct their business models to comply with the consumer environmentalism (Chen and Chang 2012). Several successful companies, such as 3M and Body Shop, change their corporate environmental mindset in which environmental management is viewed as part of new product development. Therefore, green product development is more important for firms and it is becoming a crucial part of business management (Chen 2001).

In the environmental era, companies should accept environment protection as their social responsibility, because environmental challenges could become green opportunities that stimulate them to adopt environmental management in order to enhance their green images and competitive advantages (Porter and van der Linde 1995; Chen 2008b). It is widely accepted that effective product development is important for firms in generating long-term corporate success (Cooper 1979). Prior literature argues that it is crucial for firms to integrate green ideas into the product development process to create a win–win solution for both of the firms and the society. Product development of firms will make no contribution to the pursuit of sustainability unless they can provide viable 'green' product choices for consumers (Pujari et al. 2003). Because the public has become aware of environmental issues, companies pay more attention to green product development (Chen 2010). If firms would like to develop green products successfully, they should incorporate the concept of green mindset with the activities of green product development (Chen 2010).

When green products are more popular in the market, green product development becomes more prevalent (Chen 2008a). This study defines green products as those that have less of an impact on the environment, are less detrimental to human health, are formed or part-formed from recycled components, are manufactured in a more energy-conservative way, or are supplied to the market with less packaging. If companies would like to launch their green products, green product development plays an important role to determine the sales of the green products. Green product development can not only make a differentiation strategy by satisfying environmental needs, but also reshape marketing rules in the market. There are four differences between traditional product development and green product development which include a broader consideration of environmental concerns, a focus on product life cycle analysis, a focus on design for post-use applications, and a focus on the socio-environmental impacts of the whole supply chain (Pujari et al. 2003). Hence, the determinants of green product development are different from those of traditional product development. We argue that companies have to develop green dynamic capabilities, green transformational leadership, and green creativity to increase green product development performance. Although prior literature has widely discussed the relevant issues about new product development performance, none explores green product development performance. Therefore, we would like to fill the research gap. We propose four novel constructs—green dynamic capabilities, green transformational leadership, green creativity, and green product development performance—and develop an integral framework to further discuss their relationships and implications. Green product development is more important for companies under the context of environmentalism. We build up a research framework which can help companies raise their green product development performance through its three determinants: green dynamic capabilities, green transformational leadership, and green creativity.

We summarize the literature on dynamic capabilities, transformational leadership, creativity, and green management into a new managerial framework of green product development. Besides, we further undertake an empirical test to verify the relationships among green dynamic capabilities, green transformational leadership, green creativity, and green product development performance. We propose a new framework of green product development in compliance with environmental trends to help companies enhance their green product development performance. The structure of this study is as follows: A literature review is discussed in "Literature Review and Hypothesis Development", and five hypotheses are also proposed in this section. In "Methodology and Measurement" section, we describe the methodology, the sample, data collection, and the measurement of the constructs. Then, the descriptive statistics, reliability of the measurement, factor analysis, correlation coefficients between the constructs, discriminant validity, convergent validity, and the results of structural equation modeling (SEM) are shown in "Empirical Results" section. In the final section, we mention the conclusions and discussions about the findings, implications, and possible directions for future research.

Literature Review and Hypothesis Development

The Positive Effect of Green Dynamic Capabilities on Green Creativity

The resource-based view (RBV) argues that resources and capabilities which are valuable, rare, and inimitable form the basis of sustainable competitive advantages (Barney 1991). RBV has two different viewpoints: The focus of the steady-state perspective is on a firm's ability to gain and sustain competitive advantage; and the focus of the dynamic capabilities perspective is on a firm's ability to adapt to and take advantage of the dynamic environment (Schulze 1994). One key implication of the dynamic capabilities concept is that firms are not only competing on their ability to exploit their existing resources and organizational capabilities, but also competing on their ability to renew and develop their organizational capabilities to fit the uncertain environment (Teece and Pisano 1994; Teece et al. 1997). It is insufficient to have strong steady-state organizational capabilities to remain competitive advantage. Dynamic capabilities enable firms to react to the changing market by developing and renewing its resources and organizational capabilities to achieve sustainable competitive advantages (Winter 2003). In addition, dynamic capabilities allow firms to stretch beyond current routines to solve problems in a different way (Zahra et al. 2006). We propose an original notion, 'green dynamic capabilities', and refer to Teece et al. (1997) to define it as "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".

