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Green Innovation Sustainability: How Green Market Orientation and Absorptive Capacity Matter?

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Abstract: Although there has been much research into green innovation, limited studies focus on the influence of internal factors on green innovation. This paper investigates whether and how two internal factors, such as green market orientation and absorptive capacity, facilitate green innovation. By dividing green innovation into green product innovation and process innovation, we also test the differential effects of the two internal factors on green product innovation and process innovation. Using a survey of 262 manufacturing firms in China, our results show that green market orientation improves only green product innovation, not green process innovation, whereas green absorptive capacity improves green product innovation and process innovation simultaneously. Green market orientation (green absorptive capacity) has a stronger impact on green product (process) innovation than on green process (product) innovation. Further, we find that a positive interaction effect of green market orientation and absorptive capacity on green product innovation and process innovation is significant. The findings contribute to the green innovation literature by providing an integrated framework for exploring whether the pursuit of green market intelligence and technological knowledge improves green product innovation and process innovation.

Keywords: green market orientation; green absorptive capacity; differential effect; synergy; green product innovation; green process innovation

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1. Introduction

In the new trend of economic globalization, the wave of green production and consumption sweeps the industrial fields. A growing number of firms align competitive priorities with environmental strategies [1]. The dimensions of competitiveness among the enterprises are not only cost, quality, and delivery, but also environmental standards [2]. Firms can provide customer value to turn threats into opportunities through green initiatives [3]. Therefore, green innovation plays a potentially important role in terms of achieving sustainability for enterprises.

Extant research convincingly suggests that green innovation is regarded as a critical approach to reducing the adverse effects on the natural environment for corporate social responsibility [4,5]. Green innovation, which is different from traditional innovation, involves environmental requirements and requires adopting environmental regulations and rules to save the consumption of resources and reduce environmental pollution [6]. According to the classifications of traditional innovation, green innovation includes two primary strategic patterns: green product innovation and green process innovation [7–9]. Green product innovation involves the development of new products designed with environmental standards, which serve as raw materials that reduce firm energy consumption and environmental pollution or serve as popular goods that are beneficial to human health and the ecological environment [10]. Green process innovation involves eco-designing production processes to help firms recycle materials, save energy, and reduce environmental pollution through green technology improvements. With the exception of a few studies [11], most research on green innovation addresses a broad, all-encompassing construct instead

of distinguishing between green product innovation and green process innovation [12–14]. However, firms need both forms of green innovation to respond to environmental problems and achieve sustainability.

The activities relating to green product innovation and green process innovation are cost, complexity, time-consumption, and successful green innovation in enterprises remains difficult. Emerging from green innovation research, a key question is why some green innovations succeed while others fail. Numerous studies have examined external triggers that are conducive to green innovation, such as environmental regulations, market environment, and governmental policy [7,15,16]. However, limited attention is given to internal factors that affect green innovation outcomes. The literature highlights two essential internal drivers of green innovation. First, green market orientation is undoubtedly crucial for enterprises to achieve environmental management [17]. It reflects an enterprise's strategic posture, provides a thorough understanding of the intelligence of existing and potential markets, and aids in enterprises successfully capturing opportunities to pursue green innovation [18,19]. Second, green absorptive capacity, the ability of enterprises to learn and create new green knowledge, is an essential requirement for green innovation [7,20]. Green absorptive capacity particularly nurtures the capacities of learning new knowledge and solving environmental problems, which in turn influences the effectiveness of green innovation [21].

Green market orientation is regarded as a valuable strategic resource in green management literature, which impacts the extent to which firms make efforts to respond to pivotal information about customers' needs and competitors' actions [22,23]. Scholars have accentuated that market orientation facilitates the firms to keep abreast of the changes in the external marketplace [24]. Equally, researchers have suggested that, as firms become more aware of the market and customers' expectations of environmental products, they can adjust their organizational and environmental objectives and further devise better approaches to satisfy them [25]. However, the controversy remains, as some studies have indicated that guiding firms to focus on customer demand does not significantly impact green innovation [2]. Therefore, more attention should be paid to the influence of green market orientation on green innovation.

Likewise, green absorptive capacity is another important internal factor that influences the direction and intensity of green innovation [12]. Green innovation needs a lot of technical knowledge support. Previous literature in the innovation field paid a lot of attention to the absorptive capacity of technological knowledge [7]. In the green innovation context, such emphasis on green absorptive capacity may help enterprises to nurture green innovation. Therefore, this study focuses on the advantage of green absorptive capacity in the R&D field. Scholarly research has affirmed that the green absorptive capacity of environmental knowledge has the fundamental dynamic capability of fostering green innovation for responding to environmental pressure [26]. Extant research has demonstrated that the green absorptive capacity is important for green product innovation and green process innovation since green technological knowledge is one of the central principles and driving forces of firms' green innovation [27,28]. On the one hand, firms can acquire, disseminate, and utilize new green technological knowledge in the external environment to facilitate green innovation; on the other hand, firms tend to recognize and absorb the adverse effects of their operations on the ecological environment which further spur them on to develop environmentally orientated products and processes.

Nevertheless, prior research on green innovation has predominately explored the individual impact of either green market orientation [13] or green absorptive capacity [1,12] on green innovation. Little is known about the impact of the two on green innovation when considered simultaneously. Extant literature has argued that the two mechanisms are comparable but distinctive [27]. Najafi-Tavani et al. [29] have suggested that market orientation and absorptive capacity are complementary in an R&D context. Specifically, green market orientation and green absorptive capacity are not mutually exclusive, which could be simultaneously pursued for exploring new innovation opportunities and enhancing

its competitive advantage [27]. Furthermore, both market intelligence and technological knowledge are viewed as important determinants of innovation effectiveness [30]. Some researchers suggest that some valuable market information should be combined with technological absorptive capabilities in order to motivate innovation activities [31,32]. Others argue that the interaction between market orientation and absorptive capacity may not generate an innovative outcome. In addition, few researchers focus on a green R&D context when studying the complementary effect of market orientation and absorptive capacity. Therefore, further research needs to be done to explore the complementary effects of green market orientation and green absorptive capacity in green technological innovation.

