# Green Dynamic Capability of Construction Enterprises: Role of the Business Model and Green Production

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# Abstract

Improving green dynamic capability is an important business strategy to enhance enterprises’ competitive advantage. This study proposes a theoretical framework that considers the business model and green production to analyze how green dynamic capability can be fostered by enterprises. In this study, 202 managers of Chinese construction enterprises were questionnaire surveyed, and partial least squares structural equation modeling were used to test hypotheses. Results show that: (a) The business model is positively related to green dynamic capability, so enterprises need to adjust business model to balance economic benefits and environmental responsibility; and (b) Green production directly and indirectly affect green dynamic capability through a positive mediating role of the business model. This study extends the current literature on dynamic capability by investigating the relationship between the business model, green production and green dynamic capability. This study also provides guidance for enterprises to enhance green dynamic capability and promote sustainable development.

# Keywords

Green dynamic capability; Business model; Green production; Structural equation model

# 1. Introduction

As concerns about environmental issues have become commonplace, the need for enterprises to develop green dynamic capability has grown in importance (Primc and Čater 2015). As an extension of dynamic capabilities in the field of environmental management, green dynamic capability refers to the capability of enterprises to sense seize and reconstruct internal and external organizational resources including green and technologies resources in order to cope with the change of business environment, and break through the original path-dependence and form new organizational resources and strategic practices (Eisenhardt and Martin 2000; Wohlgemuth and Wenzel 2016). Green dynamic capability supports active environmental strategies and ecological innovation practices in turbulent business environments, and is one of the main sources of enterprises’ competitive advantage (Dangelico et al. 2015). The main objective for enterprises to improve green dynamic capability is to balance the relationship between economic benefits and environmental responsibility, and ultimately achieve the strategic goal of sustainable development (Chan Albert et al. 2017; Li et al. 2019a; Li et al. 2019b; Nguyen et al. 2017). In this context, there is a growing need to improve green dynamic capability.

Dynamic capabilities can be employed as a core construct in research about sustainable development and environmental management to investigate different aspects of corporate social responsibility (Choi et al. 2019; Ramachandran 2011). However, although previous research has verified the influence of green dynamic capability on enterprise performance and competitive advantage (such as Dangelico et al. 2017; Qiu et al. 2019; Reyes-Santiago et al. 2019), few studies have empirically addressed how to improve the green dynamic capability of enterprises. In order to improve green dynamic capability, enterprises need to develop a business model that supports sustainable development (Zhao et al. 2016). As an important strategic tool for sustainable development of enterprises, the concept of the business model is rooted in the fundamental principles of how enterprises conduct business practice, and how to create and capture value (Lozano 2018). According to Inigo et al. (2017) and Schneider and Clauß (2019), based on organizational resources (e.g. human capital resources, physical capital resources and organizational capital resources), business models help enterprises apply their sustainability strategies in real-world market scenarios. This is achieved through adjusting or redesigning their organizational ecosystems (such as suppliers, customers and other stakeholders) to produce higher social, economic and environmental value, thus supporting the eventual realization of sustainable development goals.

In addition, green production can be considered as a leading strategy for enterprises to cultivate and improve their green dynamic capability (Augusto de Oliveira et al. 2019; Thompson 2019). In this case, the adoption of a green production strategy provides a route-map for enterprises to enhance their green dynamic capability (Kjaerheim 2005). Enterprises can incorporate sustainable approaches through adopting standardized green production practices (de Oliveira Santos et al. 2019). However, it can be observed that many enterprises have unfortunately not paid enough attention to green production.

In response to the current deficiencies in the literature, this research study aims to answer the following research questions: (a) How can we adjust the business model of enterprises to promote their green dynamic capability? (b) How does green production affect the green dynamic capability of enterprises? (c) Does green production also play a mediator role through the business model on green dynamic capability?

Hence, the research aim is to develop a theoretical framework for green dynamic capability, analyze the impact of the business model and green production on green dynamic capability, and finally provide further guidance for enterprises to achieve sustainable development. The study adopts Chinese construction enterprises as the research object and employs the partial least squares - structural equation modeling (PLS-SEM) as the research method. The choice of the Chinese construction industry as research object for this study is not coincidental. Firstly, as the world’s second largest economy, China has achieved major economic achievements over the past 40 years of reform and the process of opening-up the economy of the country. However, a series of serious environmental problems have emerged, including environmental pollution and energy shortage. In the face of increasingly severe environmental problems, the Chinese government has adopted a sustainable development strategy to ensure high-quality economic growth. Furthermore, the Chinese government has encouraged enterprises to incorporate sustainable practices into their business activities to make them more environmentally responsible. Secondly, the construction industry is the main component of the national economy of China. In 2019, the total output value of the construction industry in China exceeded 24 trillion-yuan (3 billion euros), accounting for 25% of the total national economic output value of the country. However, in the same year, China's construction industry accounted for 30% of the country's total carbon emissions, making it a major contributor to the country's environmental pollution problem. Therefore, it is crucial that the Chinese construction sector is able to pivot towards sustainable development practices by enhancing their green dynamic capability.

The structure of this article is as follows: Section 2 reviews the previous literature and describes current progress in this field. Section 3 elaborates on the research methodology and builds a new theoretical framework based on previous literature review. Section 4 presents the results of the hypotheses testing, which are further analyzed and discussed in Section 5. Section 6 summarizes the findings from the research study and proposes some directions for future research.

# 2. Literature review

Improving green dynamic capabilities is attractive for industrial enterprises as it can effectively promote both environmental protection and economic benefits. This research study analyzes the relevant factors that affect the green dynamic capability and argues that enterprises need to implement changes in their organizational design as part of their path towards sustainable development.