Creativity is beneficial for the generation of new and useful ideas which can lead to innovation development (Wyer et al. 2010). Within organizations, creativity is the act of generating and producing new ideas, approaches, and actions, whilst innovation is the process of converting those ideas into novel, useful, and viable commercial products, services, and business practices (Wyer et al. 2010). Creativity is a necessary step within the innovation process, because creativity is a starting point for innovation (Amabile et al. 1996). Andriopoulos (2001) argues that dynamic capabilities of an organization would positively affect organizational creativity. We propose a novel notion, 'green creativity', and refer to Amabile (1988) to define it as "the development of new ideas about green products, green services, green processes, or green practices that are judged to be original, novel, and useful". According to the above discussion, we assert that green dynamic capabilities would positively affect green creativity and imply the following hypothesis:

Hypothesis 1 (H_1) Green dynamic capabilities are positively associated with green creativity.

The Positive Effect of Green Transformational Leadership on Green Creativity

Leaders with appropriate characteristics play a key role in the facilitation of organizational creativity (Halbesleben et al. 2003; Andriopoulos 2001). Empirical evidence demonstrates that transformational leadership is critical in the creative process (Woodman et al. 1993). Transformational leadership composes of four dimensions: intellectual stimulation, individualized consideration, charisma, and inspirational motivation (Bass 1985). Intellectual stimulation could help followers to build creativity-relevant cognitive processes of problem construction, information searching, solution generation, and problem solving (Reiter-Palmon and Illies 2004). Through individualized consideration, transformational leaders could foster group creativity through recognizing the unique needs of followers as well as offering coaching and consulting to followers (Gong et al. 2009). Transformational leaders, who have charisma, provide a clear vision to the team that energizes and builds generation of creativity (Avolio et al. 1999). Transformational leaders with a high level of inspirational motivation stimulate enthusiasm and support followers' initiatives and viewpoints to encourage creative thinking by inspiring them to express their ideas (Gong et al. 2009). Hence, prior research indicates that transformational leadership is positively related to employee creativity (Avolio et al. 1999; Shin and Zhou 2003; Gong et al. 2009).

Transformational leadership could enhance innovation by motivating toward higher levels of performance and encouraging employees to think creatively (Shamir et al. 1993; Sosik et al. 1997; Jung et al. 2003; Sarros et al. 2008). Mumford (2000) argues that transformational leadership could facilitate the introduction of new ideas by providing vision, motivation, and intellectual simulation to followers. Besides, Shin and Zhou (2003, 2007) point out that transformational leadership can raise the creativity of R&D teams. Transformational leaders can build an innovative climate to facilitate the development of creativity (Keller 2006). Thus, prior literature indicates that transformational leadership would positively influence group creativity (Jung 2001; Shin and Zhou 2003; Elkins and Keller 2003; Gumusluoglu and Ilsev 2009; Wang and Rode 2010; Cheung and Wong 2011; Zhang et al. 2011). We propose a novel notion, 'green transformational leadership', and refer to Bass (1998) and Gardner and Avolio (1998) to define it as "behaviors of leaders who motivate followers to achieve environmental goals and inspire followers to perform beyond expected levels of environmental performance". Based on the above statement, we argue that green transformational leadership would positively affect green creativity and propose the following hypothesis:

Hypothesis 2 (H_2) Green transformational leadership is positively associated with green creativity.

The Positive Effect of Green Creativity on Green Product Development Performance

To develop innovative solutions, organizations have to develop organizational creativity which is the primary impetus of innovation (Halbesleben et al. 2003). Prior literature argues that one of the key determinants of new product success is team creativity that could facilitate the development of new products characterized by novelty and usefulness (Chang et al. 2010). Creativity accumulated as organizational ideas can result in superior product development performance (Hunt and Morgan 1995). Besides, an innovative product development team with unique creativity can effectively respond to the consumer needs to result in the excellent product development performance (Cooper 1979; Deshpandé et al. 1993). Thus, creativity is a key determinant of new product development performance (Griffin and Page 1996; Chang et al. 2010).

