

Chapter 7

Green Product Design



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Abstract Green product design is a fundamental way to reduce environmental pollution and improve corporate performance and competitive advantage. The green product design practice reduces resource waste from the beginning and product environmental pollution in the entire life cycle process. Therefore, green product design is a key process for enterprises to implement green growth models. Existing studies on enterprises' green growth models show that, except for external institutional pressures, internal factors such as internal resources and managers' environmental perception and attitudes also play a vital role in driving enterprises to be greener. Meanwhile, with the development of the Internet, new media attention has been verified to become more powerful in enterprises' strategy adoption. This chapter explores the factors driving enterprises' green product design from internal and external aspects. It further explores the relationship between new media attention and top managers' environmental attitudes toward green product design from a new media and managerial attitude perspective. From the new media perspective, the results show that the new media attention can significantly enhance the impact of customer environmental pressure on top managers' positive environmental perceptions. Therefore, it promotes enterprises to implement a green transformation strategy. Furthermore, from the managerial attitude perspective, the results show that the manager's environmental attitude significantly moderates the relationship between resource management and organizational learning abilities, promoting the implementation of green product design. The research based on the new media

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and managers' environmental attitude perspective enriches the literature on institutional theory and resource-based view. Furthermore, it supports relevant policy-makers to implement strategies, such as the appropriate use of new media power and the manager's environmental attitude to motivate enterprises to implement green product design rather than strict environmental regulations.

7.1 Green Product Design and Enterprises' Green Growth Models

7.1.1 Concept of Green Product Design

(1) Green Product Design

Green products meet specific environmental protection regulations, causing little or no harm to the ecological environment, have low energy consumption and have the highest resource utilization rate in the entire life cycle [1]. Green product design is a proactive approach to integrate product design and environmental considerations without compromising its function and quality, including innovations for recovering product value throughout its life cycle before disposal; that is, it involves the entire life cycle of products from "cradle" to "end of life" [2]. The product design stage usually determines the types of pollutants discharged, solid and hazardous wastes generated, resources obtained, and energy consumed. Innovation and green design at this stage allow enterprises to find solutions to environmental problems. For example, China has strongly supported and encouraged the development of new energy vehicles in recent years, effectively reducing carbon dioxide emissions from the source.

(2) Implementation of Green Product Design

The contents of green product design are shown in the following four aspects. First, for green product design, product materials are marked to facilitate disassembly, such as using color or code, etc. Second, the interfaces between components that are easy to disassemble and repair are designed. Third, "life cycle assessment (LCA)" is used for product design. Fourth, standardized components that are easily reusable are used [3]. For example, marking product materials can help improve the efficiency of disassembly and installation during assembly, maintenance, and recycling. Modular and special product interface designs have been positive for product remanufacturing ability and automatic diagnosis of malfunction. For example, the modular design of Apple mobile phones and computers significantly improves the efficiency of Apple products in terms of maintenance and replacement. In addition, using clean technologies such as LCA can significantly minimize product costs and environmental problems during the life cycle and at the end of life [4]. Green product design is vital for sustainable development [5]. However, the uncertainty in environmental trends and regulations makes green product design more complex. Considering

these complexities, enterprises can introduce green innovation into product design to obtain first-mover advantages to reduce this uncertainty. This includes obtaining new technology licenses, developing unique manufacturing capabilities, creating proprietary information, and providing sustainable competitive advantages for enterprises [6].

(3) Characteristics of Green Product Design

Green product design requires designers to combine resource, energy optimization, labor, natural environment protection, and production requirements of function, quality, service life, and cost in the design conception stage. And the characteristics of green product design are shown as follows. First, green product design can reduce environmental pollution through green product design. Therefore, products are harmless or do little harm to the environment from production, use, recycling, and even disposal. Because green product design requires enterprises to develop green designs during the design stage and select clean raw materials and technological processes during production, it helps customers produce no environmental or little pollution when using products, and the scrap products generate the least waste in the recycling process. Second, it can maximize the utilization rate of raw materials. Therefore, green products can minimize and reduce raw materials that are scarce, expensive, toxic, and harmful. Because green product design requires designers to simplify the product structure, properly use materials, make the parts and materials recycled and reused cleaner, and meet the basic functions of products in the design stage. Third, it can save energy to the greatest extent. Green products can lower energy consumption in their life cycle, maximize renewable energy, and adopt advanced technology to improve the utilization capacity to save energy to the greatest extent. For example, “the blade battery” developed by BYD, a powerful battery with new lithium iron phosphate technology, has higher safety than the traditional lithium battery and has obvious advantages in prolonged life span and endurance, finally, significantly reducing the environmental pollution.¹

7.1.2 Goals of Green Product Design

As the center of green design, green product design considers the product’s impact on resources and the environment during the entire life cycle. When considering the function, quality, development cycle, and cost of a product, it is also necessary to optimize relevant factors to minimize the overall negative environmental impact of the product in its manufacturing, use, maintenance, and recycling processes. Therefore, the product can meet the requirements of green environmental protection [7]. Basic thinking of green product design combines all the factors that affect the environment and pollution prevention measures into the product design stage; furthermore, it considers environmental performance as the main design goal and starting point

¹ <https://en.byd.com/?s=the+Blade+Battery>.

to minimize the product environment effect in the design stage. Therefore, green product design aims to protect the environment, reduce lifecycle costs, and improve enterprise performance [8].

(1) Environment Protection

The primary goal of green product design is to protect the environment and reduce the level of product environmental pollution. However, the level of product environmental pollution is mainly determined by the level of green products in the design stage. With the aggravation of environmental pollution, a green product design strategy has become a fundamental method to solve this environmental problem. Through green product design, the environmental pollution problem can be solved by reducing the use of toxic materials and using recyclable and degradable materials. For industrial design, the main goal of green product design is “3R1D,” that is, reducing, recycling, reusing, and degradable [9]. It should reduce the consumption of materials, energy, and the emission of harmful substances, make the products and parts easy to classify, recover, recycle, reuse, and non-reusable components should be easily degradable. The characteristics of green product design in environmental protection are as follows: minimizing the use of non-renewable materials; avoiding the use of toxic materials; using renewable resources according to the replenishment rate of renewable resources; making the product easy to reuse, recycle, or degrade at the end of its life cycle. For example, Nike’s “move to zero” series of sports shoes is a typical example that their raw materials are waste plastics. Through a series of green technologies, it can be recycled to reproduce and also can be 100% recycled at the end of life, truly achieving the goal of “3R1D”.²

(2) Reducing Costs of Product Life Cycle

An additional goal of green product design is to reduce product life cycle costs. As resource and environmental pollution issues become severe in the manufacturing industry, the concept and content of green design have become the focus of green research. However, preliminary research about green design is mainly from the aspect of manufacturing technology. It only considers how to make greener products using manufacturing design schemes and technologies but does not consider green costs. Therefore, a cost–benefit analysis is required for further exploration. The traditional cost–benefit analysis of manufacturing holds that the product cost is the sum of the sales and manufacturing costs, excluding service and environmental pollution costs. Thus, the cost–benefit analysis of green manufacturing further considers the income of energy savings, reused parts, and recycled materials. Additionally, it considers the ecological cost savings caused by reducing pollution in product production, the reduction of environmental protection expenses during the product life cycle, and the disassembly, material regeneration, and other waste disposal costs. Therefore, implementing enterprises’ green product design strategy reduces the manufacturing and

² <https://news.nike.com/news/move-to-zero-spring-summer-2022-official-images>.

sales costs and greatly reduces production costs in their entire life cycle, recycling, and scrap degradation stages.