## 2.1 Green dynamic capability

The concept of dynamic capability was first proposed by Teece and Pisano (1994), who believed that dynamic capability is the ability of an organization to integrate, establish and reconfigure internal and external resources to cope with a rapidly changing environment*.* In today’s competitive, unstable and complex business environment, dynamic capability offers an effective approach to improve the competitiveness of enterprises (Wohlgemuth and Wenzel 2016). Indeed, the competitive advantage of enterprises is derived from their operational performance and an organizational strategy. These are supported by the enterprise’s management processes and resources, such as human resources, capital, infrastructure and technology (Eisenhardt and Martin 2000). However, in many industries, it can be difficult to determine future competitive trends. This is usually exacerbated by the pace of technological change as well as the difficulty in predicting customers’ ever changing demands (Lin and Chen 2017). Still, if enterprises cannot make the corresponding strategic adjustments to their business model, the competitive position of the enterprise will be threatened (De Marchi 2013). As an effective means to solve this problem, dynamic capability can be considered as the ability by which enterprises change resources and adopt new workflows. This involves discarding old resources, while acquiring new resources and developing new processes, as well as integrating them for generating future competitive advantage to cope with turbulent business environments (Dottore 2009; Zhou et al. 2018).

Consequently, green dynamic capability can be viewed as an extension of dynamic capability but applied to the field of environmental management (Qiu et al. 2019). Compared with dynamic capability, enterprises need to integrate resources related to environmental protection (Zahra et al. 2006). Similarly, the adoption of a green dynamic capability can lead to the absorption of information related to the sustainable development of enterprises, such as changes in the performance of green technologies as well as the green preferences of consumers (Protogerou et al. 2011). In fact, green dynamic capability mainly includes three aspects or sub-areas, namely environmental sensing capability, resource seizing capability and resource reconfiguring capability (Mousavi et al. 2018). It is useful to explore these sub-areas in further detail.

(1) Environmental sensing capability

Environmental sensing capability can determine the future direction of an enterprise by identifying and managing potential opportunities (or risks) in the current business environment (Teece 2010). Environmental sensing capability requires that enterprises identify opportunities (or risks) and seize them by redeploying organizational resources and according to their strategic needs. Thus, Hartman et al. (2017) highlighted that environmental sensing capability can be viewed as the most fundamental link to dynamic capability.

Specifically, environmental sensing capability refers to enterprises being able to identify their future development trends in their business environment by means of intelligence collection (Salunke et al. 2019). This intelligence includes information relating to the green preferences of customers, market demand and development of clean technologies.

(2) Resource seizing capability

In order to pursue a commercial development strategy, enterprises need to absorb and learn from data, information and experiences that create and sustain a competitive resource base (Teece 2007). On the one hand, seizing resource capability emphasizes which information is worth utilizing by the enterprise, i.e. which information has the highest value (Dangelico 2016). Furthermore, resource seizing capability requires that an enterprise applies the newly acquired technological information (i.e. information sensed and seized by the enterprise) to the routine operations of that enterprise (i.e. through a process of technology commercialization).

Hence, to sum up, resource seizing capability can be defined as the enterprise’s capacity to absorb information relating to green development and apply it to technology commercialization activities.

(3) Resource reconfiguring capability

After successfully sensing and seizing the opportunities (or risks) that exist in the business environment, enterprises can keep a competitive advantage in the market (Wang and Ahmed 2007). However, a key to sustained competitive advantage is possessing the capability to reconfigure resources as the enterprise grows and as the business environment changes (Lin and Wu 2014). In this context, enterprises need to reconfigure capabilities in order to remain adaptable to the external business environment and, if obstacles arise, adopt alternative business development modes.

## 2.2 Business model

In the 1980s, the concept of the business model was widely adopted as part of enterprise management and as a mechanism to improve economic benefits while securing competitive advantage. Generally, the business model is the platform that exists between enterprise strategy and implementation, and the means for enterprises to create value and obtain competitive advantage (Roome and Louche 2015).

Although the concept of the business model is rather abstract, its main features can be elucidated from the literature. The literature generally considers that the business model lies between the strategic level and the practical level. The important function of the business model is to describe how the enterprise creates, delivers and captures value for a wide range of stakeholders (namely customers, employees, shareholders, suppliers as well as wider society) (Neumeyer and Santos 2018; Osterwalder and Pigneur 2010; Schaltegger et al. 2015). Indeed, Inigo et al. (2017) likened the business model to a bridge between corporate strategy and the real world. In an ideal state, the business model can link the various business activities of an enterprise with its corporate strategies. In related work, Casadesus-Masanell and Ricart (2010) argued that strategy is a contingent action plan that enables the deployment of the business model to support the achievement of specific corporate objectives. Thus, an enterprise’s business model is a reflection of its implementation strategy, and thereby materializes a connection between strategy and enterprise activities (i.e. the commercial business environment).

The business model of an enterprise is value-based since the model generally involves value dimensions in its constituent elements. Abdelkafi and Täuscher (2015) and Schneider and Clauß (2019) pointed out that a business model contains at least three core value dimensions, namely value proposition, value creation and value capture. Among them, the value proposition refers to the value provided by the enterprise to customers. Value creation refers to the capacity of an enterprise to create value, which comes from its key resources and processes. Whereas value capture represents the profit model of the enterprise, and illustrates how the enterprise can create more value for itself by satisfying the customers’ value proposition (Teece 2018). Based on the resource-based view of the enterprise, some scholars believe that a successful business model needs to contain three key characteristics – being valuable, rare, inimitable and non-substitutable –to obtain a more lasting competitive advantage for the enterprise. In this research study, value creation is broken down into key processes and corresponding key resources; and the business model is divided into four components, namely value proposition, key processes, key resources, and value capture. This approach is similar to the works of Johnson et al. (2008) and Boons and Ludeke-Freund (2013).

However, improving an enterprise’s green dynamic capability requires them to incorporate environmental issues into their business strategies. This as part of pursuing a sustainable development trajectory (Peralta et al. 2019; Zhao et al. 2018). Firstly, in order to realize the adoption of economic, environmental and social benefits, enterprises need to implement major innovations, but such innovations often require enterprises to change their core business method, i.e. the business model (Kiron et al. 2013; Stubbs 2019). An excellent business model effectively reconstructs the enterprise’s purpose and means of creating value. It helps the enterprise to understand how to create and distribute value for a wide range of stakeholders (not only customers, but also stakeholders from the social and ecological environment) (Zott et al. 2011). Secondly, technological innovation alone cannot solve any problem of business sustainability, because the sustainability issue is a systematic and multi-level problem (Geels 2010). A single technological innovation can only give an enterprise a temporary competitive advantage, but this advantage will not be maintained as the public's demand for environmental protection increases. Consequently, this requires enterprises to change their business models to meet the needs of green development as part of pursuing a sustainable development strategy (Schaltegger et al. 2016).

