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The Moderating Role of IT Capability on Green Innovation and Ambidexterity: Towards a Corporate Sustainable Development

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Abstract: Green innovation (GI) is widely regarded as a strategy for pursuing sustainable corporate development. Drawing from the organisational information processing theory, this study investigates the moderation effect of information technology (IT) capability in shaping the impacts of ambidexterity and two types of GI practices, green product innovation (GPDI) and green process innovation (GPCI). Using a selective sampling of 368 firms in China, this study validates a 30-item measurement scale and approves the proposed theoretical model. The data obtained were then analysed using the structural equation modelling (SEM) executed by the AMOS 23 application. The results confirm the vital role of two sides of ambidexterity, namely, exploitation and exploration, in improving GI and the positive effects of GI on sustainable corporate development (i.e., environment, social, and financial sustainability). More importantly, IT capability only positively moderates the relationship between GI and one side of ambidexterity, i.e., exploitation. This study contributes to the strategies to better prepare companies in developing markets to achieve GPDI and GPCI as core competencies. Findings also provide evidence for practitioners to invest in GI to facilitate better corporate sustainability.

Keywords: sustainability; green innovation; information technology; ambidexterity; information processing theory; IT capability

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1. Introduction

Currently, the environmental pollution caused by the global industry in the manufacture of products and the production process makes society unable to ignore environmental issues and the footprint of human activities. Under this severe situation, various countries are actively formulating environmental regulations to enhance the impetus for corporate green innovation (GI) [1]. Additionally, organisations are increasingly aware that innovation efforts undertaken without regard for the environmental impact of their operations and activities can harm the environment and hinder their long-term survival [2]. As consumers become more aware of the importance of green products and consumption, companies are investing a lot of money in green technologies to deal with environmental crises and balance economic development and environmental protection [3,4]. Due to the growing public concern about environmental issues, GI has experienced substantial growth, which has become the primary way to achieve enterprises' environmental requirements and sustainable development [4,5]. This phenomenon has also stimulated scholars' interest in studying green innovation and management.

Many studies have explored the multiple driving factors of firms engaging in GI [6], such as environmental regulation, stakeholders' environmental requests and environmental capability. As the primary driver of green innovation, stakeholder pressures or effects have attracted extensive research attention [7–9]. However, we contend that the antecedents of GI have not been thoroughly tested [10]. In particular, few studies have considered the role of IT capabilities in GI [11,12]. IT capability is described as the ability to manage three types of IT assets: IT infrastructure, IT human abilities, and the company's ability to use IT, which are essential resources that drive a firm's competitive advantage [13]. Although the importance of ambidexterity on GI has been discussed by previous studies [5,14,15], there is a limited understanding of ambidexterity as an antecedent together with the IT capability that explores their effects on GI from the literature. To address this gap in the literature, we build on information processing theory to investigate ambidexterity as a driver of the implementation of GI and how this is moderated by IT capability. Furthermore, a considerable number of studies have argued that companies need to consider the benefits of GI to customers and themselves before implementing GI practices [3], such as financial outcomes [16], customer capital [11], and competitive advantage [17]. However, there are controversies on whether GI practice influences firm performance. For instance, Albort-Morant et al. [18] stated that GI does not necessarily have the advantage of financial benefits. In this way, investments in GI could give rise to massive losses for companies, such as increased costs [19]. Hence, examining the relationship between GI and firm performance is still necessary.

The objectives of this study are threefold. First, we use ambidexterity as a key antecedent of GI practices. Specifically, we focus on two constitutive elements of ambidexterity: exploitation and exploration. When the concept of ambidexterity is applied in management research, organisations could use exploitation and exploration techniques to achieve improvement and success [20,21]. This can help us identify which actions (or antecedents) are more likely to lead to the successful implementation of green innovation. Second, we examine the joint effects of ambidexterity and IT capability on GI. Drawing on the organisational information processing theory (OIPT) [22], this study explores whether exploitation and exploration affect GI and investigates how this relation is moderated by IT capability. This study argues that companies can use IT capability to process information effectively to reduce innovation uncertainty. The OIPT offers a new perspective to reveal differences behind the varying effects of exploration and exploitation on GPDI and GPCI through IT capability moderation. The results of this study can also provide guidelines on whether companies should invest in IT technology to promote GI and help enterprises establish new strategic management of GI. Third, to better understand the influence of GI, we analyse how GPDI and GPCI impact sustainable corporate development, including environmental, social, and financial sustainability. Considering the above, we construct a comprehensive conceptual framework that includes driving factors and consequences of GI.

The remainder of this study is organised as follows: Section 2 reviews the current literature on OIPT and GI. Section 3 is dedicated to hypothesis development. This is followed by a presentation of the methodology describing how we collected the survey data and applied the structural equations modelling (SEM) methods in Section 4. Then, we report the empirical results in Section 5. Lastly, Section 6 discusses the results and presents the conclusions, as well as recommendations for future opportunities.

2. Theoretical Foundation

2.1. Organisational Information Processing Theory (OIPT)

Information processing theory (IPT) evolved from the psychology discipline, suggesting that learning is a complex and internal process occurring with some mental processes [22]. Since then, this theory has been extensively adopted in organisation research, also known as organisational information processing theory (OIPT), which is further developed by Galbraith [23] for organisation design. OIPT views an organisation as an open information processing system which deals with uncertainties and fluctuations from different sources. Organisations can increase their information processing capabilities (i.e., information collection, storage, and transformation) and information quality to reduce uncertainty and achieve high-level performance, allowing the focal company to understand how the internal and external integration lead to different performance outcomes [24,25]. Thus far, this theory has been widely applied in investigating various topics in different disciplines, such as supply chain management [26], digital technologies [27], and information systems [28]. Specifically, Galbraith [29] proposed four strategies to reduce the need for information processing (i.e., creation of slack resources and creation of self-contained tasks) and increase corporate capacity in information processing (i.e., investment in vertical information systems and creation of lateral relation), thus helping corporates to address the dynamic changes in the business environment. Slack resources refer to a resource's availability level, which is an additional cost for a corporation [30]. Suppose that a corporation chooses to operate at a lower level of performance. In that case, there is a decrease in task uncertainty, as less information has to be processed, leading to the target being met much more effortlessly [31]. The creation of self-contained tasks refers to decreasing the amount of information, which has to be processed by adding the needed resources to perform the tasks directly to the different subunits (e.g., producing products with the specific national requirements in a country to serve the local market demand), thus reducing the information to be processed by the central organisation. Galbraith [29] also suggested that companies increase information processing capacity by employing computers and machine combinations to avoid an overload of traditional hierarchical channels. Lastly, the creation of lateral relations refers to passing the decision making from higher to lower levels, avoiding the overload of processing, e.g., different subunit managers discuss and make decisions together to address unanticipated events instead of decided by higher levels.