Although a few studies have discussed the effect of green market orientation and green absorptive capacity on firms' green innovation, their inconsistent and unclear results suggest that the role of green market orientation and green absorptive capacity in nurturing green innovation deserves further exploration. First, many studies do not distinguish between two forms of green innovation (that is, green product innovation and green process innovation). Green product innovation and green process innovation are two heterogeneous innovative behaviors that can occur individually and simultaneously [2,33]. Second, the existing literature has not discussed the differential effects of green market orientation and green absorptive capacity on green product innovation and green process innovation. Green market orientation or green absorptive capacity may have a different effect on green product innovation and green process innovation. Finally, few studies have integrated green market orientation, green absorptive capacity, and green innovation into a holistic research framework. Most of the literature explores the influence of green market orientation or green absorptive capacity on green innovation [12,13] but does not examine whether the simultaneous development of both green market orientation and green absorptive capacity can contribute to superior green innovation. Utilizing panel data collected from an online survey of 262 Chinese manufacturing firms in different industries, this study addresses the aforementioned research gaps by examining the differential and synergistic roles of green market orientation and green absorptive capacity on firms' decisions regarding whether to undertake green innovation initiatives.

This study offers several theoretical contributions to scholars in green management and practical implications to enterprise managers for sustainability. Theoretically, through empirically analyzing the individual and combined effects of green market orientation and green absorptive capacity on green product innovation and green process innovation, we can illuminate the theoretical problem of tying up both green market intelligence and technological knowledge to maintain a robust level of green innovation within the existing green management literature [34]. Practically, understanding this can help firms' managers make an informed decision regarding how their resources and capabilities could be best guided. This guidance is crucial and timely because both the urgent requirement of the ecological environment and firms' sustainability is encouraging firms to strengthen green product innovation and green process innovation. Finally, our research results can facilitate the development of manufacturing firms in emerging economies.

2. Theoretical Background and Research Hypotheses

In the literature on corporate environmental management, the Natural Resource-based View (NRBV) is often applied for analyzing and explaining the links between a firm's resources, capabilities, and the effectiveness of green innovation [22,35,36]. According to the NRBV, firms must adjust their resources and capabilities and further make changes to address changing environmental pressure [25]. These changes often involve the development of new things or the improvement of current things that can be regarded as innovations [37]. Therefore, firms' investment in green innovation may play a pivotal role. According to Tariq et al. [38], green innovation is divided into green product innovation and green process innovation. Green product innovation reflects the development of new or improved products by the usage of environmentally healthier materials and the removal of hazardous substances in order to reduce environmental pollution and energy

consumption [10]. It helps firms to attract new customers or maintain current customers by exploiting green market opportunities, thus responding to environmental pressure. Meanwhile, green process innovation reflects the implementation of a new or significantly improved production in order to reduce harmful air and waste water emissions, improve resource and energy efficiency, and recycle waste [39], which help firms to gain a competitive advantage through lowering overall cost and result in greater efficiency. Final products and production processes must be adapted so that firms can invest more in technological improvements to the design of new products and the production process [2,40]. Though sustainable green innovation addresses environmental issues explicitly and leads to the balance between financial and environmental performance, it is not clear for firms to recognize which factors can foster green innovation.

The NRBV proposes that, as environmental issues become increasingly severe, firms are required to develop resources and capabilities to monitor and control the influence of their products and production process on the natural environment [12,22]. The ultimate goal is to stimulate green innovation through the allocation of internal resources and capabilities to achieve long-term sustainable development. These resources and capabilities can manifest in green market orientation and green absorptive capacity [7,13]. On the one hand, green market orientation is regarded as a valuable resource that encourages firms to build and keep in contact with the external environment, and further helps firms to identify customers' needs and monitor competitors' activities [1,41]. It can facilitate firms to improve their product and process or introduce new ones, thus achieving their goals of environmental management through satisfying potential green market needs. On the other hand, green absorptive capacity is viewed as a significant capability that can impact green innovation adoption [12]. Since this study examines the absorptive capacity of technological information, it can promote firms to learn about new technologies from the external environment to add features for a given product or to introduce clean and end-of-pipe technologies for the production process. Most innovative firms need to absorb, recognize, and employ external market intelligence and technological knowledge [42]. Thus, green market orientation and green absorptive capacity play crucial roles in enhancing green innovation.

In this section, we propose a theoretical framework depicting the individual and combined effects of green market orientation and green absorptive capacity on green product innovation and green process innovation. Figure 1 presents our theoretical framework.

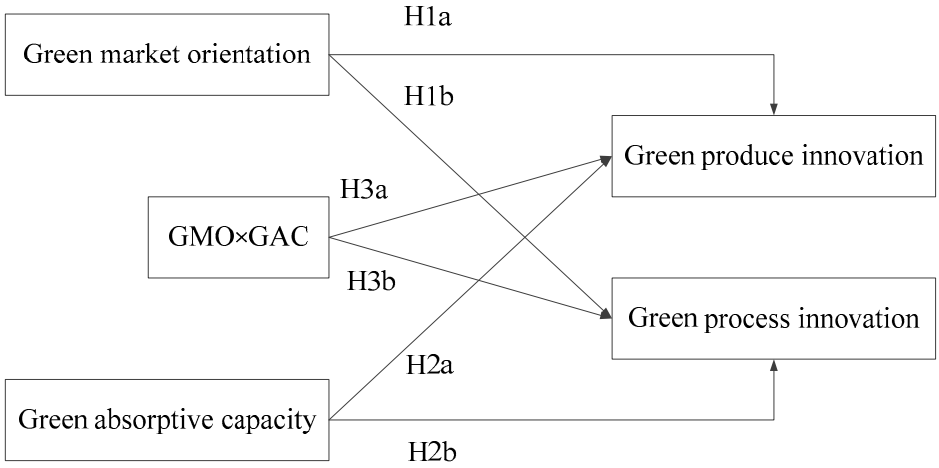


Figure 1. Theoretical framework.

2.1. Green Market Orientation and Green Innovation

Market orientation is first introduced as a new conception by Kohli and Jaworski [43], referring to firms' strategic orientation to generate, disseminate, and respond to market intelligence about customers' demands and competitors' operations. It reflects a respon-

sive approach to the external market environment, thus helping firms build a bond with customers and monitor competitors [44]. Such activities make firms aware of their latent drawbacks, resulting in more refinement and improvement. Moreover, gathering market information can help firms in searching for new innovation opportunities by identifying and analyzing potential, unsatisfied market needs, or keeping a watchful eye on problems that customers are usually able to express [45,46]. This will allow firms to improve their current products or processes and introduce new ones. Therefore, firms with a market orientation have a better understanding of the market environment to improve their innovative ability, generating long-term customer value to achieve sustainable competitive advantages.