From the customer viewpoint, a creative idea is assessed by the degree to which the idea is useful and original to the target customers (Ford 1996). A new product idea would significantly influence the success of new product development (Cooper 1979). Pirola-Merlo and Mann (2004) posit that team creativity could be defined as group-level creativity developed by interactions of team members. Team creativity positively affects team performance (Bain et al. 2001). For firms, team creativity is viewed as a main source of innovation (Yoon et al. 2010). Hence, prior research indicates that the creativity of product development teams positively affects the product development performance (Cooper 1979; Smith and Reinertsen 1992; Amabile et al. 1996; Griffin 1997). We propose a novel notion, 'green product development performance', and define it as "the development performance of products that have less of an impact on the environment, are less detrimental to human health, are formed or part-formed from recycled components, are manufactured in a more energy-conservative way, or are supplied to the market with less packaging". According to the above discussion, we posit that green creativity would positively affect green product development performance and imply the following hypothesis:

Hypothesis 3 (H_3) Green creativity is positively associated with green product development performance.

The Positive Effect of Green Dynamic Capabilities on Green Product Development Performance

Companies need to apply their dynamic capabilities to develop new products through the recombination of existing knowledge and the acquisition of new knowledge (Andriopoulos 2001). Dynamic capabilities are more important in the dynamic environment because they are developed to fit the change (Eisenhardt and Martin 2000; Winter 2003). Since innovation would face high level of uncertainty, dynamic capabilities are a crucial driver in the innovation process. Innovation requires a search for new information outside the existing knowledge base in order to renew and develop its organizational capabilities (March 1991; Lee and Kelley 2008). Hence, dynamic capabilities enable firms to integrate resources to improve innovative outcomes (Lee and Kelley 2008). Arora (2002) argues that a firm with stronger dynamic capabilities could develop better innovations that lead to better new product development performance. Hence, dynamic capabilities positively influence new product development performance (Hsu and Fang 2009).

Applying dynamic capabilities to integrate resources and coordinate activities, new product development teams can quickly develop excellent new products that better match customer needs (Pavlou and El Sawy 2011). It is difficult to imitate other firms' dynamic capabilities, since dynamic capabilities have three traits: inherent complexity, path dependence, and causal ambiguity (Collis 1994; Teece et al. 1997; Lippman and Rumelt 1982). Thus, dynamic capabilities would cause competitive advantages that could positively affect innovation performance (Galunic and Eisenhardt 2001). In contrast, outdated organizational capabilities that neither match market needs nor follow technological trends would cause high level of rigidity and result in poor product development performance (Leonard-Barton 1992). Hence, dynamic capabilities would positively affect new product development performance (Clark and Fujimoto 1991; Iansiti and Clark 1994). Based on the above discussion, we argue that green dynamic capabilities would positively affect green product development performance and propose the following hypothesis:

Hypothesis 4 (H_4) Green dynamic capabilities are positively associated with green product development performance.

The Positive Effect of Green Transformational Leadership on Green Product Development Performance

Leaders play a key role in a new product development team because they could use their knowledge, leadership, empathy, and ability to persuade followers to achieve goals (Edmondson and Nembhard 2009). Previous literature demonstrates that transformational leadership could successfully stimulate innovation performance of organizations (Waldman and Bass 1991). Transformational leadership is beneficial for the development of new ideas in the innovation process, since transformational leaders act

as a catalyst by inspiring followers to consider problems in new ways (Waldman and Bass 1991; Keller 1992). Besides, transformational leadership involves behavior which gets followers to think about new ideas (Keller 1992). Thus, transformational leadership that encourages team members to conceptualize problems from various viewpoints can enhance team creativity (Elkins and Keller 2003).

Transformational leadership could provide support, encourage followers to view problems from new perspectives, and communicate a vision (Bass and Avolio 1990). In addition, transformational leadership has a positive effect on organizational innovation (Jung et al. 2003; Howell and Avolio 1993). Thus, transformational leadership can enhance new product development performance by articulating the vision, setting high performance expectations, inspiring followers with the clear goals, and caring for followers through individual support (Podsakoff et al. 1990; Sarros et al. 2008). According to the above statement, we assert that green transformational leadership has a positive effect on green product development performance and imply the following hypothesis:

Hypothesis 5 (H_5) Green transformational leadership is positively associated with green product development performance.

We argue that green dynamic capabilities and green transformational leadership positively affect green product development performance. In addition, we assert that the relationships between green product development performance and its two drivers—green dynamic capabilities and green transformational leadership—are partially mediated by green creativity. It means that green dynamic capabilities and green transformational leadership can not only directly influence green product development performance positively, but also indirectly influence it positively through green creativity. The antecedents of the research framework are green dynamic capabilities and green transformational leadership and the consequent is green product development performance, while green creativity is a partial mediator. The research framework is shown in Fig. 1.