To improve task performance, OIPT suggests that corporate should improve the fit between their information processing capability with their demands for the information [25]. In our study, the task of interest is sustainable corporate development, and the demands for information processing are determined by GI (i.e., green product innovation and green process innovation). With the rapid economic growth, the resulting environmental degradation and resource shortage draws tremendous challenges for further economic growth. Therefore, developing GI to promote a green economy is the key to implementing a sustainable development strategy. However, implementing GI in production also attracts several concerns, e.g., the extra cost of being green corporate, the dynamic and fast-changing demands from the green market, and the increasing amount of complex and uncertain information that awaits companies to absorb and process [32]. Therefore, OIPT offers a tremendous theoretical foundation by shedding light on how corporates should develop their information processing capacity to address the uncertainties of the green market.

2.2. Green Innovation (GI)

GI and related concepts (e.g., eco-innovation and environmental innovation) have attracted the attention of many scholars within the business and management literature. According to Chen et al. [33] (p. 332), GI is defined as "hardware or software innovation that is related to green products or processes, including the innovation in technologies that are involved in energy saving, pollution prevention, waste recycling, green product designs, or corporate environmental management". Specifically, GI is based on two concepts: innovation and environmental management [34]. It emphasises improvements in developing environmentally friendly products and processes to reduce environmental risks [17,35]. This can be achieved by adopting diverse corporate practices, such as selecting greener raw materials, designing products using eco-design principles, and reducing water and electricity consumption [36]. GI is a strategic need for companies, which provides an opportunity to eliminate or mitigate the negative impact of their operations on the environment while enabling businesses to meet customers' demands [37].

Following the previous literature [3,10,38,39], GI captures improvements in product design and manufacturing processes, which comprises either green product innovation (GPDI) or green process innovation (GPCI). GPCI can be considered a process-oriented environmental management practice in green operations [40], which is the improvement of the production processes concerned with reducing adverse environmental impact. GPDI is referred to the innovation of products or services that use renewable and nontoxic materials in product development [41,42]. Weng et al. [7] considered GPDI practices as the degree to which new products reduce pollution and energy consumption, while GPCI practices were identified as the extent to which new processes reduce pollution and energy consumption.

Many studies are interested in understanding what the key drivers are in establishing GI, such as environmental regulations [43], capabilities [35], information technology [11], and the pressure or effects of stakeholders [8,44]. Leenders and Chandra [34] investigated the internal and external drivers of GI, such as environmental orientation, government regulation, and consumer demand. El-Kassar and Singh [39] developed a holistic model that links corporate environmental ethics, stakeholders' perceptions of green products, and demand for green products as drivers of GI. Zhang et al. [45] believe that formal control and social control should be applied as complements in promoting GPDI. Nevertheless, few studies can be found in the literature exploring the relationship between information technology capability and GI [11].

Previous studies have also indicated that GI prevents opportunities for imitation [18] and has positive effects on labour productivity [3], environmental performance [36,46], and competitive advantage [6,44]. Weng et al. [7] also argued that GPDI and GPCI could reduce the negative impact of business on the environment and enhance corporate financial and social performance by minimising cost and waste. Qiu et al. [47] found that GPDI is sustained to exert a positive effect on competitive advantage and green dynamic capability in the Chinese manufacturing industry. Zhang et al. [45] showed that the awareness and adoption of GPDI stimulate a firm's sustainability in the environment and society. However, much of the extant research is still controversial and presents mixed findings. For instance, the relationship between GI and a firm's finance is controversial [48,49], and knowledge about how firms contribute to society is limited. For this study, we consider ambidexterity as the antecedent of GI and explore the moderating effects of IT capability between ambidexterity (i.e., exploration and exploitation) and GI, while investigating the impacts of GI on corporate sustainable development.

3. Hypothesis Development

3.1. Ambidexterity and Green Innovation (GI)

"The Roman god Janus had two sets of eyes: one pair focusing on what lay behind, the other on what lay ahead" [50]. When applying this concept in the field of management study, ambidexterity indicates the organisation's capability to use both exploration and exploitation techniques to achieve success; central to both exploitation and exploration are learning, improvement, and acquisition of new knowledge [51]. Exploration refers to pursuing a new understanding of things that might come to be known through search, variation, risk-taking, experimentation, flexibility, discovery, or innovation. Exploitation is defined as the use and development of things already known via refinement, choice, production, efficiency, selection, implementation, and execution [20,52,53].

Drawing from the lens of ambidexterity, organisation executives and managers should constantly look backward to learn from the known and look forward to learn from the new field [54,55]. Ambidexterity is a crucial strategy of firms' innovation, which assumes that exploitation and exploration are conducted simultaneously to maintain a competitive advantage. Specifically, exploitation refers to improving and learning from the currently available information; exploration refers to dividing resources to gain new information about alternatives, of which the return is uncertain [56]. The existing literature presents that organisation ambidexterity is an effective way to improve organisational learning, achieve innovation, and facilitate organisational performance [53,57].