## 2.3 Green production

The current awareness of environmental issues has improved our understanding of the causes of pollution, and consequently the focus of environmental protection has shifted from pollution control to pollution prevention (Luo et al. 2017). According to de Oliveira Santos et al. (2019), although pollution control attempts to reduce the emission of pollutants at the end of the production process, it fails to thoroughly investigate the causes of pollutants and solve the pollution problem at the source.

Green production, as an effective means to enable pollution control and prevention, aims to reduce the environmental impact of an enterprise’s production process (Mikaelsson and Larsson 2017; Sungho and Sungwoo 2009). It also refers to the voluntary adjustment of enterprises’ production philosophy through formulating the corresponding production principles and production practices to reduce the adverse impact on the environment caused by the business processes (Rao 2004).

Adopting a green production strategy requires enterprises to fully consider environmental factors in the production process, which mainly include green production principles and green production practices (Du et al. 2018). In this regard, an enterprise formulates corporate objectives and procedures in alignment with some sustainable development goals. This is done to regulate production behaviors and adopt environmentally-friendly production practices that ultimately result in pollution reduction caused by the production process (Sheng 2017).

(1) Green production practices

In recent years and with the growing importance of green development, there has been an increasing interest in green production practices. Green production practices have hitherto been mostly defined from an environmental standpoint that involves minimizing the impact of the enterprise activities on the environment. Therefore, in this research study, green production practices are understood as actions that have a positive impact on enterprises’ social, economic and environmental performance. For instance, this could include adopting environmentally-friendly production technologies and sustainable materials as well as renewable forms of energy. Green production practices also require enterprises to fully consider both pollution prevention and control.

The most widely adopted approach to pollution control in the past was the so called ‘end-of-pipe control’. This refers to the development and implementation of effective treatment technologies for the generated pollutants at the end of the production process (Mantovani et al. 2017). However, the end-of-pipe approach also has certain limitations (Hammar and Löfgren 2010). Pollution control facilities at the end of the production process usually involve higher investment and operational costs. These can lead to an increase in production costs and a corresponding decrease in the economic benefits. Similarly, end-of-pipe control does not involve the effective use of resources and does not prevent waste generation. Hence, in order to solve pollution production problems, there is a need to implement pollution prevention practices (Wu et al. 2019). This involves enterprises to adopt more environmentally-friendly technologies, energies, materials and products that avoid the production of pollutants.

(2) Green production principles

Green production requires enterprises to conduct environmental assessments on their production processes and, whenever necessary, change production practices to achieve sustainable development. Green production pays more attention to the change of technology and the management of personnel. However, when practice is based only on a change of technology, the long-term effectiveness of green production is not guaranteed (Xiong et al. 2010). In order to ensure that green production practices are sustainable, industrial companies need to develop additional tools and well-defined enterprise policies or production principles (Khan 2008). Hence, green production principles represent the enterprise’s understanding of resource conservation and environmental protection, including the enterprise’s values, codes of conduct and institutional rules. Consequently, green production principles limit some parts of the production process, provides a guide for the employees’ behavior, and ensures the long-term effectiveness of green production processes (Augusto de Oliveira et al. 2019).

## 2.4 Research gaps

Most previous studies have only analyzed dynamic capability (e.g. Dottore 2009; Wohlgemuth and Wenzel 2016; Zhou et al. 2018), but only a small part have extended the dynamic capability concept to the field of environmental management. In response, as the studies by Dangelico et al. (2013) and Dangelico et al. (2015) suggested, this research combines dynamic capabilities with environmental sustainability to help enterprises overcome emerging sustainability challenges.

Furthermore, in those few existing studies on the analysis of green dynamic capability (e.g., Dangelico et al. 2017; Qiu et al. 2019; Reyes-Santiago et al. 2019), no guidance is provided about how to nurture green dynamic capability and help enterprises gain a competitive advantage. In other words, few studies have analyzed the driving factors of enterprises' green dynamic capability. In order to fill this gap, a theoretical framework, including the business model and green production has been established to analyze and develop the enterprises’ green dynamic capability.

# 3. Methodology

## 3.1 Research steps

This research study examined the driving factors of green dynamic capability of construction enterprises according to the following steps (see Figure 1). Firstly, the theoretical framework of the study was established from an extensive literature review (see Figure 2). Secondly, four hypotheses were proposed to investigate the driving factors of green dynamic capability of construction enterprises (see Figure 3). Thirdly, a research questionnaire was designed to analyze the views of professionals from the industry on green dynamic capability. Fourthly, PLS-SEM was used to analyze the relationship between latent variables. Finally, the model and its hypotheses were tested.



Figure 1. Research process

## 3.2 Theoretical framework and hypotheses development

As the public interest in environmental protection grows, enterprises seek to keep a competitive advantage in a turbulent business environment. This pressure prompts the need to improve their green dynamic capability. This research study establishes a theoretical framework along with the development of a general theory of dynamic capability (as in Figure 2). In general, dynamic capability is the source of enterprise performance and competitive advantage. However, with growing calls for environmental protection, green concepts also need to be integrated in the scope of dynamic capability. On the basis of the literature review, this section provides a deeper analysis and discussion on the conditional relationship among enterprises’ green dynamic capability, business models and green production. Then, it proposes four hypotheses to verify the existence (or not) of these relationships.



Figure 2. Theoretical Framework

(1) The direct effect of the business model on green dynamic capability

As enterprises are faced with increasingly serious environmental issues, green dynamic capability can also be regarded as an effective approach to achieve business success. Improving green dynamic capability involves environmental sustainability and should be regarded as a win-win for the enterprises and the environment, not an additional cost. Teece (2010) pointed out that developing green dynamic capability requires enterprises to fully optimize resources and the business model can play an important role in this process. Boons and Ludeke-Freund (2013) found that the key to enhance green dynamic capability is to reshape the business model and ensure that it is consistent with the strategic orientation of the enterprise. Furthermore, Zott et al. (2011) explained these points through describing how changing business models can reconfigure the resources and capabilities of enterprises. This would enable enterprises to adapt to changing market environments and promote their green dynamic capability. Therefore, we propose the following hypothesis.