(3) Improving Enterprises' Performance

Enterprise performance can be divided into economic, environmental, and social performance. Existing studies suggest that enterprises' green product design strategies can significantly improve their economic and environmental performance and obtain a sustainable competitive advantage. Green product design can significantly improve the reusable and recycling abilities of the product and the utilization efficiency of resources and energy by using the lowest lifecycle cost to design green products to reduce production costs and improve enterprises' economic performance. Integrating the green concept into an enterprise's product design can improve its financial performance by significantly reducing the risk of punishment for violating established environmental regulations and the relevant operational costs. In addition, an enterprise's green product design strategy significantly affects its environmental performance. By combining the "3R1D" into the product design stage, product environment pollution in the entire life cycle can be effectively reduced, and enterprises' environmental performance can be significantly improved [10]. Enterprises obtain good economic, social, and ecological performance through the green product design strategy. Enterprises can meet customers environmental protection needs through green product design and provide them with low-cost and high-quality products. It can improve customer satisfaction and loyalty, further, to obtain the recognition of various stakeholders and a good reputation, and improve corporate social performance. For example, BYD's successful R&D of "the blade battery" significantly reduces the production cost, provides higher safety, and prolongs the product life cycle.³ Therefore, it improves an enterprise's economic, environmental, and social performance.

7.1.3 The Importance of Green Product Design for Enterprises' Green Growth Models

The core of enterprises' green growth model is to achieve green growth and overall optimization. Enterprises can reduce environmental pollution while achieving good economic, social, and operational performance. Green product design is well placed to help companies achieve a green transformation of the whole process from the source of the product and achieve sustainable growth by reducing costs and operational risks, which could achieve overall optimization. As a key step in the greening of products, green product design lowers production costs by increasing product reusability and recycling, thus effectively reducing environmental pollution and

³ <https://en.byd.com/?s=the+Blade+Battery+performance>.

increasing efficiency through modular design. Green product design can reduce regulatory risk, lower operational costs, and enhance the economic and environmental performance of enterprises. Additionally, implementing a company's green product design strategy satisfies laws and regulations while meeting the environmental needs of customers. It reduces environmental pollution while gaining support from various stakeholders and improves the company's social reputation and image, achieving green and sustainable growth. Although green product design requires a large amount of capital, companies with a strong green product design can also help them earn more benefits.

For example, in September 2021, the Ministry of Industry and Information Technology of China announced the green product design enterprises and the MACO list. With a strong industry influence and market competitiveness, good business management status, and a leading position in the industry in the product market, MACO has established a sound management system for quality, environment, energy, and occupational health and safety. It has strong technical research and innovation capabilities, product design and development institutions, professional teams, well-known independent brands with obvious industry or regional characteristics, and strong representativeness, innovation, and replicability. By incorporating the concept and requirements of green design into the strategic planning of enterprise development, this company possesses the basic ability to carry out product life cycle evaluation to apply the basic database of green design and advanced design tools and methods. It can transform green design applications such as inspection and verification, measurement and testing, and large-scale production. Green design-related work has been carried out. The products meet the relevant standards for green design product evaluation or participation in formulating technical specifications, standards, or policies related to green design products. The proportion of green design products in the product design has increased annually. They are the production volume and output value leaders in the industry. Emphasis on green design and environmental planning is one of the main reasons for MACO's strong core competencies. The company has a reputation for being the cleanest factory in the world. With the introduction of the world's most advanced dust collection system, MACO's particulate matter has been tested by a third-party authority to be less than 1 mg/m, below the detection limit of the standard method, and is considered "undetectable." In the actual testing environment, the particulate matter emission concentration of the MACO factory is less than 20ug/m, reaching the international quality air standard of 0-25ug/m. It is far lower than the Chinese quality air standard of 0-50ug/m, achieving the "MACO miracle" of emission of the same standard as the international quality air in 2019. In October of the same year, MACO was officially awarded as the designated supplier for the China Pavilion at the 2020 Dubai World Expo.⁴

⁴ <http://www.meichao.com/>

7.2 External Factors of Green Product Design

Green product design seeks to create products with the least environmental impact. This includes many activities, ranging from disassembly design (such as interface and component design) to broader life cycle assessment practices [11]. Although research and practices on green product design have been well developed, there are still obstacles to implementing them. These include external new media pressure, government rewards and punishments, customer demands and peer pressures, and enterprises' internal resources and organizational learning ability [12]. Motivations and abilities are key factors for success in implementing green product design practices. Therefore, the key factors affecting enterprises' green product design can be divided into external pressures and internal abilities. This section mainly explores external pressures from the perspective of new media attention.

7.2.1 *The Influential External Factors of Green Product Design*

With deteriorating environmental pollution, motivating enterprises to implement proactive environmental strategies such as green product design, which is the way to solve environmental pollution. Existing studies on the driving forces for encouraging an enterprise to implement green product design include external institutional pressure, top managers' environmental perception, and the new media supervision effect. However, with the establishment of China's environmental laws and regulations, the power of institutional pressure on enterprises' green product design has decreased. However, with the development of the Internet, the media, as one of the stakeholders, plays a more important role in enterprises' green transformation, especially new media. Media supervision can reduce enterprises' environmental pollution and amplify other external stakeholders' powers through their fast response speed and wide communication range, encouraging the implementation of green product design. For example, the Tengger Desert pollution case is famous for its high penalty amount (620 million RMB) in China.⁵ When local governments and newspapers reported this case in 2012 and some pollution enterprises in this industrial park were punished by the government and environmental protection departments, they responded passively by covering up the pollution pool. However, when this pollution event was mentioned again by the government and other stakeholders, reported by the China Central Television (CCTV), and spread by new media in 2014, enterprises proactively implemented green transformation and green environmental strategies. Therefore, this section further explores the driving forces that promote enterprises to implement green product design and how new media works.

⁵ <https://tv.cctv.com/2019/11/30/VIDERL5YzkmySZNq1kdXRPYW191130.shtml>.

According to the literature review, existing studies mainly focus on institutional theory to explore how these regulatory, customer, and competitor pressures motivate enterprises to be greener. For example, the government can use the rewards and punishments pressure to motivate and drive enterprises to implement green innovation. Additionally, customers can support or resist enterprise-related products or services to influence their green product design. Competitors can affect the focal firm's perception of green strategy by promoting product design implementation and competitive advantage. However, most existing studies ignore the effects of new media attention on green product design [13]. With the development of new media, the supervision and incentive effects are more powerful. New media can significantly regulate the relationship between stakeholders and corporate environmental strategy by providing a communication platform for stakeholders. For example, in Nestle's incident, the boycott activities of NGOs by publishing their video on social platforms pushed Nestle to be greener, implement a proactive environmental strategy, and use sustainable palm oil.⁶ However, acting as a "regulator" to regulate the impact of various stakeholders on enterprise strategy, whether the attitude of new media attention is positive or negative, new media attention can also promote strategic transformations through its reports.