Since the iconic paper published by March [56], organisational ambidexterity has received remarkable attention in innovation. Building upon existing work on the ambidexterity framework, many researchers have assessed the extent to which the utilisation of exploration and exploitation is linked to innovation. Moreover, in the context of green, some studies discussed the impact of exploration and exploitation on companies' GI. Tushman and Smith [58] stated that exploration is associated with radical innovation, and exploitation is associated with incremental innovation. Moreover, Cui et al. [59] suggested that

GI is positively affected by vertical exploitative and lateral explorative learning. Cegarra-Navarro et al. [60] claimed that exploitation and exploration can improve firms' alignment with new users' demands. Their adaptability in a socioeconomic context can be facilitated through internal orientation and external engagement with stakeholders.

Integrating exploratory and exploitative learning can enhance incremental and radical innovation fields [61]. Therefore, exploitation and exploration have been recognised as an essential managerial process necessary for achieving sustainability success with the ability to be aligned and efficient in business demands while being adaptive to environmental changes [62]. Meanwhile, some researchers believe that explorative learning creates new knowledge, and exploitative learning refines existing knowledge to reduce pollution, which has different effects on GI [5,63]. Notwithstanding extensive research on the relationship between innovation and organisation ambidexterity, current studies have not fully uncovered the relationship between ambidexterity and GI. Hence, this study further investigates the fundamental mechanism of ambidexterity and presents the role of ambidexterity in achieving GI. In summary, we propose the following hypotheses:

H1a: *A high level of exploitation can help improve GPDI.*

H1b: *A high level of exploitation can help improve GPCI.*

H2a: *A high level of exploration can help improve GPDI.*

H2b: *A high level of exploration can help improve GPCI.*

3.2. The Moderating Effect of IT Capability

Organisational capabilities are essential in driving an organisation's performance, and the capability of IT has been identified as a significant component of organisational capability [57,64]. Drawing on OIPT, in the current fast-changing market, the constantly generated and overloading information might limit decision makers' ability to take timely actions. It is challenging for an organisation to respond agilely to a significant volume of market information with a limited information processing capacity [23,25].

Although IT infrastructure is typically imitable and cannot lead to a competitive advantage by itself [65], IT capabilities can be achieved by acquiring, implementing, combining, and reconfiguring IT-based resources and other organisational resources to gain a competitive advantage [66]. IT can also effectively enhance the capabilities of information-sharing and processing [67,68]. Building on the OIPT, IT capability can create slack resources by enhancing organisational data collection and processing. For example, a higher IT capability allows companies to be more responsive to the market and embrace emerging business opportunities [29]. A higher level of IT capability can also support the development of vertical information systems and the creation of lateral relationships, strengthening overall corporate performance [29]. Moreover, prior studies have demonstrated that IT capability could positively influence organisational agility [57,69].

On the other hand, existing studies on innovation provide extensive theoretical argumentation about the potential of firms' IT capability in driving remarkable innovations in business processes, products, and services [70,71]. For instance, according to a matched-pair field survey of 300 business and IT personnel, Panda and Rath [72] suggested a significant positive impact of IT capability on business process agility. Moreover, Soto-Acosta et al. [73] also demonstrated that IT capability has a positive and significant influence on manufacturing enterprises' innovation ambidexterity. Therefore, organisations increasingly rely on information technology (IT) to enhance agility [74].

In this section, our hypothesis considers the moderating effect of IT capability in the exploitation and exploration of GPDI and GPCI. Building on ambidexterity, exploitation and exploration are two fundamental approaches for organisation learning, improving, and acquiring new knowledge and pursuing firms' innovation [55]. According to March [56], exploitation is about efficiency, control, certainty, and variance reduction; a higher level of IT capability could help organisations reduce the challenge of information processing when performing innovation, create slack resources, and help organisations in their current viability. We predict that the levels of IT capability will positively moderate the relationship between organisational exploitation of GI (i.e., GPDI and GPCI). In the same vein, we suggest that a higher level of IT capability may enhance the corporate exploration of GI (i.e., GPDI and GPCI). Exploration is about search, discovery, autonomy, and innovation [56]. The returns from the exploration undertake more risk and less certain returns compared to the organisational exploitation [56]; when organisation devote their energy to exploration, a higher level of IT capability could help organisations to act more agile [75,76]. Moreover, given the constantly evolving business environment, existing organisational competencies may become obsolete if insufficient innovation capability exists. In contrast, high levels of IT capabilities have been acknowledged as an underpinning of a business's ability to identify and respond to market-related changes and opportunities [69]. To summarise the above arguments, we propose the following hypothesis:

H3: *IT capability positively moderates the impacts of exploitation on (a) GPDI and (b) GPCI.*

H4: *IT capability positively moderates the impacts of exploration on (a) GPDI and (b) GPCI.*

3.3. Green Innovation (GI) and Corporate Sustainable Development

As environmental pollution and degradation pose increasing challenges and threats to human survival, green innovation is seen as an effective way and tool to achieve sustainable growth and reduce negative environmental impacts [77]. A growing body of literature has also shown that implementing GI has performance implications for organisations [37,78]. For example, GI can give a lift to environmental [7,36] and financial performance [42,44].

Specifically, GPDI is one type of GI which aims at reducing contamination and conserving resources. Fewer by-products in production help corporations meet the demands of customers to protect the environment [79]. Performing GPDI can also achieve energy efficiency and reduce the disposal impact on the environment, e.g., by innovating product designs that are removable, reusable, and recyclable and those that are easier to store during transportation [80]. Li et al. [81] suggested that GPDI can help business balance profitability and environmental responsibility. Qiu et al. [47] argued that GPDI is positively correlated with both competitive advantage and green dynamic capability. On the other hand, GI also involves GPCI, which aims to enhance the efficiency of production processes by minimising waste and resource consumption [18,82]. Seman et al. [83] showed a positive relationship between GPCI and corporate environmental performance. These studies suggest that, rather than non-innovative companies, GPDI and GPCI can help organisations towards reducing the negative impact on the environment [46,49] and attain competitive advantages, such as higher productivity [3], as well as greater market share and market position [17,49]. Additionally, Zhang et al. [45] indicated that a higher adoption and awareness of GPDI stimulates better social and environmental performance. Organisations develop and gain more advantages on GI, such as innovating environmentally friendly products, complying with laws and regulations on environmental protection [45], creating a greater working environment to improve employee satisfaction, and ensuring employee safety during production and manufacturing [78]. This also reflects corporate social responsibility awareness and is a form of corporate participation in society.