However, as environmental problems become increasingly severe, it is very essential for firms to take the natural environment into account in implementing market orientation. Crittenden et al. [41] have suggested that firms should extend the market orientation by incorporating the demands of environmental issues. According to the Stakeholder theory, green market orientation extends market orientation by arguing that a firm should achieve goals beyond just economic interests. It means that profitable enterprises should take a more balanced approach whereby firms can adjust their organizational objectives to avoid harm to the environment, rather than make money by unscrupulous means [47]. Some scholars have suggested that green market orientation can help firms to develop unique capabilities to achieve superior environmental and financial performance. Chen et al. [1] define green market orientation as the guidance by which firms' managers can realize the importance of environmental issues that their firm should face. Li et al. [25] consider green market orientation as a company's philosophy in increasing its customers' satisfaction through providing green products and services. Wang and Chao [13] regard green market orientation as an organization's response to its customers' needs and competitors' engagement in environmental management. Here, we define green market orientation as the strategic resource that enables firms to develop unique capabilities to guide their direction toward acquiring and responding to the environmental needs of their customers and competitors' operations of environmental management.

Green market orientation represents a strategic posture and market-based approach, which focuses primarily on directing firms to understand customers' environmental demands and monitor competitors' environmental strategies. As suggested by Medeiros et al. [48] and Xie et al. [49], consumer needs and expectation fulfillment are often key driving forces for firms to implement new product developments. That is, market demand affects organizational decisions to increase production efficiency and reduce the consumption of energy and the emission of hazardous substances in production [50]. Green market orientation encourages firms to build and maintain bonds with their current market and put market intelligence at the center of organizational corporate operations and activities. Firms with a green market orientation have superior market-sensing and customer-linking capacities regarding environmental issues, which help firms to move to green innovation [10].

On the one hand, the high level of green market orientation favors firms' sensing new ideas through carefully identifying and analyzing customers' environmental demands, and increases firms' proactiveness to improve their green products or introduce new ones [51,52]. According to the demand-pull theory, market demands are very valuable to the development of green products [50]. That is, using green market orientation, firms can acquire a green market knowledge advantage through generating and disseminating customers' intelligence, thus responding to customers' demands by transforming this knowledge into green products. In addition, in an intensely competitive environment, firms with a high level of green market orientation have competitive-sensing abilities that acquire green market intelligence from various competitors [13]. This environmental information allows firms to predict their future environmental products. Without this information, firms will not confidently develop green product innovation plans. So, a green market orientation promotes the firm's movement to implement green product innovations.

On the other hand, it should be noted that firms not only implement green product innovation to respond to market demand and competitors' activities but also change their original production patterns [53]. The green production process represents the green image of a firm. Consumers' attention is increasingly paid to the environmental benefits and energy savings of the production of a product. Consumers' attention will be attracted by a green image from environmentally friendly firms [54]. Thus, a green market orientation firm shows good identification for environmentally friendly customers and captures competitors' environmental strategy information. This may motivate a firm to maintain a green image for customer acquisition and retention by the implementation of green process innovations. Moreover, green process innovation requires different green knowledge from competitors [13]. Green market orientation helps firms to monitor the external market and assess the competitive landscape [55]. Such activities will help firms to identify green technological innovation directions to maintain and enhance their competitive position. Thus, firms with a strong green market orientation will enhance process innovation capability regarding environmental issues. Accordingly, we propose that:

Hypothesis 1a (H1a). *Green market orientation has a positive impact on green product innovation.*

Hypothesis 1b (H1b). *Green market orientation has a positive impact on green process innovation.*

It is consistent with the view that the two forms of green innovation evolve from different aspects of organizational operations [38]. While green market orientation could enhance both forms of green innovation, we should adopt the view that the magnitude with which green market orientation drives either form of innovation is not equivalent. Green market orientation mainly focuses on gathering market intelligence [25]. The motivation for green product innovation mainly originated from market forces since its primary aim is to develop new market opportunities and satisfy customers' needs as best as possible [10]. Although green market orientation may entail the capacity to recognize customer appeals for the green production process, a market-based approach is insufficient for green process innovation. This is because green market orientation encourages firms to maintain bonds with their customers and understand the current market need, rather than offer technological knowledge. Alternatively, green process innovation aims to improve production processes, reduce energy consumption, and maintain ecological sustainability, which lowers overall costs and results in greater efficiency. However, these benefits are not directly available to customers [56]. In contrast, although developing green products is more costly, they can offer better green products to respond to market demand because environmentally friendly consumers are willing to give a high price for better green products [57]. Compared with green process innovation, green product innovation puts more emphasis on satisfying the current market and attracting new customers [58]. Though more costly, time-consuming, and difficult, green product innovation is more visible and is directly beneficial to customers [59]. Thus, when firms with a high level of green market orientation have a thorough understanding of customer environmental demands, they prefer to undertake green product innovation because it is more likely to gain customers' trust. Therefore, we think that the links between green market orientation and green product innovation are stronger than those between green market orientation and green process innovation. Accordingly, we propose that:

Hypothesis 1c (H1c). *Green market orientation will have a stronger impact on green product innovation than green process innovation.*

2.2. Green Absorptive Capacity and Green Innovation

Over the past three decades, the literature on absorptive capacity has grown. Absorptive capacity, first defined in the R&D context by Cohen and Levinthal [42], refers to the ability to identify external value information, acquire this knowledge, integrate it into the current knowledge base, and employ it in an organizational operation. Most research

has confirmed that absorptive capacity is a vital capacity for acquiring and exploiting external knowledge to nurse innovation and competitive capacities [60]. As environmental problems become increasingly severe, firms need to gather timely green information that is critical for implementing green practices. It is very essential for firms to take environmental issues into account in an organizational capacity. Delmas et al. [26] have suggested that firms should extend their absorptive capacity by incorporating environmental standards. Chen et al. [61] suggest that green absorptive capacity extends absorptive capacity by arguing that a firm should achieve green growth through utilizing external environmental knowledge. Although some studies have extended the definition and context effects of absorptive capacity, most studies focus on the R&D context. Technological knowledge is a critical component of absorptive capacity in the innovation process since a firm's central principle and driving force for achieving a competitive advantage is its technological capacity. Green strategies mainly place emphasis on green technological innovation in the environmental management field since green innovation needs a lot of technical knowledge support. Therefore, this study focuses on the advantage of green absorptive capacity in the R&D field, particularly technological knowledge. We define green absorptive capacity as the ability to acquire, assimilate, transform, integrate, and exploit external green technological knowledge. This capacity reflects a learning capacity and knowledge-based approach, which helps firms to add new green technological knowledge to their existing knowledge base, create new green technological knowledge from a novel combination of new and existing technological knowledge, and utilize this knowledge in green innovation.