**H1:** In construction enterprises, the business model is positively related to green dynamic capability.

(2) The direct effect of green production on green dynamic capability

Green production represents a long-term planning strategy adopted by enterprises to avoid environmental pollution problems. It can also be considered an important approach to improve the environmental performance of enterprises. Green production requires enterprises to adopt more environmentally-friendly methods in their operations to reduce threats to the environment. Muñoz-Villamizar et al. (2018) believed that in order to achieve sustainable development goals, enterprises should consider various approaches, such as observing local environmental laws, launching green innovation activities and implementing green production processes. However, although these approaches can be combined, sustainability-oriented enterprises are more willing to shift to green production and green innovation practices (Muñoz-Villamizar et al. 2018). Similarly, the research by Hernandez-Vivanco et al. (2018) highlighted that the implementation of green production requires stronger enterprise’s effort and strategic commitment. Yet, on pursuing green production, sustainability-oriented enterprises will also actively carry out innovative activities such as improving their green dynamic capability. From the perspective of the enterprises' willingness to innovate, Luo et al. (2017) pointed out that only those enterprises that support green production can implicitly comprehend the importance of environmental protection. Therefore, Silvestre and Silva Neto (2014a) believed that enterprises often take into account the impact of production activities on the environment when formulating business strategies and actively improving their green dynamic capability. Silvestre and Silva Neto (2014a) also claimed that enterprises can improve sustainable performance by adopting green production innovations under the condition of good organizational dynamic capabilities and policy changes. The accumulation of organizational dynamic capabilities can be achieved through various learning processes including learning when conducting green production (Silvestre and Silva Neto 2014b). Green production can also improve dynamic capability via technology knowledge acquisition, knowledge communication, knowledge application and results assimilation (Gilbert and Cordey-Hayes 1996). Therefore, it is hypothesized that green production conducted by enterprises is positively related to corporate green dynamic capability.

**H2:** In construction enterprises, green production is positively related to green dynamic capability.

(3) The direct effect of the business model on green production

A few studies have analyzed the impact of business models on green production. Tseng et al. (2018) suggested that the adoption of green production is one of the most challenging issues for enterprises to achieve the United Nations’ sustainable development goals (SDGs). To solve this problem, though, they need to rely on the cooperation among the various departments within the same enterprise. Brennan and Tennant (2018) discussed the sources of sustainable value in the process of enterprise development and pointed out that in order to obtain greater sustainable value through green production, enterprises need to change their business model. Lopez et al. (2019) proposed that enterprises generally adopt green production in terms of internal (institutional) and technological factors. However, overcoming these obstacles requires a supporting business model. Finally, Rao (2004) believed that green production practices and green production principles are the key factors of green production. Therefore, we propose the following hypothesis.

**H3:** In construction enterprises, the business model is positively related to green production.

(4) The mediation effect of green production

The implementation of green production can greatly improve the efficiency of production processes, reduce environmental costs, and contribute to the development of a sustainable innovation culture (Silvestre and Silva Neto 2014a). These can also lead to cultivate and improve green dynamic capability. Severo et al. (2017) pointed out that the efforts made by enterprises are important to realize sustainable innovation. Although many literature sources have proposed that the main factor that drives enterprises to implement green production is external pressure (such as regulatory pressure), Augusto de Oliveira et al. (2019) suggested that, compared with external pressure, the change of internal company’s environment and stakeholders’ demands can equally motivate enterprises to implement green production. Additionally, Lopez et al. (2019) pointed out that a successful business model will support resource efficiency measures such as green production. Therefore, we propose the following hypothesis.

**H4:** In construction enterprises, green production mediates the relationship between the business model and green dynamic capability.



Figure 3. Hypothesis model

## 3.3 Questionnaire development

In order to verify the driving factors of green dynamic capability in enterprises, the business model and green production were included in the analysis framework. Therefore, the questionnaire was divided into these same three parts: the business model, green production and green dynamic capability.

This research study refers to the practice of Teece (2018). Teece regards the business model as a second-order formative construct consisting of four first-order reflective constructs (i.e., customer value proposition, key resources, key process and value capture). These four constructs comprise a total of twelve indicators. The indicators under the customer value proposition construct mainly investigate whether the products and services of the enterprise can meet the needs of customers. The indicators under the key resources construct analyze whether the enterprise has the necessary resources (such as human resources and technologies) for development. The indicators within the key process construct assess whether the existing business processes can solve the various problems encountered in the operation process and meet the customers’ needs. The indicators under the value capture construct analyze the ability of enterprises to create value (such as social and economic value, etc.).

Regarding green production, this research study relied upon the work of Augusto de Oliveira et al. (2019). In their study green production was regarded as a second-order formative construct consisting of two first-order reflective constructs (green production practices and green production principles) comprising eight indicators. Among them, the indicators under the green production practices construct mainly investigate whether enterprises can flexibly use green technologies and materials in the production process, and ultimately reduce the negative impact on the environment. The indicators under the green production principles construct reflect whether enterprises have a set of production norms to constrain pollution behaviors in the production process.

On the other hand, green dynamic ability as discussed earlier, included three first-order reflective constructs, namely, environmental sensing capability, resource seizing capability and resource reconfiguration capability (Teece et al. 1997). The indicators under the environmental sensing capability construct mainly examine a company's capability to utilize various information sources and scan or monitor internal and external information (Lin and Chen 2017). The indicators under the resource seizing capacity construct analyze the capability of an enterprise to absorb and integrate internal and external resources into its business activities. The indicators under the resource reconstruction capability construct focuses on whether an enterprise can reallocate resources and generate new resources to cope with future constraints.

It is worth mentioning that, according to Diamantopoulos and Winklhofer (2001) and Diamantopoulos et al. (2008), all indicators are set as reflective indicators in this study. However, at the construct level, all first-order constructs are formative constructs, that is, the model of this study is of a reflective-formative type. This is because first-order constructs under second-order constructs are not interchangeable. This means each first-order construct encompasses all specific aspects of its second-order constructs.