Existing studies based on institutional theory mainly focus on the direct impact of institutional pressure on green product design without considering the mediation effect of top managers' environmental perception. However, top managers' attention and interpretation of external pressure to the external environment are critical to linking external pressures and enterprises' proactive environmental strategies [14]. The stronger the new media dissemination role in the external environment, the more obvious the amplification effect of new media attention, and their moderation effect between institutional pressures and top managers' environmental perception. Furthermore, new media attention has enhanced external institutional pressure through timely and extensive coverage of environmental needs from various stakeholders. This pushes top managers to perceive more opportunities toward the external environment and adopt a green product design strategy more willingly. Therefore, based on institutional theory and upper echelon theory, this section explores the motivational effects of external institutional pressures, new media attention, and top managers' environmental perceptions on green product design from the new media perspective, as shown in Fig. 7.1.

7.2.2 Green Product Design Model and Hypothesis from the Perspective of New Media Attention

Based on the literature review, we propose the following theoretical model (see Fig. 7.2) and further explain the relationship between various motivation factors.

⁶ https://www.greenpeace.org/international/?s=Nestle&orderby=_score.

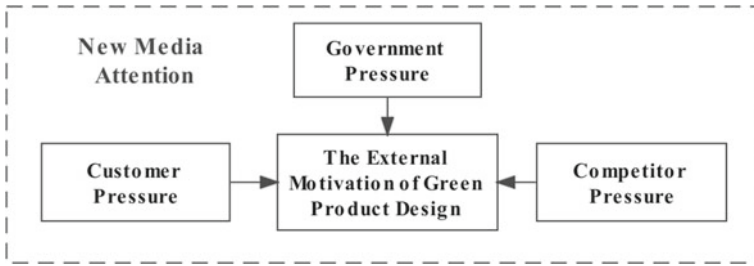


Fig. 7.1 The external motivation of green product design

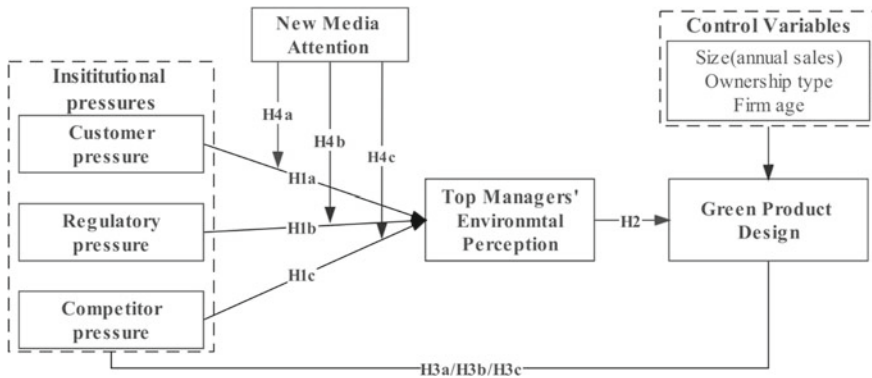


Fig. 7.2 Theoretical model

(1) Customer Pressure

Based on institutional pressure, some studies show that customer needs for green products or services are the second main driving force for enterprises to implement green product design [13]. Early studies on institutional pressure and enterprises' green product design indicated that the government's regulatory pressure was the main motivation to implement green transformation. However, with improving customers' environmental awareness, customers have become the main source of inspiration for enterprises' green transformation. This is because customers can directly affect enterprises' economic performance by supporting and resisting their products in the market. In addition, customers' support and loyalty to their products provide a good reputation and competitive advantage for enterprises' sustainable development. Therefore, actively responding to customers' environmental needs has become a top priority for top managers [15]. Implementing a green product design strategy can meet customers' environmental needs and significantly reduce the products' production and operational costs by implementing green behaviors, such as modular design and using reusable and easily recyclable materials in the product design stage. Therefore, implementing this strategy can significantly improve

customer satisfaction and enhance enterprise performance and competitive advantage. The BYD's "the blade battery" is a case in point. Therefore, we propose the following hypothesis:

Hypothesis 1a: Customer pressure positively affects top managers' environmental perception.

(2) Regulatory Pressure

Regulatory pressure emanating from the government and relevant departments, and which is gradually viewed as the greatest driving force motivating top managers to implement green innovation [16]. There are two ways in which regulatory pressure encourages top managers to perceive these pressures as opportunity to adopt green product design. On the one hand, the government and relevant departments can reduce costs and market risks for the enterprise's green product design strategy by formulating relevant incentive policies, such as environmental protection subsidies, lowering taxes, and establishing green channels. For example, BYD is the leading electric vehicle enterprise in China, and the success of its green product design and innovative concept is based on the government's supportive policies. In addition to the relevant capital support and consumption subsidies, the government supports BYD's innovation and green product design by constructing infrastructure and charging piles [17]. On the other hand, the government can also improve rules regarding environmental criteria and strengthen the implementation of regulations and policies to promote reactive enterprises to become greener. Through such regulations, the government stipulated the target level of environmental performance and punished enterprises with poor compliance or even moved them out [18]. For example, as the Chinese "double carbon" goal strives to achieve a carbon peak by 2030 and carbon neutralization by 2060, many thermal power enterprises have been pushed to become greener.⁷ Therefore, we propose the following hypothesis:

Hypothesis 1b: Regulatory pressure positively affects top managers' environmental perception.

(3) Competitor Pressure

In addition to regulatory and customer pressure, competitors who successfully implement green transformation strategies are also an important driving force motivating top managers toward green product design. Competitor pressure occurs when enterprises imitate competitors who have successfully carried out green transformations and attempt to copy their success [19]. The competitors' successful green transformation gives them the advantages of first-mover, unique market share, and market competitiveness. These advantages persuade enterprises to implement green product design and reduce the survival risk. Therefore, they need to be greener to maintain the market share and competitiveness of enterprises. By positively responding to competitor pressure, the enterprise can reduce the risks of uncertain results and green product design activities and obtain the legitimacy of entering the green market

⁷ <https://www.drc.gov.cn/DocView.aspx?chnid=379&leafid=1338&docid=2904498>.

and getting scarce resources, for example, the success of NIO's new energy vehicle. Therefore, we propose the following hypothesis:

Hypothesis 1c: Competitor pressure positively affects top managers' environmental perception.

(4) Mediation Effect of Top Managers' Environmental Perception

According to upper echelon theory, top managers' environmental perception is vital for an enterprise to successfully implement green product design practices. Studies show that executives' perceptions, beliefs, and attitudes can significantly affect an enterprise's green strategy. In a complex decision environment, managers who make strategic choices are determined by their environmental perception and how they interpret these external pressures. When managers view the unpredictability of new technologies and green strategies as threats to their jobs or their company's operations, they are less likely to risk and choose a proactive environmental strategy and seek to minimize losses rather than maximize gains. Therefore, these managers are unlikely to search for innovative environmental technologies because they can disrupt the current production and operating systems. However, with increased institutional pressures and the vital role of environmental issues in enterprises' survival, the top manager usually interprets the external environment, such as issue legitimation and discretion, as an opportunity to choose proactive environment strategies [20]. Hence, we propose the following hypotheses:

Hypothesis 2: Top managers' environmental perception positively affects an enterprise's green product design.