Green innovations are the result of searching for green technological competitiveness. According to Zieger and Nogareda [62], in order to develop green innovation effectively, particular criteria must be met. First, it must be based on green technological knowledge. Second, new products or processes must be introduced. When firms implement a green development strategy, they should spend more time and resources on recognizing, acquiring, assimilating, understanding, and applying green technological knowledge in order to develop green products and production processes. Some scholars in the green management field have pointed out that firms with green absorptive capacity are able to recognize the environmental issues and, thus, know how to overcome green inertia [63]. Specifically, a high level of green absorptive capacity helps firms to respond to uncertainties inherent in the juxtaposition of green innovation [1]. Therefore, we suggest that the green absorptive capacity of technological knowledge has a positive and significant influence on green product innovation and green process innovation.

Green product innovation mainly aims to change product designs by using nontoxic or biodegradable materials in order to provide the market with new or improved eco-friendly products [10]. Green process innovation aims to modify the production process by introducing new clean technologies and end-of-pipe technologies. The two primary strategies both concern firms' technological competencies. Thus, the knowledge necessary for green product innovation and green process innovation is based on specific technology [62]. Acquiring green technological knowledge will exhibit a stronger association with an external search than an internal one. Green absorptive capacity is the organizational mechanism that enables firms to acquire, transform, and apply external green technological knowledge. According to Zhang et al. [7], the extent to which green product innovation and green process innovation work effectively depends on the absorptive capacity of technological knowledge. Firms with a high level of green absorptive capacity can scan and assimilate green technological knowledge existing in the external environment, thereby enhancing green product innovation and green process innovation. Albort-Morant et al. [64] have demonstrated that firms' absorption of external technological knowledge concerning environmental issues fosters green product innovation and green process innovation. Therefore, high green absorptive capacity enables firms to develop new environmentally-oriented products and processes. Accordingly, we propose that:

Hypothesis 2a (H2a). *Green absorptive capacity has a positive impact on green product innovation.*

Hypothesis 2b (H2b). *Green absorptive capacity has a positive impact on green process innovation.*

While green absorptive capacity could enhance both forms of green innovation, we should adopt the view that the magnitude with which green absorptive capacity drives either form of innovation is not equivalent. More specifically, in the relationship between green absorptive capacity and green innovation, there are different effects of green absorptive capacity on green product innovation and green process innovation. Although the positive impact of green absorptive capacity on green innovation has been empirically confirmed by many researchers in the green management field, which form of green innovation is more effective has rarely been explored [12,20]. This study argues that green absorptive capacity will have a stronger effect on green process innovation than green product innovation. According to Giuseppe [65], among the forces which actuate firms to decide to undertake a process innovation, an emphasis is put on external technological opportunities in collaborative agreements between firms or research institutions. The absorptive capacity of technological knowledge realizes the benefits of collaborative innovation networks and reflects effective learning in collaboration with other firms [66]. Process innovation is rather complex and represents a technological frontier and needs various kinds of knowledge. Thus, when firms have a high level of green absorptive capacity, they are in a better position to develop and exploit green technological knowledge acquired through collaborative innovation networks, thereby being more likely to invest time and money into cleaner technologies or end-of-pipe technologies to reduce air or water emissions and lessen energy consumption. In contrast, the fundamental purpose of green product innovation is to fulfill the requirements of environmentally friendly consumers [67]. Among the driving forces which impact firms' decision to employ green product innovation, an emphasis is put on market demands [68]. In comparison to green process innovation, green product innovation may show a low propensity to requirements of technological knowledge. Therefore, we anticipate that the links between green absorptive capacity and green process innovation are stronger than those between green absorptive capacity and green product innovation. Accordingly, we propose that:

Hypothesis 2c (H2c). *Green absorptive capacity will have a stronger impact on green process innovation than green product innovation.*

2.3. The Synergistic Effects of Green Market Orientation and Green Absorptive Capacity on Green Innovation

In the innovation literature, studies have emphasized the importance of market intelligence and technological knowledge [67]. Green market orientation primarily reflects a market-driven approach, which mainly focuses on listening to customer voices, monitoring competitor dynamics, understanding market demands, and adapting offering [13]. Green absorptive capacity reflects a technology-push approach, which puts an emphasis on scanning, acquiring, combining, and utilizing external technological knowledge [63]. Since innovation is driven both by the market and technology. The market-driven and technology-push perspectives should be regarded as complementary, not mutually exclusive [68]. The simultaneous investment in both green market orientation and green absorptive capacity may positively impact green product innovation and green process innovation. Thus, research conducted in the context of a firm's green innovation argues that green market orientation and green absorptive capacity should go hand-in-hand.

Furthermore, Stefano et al. [69] suggest that market intelligence and technological knowledge are mutually related and complementary. In order to gain superior innovation, firms need to develop both concurrently and their potential synergies. Moreover, the literature on green management has emphasized that in order to increase green innovation and sustainability, it is very important for firms to engage with technological knowledge acquired from external collaborators in satisfying market demands for environmentally friendly products [49]. This view is consistent with Rakthin et al. [27] who have suggested that the dual strategy of both market orientation and absorptive capacity can mutually

promote innovation. Similarly, Renko et al. [70] note that "market orientation and absorptive capacity may not be unique resources, individually, and cannot develop into successful innovation, but their combination can create a unique resource and capability for firms". Therefore, a proper condition configuration of green market orientation and green absorptive capacity would enhance firms' green knowledge concerning their market demands and technological information, thus producing complementary market-driven and technology-push strategies.