The questionnaire for the study was developed through an extensive literature research and refined after consulting with experts. The authors consulted with an expert in engineering management and two senior managers of construction enterprises on the content validity of the questionnaire. Then, the questionnaire was submitted to a professor of statistics to check the overall structure and consistency of the questionnaire. Next, the questionnaire was sent to 10 enterprises randomly selected from the “Top 100 Chinese construction enterprises in comprehensive strength” for preliminary testing. According to the preliminary test results, some contents of the questionnaire were adjusted to ensure that all items in the questionnaire could be easily understood. After the refinement of the questionnaire, the final questionnaire was created as shown in Table 1. The questionnaire used a 5-point Likert scale to evaluate the respondents' perceptions of their enterprises, ranging from 1 = strongly disagree to 5 = strongly agree.

Table 1. Questionnaire survey

|  |  |  |  |
| --- | --- | --- | --- |
| Second-order construct | First-order construct | Observed indicator | Reference |
| Business model  (BM) | Customer value proposition  (CVP) | CVP1: The green products provided by the enterprise meet the needs of customers. | Werani et al. (2016);  Raimundo Díaz-Díaz et al. (2017) |
| CVP2: For customers, green products and services are more attractive than traditional products. |
| CVP3: Customers are very satisfied with the green products and services provided by the enterprise. |
| Key resources  (KR) | KR1: The enterprise has professionals in the direction of green building. | Johnson et al. (2008) |
| KR2: In the field of green building, the enterprise's technology (such as patents, research and development, etc.) can meet the needs of the enterprise's work. |
| KR3: The enterprise will use green materials in the construction process, which is a key resource for the enterprise to conduct business activities. |
| Key processes  (KP) | KP1: Through the enterprise's production activities, high-quality green products can be designed and produced. | Lorange and Fjeldstad (2010);  Fjeldstad and Snow (2018) |
| KP2: Through the existing activity process, the problems encountered in the construction process can be solved. |
| KP3: The enterprise has always maintained close contact with its partners to ensure the normal development of the project. |
| Value capture  (VC) | VC1: Green building products and services can bring more profits than traditional building products. | Osterwalder et al. (2004);  Johnson and Euchner (2018) |
| VC2: The enterprise's green technology can build a competitive edge over its competitors. |
| VC3: Under the premise of guaranteeing the quality of products or services, the enterprise can obtain more income by reducing costs. |
| Green production  (GP) | Green production practices  (GPP) | GPP1: In the process of engineering construction, enterprises will consider environmental problems to reduce the impact on the surrounding environment. | Rao et al. (2004);  Luo et al. (2017);  Severo et al. (2017);  Du et al. (2018) |
| GPP2: Enterprises will actively use renewable energy in the construction process. |
| GPP3: In the process of project construction, enterprises will take the initiative to adopt energy-saving and clean technology. |
| GPP4: The enterprise recycles the pollutants it produces to minimize or even eliminate pollutants. |
| Green production principles  (GPPR) | GPPR1: The enterprise has a set of rules used to guide the production and restrain the non-green behavior in the production process. |
| GPPR2: Enterprises will implement cleaner production regulations and implement cleaner production policies. |
| GPPR3: The enterprise will regularly supervise the production process and evaluate whether the production process is environmentally friendly. |
| GPPR4: The enterprise has a complete set of green production standards, can guide the staff's production behavior. |
| Green dynamic capability  (GDC) | Environmental sensing capability  (ESC) | ESC1: Enterprise often observe the market's demand for green technology to identify new green development opportunities. | Stanovcic et al. (2015) |
| ESC2: The enterprise often observes the market and analyzes the impact of the development of green technology on customers. |
| ESC3: The enterprise regularly reviews its green production activities to ensure it meets customer needs. |
| Resource seizing capability  (RSC) | RSC1: The enterprise has procedures in place to develop new green knowledge. | Wong et al. (2013);  Ben Arfi et al. (2018) |
| RSC2: The enterprise is able to digest and absorb the green knowledge it finds. |
| RSC3: The enterprise can apply the green knowledge it has learned to the actual construction process. |
| Resource reconfiguring capability  (RRC) | RRC1: The enterprise is able to assign employees with green production knowledge to the right positions, so that the professional skills of employees can be further developed. | Lin et al. (2017) |
| RRC2: When the enterprise is doing green production, it ensures that employees can fully utilize his expertise. |
| RRC3: The enterprise is able to successfully allocate resources and carry out green technology innovation activities. |

## 3.4 PLS-SEM model

The PLS-SEM method was adopted to analyze the driving factors of green dynamic capability in construction enterprises. PLS is a branching method of SEM originated in the 1960s (Hair et al. 2014) that has been widely used in social sciences research. Similar to the traditional covariance-based SEM (hereinafter referred to as CB-SEM), PLS-SEM can simultaneously process a set of dependent variables and independent variables. From the perspective of testability, these variables can be divided into two categories, namely: manifest variables and latent variables. The manifest variable is a variable that can be directly observed and measured, which is called the indicator. The latent variable is called the construct (generally used to represent low-order latent variables), which cannot be directly observed, but can be measured indirectly by examining the relationship between manifest variables.

PLS-SEM consists of a two-part model: the measurement model and the structure model. Since latent variables cannot be directly measured, they must be indirectly speculated from manifest variables. Hence, the role of the measurement model is to examine the relationship between latent variables (represented by symbols ξ and η) and manifest variables (expressed by X and Y). As a result, expressions (1) and (2) are proposed where Δx and Δy are factor loadings, and δ and ε represent error terms generated during measurement. Hence, the structure model proposes a hypothetical causal relationship for each latent variable.

（1）

（2）

However, unlike the traditional CB-SEM method, PLS-SEM is a biased prediction method. This does not mean that the PLS-SEM model cannot be validated. PLS-SEM relies on a network relationship between pre-hypothetical latent variables to predict and explain the target structure. More precisely, the PLS-SEM method obtains the construct scores of the latent variables by calculating the index items including the measurement errors. This method of calculation for construct scores may have a certain degree of deviation, but this deviation can be partially cancelled when analyzing latent variables with a large number of indicators. PLS-SEM uses an iterative algorithm (mainly through the use of the Bootstrapping method) to calculate the parameters of each measurement model and solves the path coefficients of the structural model. The Bootstrapping method is appropriate to compute highly complex models with sufficient sample sizes.