Methodology and Measurement

Data Collection and the Sample

We apply the questionnaire survey to verify the hypotheses in the Taiwan's electronics industry. There are three reasons to select the Taiwan's electronics industry as research object. First, Taiwan's electronics products which are highly export-oriented face strict environmental regulations, such as Montreal Convention, Kyoto Protocol, Restriction of the Use of Certain Hazardous Substances in EEE (RoHS) Directive, Waste Electronics and Electrical Equipment (WEEE) Directive, Energy Using Product (EuP) Directive, and Integrated Product Policy (IPP) Directive, so that Taiwan's electronics companies need to develop green products which can satisfy their customers' environmental needs (Chen 2010). It is meaningful to investigate the influences of green dynamic capabilities and green transformational leadership on green product development performance and to discuss the mediation role of green creativity when environmental trends become a huge challenge for them. Second, comparing to large multinational enterprises (MNEs), most of Taiwan's electronics companies are small and medium-sized enterprises (SMEs) (Chen et al. 2006), so it is worth discussing environmental management of Taiwan's electronics companies which have no enough resources. Third, Taiwan is a newly emergent manufacturing base in the world. It is interesting to explore how Taiwan's electronics companies enhance their green product development performance via green dynamic capabilities, green transformational leadership, and green creativity, when environmental regulations become stricter and environmental trends become more

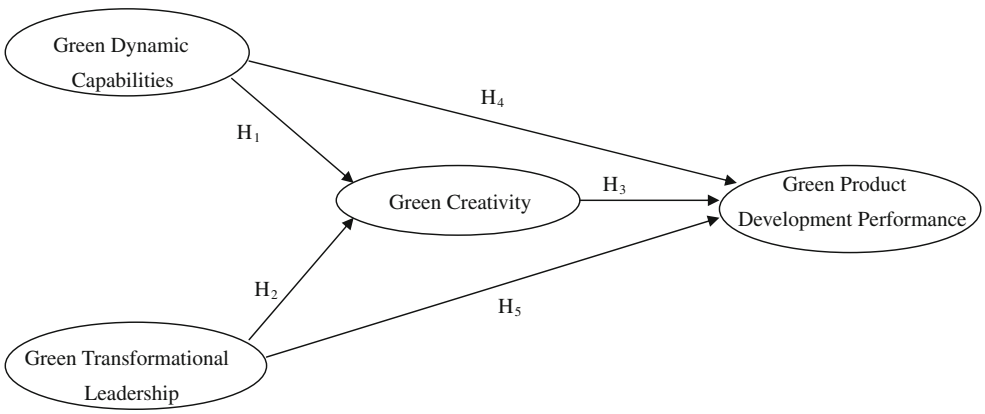


Fig. 1 Research framework

popular. These specific characteristics in the Taiwan's electronics industry can contribute to theoretical development. The sample of questionnaire survey was randomly selected from "Business Directory of Taiwan" of Business Express Co., Ltd. The respondents of the questionnaires are the CEOs, the managers of environmental, marketing, manufacturing, or R&D departments, and leaders and members of green product development projects in the Taiwan's electronics companies. To heighten the valid survey response rate, the research assistants of this study called to each company which was sampled, explained the objectives of the study and the questionnaire contents, and confirmed the names and job titles of the respondents prior to questionnaire mailing. The respondents were asked to return the completed questionnaires within 2 weeks through mailing.

We refer to the past literature to design questionnaire items. Prior to mailing to the respondents, eight experts and scholars were asked to modify the questionnaire in the first pretest. Subsequently, the questionnaires were randomly mailed to 12 CEOs, managers of environmental, marketing, manufacturing, or R&D departments, and leaders and members of green product development projects in different Taiwan's electronics companies and they were asked to fill in the questionnaire and identify the ambiguities in terms, meanings, and issues in the second pretest. High content validity is a necessary requisition for the questionnaire in this study. To avoid common method variance (CMV), the respondents of different constructs in this study are different. The respondents of "green dynamic capabilities" are CEOs or managers of environmental departments. They are asked to evaluate their companies' green dynamic capabilities. This study asked every respondent to point out a specific green product development project which accounts for the most revenues for the company. Then, every respondent was requested to regard this green product development project as the focal one to evaluate its project leader's "green transformational leadership", its project team's "green creativity", and its "green product development performance". The respondents of "green transformational leadership" are members of green product development projects; those of "green creativity" are leaders of green product development projects; and those of "green product development performance" are managers of marketing, manufacturing, or R&D departments in the Taiwan's electronics companies. Eight hundred questionnaires were sent to the selected companies. There are 254 valid questionnaires, and the effective response rate is 31.75 %.