Hence, we propose the following synergistic effects of green market orientation and green absorptive capacity on green product innovation or green process innovation:

Hypothesis 3a (H3a). *The interaction between green market orientation and green absorptive capacity positively influences green product innovation.*

Hypothesis 3b (H3b). *The interaction between green market orientation and green absorptive capacity positively influences green process innovation.*

3. Methods

3.1. Samples and Data Collection

To examine the theoretical model proposed, we collected data via a survey approach. The data are gathered from Chinese manufacturing firms located in Shaanxi, Henan, Jiangsu, and Guangdong. These regions represent different levels of culture and economy. Manufacturing firms face increasing environmental challenges, such as air pollution, waste of water resources, and energy dissipation. Manufacturing firms were identified from the business directory of the local government. Most manufacturing firms generally discharge pollutants beyond the average environmental pollution. So, it is more likely for them to introduce green innovation and deploy more complex technologies. Some previous research on environmental management has employed manufacturing firms [70].

We randomly sampled 800 manufacturing firms. Since upper-level managers have a better understanding of the research variables and different environmental practices of their business units, the targeted informants were CEOs, owners, operating managers, environmental managers, or of similar positions. The self-administered questionnaire was e-mailed to the targeted informants that are responsible for green innovation. Prior to the data analysis, we needed to screen the obtaining 286 questionnaires and drop 24 samples due to missing data. Thus, we ended up with 262 observations considered valid. The sampling process yielded useful questionnaires with a response rate of 32.75%. Samples and respondent characteristics are shown in Table 1. The statistical results show that the age composition of the respondents was wide and basically coincided with the normal distribution. A total of 87.4% of the respondents had received a bachelor's degree or above, which was consistent with the educational background characteristics of the researchers. For the respondents, having a good educational background is conducive to the understanding of research questions, thus guaranteeing the validity and quality of the observations. In general, the samples reflect the overall characteristics of the research objects.

3.2. Measures

Data were collected by a structured questionnaire, and all constructs were measured based on validated scales from previous empirical studies. The standardized questionnaire included the following four constructs: green market orientation (GMO), green absorptive capacity (GAC), green product innovation (PDI), and green process innovation (PCI) (see Table 2). Except for demographic firm information, the remaining questions measured the respondents' opinions using a Likert scale (five-point).

Table 1. Sample feature.

Firms Profiles	N	(%)	Respondents Profiles	N	(%)
Firm Age			*Gender*		
<5 years	56	21.37	Male	156	59.54
5–10 years	108	41.22	female	106	40.46
			age		
10–15 years	64	24.43	<25 years	45	17.18
>15 years	34	12.98	25–35 years	112	42.75
			35–45 years	76	29.01
Firm Scale			>45 years	29	11.07
<100 employees	71	27.10	*Education Level*		
			High school graduate/diploma	33	12.60
100–500 employees	53	20.23	Bachelor's degree	135	51.53
			Master's degree	94	35.88
500–1000 employees	85	32.44	*position level*		
			first-line manager	110	41.98
>1000 employees	53	20.23	Middle Manager	98	37.40
			top managers	54	20.61

Table 2. Reliability and validity.

Variable Name	Items	Factor Loadings	Cronbach'α	CR	AVE
Green market orientation	GMO1: Our firm continuously seeks to increase the environmental value that is provided to customers.	0.714	0.905	0.916	0.578
	GMO2: Our firm periodically revises environmental-friendly products to match customers' needs.	0.706			
	GMO3: Our firm supplies customers with environmental protection information in order to enable them to get the best from our firm.	0.713			
	GMO4: Our firm's competitive advantage is based on a better understanding of customers' demands for environmental protection.	0.719			
	GMO5: Our firm's salespeople often share information about competitors' environmental operations and strategies.	0.884			
	GMO6: Our firm responds quickly to competitors' environmental operations and strategies.	0.723			
	GMO7: In our firm, top managers regularly discuss the strengths and weaknesses of competitors' environmental operations and strategies.	0.748			
	GMO8: Top managers quickly share information about competitors' important environmental operations and strategies	0.855			
Green absorptive capacity	GAC1: Our firm has routines to ensure the recognition and acquisition of green technological knowledge.	0.856	0.918	0.912	0.564
	GAC2: Our firm's organizational structure facilitates analyzing and understanding information from external green technological knowledge.	0.716			
	GAC3: Our firm is able to integrate existing green technological knowledge with new obtained and incorporated green technological knowledge.	0.720			
	GAC4: Our firm is able to communicate green technological knowledge across its divisions.	0.796			

Table 2. *Cont.*

Variable Name	Items	Factor Loadings	Cronbach'α	CR	AVE
	GAC5: Our firm has employed life cycle analysis as a means to recognize the environmental effects of our products and production processes.	0.706			
	GAC6: Our firm has implemented environmental declarations as a means to recognize the environmental effects of our products and production processes.	0.701			
	GAC7: Our firm has green technological knowledge to influence strategic decisions so that they meet environmental interests.	0.734			
	GAC8: Our firm often applies green technological knowledge to its operations and practices in order to develop in line with environmental interests.	0.766			
Green product innovation	PDI1: Our firm chooses the materials of the product that produce the least amount of pollution for conducting the product development or design.	0.831	0.844	0.853	0.592
	PDI2: Our firm chooses the materials of the product that consume the least amount of energy and resources in conducting the product development or design.	0.715			
	PDI3: Our firm uses the fewest amounts of materials to comprise the product in conducting the product development or design.	0.756			
	PDI4: Our firm circumspectly deliberates whether the product is easy to recycle, reuse, and decompose in conducting the product development or design.	0.772			
Green process innovation	PCI1: Our firm's manufacturing process effectively reduces the discharge of hazardous substances or waste.	0.977	0.893	0.933	0.778
	PCI2: Our firm's manufacturing process recycles waste and emissions that enable them to be disposed of and reused.	0.894			
	PCI3: Our firm's manufacturing process reduces the consumption of water and energy.	0.893			
	PCI4: Our firm's manufacturing process reduces the use of raw materials.	0.749			

CR = composite reliability. AVE = average variance extracted.