Hypothesis 3: (a) Customer pressure, (b) regulatory pressure, and (c) competitor pressures positively affect the enterprise' green product design via the top manager's environmental perception.

(5) The Moderation Effect of New Media Attention

Firms are under pressure from many outside stakeholders who want them to change. These pressures are stronger when expressed through new media attention and often persuade management to make changes. With the development of new media, such as Twitter, websites, and other social media types, media power has become stronger through their timely, fast, and widespread influence. Therefore, it is easier for new media to blow institutional pressures on irresponsible companies, damaging their reputation and pushing managers or enterprises towards greener strategies. Existing studies explore the relationship between new media and green product design directly. First, as one of the stakeholders, new media can affect enterprises' green strategies by investigating and reporting their relevant environmental problems and protection activities. For example, in the Enron accounting cases, the media's investigations and

reports exposed the fraud in Enron.⁸ Second, as an effective information dissemination and exchange platform, new media can significantly amplify external environmental pressures through the timeliness of the information and wide transformation effect [21]. For example, the government and consumers' environmental pressures on enterprises' green strategies can be significantly strengthened by reporting and dissemination of new media. Finally, in addition to the amplification effect, new media can also supervise enterprises' environmental protection behaviors through its timely and extensive impact and encourage them to implement green transformation through its rapid and extensive communication ability.

However, some researchers have realized that no matter how powerful the new media's amplification effect and supervision role, it must influence the managers' perception, and then, affect the enterprises' environmental strategy [14, 22]. The tone of new media coverage and the level of external stakeholders' environmental needs can directly affect top managers' reputation, capital income, and careers, thus influencing managers' environmental perception. Some studies indicate that positive new media attention can significantly improve managers' reputation, future careers, and enterprises' performance and competitive advantage, thus increasing top managers' positive environmental perception. However, some researchers find that negative new media attention can also improve top managers' environmental perception. Their negative attention threatens managers' interest and enterprises' survival, pushing them to be more positive. Furthermore, negative media attention will increase operational costs and reduce enterprises' performance. Still, it can also seriously damage executives' careers, and this attention is directed toward enterprises' upstream and downstream partners [23]. Therefore, managers will cultivate more positive perceptions of external environmental pressures, especially through amplifying new media attention. Thus, we propose the following hypothesis:

Hypothesis 4a: New media attention moderates the positive relationship between regulatory pressure and top managers' environmental perception. The relationship is stronger when new media attention is high and weaker when low.

Hypothesis 4b: New media attention moderates the positive relationship between customer pressure and top managers' environmental perception. The relationship is stronger when new media attention is high and weaker when low.

Hypothesis 4c: New media attention moderates the positive relationship between competitor pressure and top managers' environmental perception. The relationship is stronger when new media attention is high and weaker when low.

⁸ <http://large.stanford.edu/courses/2018/ph240/smith1/>

7.2.3 Results and Conclusions of Green Product Design Model from the Perspective of New Media Attention

(1) Data Sources and Analysis

The data were collected through a questionnaire and using a Likert 7 scale. The questionnaire items are mature scales. The reliability and validity of the questionnaire were tested through a small-scale pre-test. The results show that the questionnaire has good reliability and validity. Then, we conducted large-scale data collection through online and offline methods and distributed 200 and 1000 questionnaires, respectively. 71 and 274 valid questionnaires were collected, with an effective rate of 35.5% and 27.4%, respectively. Furthermore, we used SmartPLS software (version 3.3.3) to analyze the survey data.

(2) Reliability and Validity Test

Table 7.1 shows the descriptive statistical analysis results of the participants' basic information, and Table 7.2 shows the reliability and validity of test results. All reliability and validity indicators were greater than 0.7, indicating that the questionnaire was valid and reliable.

(3) Common Method Variance

There may be a false correlation between variables due to the data collection method. Independent and dependent variables were measured during the questionnaire design

Table 7.1 Sample profile

Item	Sample characteristics	Frequency	%
Enterprise size	Less than 500	77	22.3
	500–999	152	44.1
	1000–5000	76	22.0
	More than 5000	40	11.6
Ownership type	State-owned	81	23.5
	Publics	22	6.4
	Private	162	47.0
	Wholly foreign	26	7.5
	International joint	54	15.7
Enterprise age	Less than 10 years	107	31.0
	10–30 years	219	63.5
	More than 30 years	19	0.1
Media Type	Traditional media	49	14.2
	New media	296	85.8
	Total	345	100

stage to eliminate common method variance (CMV). Procedural remedies were adopted during the data collection stage. We interoperated the survey to be anonymous, and there were no right or wrong answers so that the participants could answer the questions honestly. There was a 3-h break between surveys #1 and #2 in the outline data collection stage. We inserted a 30-s video in the middle of the survey in the online stage to reduce common method bias. Finally, we used Harmon’s single-factor test to detect CMV. The results show that no factor accounts for >40% of the variance, indicating that the CMV is not a concern. These results suggest that CMV is unlikely to be a severe concern in this study.

(4) Results

We used the SmartPLS software (version 3.3.3) to test the hypotheses. Figure 7.3 shows the results. This research model can explain 41.9% of the deviation in green product design. The results indicate that customer environmental, regulatory, and competitor pressures have a significant positive effect on green product design ($\beta = 0.238, p = 0.000 < 0.001$; $\beta = 0.264, p = 0.000 < 0.001$; $\beta = 0.200, P = 0.000 < 0.001$). Therefore, Hypotheses 1a-c are supported. Top managers’ environmental

Table 7.2 Reliability, validity, and correlation

Constructs	Alpha	CR	AVE	CUP	RP	COP	TMP	NMA	GPD
CUP	0.779	0.857	0.600	0.775					
RP	0.728	0.845	0.513	0.283	0.803				
COP	0.866	0.909	0.713	0.600	0.344	0.845			
TMP	0.831	0.888	0.664	0.547	0.494	0.403	0.815		
NMA	0.725	0.827	0.548	0.486	0.513	0.399	0.472	0.740	
GPD	0.728	0.846	0.648	0.506	0.533	0.395	0.517	0.462	0.805

Note Alpha = Cronbach’s alpha; CR = Composite reliability; AVE = Average variance extracted; COP = Competitor pressure; CUP = Customer pressure; RP = Regulatory pressure; TMP = Top managers’ environmental perception; NMA = New media attention; GPD = Green product design. The bold values in diagonal cells are square roots of AVEs