Socially desirable responding (SDR) means the inclination of respondents to fill in questionnaires in a way which is viewed favorably by other persons would influence the validity of questionnaire survey (Nederhof 1985). In order to decrease SDR for the four constructs, we apply the following three ways that include being anonymity, promising of confidentiality, and asking to be honest (Nancarrow et al. 2001). First, the respondents in this paper do not need to reveal their names, titles, and company names in the questionnaires. It is meaningless for the respondents to exaggerate the four constructs in the questionnaires. The level of SDR varies with the level of anonymity in the questionnaires. The more anonymity is assured, the less SDR is detected (Randall and Fernandes 1991). Second, we keep confidentiality all the time. In the questionnaire, we do not only address the questionnaire survey is only for the academic purpose, but also promise of confidentiality for the questionnaire survey. Third, the respondents were asked to fill in the questionnaire honestly. The more honesty is assured, the less SDR is detected (Phillips and Clancy 1972). Thus, there is no SDR in this study.

The Measurement of the Constructs

The measurement of the questionnaire items in this study is by means of "five-point Likert scale from 1 to 5" rating from strongly disagreement to strongly agreement. The definitions and measurements of the constructs in this study are in the following:

Green Dynamic Capabilities

We propose an original notion, 'green dynamic capabilities', and refer to Teece et al. (1997) to define it as "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". Besides, we refer to Pavlou and El Sawy (2011) to measure green dynamic capabilities, and its measurement includes seven items: (1) The company has the ability that can fast monitor the environment to identify new green opportunities; (2) The company has effective routines to identify and develop new green knowledge; (3) The company has the ability to develop green technology; (4) The company has the ability to assimilate, learn, generate, combine, share, transform, and apply new green knowledge; (5) The company has the ability to successfully integrate and manage specialized green knowledge within the company; (6) The company has the ability to successfully coordinate employees to develop green technology; (7) The company has the ability to successfully allocate resources to develop green innovation.

Green Transformational Leadership

We propose a novel notion, 'green transformational leadership', and refer to Bass (1998) and Gardner and Avolio

(1998) to define it as "behaviors of leaders who motivate followers to achieve environmental goals and inspire followers to perform beyond expected levels of environmental performance". Furthermore, we refer to Podsakoff et al. (1996) to measure green transformational leadership, and its measurement includes six items: (1) The leader of the green product development project inspires the project members with the environmental plans; (2) The leader of the green product development project provides a clear environmental vision for the project members to follow; (3) The leader of the green product development project gets the project members to work together for the same environmental goals; (4) The leader of the green product development project encourages the project members to achieve the environmental goals; (5) The leader of the green product development project acts with considering environmental beliefs of the project members; (6) The leader of the green product development project stimulates the project members to think about green ideas.

Green Creativity

We propose an original notion, 'green creativity', and refer to Amabile (1988) to define it as "the development of new ideas about green products, green services, green processes, or green practices that are judged to be original, novel, and useful". In addition, we refer to Rego et al. (2007) and Barczak et al. (2010) to measure green creativity and its measurement includes six items: (1) The members of the green product development project suggest new ways to achieve environmental goals; (2) The members of the green product development project propose new green ideas to improve environmental performance; (3) The members of the green product development project promote and champion new green ideas to others; (4) The members of the green product development project develop adequate plans for the implementation of new green ideas; (5) The members of the green product development project would rethink new green ideas; (6) The members of the green product development project would find out creative solutions to environmental problems.

Green Product Development Performance

We propose a novel notion, 'green product development performance', and define it as "the development performance of products that have less of an impact on the environment, are less detrimental to human health, are formed or part-formed from recycled components, are manufactured in a more energy-conservative way, or are supplied to the market with less packaging". Besides, we refer to Marsh and Stock (2006) to measure green product development performance and its measurement includes five items: (1) The green product development project contributes a key source of revenues to the company; (2) The green product development project develops excellent green products; (3) The green product development project continually improves its development processes over time; (4) The green product development project is more innovative in green product development than its competitors; (5) The green product development project can meet its environmental goals in green product development.