(1) Green market orientation

According to Chen et al. [1] and Wang [13], a GMO refers to generating, disseminating, and responding to market intelligence of customers' green needs and competitors' green operations. Contrary to the previous literature on MO, this study incorporates the environmental standard into market orientation. The operationalization of this construct adopts the market orientation scale from Narver and slater [71] and Li et al. [25], using eight items to reflect two dimensions of GMO: four items for green customer orientation and four items for green competitor orientation. The structured questionnaire asked the respondents to assess the extent of direction toward developing and processing the environmental protection concerns of customers and competitors' environmental strategy information.

(2) Green absorptive capacity

Given the concept of green absorptive capacity as a critical determinant for learning about green technological knowledge and undertaking green innovation [26,42], the operationalization of this construct in this study is adapted from Pernilla et al. [14] and Pacheco et al. [63]. Unlike some literature focusing on the market or non-green techno-

logical knowledge context, this study aims to explore green technological knowledge as a critical component of green absorptive capacity. Therefore, this study applies eight items to reflect the advantage of green absorptive capacity in the R&D field. The eight items tap two dimensions of green absorptive capacity: four items for green potential absorptive capacity and four items for green realized absorptive capacity. The structured questionnaire asked the respondents to assess their firm's competence to scan, recognize, acquire, and assimilate technological knowledge for fostering green innovation.

(3) Green product innovation

According to Tariq et al. [38] and Qiu et al. [2], green product innovation is measured by four items that ask respondents to assess the extent to which environmental standards are used in new products or the development of recycling, reusing, and decomposing goods that benefits the ecological environment.

(4) Green process innovation

According to Tariq et al. [38] and Qiu et al. [2], green process innovation is measured by four items that ask respondents to assess the extent of materials recycling, energy-saving, and reduction in environmental pollution during the production process.

(5) Control variables

Several factors may influence the relationships between green market orientation, green absorptive capacity, and green innovation. Consistent with the previous literature, we introduce firm size and age as controlled variables in this analysis. Firm size is measured from the natural logarithm of the number of employees. Scholars argue that, compared with larger firms, smaller firms are more likely to become innovative [72]. Similarly, firm age is an important determinant of green innovation. This variable is considered because firm age impacts resource base and, thus, the stability of investments in R&D [2].

3.3. Reliability and Validity Analysis

The data are suitable for performing CFA (confirmatory factor analysis) and EFA (exploratory factor analysis) because the Kaiser-Meyer-Olkin (KMO) score is 0.840, about the minimum threshold of 0.6 [73]. First, EFA reveals a clear four-factor structure with eigenvalues > 1, explaining 66.687% of the total variance, including GMO, GAC, PDI, and PCI. Next, based on CFA, we assess the internal consistency among the items for each measure using all variables by using Cronbach's alpha and determine the reliability of the constructs by calculating the composite reliability (CR) of the measures [74]. As Table 2 shows, The Cronbach'α values ($0.840 < \text{Cronbach}'\alpha < 0.920$) of all scales surpass the threshold of 0.70, indicating good internal reliability. Furthermore, the CR values ($0.850 < CR < 0.940$) of all constructs are above the minimum threshold of 0.70. These results suggest that all constructs have acceptable construct reliability. Finally, we assess the uni-dimensionality and convergent validity of each construct by employing standardized factor loadings (λ) and calculating the average variance extracted (AVE) [75]. The λ value ($0.7 < \lambda < 0.98$) of all items is above 0.7 at a highly significant level ($p < 0.001$), confirming their uni-dimensionality validity of each construct. Moreover, we calculate the AVE of each variable. This value ($0.560 < AVE < 0.780$) is above the recommended 0.70 level and below the corresponding CR, indicating the convergent validity. In addition, we assess the discriminant validity of each construct by checking whether the correlation coefficients for any two constructs are less than the square root of the corresponding AVE estimates [74]. As listed in Tables 2 and 3, the square roots of the AVE value of each pair of constructs are greater than the correlation coefficients between them, suggesting discriminant validity between any two constructs.

Table 3. Descriptive statistics and correlations.

Variable	Mean	SD	1	2	3	4	5	6
1. Firm age	2.290	0.947	-					
2. Firm scale	2.458	1.095	0.008	-				
3. GMO	3.559	0.766	0.087	−0.079	**0.760**			
4. GAC	3.585	0.757	−0.037	−0.014	0.048	**0.751**		
5. PDI	3.493	0.825	0.064	−0.137 *	0.314 **	0.274 **	**0.769**	
6. PCI	3.379	0.906	−0.109 *	−0.031	−0.023	0.314 **	0.412 **	**0.882**

Note: Square root of the AVE is on diagonal. * $p < 0.05$; ** $p < 0.01$.

4. Results

Table 3 presents the means, standard deviations (SD), and correlation coefficients of all measured variables. The correlations between any two variables are below the threshold of 0.70, which provides preliminary support for our following hypotheses test. Given the possibility of multicollinearity problems, we must calculate VIF (variance inflation factor) after each regression. The values of VIF range from 1.00 to 2.00, being below the threshold value of 10, thus indicating that it is less likely to have significant multicollinearity problems.

To test the hypotheses, we employ hierarchical linear regression in this study. The results of the relationships between GMO, GAC, and green innovation are shown in Table 4. In Models 1 and 4, only controlled variables are induced. GMO and GAC are together entered in Models 2 and 5 to predict PDI and PCI. In Models 2 and 5, GMO has significant and positive effects on PDI ($\beta_1 = 0.311$, $p < 0.01$), whereas its impact on PCI is not significant ($\beta_2 = -0.032$, $p = 0.657$), corroborating hypotheses H1a while rejecting hypotheses H1b. Conversely, GAC has a significant positive impact on both PDI ($\beta_3 = 0.283$, $p < 0.01$) and PCI ($\beta_4 = 0.453$, $p < 0.01$), supporting hypotheses H2a and H2b.

Table 4. Regression results.