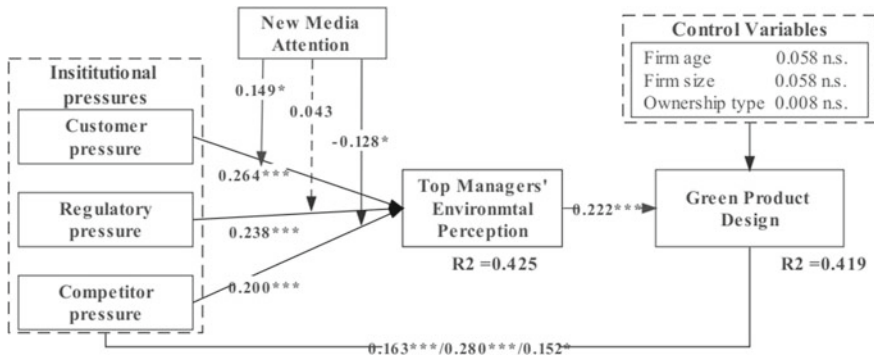


Fig. 7.3 Theoretical model result

perception has a significant positive impact on green product design ($\beta = 0.222, P = 0.000 < 0.001$); thus, Hypothesis 2 is supported. The three institutional pressures also have a significant positive effect on green product design ($\beta = 0.152, p = 0.037 < 0.05$; $\beta = 0.280, p = 0.000 < 0.001$; $\beta = 0.163, p = 0.000 < 0.001$). Thus, supporting Hypothesis 3. However, institutional pressures on green product design show that customer pressure becomes the greatest force motivating enterprises' green product design, followed by regulatory and competitor pressure, inconsistent with the literature review.

The path coefficients show that Hypothesis 4a ($\beta = 0.149, p = 0.022 < 0.05$) and Hypothesis 4c ($\beta = -0.128, p = 0.020 < 0.05$) are significant. This indicates that new media attention can positively moderate the relationship between customer pressure and top managers' environmental perception. However, the relationship between competitor pressure and top managers' environmental perception is negative; thus, Hypothesis 4a is supported and Hypothesis 4b is partly supported. However, there is no significant moderating effect between regulatory pressure and top managers' environmental perception. Therefore, Hypothesis 4c is not supported.

To further interpret this moderating effect, we plotted a simple slope. Three regression lines of competitor and customer pressure on top managers' environmental perception were plotted above and below the mean of the dependent variable based on one standard deviation. Furthermore, we plotted the interaction in Fig. 7.4 and Fig. 7.5. As shown in Fig. 7.4, a simple slope analysis confirms that new media attention can positively moderate the relationship between customer pressure and top managers' environmental perception ($\beta = 0.149, p = 0.022 < 0.05$). Conversely, it negatively moderates the relationship between competitor pressure and top managers' environmental perception, weakening top managers' environmental

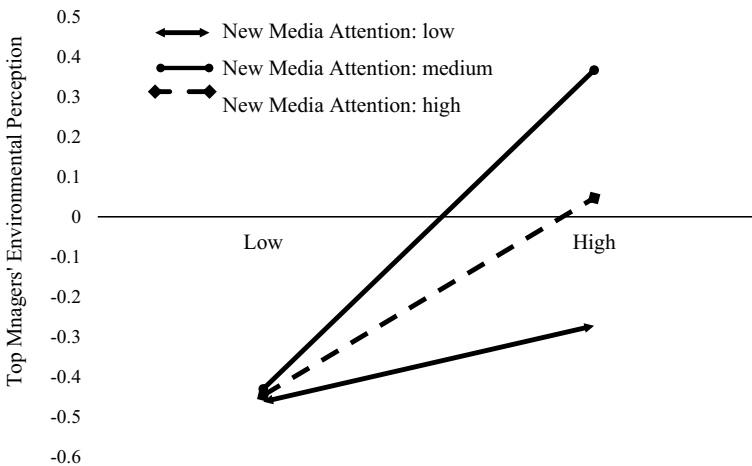


Fig. 7.4 Interaction of customer pressure and new media attention on top managers' environmental perception

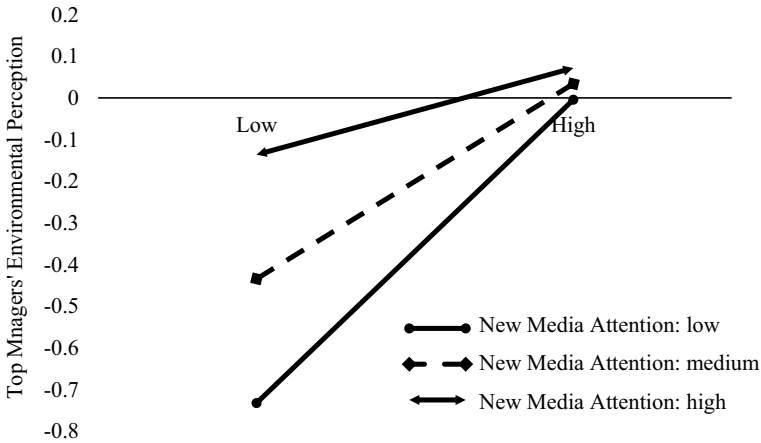


Fig. 7.5 Interaction of competitor pressure and new media attention on top managers' environmental perception

perception when new media attention increases from low to high, as shown in Fig. 7.5 ($\beta = -0.128$, $p = 0.020 < 0.05$).

(5) Conclusion

The results show that the three institutional pressures positively affect top managers' environmental perception of green product design and positively motivate them to implement it. The results also indicate that customer pressure has the most significant impact on enterprises' green transformation, followed by regulatory and competitor pressures. In addition, new media attention significantly enhances customer pressure and motivates top managers to adopt green product design strategies. However, the effect of competitor pressure on new media amplification is weakened. The widespread use of new media provides customers with more opportunities to express their environmental needs, significantly enhancing external environmental pressure, providing top managers more opportunities, and promoting enterprises to implement green product design. Enterprises that imitate competitors' successful environmental practices can better maintain their performance and competitiveness. However, excessive imitation can cause enterprises to lose innovation and market share. Thus, new media attention negatively moderates the relationship between competitor pressure and the enterprise's green product design strategy [24]. With the development of environmental laws and regulations, regulatory pressure plays a basic role in motivating enterprises to be greener; therefore, new media attention can positively moderate the relationship between regulatory pressure and top managers' environmental perception, but the effect is not significant.

7.3 Internal Factors of Green Product Design

In addition to the external factors that influence the design of green products, factors within the company also influence the effects of green product design. For example, the company's resource management capabilities, manager's environmental attitude, and organizational learning capabilities are particularly influential on green product design. This section explores the impact of these significantly influential internal factors on green product design.

7.3.1 *The Influential Internal Factors of Green Product Design*

(1) Research Background

With the introduction of more environmental policies, many companies are positioning green product designs as the basis for their business development. Different subsidy policies have made companies frequently engage in green product design. The larger the company is, the more pollution the company discharges. Therefore, companies need to manage their existing resources to maximize the value to adapt to changing market conditions.

Several companies risk avoiding penalties and use the same design production models. These phenomena also make it more difficult for regulators to monitor the situation, leading to pollution accidents. For example, in March 2021, Tangshan Songting, Tangshan Jinma, and Tangshan Zhonghou Plate did not redesign products to meet market demand but instead used concealment, misrepresentation, and false reporting of corporate information to avoid scrutiny by the relevant review authorities.⁹ The fact that these three companies were polluting was eventually discovered after residents reported them. The managers of the above three enterprises adopted illegal production methods despite knowing about the policy penalties, placing them at the risk of seizure and suspension.