The use of CB-SEM was ruled out in this study for several reasons. CB-SEM is a calculation method that usually requires larger sample sizes for analysis. Generally speaking, the sample size should be more than 200 and more than 10 times of the topic item (Hoogland and Boomsma 1998; Kline 2016). That is why most pieces of research in social sciences do not collect a sufficient sample size to meet CB-SEM requirements (Hair et al. 2011). At the same time, PLS-SEM is a better choice than CB-SEM on the premise that the model contains formative constructs. Besides, PLS-SEM does not require data to follow normal distribution, and data collection is more flexible and convenient. For these reasons, the PLS-SEM method was deemed more suitable here.

Hence, in this study, the measurement model was first analyzed. Then, the path coefficients of the structural model were calculated by bootstrapping (5,000 iterations). Finally, as the study focused primarily on testing the previous four hypotheses, PLS-SEM was also considered more suitable for building a theoretical model and verifying the hypothesized causalities.

## 3.5 Samples and data

In the empirical part of the research, this study used the Chinese construction industry as the research object to analyze the driving factors that influence green dynamic capability of enterprises. As mentioned earlier, analyzing Chinese construction enterprises is representative because this country is now concerned about integrating sustainable development in its process of economic growth (Lin et al. 2014). The Chinese construction industry is also starting to focus on green innovation and resource use optimization (Chang et al. 2016).

Then, the population samples of this study were taken from the “Top 100 Chinese construction enterprises in comprehensive strength” ( Chinese Construction Enterprises Management Association 2019). 500 questionnaires were distributed to these companies’ middle and senior managers by email. These managers are closely familiar with the daily operations and processes of their enterprises. They also have a deep understanding of the current and future strategies. Hence, their responses should accurately reflect the current development levels of their enterprises.

At the beginning of the questionnaire, the research purpose of the survey was briefly introduced, and the anonymity of the interviewees was guaranteed. By the end of the surveying period, a total of 238 questionnaires were collected (recovery rate of 47.6%). Among them, 36 questionnaires were excluded because they had not been totally completed. The remaining 202 questionnaires were used for hypotheses testing. The basic information of interviewees is shown in Table 2. Most of the respondents in the survey ranged between 36 and 45 years old (48.5%). Among them, 35.2% of employees had a work experience of 5 to 15 years, and most of them were middle managers. 12.9% of the respondents had more than 20 years of work experience and were all senior managers.

Table 2. Respondent demographics

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Frequency | Percentage |
| **Sex** | | | |
|  | Male | 114 | 56.4% |
|  | Female | 88 | 43.6% |
| **Age** | | | |
|  | 26-35 | 38 | 18.8% |
|  | 36-45 | 98 | 48.5% |
|  | 46-55 | 46 | 22.8% |
|  | 55 and above | 20 | 9.9% |
| **Work experience** | | | |
|  | 0-5 | 11 | 5.4% |
|  | 5-10 | 57 | 28.2% |
|  | 10-15 | 70 | 35.2% |
|  | 15-20 | 38 | 18.3% |
|  | 20 and above | 26 | 12.9% |
| **Role** | | | |
|  | Middle managers | 124 | 61.4% |
|  | Senior managers | 78 | 38.6% |
| **Enterprise scale (number of employees)** | | | |
|  | 500-2000 | 100 | 49.5% |
|  | 2000 and above | 102 | 50.5% |

# 4. Results

In this section, the PLS-SEM method is used to analyze the research hypotheses, and the accuracy of each result (e.g. path coefficients, R2 values) is tested by the Bootstrapping method. In order to process the statistical calculations, we used the SmartPLS 3.0 software. Namely, we extracted 5,000 subsamples to estimate the PLS path model from each subsample. Then, the results of the PLS-SEM model were derived using the estimators of the 5,000 subsamples; t-values, P-values, and confidence intervals were also calculated to evaluate the results significance. It should be noted that since the model of this study is of a reflective-formative type (i.e. reflective first-order and formative second-order), the use of the presented indicator approach will result in the coefficient of determination (R2) of reflective first-order construct to formative second-order construct approaching 1. That is, the low-order constructs can explain their respective higher-order constructs. At the same time, the path coefficient of the higher-order constructs to other higher-order constructs will be 0 (i.e. not significant). Finally, Becker et al. (2012) and Ringle Christian and Sarstedt (2016) pointed out that a two-stage approach should be preferred when PLS-SEM involves formative second-order constructs. Therefore, this two-stage approach was adopted when the model was estimated, and the results are shown in Figure 4.



Note: The model’s goodness of fit (Gof) is 0.570.

Figure 4. Structural equation model calculation results

Furthermore, the PLS-SEM evaluation was divided in two steps to evaluate the hypotheses. Following (Chin 2010) calculation approach, the remainder of this section is divided into three parts. The first part is devoted to test the SEM structure model according to the relevant norms. The second part examines the structure model and its predictive power. The third part analyzes the influence of mediating effects.

## 4.1 Measurement model analysis

The first step to evaluate the PLS-SEM model results is to analyze the reliability and validity of its measurements. Hair et al. (2019) pointed out that the evaluation of the reflective measurement model can be mainly conducted from four aspects, namely, factor loading, internal consistency reliability, convergent validity and discriminant validity. The results of these four aspects are shown in Tables 3 and 4.