Many studies have been published on the positive effects of GI on organisational performance. However, the relationship between GI and corporate sustainable development is inconclusive. Several executives and managers consider GI efforts to burden their business development [19]. Chang (2011) analysed that GPDI significantly impacts enterprises' competitive advantages rather than GPCI. Prior studies have also argued that GI is not positively associated with a corporation's financial performance [10,16]. To summarise, there are two opposite views on the effectiveness of GI on business performance. This study probes the impact of GI on corporate sustainability development in three dimensions, i.e., environmental sustainability, social sustainability, and financial sustainability. Accordingly, the following hypotheses are proposed:

H5a: *GPDI significantly impacts organisational environmental sustainability.*

H5b: *GPCI significantly impacts organisational environmental sustainability.*

H6a: *GPDI significantly impacts organisational social sustainability.*

H6b: *GPCI significantly impacts organisational social sustainability.*

H7a: *GPDI significantly impacts organisational financial sustainability.*

H7b: *GPCI significantly impacts organisational financial sustainability.*

The primary hypotheses (H5, H6, and H7) and the overall model to be tested are illustrated in Figure 1.

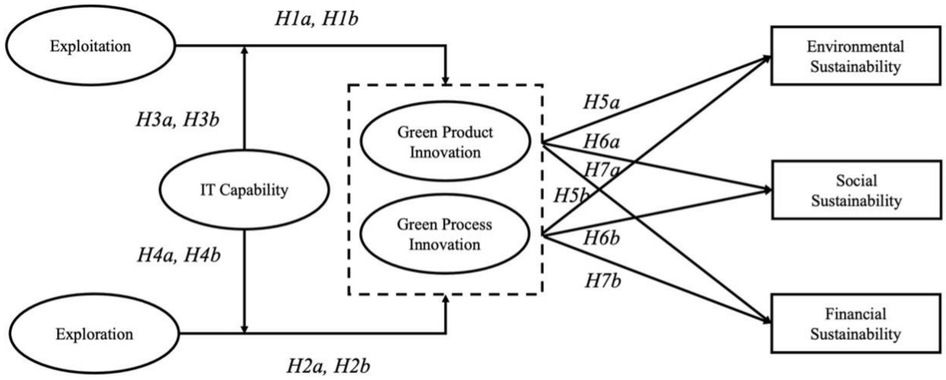

Figure 1. Conceptual framework.

4. Methodology

4.1. Survey and Data Collection

This study focuses on businesses in China. Over the past 40 years, China has experienced increased economic growth at the expense of environmental quality. In recent years, a "green mindset" has emerged, with the legal environment adding to the relevance of this inquiry [10]. China's main target in its 13th Five-Year Plan is to reduce CO_2 emissions per unit of GDP by 18% by 2020 compared to 2015. China also signed the Paris Climate Agreement in September 2016. With the rapid progress that IT has achieved in China in recent decades, the potential for employing IT to develop strategies to support green business operations has dramatically increased. Despite this potential, research on the role of IT in business sustainability is still limited [84]. Therefore, this study provides a timely examination of the relationship between green product/process innovation and firm performance and how IT influences the relationship between ambidexterity and green innovation in China.

The data used in this study was collected by questionnaires filled out by the senior managers of companies in China. Since the unit of analysis of this study focuses on the adoption of GI in a single firm, we targeted the respondents as practitioners with related knowledge and experience to obtain practical insight into GI. The firms were selected from two databases, the China Business Council for Sustainable Development (CBCSD) and the China Yellow Pages. The firms in CBCSD are dedicated to integrating green ideas in business and fit our requirements as the research object. However, the firms in this database are most likely large corporates, and the number of involved companies is limited. To cover all possible sides of firms, we also checked other enterprises which were designed to be green in its product and process. We evaluated the firms in the China Yellow Pages by looking over their official web pages and documents. We also checked whether they usually advertise their ecological mission, green performance, and green benefits of their product, services, and business.

In this case, the questionnaires were mailed out to 1200 companies. To address practitioners' privacy concerns and avoid bias in self-reported data, the anonymity and confidentiality of all respondents were ensured by presenting the results in aggregate format. A total of 425 responses were received; 57 were excluded due to missing data. This yielded 368 usable questionnaires, with an overall response rate of 30.7%. Table 1 shows the descriptive statistical characteristics of the valid questionnaire.

Table 1. Sample characteristics.

Firm Characteristics	Categories	N	% (N = 368)
Industry type	Manufacturing	152	41.3
	Agriculture, food production	37	10.1
	Building industry	30	8.2
	Service, consultancy	17	4.6
	Processes for natural resources	41	11.1
	Chemicals	57	15.5
	Biological engineering/pharmacy	5	1.4
	Other	29	7.9
Ownership	State owned or state holding company	81	22.0
	Private company	57	15.5
	Joint venture	216	58.7
	Wholly foreign owned company	10	2.7
	Other	4	1.1
Role of responder	Vice president or above	4	1.1
	President's assistant	5	1.6
	Department manager	146	39.7
	Senior manager	56	15.2
	Operator	120	32.6
	Other	36	9.8
Firm size (number of employees)	≤50	94	25.6
	51–200	144	39.1
	≥200	130	35.3

This study also detects non-response bias by assessing significant differences between the early and late-arriving surveys [85,86]. Although non-response bias can be evaluated by comparing the significant differences between respondents with those of non-responding firms, the non-respondents in our survey did not provide information on firm size and annual sales. Thus, this study chose to compare the early respondents and later respondents. Following the suggestions by Tse et al. [86], the χ^2 test can be applied to show that respondent and non-respondent firms share the same distribution of organisational size and annual sales at $p < 0.05$. Therefore, we used a χ^2 test to compare the questionnaires received by the first and last 25% of respondents. The results showed no statistical differences between these two groups; hence, non-response bias was not a major concern in this study.