Empirical Results

The Results of the Measurement Model

The means, standard deviations, and correlation matrix are shown in Table 1. In Table 1, there are positive correlations among the four constructs: green dynamic capabilities, green transformational leadership, green creativity, and green product development performance. The factor analysis of the four constructs is shown in Table 2. Every construct in this study can be classified into only one factor. We refer to the prior research to design questionnaire items. Before mailing to the respondents, we employ two pretests for the questionnaire revision. Therefore, the measurement of this study is acceptable in content validity. Besides, there are several measures to confirm the reliability and validity of the measurement. On one hand, one measure of the reliability is to examine the loadings of each constructs' individual items. With respect to the quality of the measurement model, the loadings (λ) of all items of the four constructs listed in Table 3 are significant. On the other hand, Cronbach's α is the other measure of the reliability. Table 3 lists Cronbach's α of the four constructs. In general, the minimum requirement of Cronbach's α coefficient is 0.7 (Hair et al. 1998). In Table 3, the Cronbach's α coefficient of "green dynamic capabilities" is 0.897; that of "green transformational leadership" is 0.903; that of "green creativity" is 0.913; that of "green product development performance" is 0.920. Because the Cronbach's α coefficients of all constructs are more than 0.7, the reliability of the measurement in this study is acceptable.

In addition, we apply Fornell and Larcker's (1981) measure of average variance extracted (AVE) to evaluate the discriminant validity of the measurement. The AVE measures the amount of variance captured by the construct through its items relative to the amount of variance due to the measurement error. To satisfy the requirement of the discriminant validity, the square root of a construct's AVE must be greater than the correlations between the construct and the other ones in the model. For example, the square roots of the AVEs for the two constructs, green dynamic capabilities and green product development performance,

Table 1 Means, standard deviations, and correlations of the constructs

Constructs	Mean	Standard deviation	A	B	C
A. Green dynamic capabilities	3.736	0.582			
B. Green transformational leadership	3.702	0.571	0.361*		
c. Green creativity	3.723	0.587	0.359*	0.352*	
D. Green product development performance	3.743	0.578	0.368**	0.342*	0.337*

* $p < 0.05$, ** $p < 0.01$

Table 2 Factor analysis of this study

Constructs	Number of items	Number of factors	Accumulation percentage of explained variance
Green dynamic capabilities	7	1	64.6
Green transformational leadership	6	1	62.5
Green creativity	6	1	61.8
Green product development performance	5	1	58.4

Table 3 The items' loadings (λ) and the constructs' Cronbach's α coefficients and AVEs

Constructs	Items	λ	Cronbach's α	AVE	The square root of AVE
Green dynamic capabilities	GDC1	0.877**	0.897	0.742	0.861
	GDC2	0.879**			
	GDC3	0.883**			
	GDC4	0.891**			
	GDC5	0.868**			
	GDC6	0.892**			
	GDC7	0.887**			
Green transformational leadership	GTL1	0.871**	0.903	0.755	0.869
	GTL2	0.869**			
	GTL3	0.865**			
	GTL4	0.874**			
	GTL5	0.883**			
	GTL6	0.869**			
Green creativity	GC1	0.857**	0.913	0.739	0.860
	GC2	0.866**			
	GC3	0.870**			
	GC4	0.865**			
	GC5	0.863**			
	GC6	0.874**			
Green product development performance	GPD1	0.855**	0.920	0.751	0.867
	GPD2	0.863**			
	GPD3	0.879**			
	GPD4	0.866**			
	GPD5	0.868**			

** $p < 0.01$

are 0.861 and 0.867 in Table 3 which are more than the correlation, 0.368, between them in Table 1. It demonstrates that there is adequate discriminant validity between the two constructs. The square roots of all constructs' AVEs in Table 3 of this study are all more than the correlations among all constructs in Table 1. Therefore, the discriminant validity of the measurement in this study is acceptable. In addition, if the AVE of a construct is higher than 0.5, it means that the convergent validity of the construct is acceptable. In Table 3, the AVEs of the four constructs are 0.742, 0.755, 0.739, and 0.751, that are all higher than 0.5. It indicates that the convergent validity of the measurement is acceptable. Based on the above results, the reliability and validity of the measurement in this study are acceptable.