Table 3. Measurement model results

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Second-order Construct | First-order Construct | Item | Loading (T-value) | Alpha | A | C. R. | AVE | f2 |
| **BM**  (VIF=2.086) | **CVP**  Weights=0.313  t-value=13.677  VIF=1.711 | CVP1 | 0.840 (26.146) | 0.722 | 0.726 | 0.903 | 0.646 | 0.313 |
| CVP2 | 0.798 (32.899) |
| CVP3 | 0.771 (17.322) |
| **KR**  Weights=0.331  t-value=15.079  VIF=2.062 | KR1 | 0.804 (23.941) | 0.702 | 0.701 | 0.834 | 0.627 | 0.331 |
| KR2 | 0.813 (26.264) |
| KR3 | 0.757 (18.513) |
| **KP**  Weights=0.293  t-value=12.656  VIF=1.784 | KP1 | 0.777 (14.340) | 0.701 | 0.701 | 0.833 | 0.624 | 0.293 |
| KP2 | 0.809 (23.220) |
| KP3 | 0.784 (23.368) |
| **VC**  Weights=0.290  t-value=12.279  VIF=1.646 | VC1 | 0.775 (14.051) | 0.703 | 0.706 | 0.835 | 0.628 | 0.290 |
| VC2 | 0.793 (16.425) |
| VC3 | 0.809 (24.098) |
| **GP**  (VIF=2.086) | **GPP**  Weights=0.534  t-value=30.246  VIF=2.260 | GPP1 | 0.831 (24.127) | 0.839 | 0.844 | 0.893 | 0.676 | 0.534 |
| GPP2 | 0.836 (28.911) |
| GPP3 | 0.870 (35.409) |
| GPP4 | 0.745 (19.245) |
| **GPPR**  Weights=0.535  t-value=34.049  VIF=2.260 | GPPR1 | 0.778 (21.981) | 0.809 | 0.812 | 0.875 | 0.636 | 0.535 |
| GPPR2 | 0.788 (20.160) |
| GPPR3 | 0.863 (39.019) |
| GPPR4 | 0.758 (20.053) |
| **GDC** | **ESC**  Weights=0.488  t-value=16.373  VIF=1.606 | ESC1 | 0.859 (36.043) | 0.765 | 0.772 | 0.865 | 0.682 | 0.488 |
| ESC2 | 0.865 (39.771) |
| ESC3 | 0.747 (16.577) |
| **RSC**  Weights=0.283  t-value=4.289  VIF=1.098 | RSC1 | 0.781 (11.575) | 0.701 | 0.706 | 0.875 | 0.700 | 0.283 |
| RSC2 | 0.803 (13.320) |
| RSC3 | 0.798 (12.611) |
| **RRC**  Weights=0.496  t-value=12.635  VIF=1.568 | RRC1 | 0.828 (27.354) | 0.782 | 0.786 | 0.875 | 0.630 | 0.496 |
| RRC2 | 0.853 (39.577) |
| RRC3 | 0.830 (27.281) |

Table 4. Discriminant validity of constructs

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | CVP | KR | KP | VC | GPP | GPPR | ESC | RSC | RRC |
| CVP | ***0.803*** | 0.791 | 0.754 | 0.704 | 0.719 | 0.714 | 0.782 | 0.434 | 0.722 |
| KR | 0.578 | ***0.809*** | 0.839 | 0.797 | 0.789 | 0.681 | 0.698 | 0.459 | 0.806 |
| KP | 0.539 | 0.612 | ***0.79*** | 0.683 | 0.688 | 0.676 | 0.718 | 0.467 | 0.742 |
| VC | 0.505 | 0.577 | 0.494 | ***0.793*** | 0.692 | 0.696 | 0.606 | 0.583 | 0.666 |
| GPP | 0.559 | 0.618 | 0.529 | 0.535 | ***0.823*** | 0.898 | 0.715 | 0.255 | 0.684 |
| GPPR | 0.549 | 0.529 | 0.519 | 0.532 | 0.747 | ***0.805*** | 0.799 | 0.342 | 0.789 |
| ESC | 0.588 | 0.525 | 0.534 | 0.449 | 0.578 | 0.636 | ***0.826*** | 0.384 | 0.772 |
| RSC | 0.31 | 0.331 | 0.34 | 0.41 | 0.195 | 0.259 | 0.285 | ***0.794*** | 0.326 |
| RRC | 0.545 | 0.614 | 0.556 | 0.499 | 0.553 | 0.634 | 0.597 | 0.243 | ***0.837*** |

Note: The italicized and bold elements on the diagonal are the square roots of the AVE. The upper right corner of the diagonal elements is the HTMT ratio. The lower left corner of the diagonal represents the correlation between the constructs’ value.

It can be seen that the factor loading of each item was between 0.745 and 0.870, i.e. always higher than the minimum of 0.7 as recommended by Chin (2010) and Hair et al. (2014). This means that this construct explains more than 50% of the indicator’s variance, thus providing acceptable item reliability (Hair et al. 2019).

Composite Reliability (C.R.), A and Cronbach's Alpha are used to assess the internal consistency reliability. In this study, Cronbach's Alpha remained between 0.701 and 0.839, whereas Composite Reliability was between 0.833 and 0.903. Hence, both values were clearly above the threshold of 0.7 (Hair et al. 2011; Straub 2004), suggesting that the model had a good internal consistency.

Convergent validity refers to the extent to which constructs converge to explain the variance of its items. The average extracted variance (AVE) was introduced to evaluate the convergent validity of each construct measure (Fornell and Larcker 1981). The AVE of each construct in this model were between 0.624 and 0.700, and above the threshold value of 0.5. This means the model convergent validity was acceptable.

In this research study, according to the suggestions of Fornell and Larcker (1981) and Henseler et al. (2015), the discriminant validity of the measure model was evaluated by using the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio. Discriminant validity refers to the degree to which one construct is different from other constructs. As shown in Table 4, the square root of the AVE value of each construct is larger than the correlation between this construct and other constructs. Additionally, the HTMT ratio of each construct is lower than 0.85, indicating the high discriminant validity of the measurement model.

Finally, this study resorted to the Harman's single-factor test to evaluate whether there was a common variance among factors. The first factor variance accounted for 37.8% of the total variance and did not exceed the commonly adopted 40% threshold (Podsakoff and Organ 1986). Then, it can be concluded that the common variance did not influence the analysis results (Shiau and Luo 2012).

## 4.2 Second-order hierarchical measurement model results

In order to evaluate the model’s goodness of fit for the first-order constructs as formative indicators under second-order constructs, this study tested the indicators statistical significance and multicollinearity (Chin, 2010; Mousavi, 2018). In terms of indicator correlation, bootstrapping was used to estimate the weights’ significance of second-order. Table 3 showed that the outer weight significance of all first-order constructs constituting a second-order construct exceeded the critical threshold of t > 1.96. Additionally, the indicators of all first-order constructs were significant.