By contrast, committed to developing and applying new energy technologies to address the climate and energy challenges facing humanity in the future, BYD has helped the company achieve its annual "carbon reduction" target through its green product design approach. According to BYD's annual report, revenues have grown from 127 to 261 billion during 2019–2021.¹⁰ Companies primarily engaged in green product design realize environmental and income benefits, creating a win–win approach to environmental revenue. In 2020, Bloom-berg was also named BYD's founder, Wang Chuanfu, one of the world's top 30 environmental leaders.¹¹ Wang

⁹ <http://tingshen.court.gov.cn/live/27281538?>

¹⁰ <https://www.bydglobal.com/cn/Investor/InvestorAnnals.html>.

¹¹ <http://bydauto.com.cn/auto/news/2020-03-04/1514435985113>.

Chuanfu has produced environmentally efficient results year after year through his positive environmental attitude and built the company into a high-end new energy vehicle company with green product design. Wang Chuanfu, an engineer by training, has led the company's technological upgradation, product development, and design. His attributes have influenced the company to have a good organizational learning environment and the ability to better develop green product design. This shows that a manager's environmental attitude has a crucial influence on the development of companies and the way they choose to design green products. Therefore, the research question is: Does the manager's environmental attitude influence green product design?

(2) Enterprises' Resource Management Capacity

Enterprise resource management capability is the ability to manage physical assets and technology [25]. The possession of scarce resources is the basis for green product design; however, the possession of resources alone does not guarantee effective product design. Resources are separate entities. Thus, resources can be used with high efficiency if they are linked and allocated. Therefore, resources must be managed effectively to achieve an effective green product design. A company's resource management capabilities include integration, bundling, and access to resources [26]. These are three ways in which a company can support a green product design process. These three areas are discussed in more detail below:

(a) Consolidation of the Resources of the Enterprise

In designing green products, labor, technology, and capital markets are often subject to opportunism and information asymmetry, complicating the efficient allocation of resources between companies. Therefore, the management of the company's resources is also a test for the company's managers: the better the ability to manage resources, the better the ability to construct a portfolio of resources. The construction of a resource portfolio is accumulating and acquiring resources. Enterprises can regroup resources by re-managing them to achieve a new mix and provide a resource base for green product designs. Abundant human and material resources can contribute to the process of green product design. Simultaneously, the recombination of resources can also generate more valuable resources for the company, further enriching the resource conditions for green product design, forming a beneficial virtuous circle.

Companies have quicker information about the resources they control than other companies and are more likely to recognize the value of their resources. When the value of external resources is difficult to assess, they become even more important. There are many obstacles to accessing external resources, especially in resource-poor environments, therefore, accumulating resources is vital. The regrouping of existing resources can also lead to the discovery of new links between resources and thus to the accumulation of more resources. A wealth of resources makes it easier for companies to design green products. Additionally, when diversified resources are accumulated, companies with fewer external needs are more resilient to risk than

those that need external resources entirely, ensuring a good operating environment for green product design. Based on the abundance of resources, as companies do not need to compete fiercely with other companies for resources, a favorable isolation mechanism for green product design will emerge, further increasing the efficiency and safety of green product design.

(b) Bundling Resources

Bundling resources can help firms develop unique resource portfolios, enabling them to find inspiration for green product design within a richer portfolio of resources [26]. Competition between firms for green product design is often driven by similarities or differences in the means by which firms use their resources and not necessarily by similarities in the resources they control. When successful companies design green products through a diversified design approach, they may be able to develop green products more effectively than their competitors, resulting in unexpected design outcomes. There is no substitute for the importance of bundling resources in a company. Many companies create and design green products by explicitly allocating resources in difficult ways for competitors to imitate, making the product more unique in the marketplace—the stronger its resource management capabilities, the greater its perceived value potential. Nevertheless, the company could develop better abilities to support its green product design by bundling resources. However, bundling resources requires a delicate balance between concentration and fragmentation to achieve greater diversity of resources, further testing a company's ability to manage resources.

(c) Access to Resources

In a healthier external environment, access to resources can help companies increase their competitiveness. This places greater demand on a company's resource management capabilities. Business managers must acquire external resources based on their business situations. A common development method is to make acquisitions that can help a company quickly acquire the resources it needs. In addition, because the information is asymmetrical in the environment, strategic acquisitions allow for timely information updates so that managers can better assess their resources. By acquiring and managing existing resources, companies can create a better design environment and foundation for green product design. In addition, as the diversity of a company's resources increases, the differences between the company and its competitors grow. This increasing heterogeneity makes it more difficult for competitors to imitate, further increasing the uniqueness of the green product. However, acquiring a resource often implies a long-term commitment to hold that resource. When a resource is highly liquid, there are more hidden risks. For example, acquiring would create hidden risks because the availability of the resource usually depends on how well it matches the requirements of the external environment [27]. Managing

resources also plays a vital role in controlling risk by helping companies find the most appropriate resources at the most appropriate time, reducing the risk for companies that lack resources and affect their green product design.

(3) Manager Environmental Attitudes

Manager environmental attitudes refer to their views and opinions on environmental issues [28]. From a stakeholder perspective, the values, experiences, and perceptions of business managers can significantly influence their perceptions and interpretations of the environment, and then influence their decisions.

The manager's decisions play a decisive role in a company's operational strategy. Although market orientation and a company's green product design environment cannot be separated, it has different dimensions and does not have a comprehensive impact on green product design. Managers are more inclined to design products consistent with environmentally friendly standards when they show a higher acceptance and positive attitude. Thus, managers' environmental attitudes drive companies' consideration of green product design.

The basic theory of values suggests that environmental attitudes are a combination of values, including egoism, altruism, and ecological orientation [29]. Individuals and ecologically oriented organizations are more likely to make their products more compatible with green standards. A positive environmental attitude increases the amount of money companies spend on green product design. Therefore, the degree to which managers have positive environmental attitudes determines the strategic choices made by companies, including the amount of human and material resources invested in green product design. However, according to attitudes, behavior, and context, a company's green product design behavior results from its internal environmental attitudes and external environment. Therefore, energy efficiency and environmental protection are high when customers demand green products. Companies are more likely to engage in more intensive green product designs to meet market and consumer needs, and can provide their managers with a more positive environmental attitude.

Managers who value the environment must have an even higher initiative in dealing with pollution in highly polluting industries. If these companies value customer feedback, they are more likely to make green product design improvements and adopt positive environmental attitudes to maintain their image with customers, increasing their competitiveness. Conversely, managers with a negative attitude towards the environment will try to design more cost-efficiently, reducing product performance in environmental friendliness and sustainability.

With the growing market demand, the demand for green products is also increasing. Therefore, implementing a green product design is an important tool for companies to differentiate themselves from their competitors and improve visibility. Furthermore, for companies more concerned about their competitors' gathering information on various aspects, a manager with a positive environmental

attitude will update their company's products and choose more advanced and environmental-friendly processes to achieve green product design.