The Results of the Structural Model

We utilize SEM to verify the hypotheses and apply AMOS 17.0 to obtain the empirical results. Table 4 shows the results of the structural model in this study. The overall fit measures of the full model in the SEM indicates that the fit of the model is acceptable (GFI = 0.903, RMSEA = 0.046, NFI = 0.906, CFI = 0.908). All of the paths estimated are significant, and all hypotheses are supported in this study. Adding more paths in the research framework would not significantly improve the fit measures. The residuals of the covariance are small and center near 0. The results of the full model in this study are shown in Fig. 2. All five paths estimated are significantly positive. Therefore, H_1, H_2, H_3, H_4, and H_5 are all supported in this study. We find out that the increase of both of green dynamic capabilities and green transformational leadership can not only meet both of the strict international environmental regulations and the popular consumer environmentalism, but also enhance both of green creativity and green product development performance. We demonstrate that green dynamic capabilities and green transformational leadership are two crucial drivers of

Table 4 The results of the structural model

Hypothesis	Proposed effect	Path coefficient	Results
H_1	+	0.252*	H_1 is supported
H_2	+	0.247*	H_2 is supported
H_3	+	0.263*	H_3 is supported
H_4	+	0.302**	H_4 is supported
H_5	+	0.277*	H_5 is supported

* $p < 0.05$, ** $p < 0.01$

green product development performance. In addition, we prove that green creativity partially mediates the positive relationships between green product development performance and its two drivers—green dynamic capabilities and green transformational leadership. It means that green dynamic capabilities and green transformational leadership can not only directly affect green product development performance positively, but also indirectly affect it positively via green creativity. Based on the above research results, we suggest that companies should raise their green dynamic capabilities, green transformational leadership, and green creativity to enhance their green product development performance to satisfy their customers' environmental needs.