4.2. Measures

The questionnaire was developed using the deductive procedure proposed by Hinkin [87]; therefore, a thorough literature review was conducted to establish the theoretical definition of the construct under examination. The initial questionnaire was developed on the basis of an extensive review of the literature and adapted to our specific research context. To ensure conceptual equivalence, the survey was developed in English, which we then translated into Chinese and back-translated into English. We designed the measurement items for each construct, and all items were measured using a seven-point Likert scale.

To assess the content validity of the measurement items, we took a three-step process. First, we had a pre-test with the help of three managers and three academicians. On the basis of the feedback from the pre-test, we modified the questionnaire and tested it again with another three practitioners and academicians for clarity and septicity. Second, we established face validity with CEOs and operational managers by conducting face-to-face discussions with the practitioners in terms of the potential ambiguity or difficulties when answering the questions in a survey; the valuable suggestions and feedback were used to make some minor modifications to the survey questions. Third, we also discussed each item's specificity, clarity, and representativeness with three academic experts. The questionnaire was then revised on the basis of their feedback. After extensive revision and checks, we had minimal concerns about the questionnaire.

Green Product Innovation (GPDI): Numerous studies have developed scales related to GI [88–92]. To develop valid measurement, this study defines GPDI as a green innovation practice that incorporates environmental factors (e.g., material usage, energy consumption, etc.) into product design considerations for both new and existing products, with the prime objective of reducing the negative environmental impacts on the products' life cycle [33,88,93]. These studies guided the selection of the measurement items for this study. Respondents were specifically questioned about product waste generation [33,90], material/energy consumption throughout the products' entire life cycle [33,90], product design for disassembly, reusability, recyclability, and recovery [33,91], and the use of eco-labelling, environment management processes [89].

Green Process Innovation (GPCI): GPCI refers to any adaptation to the manufacturing process that reduces the negative impact on the environment during material acquisition, production, and delivery [33,88]. Managers answered questions about their respective firms sourcing from suppliers that comply with environmental regulations [89], energy consumption in production/use/disposal [33,88], the use of greener technologies to achieve savings and prevent pollution [33,88], the control of operations to reduce waste from all sources [92], and new manufacturing processes that meet the standards of environmental legislation [89].

Exploitation and Exploration: Several studies developed scales for ambidexterity [94–96]. The definition of exploitation was given by March [56], who remarked that it encompasses elements such as production, efficiency, choice, and implementation. The respondents were questioned regarding the introduction of new product generations by their company [95], efficiency enhancements [94], upgrading existing knowledge and skills for existing products and technologies [96], and adjustments to procedures, rules, and policies [97]. Meanwhile, this study also follows the concept of exploration provided by March [56], which covers activities such as search, variation, risk-taking, experimentation, play, flexibility, discovery, and innovation. Thus, respondents were questioned about their businesses' new markets [97], the industry-first technologies and skills they acquired for product development, technologies and skills they acquired for the new business unit, and the significant new ideas or methods of doing things they experimented, in line with Azadegan and Dooley [94].

IT Capability: IT capability refers to the IT resources that can be used to share skills and services to support the operations and development of environmental competence of IT [98]. The study of Bharadwaj [99] also provided a framework to classify IT capabilities into three, i.e., IT infrastructure quality, IT management competencies, and IT personnel capabilities. This classification has been widely cited in business and management journals [100–103]. This study also follows the three-item scale proposed by Bharadwaj [99] to capture the relative salience of IT capability from both tangible and intangible perspectives.

Environmental Sustainability: In line with previous research [104–106], environmental sustainability was operationalised on the basis of three items covering significant improvement in its overall environmental situation [104,105], considerable progress in its compliance to environmental standards [105], and a substantial decrease in energy consumption, air pollution, wastewater, and hazardous/harmful/toxic materials emissions [104,106].

Social Sustainability: To develop valid measurements for social sustainability, the authors were guided by Sancha et al. [107] and Gualandris and Kalchschmidt [108]. These studies informed the choice of items included in this research. Respondents were asked about firms' incentives and engagement for local employment [106,108], improvement in labour safety and labour conditions in our facilities [106], and improvement of community health and safety [107].

Financial Sustainability: There are also several studies that operationalised a firm's financial sustainability. After due consideration, this study adopted the four-item scale from multiple resources [109,110]. The measurement items included an increase in market share [109], acquisition of new customers [106], decrease in the cost of materials purchased per unit of product [110], and decrease in the cost of energy consumption per unit of product [110]. Appendix A provides the details of variable measurements (see Table A1).

4.3. Validation for Measurement Instrument

Given that all of our participants were Chinese, we collected data using a questionnaire written in the Chinese language, and data were collected between July 2021 and December 2021. Due to the single respondent in each of our observations, further extra steps to evaluate the risk of common method variance (CMV) were adopted [111]. To begin, we only collected data from either CEO or senior manager of the firm since high-level executives have a relatively better understanding of their firms in terms of management and operations, which could reduce the risk of CMV issues [112]. Moreover, we intentionally interspersed dependent variables among those independent variables when designing the questionnaire. In doing so, the potential cues inferred by those managers were limited when answering the questions in the questionnaire, and this also effectively reduced the CMV risk [47]. One-way ANOVA and regression were tested, and the results met the assumptions of normality and homogeneity of variance for the *t*-test. Tolerances and variance inflation factors (VIFs) were also applied to assess multicollinearity among the predictor variables. The tolerance of the predictor variables ranged from 0.89 to 0.94, indicating that multicollinearity was not a concern because the values were not close to 0 [113]. The VIF of the predictor variables ranged from 1.06 to 1.12, representing no multicollinearity concerns [114]. The VIF of the predictor variables ranged from 1.06 to 1.12, representing that multicollinearity issues were unfounded [114]. Furthermore, we also employed Harman's single factor to evaluate the risk of CMV. The fit indices from the single-factor analysis were χ^2 = 806.912 (df = 135), CFI = 0.479, and SRMR = 0.138. The results of Harman's single factor were not as favourable or reliable as those obtained from the confirmatory factor analysis model presented below.