(4) Enterprises' Organizational Learning Capacity

Organizational learning is the process by which firms develop new knowledge and insights from the shared experiences of corporate members and has the potential to enhance firm capabilities [30]. Previous research has shown that organizational learning capabilities can lead to more prominent creative design capabilities in firms [31].

Within a company, organizational learning and knowledge are prerequisites for green product design, as outstanding organizational learning capabilities can increase the company's flexibility to achieve green product design. There are several steps in the process of organizational learning: first, the company acquires knowledge and information related to green product design; then, the information is shared and explained so that employees understand the meaning of the information and transform it into new public knowledge, and finally, the new knowledge is stored so that the company gains a higher level of competitiveness in terms of its knowledge base. The stronger the organization's ability to learn, the greater its ability to transform knowledge and create new knowledge. Therefore, the knowledge base plays a crucial role in the inspiration-finding phase of green product design.

Organizational learning allows companies to develop capabilities to create better sources of inspiration for green product design. At the same time, green product design is also a process of transformation and exploitation of existing knowledge. A company's organizational learning capability increases its absorptive capacity; in this sense, the stronger the organizational learning capability, the better the green product design. The organizational learning capability is divided into exploitation and exploratory learning [32]. The impact of different competencies on green product design varies.

(a) Exploitation Learning

Exploitation learning in business involves improvement, selection, production, efficiency, implementation, and execution and is a way of learning that builds on previous knowledge [32]. In the case of green product design, the exploitation learning approach tends to add more green elements to the original product design, such as reducing pollution emissions.

Exploitation learning is more related to existing knowledge than exploratory learning. In terms of product sustainability, the higher the learning capability is, the easier it is for companies to produce green products that meet the current needs. The learning capability focuses on existing resources and modifying existing resources for design purposes. However, these products are more likely to be fast-moving, that is, products with a short sales cycle and lose market value as customer demand changes, such as green food. However, the greater the ability to exploit learning, the greater the risk of long-term inertia, leading to reduced adaptability to new opportunities and, consequently, reduced product development efforts. Long-term exploitation learning

allows companies to enjoy short-term successes rather than being willing to upgrade and design products in time for significant technological and market changes. Therefore, exploiting knowledge is extremely powerful and can compromise the continuity of green product design.

(b) Exploratory Learning

However, as exploratory learning advances, there is a tendency to rely on this approach for green product design. Such a green product design approach requires much more knowledge and involves technical difficulty than an exploratory learning approach, delaying the design cycle of the green product design. This is likely to result in new green products behind market demand and thus miss the best time to enter the market. Even with strong exploratory learning, the cost of integrating too much new knowledge cannot be significantly reduced. Second, too much exploratory learning can lead to the development of entirely new product features incompatible with customer needs, increasing costs that should be reduced.

From the perspective of resource-based theory, the company's resources, executive decisions, and internal competencies are the resources on which the company relies. Therefore, the richness of a company's resources can help it better differentiate itself from its competitors and thus better design and launch its green products.

An enterprise has distinct resources. An enterprise's resource management capability is a good green product design source, which can help enterprise design products. However, enterprises cannot transform their resources directly into green products. In addition to good resource management capabilities, they need better organizational learning capabilities to continuously accept, analyze, understand, and internalize the key resources of the enterprise and ultimately make greater use of the available resources for green product design. The better the resource management capability is, the better the company's understanding of its resources is, and the easier it is to internalize and realize its resources for green product design. Organizational learning theory explains how a company transforms its resources into green product design outcomes [33].

A company's strategy is determined by its top management. Green product design cannot be achieved without a corresponding strategy, even with the best-quality resources and the ability to transform resource products. Managers' environmental attitudes moderate the impact of corporate resource management capabilities on organizational learning capabilities and thus indirectly influence corporate green product design. As in the comparison between the three Tangshan companies and BYD mentioned above, managers with positive environmental attitudes are more inclined to bias their corporate strategies toward environmental friendliness and carry out green product design.

7.3.2 Model and Hypothesis for Green Product Design from the Perspective of Manager’s Environmental Attitudes

There has been much research on internal factors affecting green product design. The most studied internal factors include prospects for competitive advantage, cost reduction, market effectiveness, expectations of improved reputation, opportunities for innovation, and improved product quality [34, 35]. However, there is little research on internal influences, such as resource management capability. In addition, little research has been conducted on executive environmental attitudes that moderate resource management capabilities on organizational learning capabilities. Although there is a direct correlation between organizational learning capability and green product design, few studies have considered the mediating effect of organizational learning capability in the green product design process.

The above model is then constructed, as shown in Fig. 7.6. For a company, managing resources is an important capability for increasing the value of the company’s resources and building a good foundation for green product design. Good organizational learning capabilities are also essential for companies to understand resources, internalize them, and carry out green product design processes. Developing the relevant competencies will allow companies to shorten the green product design cycle and thus be well prepared when facing changing consumer demands and excessive market pressures.

However, corporate managers need to support even the best corporate attributes, especially environmental attitudes. Positive executive attitudes can help companies choose environmentally friendly raw materials and implement proactive environmental strategies. By combining their strengths with their managers’ strategies, companies can achieve greater advantages, gaining comparative advantage in a highly competitive market and profit. They ultimately design green products with high

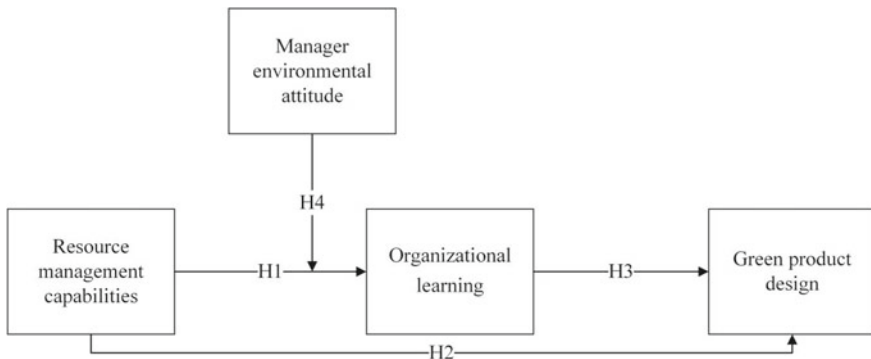


Fig. 7.6 Theoretical model

returns and a high corporate social responsibility image. Therefore, we propose the following hypotheses:

Hypothesis 1: Resource management capabilities contribute positively to the organizational learning of firms.

Hypothesis 2: Resource management capabilities positively contribute to firms' green product design.

Hypothesis 3: Organizational learning contributes positively to a firm's green product design.

Hypothesis 4: Managers' environmental attitudes play a positive role in the influence of resource management capabilities on a firm's organizational learning.

7.3.3 Results and Conclusions of the Green Product Design Model from the Perspective of Manager Attitudes

(1) Data Sources and Analysis

The study was analyzed using questionnaires, and the scales used were mature. This study collected data from corporate managers through interviews, mail, and electronic questionnaire distribution. A total of 1200 questionnaires were distributed, of which 300 were distributed online and 900 offline. A total of 439 valid questionnaires were collected, of which 115 were online, and 324 were offline, with an effective response rate of 36.6%. The company's size, ownership situation, and the number of years of business are listed in Table 7.3.