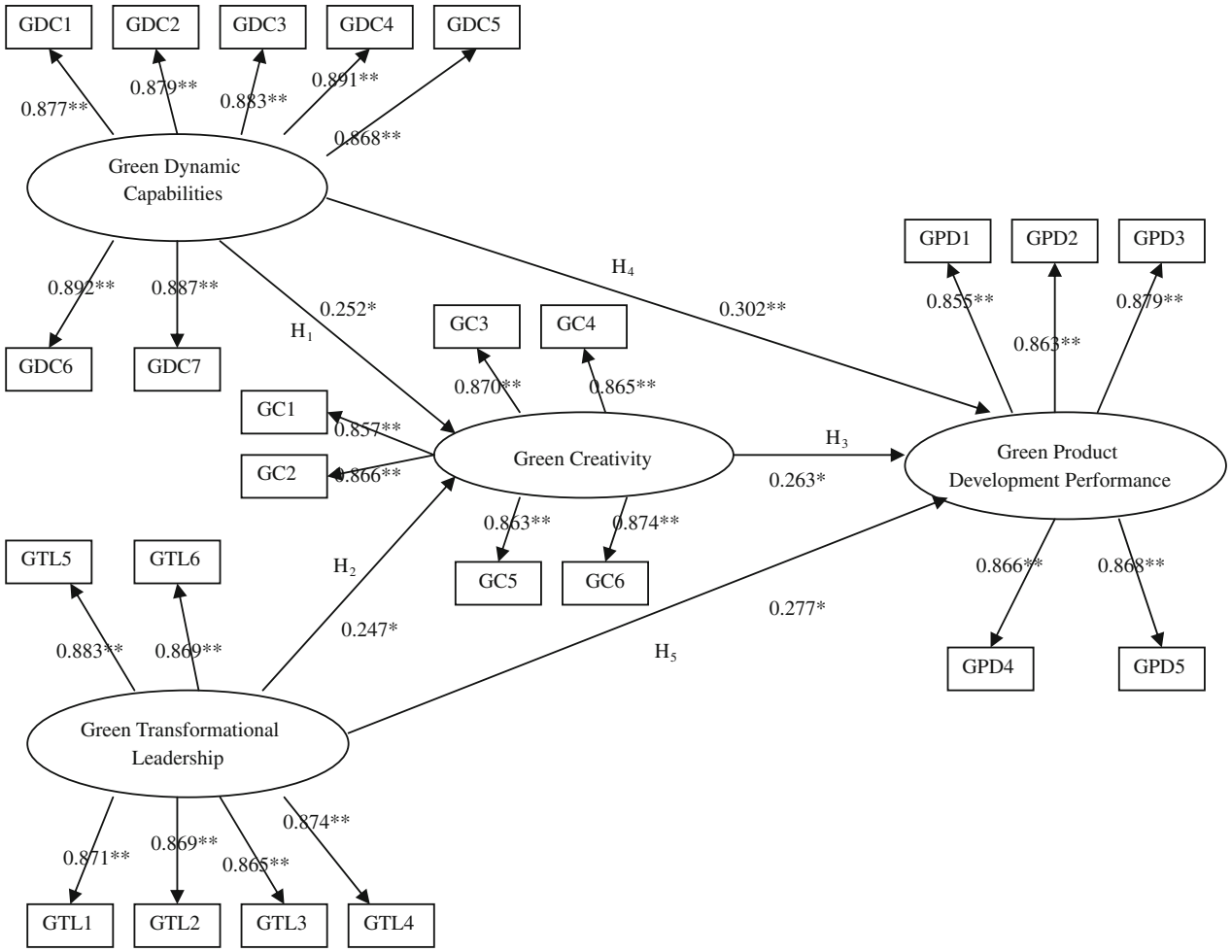
Conclusions and Implications

The literature is not conclusive on how to enhance green product development performance in an integrated framework under the context of environmentalism. Thus, we provide an approach about dynamic capabilities and transformational leadership to improve the green product development performance in the environmental era. Furthermore, we develop a research framework of green product development performance to discuss its relationships with green dynamic capabilities, green transformational leadership, and green creativity. The empirical results show that green dynamic capabilities and green transformational leadership positively relate to both of green creativity and green product development performance. In addition, we find out that the positive relationships between green product development performance and its two drivers—green dynamic capabilities and green transformational leadership—are partially mediated by green creativity. All hypotheses proposed in this study are supported. Therefore, investing resources in the increase of green dynamic capabilities, green transformational leadership, and green creativity is helpful to increase green product development performance.

The main purpose of this paper is to explore the relationships between green product development performance and its two drivers—green dynamic capabilities and green transformational leadership—and to examine the partial mediation effect of green creativity. Companies have to increase their green dynamic capabilities, green transformational leadership, and green creativity in order to raise their green product development performance. A useful starting point for companies is to develop both of green dynamic capabilities and green transformational leadership to improve green product development performance. Besides, green creativity is crucial to determine green product development performance. Companies need to enhance the green creativity of their green product development teams, since green creativity would mediate the positive relationships between green product development performance and its two drivers—green dynamic capabilities and green transformational leadership.

There are four academic contributions in this study. First, we combine the concepts of dynamic capabilities, transformational leadership, creativity, and green management to propose a research framework of green product development. Second, we develop a framework to enhance green product development performance. We prove that green dynamic capabilities and green transformational leadership positively influence green product development performance. Third, we demonstrate that green creativity partially mediates the positive relationships between green product development performance and its two drivers—green dynamic capabilities and green transformational leadership. Fourth, this paper extends the research of dynamic capabilities, transformational leadership, creativity, and product development into the field of green management.

There are four practical contributions in this study. First, we verify that enhancing green dynamic capabilities and green transformational leadership can not only increase green creativity, but also raise green product development performance. If companies would like to enhance their green product development performance, they should incorporate the concepts of green dynamic capabilities, green transformational leadership, and green creativity into their long-term environmental strategies in the stage of strategy-planning. Second, in a more sophisticated context of product development, it is worth educating experienced leaders of green product development projects to increase green dynamic capabilities, green transformational leadership, and green creativity in order to raise green product development performance. Third, companies need to enhance green creativity of their green product development projects, since there is a significant mediation effect of green creativity according to the results of this study. We find out that both of green dynamic capabilities and green transformational leadership can not only directly influence green product development performance positively but also indirectly influence it positively via green



GFI=0.903, RMSEA=0.046, NFI=0.906, CFI=0.908

Note: * p<0.05, ** p<0.01.

Fig. 2 The results of the full model

creativity. Fourth, since green product development has become an effective approach to develop differentiation and positioning strategies nowadays, firms should exploit green product development to differentiate and to position their products in order to seize new green markets. Thus, firms have to integrate green dynamic capabilities, green transformational leadership, and green creativity into their long-term strategies to improve their green product development performance.

There are three directions with respect to future research in the study. First, we focus on the electronics industry of Taiwan. Future research can focus on other industries and compare with this study. Second, we focus on Taiwan's companies. Future research can focus on other countries' companies and compare with this study. Third, we test the hypotheses by means of questionnaire survey which only provides cross-sectional data so that we cannot demonstrate the dynamic change of green dynamic capabilities, green transformational leadership, green creativity, and green product development performance in the different stages. Therefore, future research can focus on the longitudinal study to investigate the differences of green dynamic capabilities, green transformational leadership, green creativity, and green product development performance in the different stages. We hope that the research results are useful for managers, researchers, practitioners, and policy makers, and contribute to future research as reference.

Acknowledgments The authors are grateful for the funding of National Science Council in Taiwan for this study, and the project number of this study is 101-2410-H-305-074-MY3.

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