A seven-point Likert scale was used in the measurement of all items. Table 2 displays the descriptive statistics for the measurement item. As shown, a confirmatory factor analysis (CFA) was employed to analyse the unidimensionality for all constructs in the conceptual framework. The fit index of RMSEA was 0.041, which is much less than the suggested threshold value of 0.08. Furthermore, χ^2 was 581/641 and df was 359, and the ratio of χ^2 to df was 1.620, which is also lower than the suggested cutoff value of 2 in the previous literature [115]. Combined with other fit indices such as CFI = 0.959, TLI = 0.953, and IFI = 0.959, this indicated a good fit for our measurement model.

Table 3 shows the reliability of the eight constructs as measured by Cronbach's alpha, composite reliability (CR), and the average variance extracted (AVE). Hence, we can confirm the internal consistency of those indicators for each construct. Cronbach's alphas of majority constructs met the acceptable level of 0.70, but Cronbach's alpha of financial sustainability (0.664) fell slightly below the 0.70 level. The composite reliability of all three measures ranged from 0.70 to 0.85, which met the acceptable level of 0.60 [116]. Moreover, most of the latent constructs had larger AVE values than the indicated threshold value in the literature, i.e., 0.5, suggesting that most variance of the latent construct was captured by the indicators, while the AVE value of financial sustainability was below the threshold value. According to Fornell and Larcker [116] and Lam [117], the AVE may be a more conservative estimate of the measurement model's validity. A researcher may conclude that the construct's convergent validity is sufficient solely on the basis of composite reliability, even though more than 50% of the variance is attributable to error. Since the composite reliability of financial sustainability was significantly higher than the advised threshold, the internal reliability of the measurement items of economic sustainability was also acceptable.

Table 2. CFA results.

Constructs	Item Code	Completely Standardised Loading	t-Value	Item Mean	Std. Deviation
Green product innovation (GPDI)	GPDI1	0.617	Fixed	5.52	1.039
	GPDI2	0.692	10.568	5.54	0.995
	GPDI3	0.885	11.773	5.42	1.036
	GPDI4	0.631	9.864	5.59	1.086
Green process innovation (GPCI)	GPCI1	0.680	Fixed	5.41	1.121
	GPCI2	0.730	12.074	5.50	1.124
	GPCI3	0.672	11.249	5.48	1.044
	GPCI4	0.826	13.219	5.55	1.128
	GPCI5	0.691	11.519	5.44	1.189
Exploitation (EXPLOI)	EXPLOI1	0.717	Fixed	5.63	1.031
	EXPLOI2	0.661	11.048	5.60	1.031
	EXPLOI3	0.676	11.273	5.64	1.063
	EXPLOI4	0.791	12.601	5.64	1.026
Exploration (EXPLOR)	EXPLOR1	0.935	Fixed	5.62	1.127
	EXPLOR2	0.780	18.928	5.64	1.065
	EXPLOR3	0.744	17.530	5.69	1.094
	EXPLOR4	0.761	18.158	5.62	1.154
Information technology capability (ITC)	ITC1	0.730	Fixed	5.47	1.176
	ITC2	0.795	13.303	5.49	1.044
	ITC3	0.826	13.453	5.47	1.131
Environmental sustainability (ES)	ES1	0.622	Fixed	5.75	0.924
	ES2	0.657	10.000	5.96	0.946
	ES3	0.886	9.894	5.86	1.014
Social sustainability (SS)	SS1	0.729	Fixed	5.51	1.102
	SS2	0.658	10.623	5.58	1.041
	SS3	0.790	11.538	5.44	1.081
Financial sustainability (FS)	FS1	0.683	Fixed	5.75	0.937
	FS2	0.657	9.526	6.09	0.925
	FS3	0.628	9.260	5.83	1.041
	FS4	0.605	9.022	5.81	0.989

Table 3. Correlation and reliability.

	GPDI	GPCI	EXPLOI	EXPLOR	ITC	ES	SS	FS
GPDI	0.714							
GPCI	0.350 ***	0.722						
EXPLOI	0.445 ***	0.363 ***	0.713					
EXPLOR	0.276 ***	0.285 ***	0.241 ***	0.809 ***				
ITC	0.330 ***	0.239 ***	0.287 ***	0.182 ***	0.785			
Environmental sustainability (ES)	0.165 ***	0.258 ***	0.210 ***	0.231 ***	0.182 ***	0.731		
Social sustainability (SS)	0.426 ***	0.399 ***	0.327 ***	0.318 ***	0.238 ***	0.178 ***	0.728	
Financial sustainability (FS)	0.215 ***	0.261 ***	0.309 ***	0.320 ***	0.341 ***	0.306 ***	0.338 ***	0.664
CR	0.803	0.844	0.805	0.882	0.827	0.770	0.770	0.739
AVE	0.510	0.521	0.508	0.654	0.616	0.534	0.529	0.415

Note: Diagonal entries (in bold) are average variances extracted; entries below the diagonal are correlations. *** Significant at the 0.001 level.

5. Results and Analyses

This study employed a structural equation model (SEM) to analyse the proposed relationships specified in the conceptual framework (see Figure 1). SEM is a statistical methodology including factor analysis and pathway analysis. SEM is usually used to investigate the relationships among latent constructs indicated by multiple measures. By applying SEM, the latent variables can be incorporated into the analysis, accounting for measurement errors in the estimation process. Additionally, SEM enables the model to test complex relationship patterns, including multiple hypotheses simultaneously with multiple dependent variables. Table 4 displays the outcome of estimated relationships among constructs in this study and their corresponding measurement items. AMOS 26.0 was used to perform SEM, and the fit of the model was satisfactory ($\chi^2 = 581.64$; df = 359; $\chi^2/\text{df} = 1.620$; RMSEA = 0.041; CFI = 0.959; IFI = 0.959; TLI = 0.953), suggesting that the nomological network of relations fit the data and the validity of the measurement scales [73,118].