The processing tool for this study was SmartPLS 3.0, and the data were analyzed as follows.

(2) Test of Reliability and Validity

All data in this study had a confidence validity above 0.6, as shown in Table 7.4, indicating good convergent validity.

As shown in Table 7.5, the bold values in diagonal cells are square roots of AVEs. All square roots of AVE are greater than the correlation between the corresponding structure and any other structure in the same row, again demonstrating good discriminant validity.

(3) Common Method Deviation

Previous studies have shown that the effect of common method bias can be found in the measurements [36]. However, this study used two questionnaires to differentiate the independent variable from the dependent variable to avoid bias. In addition, to

Table 7.3 Sample profile

Item	Sample characteristics	Frequency	%
Firm size	Less than 500	173	39.3
	500–999	161	36.6
	1000–5000	82	18.8
	More than 5000	23	5.3
Ownership type	State-owned	19	1.79
	Publics	90	20.5
	Private	67	15.2
	Wholly foreign	239	54.5
	International joint	34	7.9
Firm age	Less than 10 years	32	7.1
	10–30 years	248	56.6
	More than 30 years	159	36.3
	Total	439	100

Table 7.4 Factor loading

Loading	RMC	GPD	MEA	OL
RMC1	0.685			
RMC 2	0.717			
RMC 3	0.681			
RMC 4	0.681			
RMC 5	0.717			
RMC 6	0.765			
RMC 7	0.709			
GPD 1		0.768		
GPD 2		0.788		
GPD 3		0.793		
GPD 4		0.722		
MEA1			0.882	
MEA 2			0.891	
MEA 3			0.883	
MEA 4			0.876	
OL1				0.768
OL 2				0.751
OL 3				0.718
OL 4				0.757

Note RMC is resource management capabilities; GPD is green product design; MEA is manager environmental attitude; OL is organizational learning

Table 7.5 Reliability, validity, and correlation

Constructs	Alpha	CR	AVE	RMC	GPD	MEA	OL
RMC	0.834	0.876	0.502	0.708			
GPD	0.768	0.852	0.59	0.617	0.768		
MEA	0.906	0.934	0.78	0.604	0.647	0.883	
OL	0.807	0.866	0.564	0.547	0.55	0.52	0.751

Note Alpha = Cronbach’s alpha; CR = composite reliability; AVE = average variance extracted

prevent respondents from linking the two sets of questionnaires, a relaxation video was played between completing the two sets of questionnaires to address this issue. Therefore, common variance bias was not a concern in this study.

(4) Results

This study used a partial least squares structural equation modeling approach for data analysis, using SmartPLS 3.0, to test our hypotheses, shown in Fig. 7.7. The results show that resource management capabilities ($\beta = 0.403$, $T = 5.8$, $P = ** < 0.01$) and ($\beta = 0.453$, $T = 8.287$, $P = ** < 0.01$) positively contribute to organizational learning and green product design, thus supporting Hypotheses 1 and 2. Organizational learning capability positively contributes to green product design ($\beta = 0.303$, $T = 8.287$, $P = ** < 0.01$). Corporate organizational learning contributes positively to green product design ($\beta = 0.303$, $T = 4.868$, $P = ** < 0.01$), thus supporting Hypothesis 3. Managers’ environmental attitudes contribute to the influence of organizational learning on resource management capability ($\beta = 0.129$, $T = 3.486$, $P = ** < 0.01$), thus supporting Hypothesis 4.

Figure 7.8 shows further tests of the moderating effect, where the impact of resource management competencies on organizational learning progressively increases with managers’ environmental attitudes.

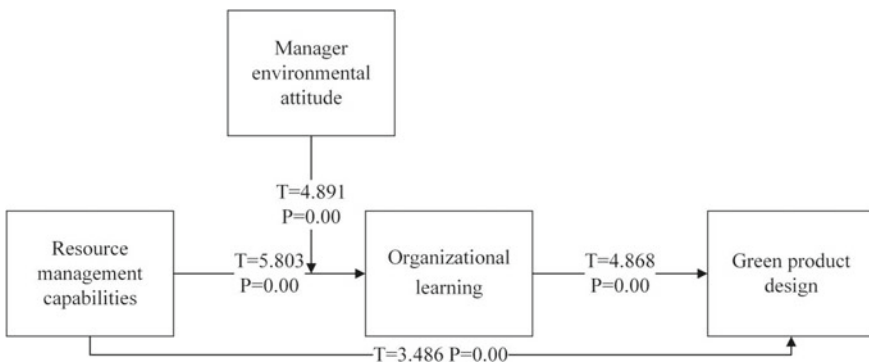


Fig. 7.7 Theoretical model result

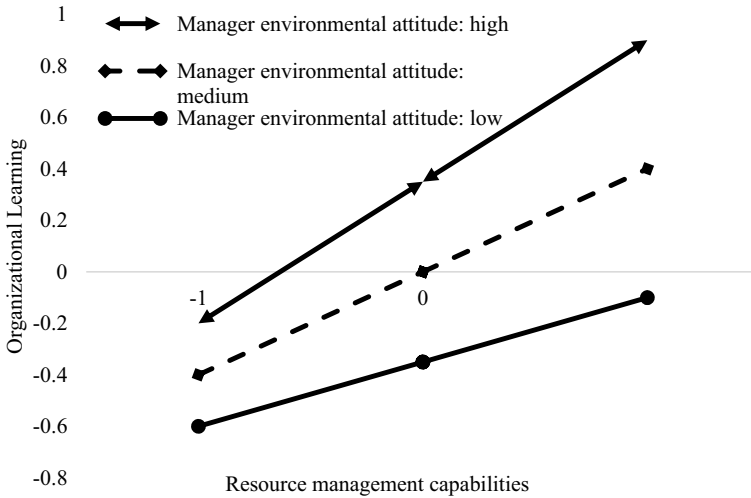


Fig. 7.8 The moderating role of manager environmental attitudes

(5) Research Findings

The data show that resource management capability positively affects organizational learning and green product design. In line with the hypothesis of this section, the stronger the resource management capability is, the more it can help companies design green products. Green product design requires more resources to pave the way, and better corporate resource management capabilities can help companies make better use of resources, ultimately influencing green product design. Effective organizational learning can also effectively implement green product design behaviors, a hypothesis further tested by the data results. Managers’ environmental attitudes also play a vital role in the influence of resource management capabilities on organizational learning. Managers’ attitudes also affect the efficiency of implementation strategies, making it easier for companies to accept and implement new resources and techniques. The data results also support the validity of this hypothesis.

Resource management capabilities, organizational learning, and managers’ environmental attitudes significantly impact the design of a company’s green products. These factors also guide companies to focus on the main factors to achieving more efficient green product design.

7.4 Summary

This chapter explains the specific impact of external factors such as regulatory pressure, customer pressure, new media, and competitor pressure on green product design.

In addition, internal factors such as resource management capabilities, manager environmental attitudes, and organizational learning capabilities are also presented as important influences on green product design. Finally, two models are constructed based on real-life events to visualize the different factors influencing green product design.

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