Independent Variables	PDI			PCI		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	3.618 (0.174) **	1.477 (0.345) **	3.599 (0.161) **	3.677 (0.192) **	2.849 (0.406) **	3.658 (0.188) **
firm age	0.057 (0.054)	0.043 (0.049)	0.043 (0.050)	−0.104 (0.059) *	−0.094 (0.058)	−0.095 (0.058)
firm scale	−0.103 (0.046) *	−0.083 (0.043)	−0.084 (0.043)	−0.025 (0.051)	−0.024 (0.050)	−0.027 (0.050)
GMO		0.311 (0.061) **	0.233 (0.047) **		−0.032 (0.072)	−0.029 (0.056)
GAC		0.283 (0.062) **	0.212 (0.047) **		0.453 (0.073) **	0.287 (0.055) **
GMO × GAC			0.123 (0.052) *			0.171 (0.055) **
R^2	0.023	0.180	0.182	0.013	0.158	0.164
AdjustedR^2	0.015	0.167	0.168	0.005	0.143	0.145
Anova F-value	3.029	14.109	14.178	1.661	13.923	14.475
Mean VIF	1.53	1.31	1.72	1.86	1.39	1.48

Notes: * $p < 0.05$; ** $p < 0.01$.

To assess the differential effects in hypotheses H1c and H2c, we further analyze differences in the coefficients of GMO and GAC in Models 2 and 5 using a statistical *t*-test. A one-tailed test was performed as the hypotheses specified directional differences. The test results corroborates both hypotheses H1c and H2c, since GMO's impact is significantly stronger on PDI and PCI ($\beta_1 = 0.311$ vs. $\beta_2 = -0.032$, $p < 0.01$) and GAC's impact is significantly stronger on PCI and PDI ($\beta_4 = 0.453$ vs. $\beta_3 = -0.283$, $p < 0.01$).

To test the synergistic effect of GMO and GAC on green innovation, one interaction term is added to each model (Models 3 and 6). The GMO*GAC interaction term has a significant positive impact on both PDI ($\beta_5 = 0.123$, $p < 0.05$) and PCI ($\beta_6 = 0.171$, $p < 0.01$), supporting hypotheses H3a and H3b. To assess the importance of this synergistic effect, we compared the two models with and without the interaction term. R^2 values increased from 0.180 to 0.182 for PDI and from 0.158 to 0.164 for PCI when including the interaction term.

Thus, we conclude that the corresponding effect sizes for the synergistic effect of GMO and GAC are small.

5. Discussion

The objectives of this paper are (1) to investigate how green market orientation and green absorptive capacity influence green product innovation and green process innovation, and (2) to explore how the interaction between green market orientation and green absorptive capacity influences green product innovation and green process innovation. By pointing out the inconsistent arguments in the existing literature, we have provided a more accurate exposition as to how green market intelligence and green technological knowledge influence green product innovation and green process innovation. Based on the Natural Resource-based View, we have developed a theoretical framework to link these important concepts together.

First, the results show that green market orientation significantly impacts the implementation of green product innovation but does not influence the adoption of green process innovation. The positive link between green market orientation and green innovation is not unexpected given prior evidence [11,25], but some research has indicated that green market orientation does not influence green innovation [23,76]. The possible reason for the inconsistent conclusions in the previous literature is that they did not distinguish between two forms of green innovation. This result may provide an explanation for the inconsistent conclusions in the previous literature. Green product innovation and green process innovation are two heterogeneous innovative behaviors that can occur individually and simultaneously [38]. One of the key tasks of an enterprise is to satisfy its customers' demands as best as possible. Green process innovation can help firms improve their environmental image and cut production costs, but for customers, these benefits are not directly available. With increasing societal awareness of environmental problems and consumers' enthusiasm for environmental products, more and more firms have begun to adopt green product innovation and satisfy customers' demands. Thus, green market orientation is a vital impetus for managerial cognition and the framing of customers' preference for green products, which plays a key role in a firm's adoption of green product innovations, but it is not possible to improve the level of green process innovation. Simultaneously, our study provides evidence that green market orientation has a stronger impact on green product innovation than green process innovation. This finding is consistent with Qiu et al. [2], who assert that the effects of green market forces on firms' performance mainly occur through green product innovation rather than through green process innovation. Firms must also recognize that the provision of new products required by customers through green innovation can be used as an alternative means to respond to market demands. In other words, the effect of green market orientation on firms' performances mainly occurs through the development of new products rather than through changes to existing pollution abatement equipment.

Second, our results more deeply illustrate the complexity of the link between green absorptive capacity and green innovation. The results indicate that green absorptive capacity has a positive impact on green product innovation and green process innovation. This finding is in harmony with prior research that supports the positive impact of green knowledge acquisition and utilization on green innovation adoption [77,78]. Firms tend to absorb external knowledge concerning the negative impact of their operations on the environment such as the impact of pollution, waste, and other environmental outcomes, and combine the new knowledge with their knowledge base to facilitate the adoption of green product innovation practices and green process innovation practices into their operations. Moreover, consistent with our prediction, the findings emphasized a stronger impact of green absorptive capacity on green product innovation than green process innovation. Process innovation is rather complex and represents a technological frontier and needs various kinds of knowledge [79]. More specifically, new knowledge may be a powerful spur to the adoption of green process innovation. In comparison to green product

innovation, green process innovation may show a high propensity for requirements of technological knowledge. That is, when firms have a high level of green absorptive capacity, they are in a better position to develop and exploit green knowledge acquired through a collaborative innovation network, thereby being more likely to invest time and money in cleaner technologies or end-of-pipe technologies to reduce air or water emissions and lessen energy consumption.

Third, as expected, the interaction between green market orientation and green absorptive capacity has a significant positive effect of quasi-equal magnitude on both green product innovation and green process innovation. This empirical finding supports the view of Yang and Tsai [80] that market orientation and absorptive capacity interact to improve firm innovation. According to knowledge management, market intelligence and technological knowledge are mutually related and complementary [69]. Firms' focus on market intelligence imparts a clear compass heading for their green innovation efforts, along with a strong consensus to better utilize external technological knowledge through coordinated integration of distinct functional expertise to fulfill the ultimate purpose of green innovation. As Renko et al. [77] show, market orientation and absorptive capacity may not be unique resources, individually, and cannot develop into successful innovations, but their combination can create a unique resource and capability for firms. A proper condition configuration of green market orientation and absorptive capacity would enhance firms' green knowledge concerning their market demands and technological information.