Table 4. Results of hypotheses.

Path	β	t-Value	*p*-Value
Main effect			
Exploitation → GPDI	0.052	2.413	0.126 **
Exploitation → GPCI	0.063	2.007	0.126 **
Exploration → GPDI	0.059	3.174	0.186 ***
Exploration → GPCI	0.070	3.309	0.233 ***
GPDI → Environmental sustainability	0.057	1.674	0.095 *
GPDI → Social sustainability	0.084	5.117	0.429 ***
GPDI → Financial sustainability	0.068	2.599	0.177 ***
GPCI → Environmental sustainability	0.051	3.618	0.183 ***
GPCI → Social sustainability	0.068	4.690	0.319 ***
GPCI → Financial sustainability	0.059	3.569	0.209 ***
Interaction effect			
Exploitation × IT capability → GPDI	0.009	3.284	0.029 ***
Exploitation × IT capability → GPCI	0.010	2.538	0.026 **
Exploration × IT capability → GPDI	0.010	−0.941	−0.009
Exploration × IT capability → GPCI	0.012	−0.720	−0.009

* Significant at the 0.1 level; ** significant at the 0.05 level; *** significant at the 0.01 level.

In H1a and H1b, we hypothesised that exploitation is positively associated with GPDI and GPCI, respectively, and the results indicate that the positive impact of exploitation on GPDI and GPCI was positive and significant ($p < 0.05$). Therefore, H1a and H1b were supported. In H2a and H2b, we predicted that exploration would be positively associated with GPCI, and the results also show that the impact was positive and significant ($p < 0.001$). Consequently, H2a and H2b were supported. Then, we considered whether IT capability played a moderator role in the previous relationship. Specifically, the results of H3a and H3b indicate that IT capability positively influenced the relationship between exploitation and GPDI and the relationship between exploitation and GPCI. Interestingly, the moderator role of IT capability was insignificant in the relationship between exploration and two types of GI, namely, GPDI and GPCI.

Regarding the relationship between GI and the firm's sustainability, we proposed hypotheses on environmental sustainability in H5, social sustainability in H6, and financial sustainability in H7. In detail, we hypothesised that GPDI is positively related to environmental sustainability in H5a, and that GPCI is positively associated with environmental sustainability in H5b. The positive effects of GPDI on environmental sustainability ($\beta = 0.10$, $p < 0.01$) and GPCI on environmental sustainability ($\beta = 0.18$, $p < 0.001$) were both significant. GPDI and GPCI were hypothesised to be positively associated with social sustainability in H5a and H6b. The positive effects of GPDI on social sustainability ($\beta = 0.43$, $p < 0.001$) and GPCI on environmental sustainability ($\beta = 0.32$, $p < 0.001$) were both significant. Lastly, we hypothesised that GPDI and GPCI are positively associated with financial sustainability in H7a and H7b. As expected, the positive effects of GPDI on economic sustainability (β = 0.18, $p < 0.01$) and GPCI on environmental sustainability (β = 0.21, $p < 0.001$) were both significant. The results show that both types of GI can positively influence a firm's sustainability.

6. Discussion

The results of this study shed some light on the role played by organisational ambidexterity in improving GI. Ambidexterity has been articulated in the literature regarding its role in improving organisational innovation and achieving success [20,53]. However, the alignment of ambidexterity in impacting green innovation has barely been studied. The organisational information processing theory suggests that organisations act as open information processing systems to solve uncertainties and fluctuations from different sources [24,119]. Companies can comprehensively understand how to improve their performance outcomes by improving their information processing capabilities and information quality [25]. Advancing this perspective, we examined the role of information technology in helping a company enhance its organisational ambidexterity to achieve GI. Moreover, the extent of research on the impact of GI in improving a firm's performance is controversial and presents inconsistent findings. This study further identified how GPDI and GPCI influence a firm's triple bottom line. The study extends the literature by analysing how IT capability can adequately align with organisational ambidexterity in improving GI and how GI contributes to the firm's environmental, financial, and social performance. The findings in this study provide the basis for some theoretical and managerial insights regarding GI and the development of IT capability in an interorganisational setting.

6.1. Theoretical Implications

The extant literature indicates that the difficult environmental situation has driven the increasing adoption of green innovation (GI) [1]. Furthermore, current organisational behaviour research has identified GI as one of the critical factors in reinforcing competitive advantage and corporate sustainable development [79]. Therefore, understanding the mechanism of GI and how this practice can better contribute to the sustainable development of the environment and business are essential [2,5]. Our research makes significant theoretical contributions. Among the two main streams of GI literature (i.e., GI drivers and GI outcome) [6], existing studies have investigated the influence of IT capability on customer capital, green supply chain management, and environmental performance [11,83]. Many studies have also explored several driver forces of GI, such as absorptive capacity and relationship learning, knowledge sharing, and green requirements [6,18]. However, the literature has remained silent about the antecedents and consequences of GI under the combined influencing of IT capability with different types of organisation learning (i.e., exploitation and exploration).

Drawing on the OIPT [23], this research applied the SEM methodology, providing evidence to explain the mechanism of developing green innovation with IT capabilities in different paths of organisational learning (i.e., exploitation and exploration). OIPT [29] suggests that corporations increase their capabilities in information processing by creating slack resources, self-contained tasks, and lateral relations, as well as investing in vertical information systems. In this study, our results showed that exploitation and exploration learning significantly and positively affect GI. Additionally, we highlighted the importance of IT capability in GI. Notwithstanding, IT capability did not indirectly impact GI; it had a significant and positive moderation effect on the relationship between exploitation learning and GI (i.e., GPDI and GPCI).

Our findings on the complex GI process and organisational sustainability align with the existing literature about IT capability in enhancing firm performance [68]. We demonstrated that IT capability can positively moderate the relationship between exploitation learning and GPDI and GPCI. Therefore, our research enriches the current literature on the relationship among organisational ambidexterity learning, green innovation, and IT capability. Meanwhile, we provide further support for the positive effect of a higher level of IT capability on organisational performance.

Moreover, building on the three dimensions of corporate sustainability development, we investigated the relationship between GI and corporations' environmental sustainability, social sustainability, and financial sustainability. This research provides empirical evidence on a more in-depth mechanism of how GI impacts corporate sustainability development. Specifically, our results support prior discussions on the relationship between GI and financial sustainability [42,44], social sustainability [78], and environmental sustainability [83]. Therefore, this research contributes to the literature on the relationship discussion between GI and corporate sustainability development.

6.2. Practical Implications

This study provides business managers and practitioners with a more profound implication for exploring the antecedents and effects of green innovation. First, this study offers some valuable insights for firm managers concerning the exploitation and exploration for GI. A high level of exploitation and exploration has a direct influence on improving GI practices. This indicates that, in the process of innovation, business needs to strive to activate and enrich their ways and means of learning, improving, and accepting new knowledge. The essence of GI is the dissemination, co-creation, and accumulation of environmental and technical expertise that can be incorporated into new products, services, and processes that satisfy various customers [11].

In this sense, a further contribution of this study is the role of IT capability in improving corporate GI. These results provide valuable guidelines for related practitioners to show that their engagement in IT activities is crucial for enhancing GI, which improves the business's sustainable performance. Therefore, a top manager ought to leverage the corporate existing IT resources and explore new potential IT resources or information for future business opportunities [120]. Additionally, the findings demonstrate that exploration is more dominant than exploitation in improving corporate GI. In contrast, firm managers cannot ignore the role of IT capability when developing GI practices on the basis of historic decisions and the experiences previously encountered. On the contrary, the findings show that the role of IT capability in moderating the relationship between exploration and GI is not apparent. One possible explanation is that investing in exploration can help companies obtain innovation opportunities, while absorbing and leveraging external opportunities and knowledge is a cost-effective and time-consuming process. Business managers should recognise that IT investment also needs costly and labour-intensive development and support. Therefore, we suggest that managers and practitioners fully consider the cost risk of business learning and IT activities and then balance the two poles of exploration and exploration to eliminate the tension and uncertainty of investing in GI.

Furthermore, the results reveal important implications for business strategy and society. In the modern business environment, due to the commitment to environmental protection, many managers or related practitioners have gradually incorporated GI when considering long-term development, thereby increasing their attention to environmental issues. Companies can promote GI to improve performance [10]. This study supports this argument and suggests that GI can have varying degrees of positive impact on corporate environmental, social, and financial performance. That is, companies effectively incorporate green or ecological concepts into their innovation practices, which can be reflected in their investments in developing high-quality resources and technologies, increasing the effective utilisation rate of new product development, or improving the conversion efficiency of production processes. By doing so, companies can enhance sustainable market competitiveness and better address environmental issues, which in turn helps companies achieve more gains in environmental, social, and financial perspectives [45,121]. Nonetheless, engaging in any type of innovation may involve risks, such as input or switching costs [10]. Therefore, corporate managers need to be open to participating in GI practices and remain sensitive to managing environmental issues in their continued operations and development. Government agencies and policymakers can also encourage the GPDI and GPCI through several progressive or punitive measures. To a certain extent, this will increase the emphasis of company managers on environmental protection and GI.

6.3. Limitations and Future Research

As with all studies, there were some limitations that upcoming researchers can work on in the future. First, existing research settings were unable to observe whether the corporate GI, ambidexterity, IT capability, and sustainable development can provide the same analytical results over a longer time window. Therefore, it is suggested that future researchers use a similar research framework or model to investigate the dynamics of innovative green practices within firms at different points in time, thereby further validating the various relationships established in theoretical models. Second, we conducted this empirical study using a dataset collected in China. Similar analyses could examine the antecedents and impacts of GI in other countries, which may yield different insights into the relationship among ambidexterity, GI, IT capability, and corporate sustainable development in diverse and multicultural contexts. Moreover, future research can also make efforts to distinguish various enterprises, such as comparing the differences across large, small, and medium-sized enterprises.

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Appendix A

Table A1. Survey Items.

	Label	Item
Exploitation	EXI1	Introduction of new generations of products.
	EXI2	Place strong emphasis on improving efficiency.
	EXI3	Upgraded current knowledge and skills for familiar products and technologies.
	EXI4	Frequently adjust procedures, rules, and policies to make things work better.
Exploration	EXR1	Opening up new markets.
	EXR2	Acquire product development skills and processes which are entirely new to the industry.
	EXR3	Acquired technologies and skills entirely new to the business unit.
	EXR4	Frequently experiment with significant new ideas or ways of doing things.

Table A1. *Cont.*

	Label	Item
Green product innovation	GPD1	Design of products for reduce consumption of material/energy during the full life cycle.
	GPD2	Design of products for reduce waste generation during the full life cycle.
	GPD3	Using eco-labelling, environment management system.
	GPD4	Design for disassembly, reusability, recyclables, and recovery.
Green process innovation	GPC1	Sources from suppliers who comply with environmental regulations.
	GPC2	Consumption low energy (such as water, electricity, gas, and petrol) during production/use/disposal.
	GPC3	Use of cleaner technology to make savings and prevent pollution.
	GPC4	Controls operations process to reduce waste from all sources.
	GPC5	Updates manufacturing processes to meet standards of environmental law.
IT capability	IT1	IT infrastructure quality.
	IT2	IT human resources competencies.
	IT3	Business process digitisation.
Environmental sustainability (ES)	ES1	Significant improvement in its overall environmental situation.
	ES2	Significant improvement in its compliance to environmental standards.
	ES3	Significant decrease in energy consumption, air pollution, wastewater, and hazardous/harmful/toxic materials emissions.
Social sustainability (SS)	SS1	Incentives and engagement for local employment.
	SS2	Improvement in labour safety and labour conditions in our facilities.
	SS3	Improvement of community health and safety.
Financial sustainability (FS)	FS1	Increase in market share.
	FS2	Acquisition of new customers.
	FS3	Decrease in cost of materials purchasing per unit of product.
	FS4	Decrease in cost for energy consumption per unit of product.

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