6. Conclusions and Implications

Despite an outpouring of studies in management journals that analyzes green knowledge acquired by the external environment to facilitate green innovation, little is known about how green market knowledge and green technological knowledge influence green product innovation and green process innovation. Drawing from panel data on 262 Chinese manufacturing firms, this study empirically explores the differential and synergistic effects of green market orientation and green absorptive capacity on green product innovation and green process innovation. The findings corroborate that green market orientation has a significant positive impact on green product innovation, and the effect of green market orientation on green process innovation is not statistically significant. Regarding the influence of green absorptive capacity, it has significant positive effects on both green product innovation and green process innovation. More importantly, there are the heterogeneous effects of green market orientation and green absorptive capacity. Specifically, the effect of green market orientation is significantly stronger on green product innovation than on green process innovation, while the impact of green absorptive capacity is significantly stronger on green process innovation than on green product innovation. Finally, we explore whether pursue green market orientation and green absorptive capacity simultaneously can be beneficial for green innovation. Our findings show that the interaction between green market orientation and green absorptive capacity has a significant positive effect of quasi-equal magnitude on both green product innovation and green process innovation. Therefore, the findings confirm the analysis that green market orientation and green absorptive capacity affect firms' green innovation.

6.1. Theoretical Implications

This study makes several contributions to the research on the relationships between green market orientation, green absorptive capacity, and green innovation. Our paper presents a comparative study of the differential effects of internal factors on firms' green innovation. Internal resources and the capability of acquiring green knowledge to foster green innovation mainly manifest in green market orientation and green absorptive capacity. In the green management literature, most studies separately examine the effect of green market orientation and green absorptive capacity in actuating firms to pursuing green innovation. However, few studies investigate the relationship between market orientation and absorptive capacity and how they comparably lead to innovation. Such oversight can

lead to inaccurate estimations of the relationships between green market orientation, green absorptive capacity, and green innovation. The results show that the different impacts of green market orientation and green absorptive capacity on firms' green innovation are revealed. The finding supports the contention that a dual strategy of both market orientation and absorptive capacity can mutually promote innovation [27]. Green market orientation represents a strategic posture and market-based approach that mainly focuses on gathering market intelligence. Green absorptive capacity reflects a learning capacity and knowledge-based approach that emphasizes the recognition and exploitation of new knowledge more than addressing market needs. Since innovation is driven both by the market and technology, the market-based and knowledge-based perspectives should be regarded as complementary, not mutually exclusive. Therefore, our finding contributes to managing green market intelligence and green technological knowledge in order to undertake green product innovation and green process innovation.

Our main theoretical contribution is the examination of the impact of the interaction of green market orientation and green absorptive capacity on green innovation. We find that the interaction has a significant and positive synergistic effect on firms' green product innovation and green process innovation. Rather than being competitive, green market orientation and green absorptive capacity in the learning firms are complementary. This finding supports the view that the co-existence of market orientation and absorptive capacity helps in enhancing a firm's knowledge concerning market demands and technological information, which produces a complementary market-driven and technology-push strategy. It also echoes Tariq, Badir, Tariq and Bhutta [38] who suppose that the different paths to green innovation could be complementary. Similarly, it addresses the call of Aboelmaged and Hashem [12] to understand how green absorptive capacity fosters green innovation. In this research, green absorptive capacity emerges as the driving force of both forms of green innovation, and green market orientation strengthens the effect of green absorptive capacity on green innovation through their positive interaction.

6.2. Managerial Implications

The findings have several managerial implications for firms' managers. Strong green market orientation is related to a high level of green product innovation, and stimulus for green product innovation comes from customers' environmental demands and competitors' green strategies. To be successful, managers should be aware of the tight association between green market intelligence and green product innovation. They should listen to the environmental demands of customers and ascertain dynamic environmental information about competitors, providing the value market intelligence to develop green product innovation.

Our study also cautions firms' managers in being calculated to enhance green market orientation for the implementation of green process innovation. We find that green market orientation alone is not sufficient to generate green process innovation. This is because the benefits of green process innovation are not directly available for market demands, and while green process innovation can improve firms' green image and cut production costs, firms are prone to spend more on renewing green products that are more likely to gain the trust of consumers.

This study reinforces the strong relevance of learning capacities in supporting the development of green product innovation and green process innovation. Thus, firms should scan the external environment by developing green absorptive capacity, and monitor the changes regarding sustainability, thus acquiring new knowledge of environmental technologies.

The main managerial implication for firms' managers is that they should keep one eye on green market intelligence and another on green technological knowledge. Specifically, if there is a stronger green market orientation that gathers and comprehends market information about environmental issues, a green absorptive capacity allows firms to be more environmentally innovative by learning about green technological knowledge. Therefore, firms' managers need to strive to renew green market orientation and green absorptive

capacity, both of which will generate stronger green product innovation and green process innovation.

6.3. Limitations and Future Directions

This study contains some limitations that can provide future research opportunities. First, the sample size is not large enough, and the data are collected from a single country, indicating that the sample may not be representative. This limitation may prevent us from drawing more accurate conclusions, so special attention needs to be paid to generalizations. A larger and more diverse sample can reinforce the reliability and generalizability of the results. Future research will enlarge the sample size to countries other than China. Second, in this study, we regard green market orientation as a strategic resource and green absorptive capacity as a green market orientation-deploying capacity. Not only green absorptive capacity but also other capacities may deploy green market orientation, for example, green dynamic capacity. Similarly, green absorptive capacity may deploy not only green market orientation but also other resources, for example, green entrepreneurial orientation. Therefore, future research should explore the impact of the interaction between green market orientation and other capabilities (not limited to only green absorptive capacity), and green absorptive capacity and other resources (not limited to only green market orientation) on green product innovation and green process innovation to advance natural resource-based views. Third, this study does not purport to represent all possible consequences of technological knowledge of green absorptive capacity and contributes to the existing literature on the relationship between green market orientation and green absorptive capacity by investigating green absorptive capacity in a technology-oriented context. The contribution is important because this paper moves the relationship between market orientation and absorptive capacity beyond a market-oriented focus. Future research may account for a broader business context. Finally, in this research, we do not explore the results for different types of manufacturing firms based on different industries. Green innovation behaviors from manufacturing firms may vary across industries, for example, being related to low and high levels of pollutant discharge among different industries. Thus, future research may further compare the different effects of green innovation across different industries.

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