Finally, this study analyzed potential multicollinearity among formative indicators by calculating the variance inflation factor (VIF) of each indicator. Table 3 showed that the VIF values of all indicators were below the threshold value 5. This means there is hardly any multicollinearity among the indicators.

## 4.3 Structural model analysis

When the result of the measurement model was deemed satisfactory, the next step consisted of testing the structural model. Hair Joseph et al. (2019) suggested that the collinearity of the structural model should be considered in the test of the structural model. Then, the determination coefficient (R2), the predicted correlation (Q2) as well as the path coefficient of the endogenous structure were all analyzed.

Firstly, as it was already checked in Table 3, all VIF values of all second-order constructs were below 5, indicating that there were no multicollinearity problems in the structural model.

Secondly, Table 5 provides the determination coefficient (R2) and predictive correlation (Q2) of the construct. R2 is a measure of the model’s predictive power, indicating the portion of the endogenous latent variable whose variability can be represented by the model. It can be observed that the R2 value of green dynamic capability (GDC) is 0.641, which means that 64.1% of the changes in the green dynamic capability of enterprises can be explained by the business model and the green production of enterprises.

Table 5. Predictive relevance of the endogenous constructs

|  |  |  |
| --- | --- | --- |
|  | R2 | Q2 |
| Green Dynamic Capability (GDC) | 0.641 | 0.612 |
| Green Production (GP) | 0.521 | 0.506 |

According to Bamgbade et al. (2019) , Q2 is mainly used to evaluate the predictive power of the model. When the Q2 values are 0.00, 0.25, and 0.50, it means the model has a small, medium, and large predictive power, respectively. Table 5 shows that the Q2 values of GP and GDC are both higher than 0.50. Therefore, this research model has a good predictive power to explain the development of green dynamic capability of construction enterprises and green production. Finally, table 3 also provided the effect size (f2) of each construct and it was found that their values mostly were within 0.15 and 0.35, indicating a medium effect. The f2 value of a few constructs exceeded 0.35, which means those constructs had a strong effect.

Finally, in order to verify the research hypotheses, the structural model’s path coefficients and their significance levels were evaluated. As shown in Tables 6 and 7, the impact of the business model and green production on green dynamic capability was 0.559 and 0.297 (p <0.001). Therefore, hypothesis 1 and hypothesis 2 are supported. For hypothesis 3, it can be seen from Table 6 that the business model has a direct impact on green production (β =0.722). Therefore, hypothesis 3 is also supported. Furthermore, this study used the bootstrapping function of SmartPLS 3.0 to investigate the existence of a possible mediating effect. As can be seen from Table 7, the mediating effect of the business model (BM) on green dynamic capability (GDC) through green production (GP) is significant at 95% confidence level. Then, hypothesis 4 is supported too.

Table 6. Structural model result

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Path coefficients | S.E. | T-value | P-value | Status |
| BM | → | GDC | 0.559 | 0.078 | 7.127 | 0.000 | H1: Supported |
| BM | → | GP | 0.722 | 0.049 | 14.789 | 0.000 | H2: Supported |
| GP | → | GDC | 0.297 | 0.073 | 4.060 | 0.000 | H3: Supported |

Table 7. Mediator effect

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Indirect effect | Total effect | S.E. | T-value | VAF (%) | Status |
| BM→GP→GDC | 0.215 | 0.774 | 0.035 | 22.261 | 27.7 | H4: Supported |

Finally, this study also adopted Hair's recommendation (Hair et al. 2011) of using the Variance Accounted For (VAF) value to distinguish the intensity of mediating effect. Table 7 shows that the VAF of green production is 21.7%, indicating that some mediation exists.

## 4.4 Importance-Performance Map Analysis (IPMA)

In this study, the analysis phase was extended to the construct and indicator levels by using the Importance-Performance Map Analysis (IPMA) of PLS-SEM. IPMA is a useful analysis technique that compares the total effect of the predecessor construct (i.e. represents the importance of the predecessor construct to the target construct) with their average latent variable scores (i.e. represents the performance of predecessor constructs). The goal of IPMA is to identify predecessor constructs that are of relatively high importance to the target construct, even if the predecessor constructs have relatively low performance (Mousavi et al. 2018; Ringle Christian and Sarstedt 2016). Table 8 provides information about the IPMA results.

Table 8. IPMA results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Second-order construct | First-order constructs | Item | Importance | Performance |
| BM  Importance: **0.559**  Performance:66.665 | CVP  Importance: 0.175  Performance: 65.094 | CVP1 | 0.412 | 62.500 |
| CVP2 | **0.436** | **67.698** |
| CVP3 | 0.398 | 65.223 |
| KR  Importance: **0.185**  Performance: 61.964 | KR1 | 0.402 | 61.634 |
| KR2 | 0.417 | **64.604** |
| KR3 | **0.418** | 59.406 |
| KP  Importance: 0.164  Performance: 66.433 | KP1 | 0.392 | **68.936** |
| KP2 | 0.385 | 68.193 |
| KP3 | **0.486** | 63.036 |
| VC  Importance: 0.162  Performance: **73.057** | VC1 | 0.404 | 72.153 |
| VC2 | 0.411 | 73.020 |
| VC3 | **0.446** | **74.010** |
| GP  Importance: 0.297  Performance:**69.661** | GPP  Importance: **0.162**  Performance: **69.633** | GPP1 | 0.307 | 69.307 |
| GPP2 | 0.303 | 67.946 |
| GPP3 | **0.328** | 68.936 |
| GPP4 | 0.274 | **72.525** |
| GPPR  Importance: 0.156  Performance: 69.625 | GPPR1 | 0.314 | 64.686 |
| GPPR2 | 0.300 | 71.287 |
| GPPR3 | **0.331** | **71.906** |
| GPPR4 | 0.296 | 71.040 |
| GDC | ESC  Importance: 0.488  Performance: **67.824** | ESC1 | 0.204 | **72.401** |
| ESC2 | **0.207** | 70.421 |
| ESC3 | 0.179 | 60.066 |
| RSC  Importance: 0.283  Performance: 64.517 | RSC1 | **0.120** | **66.007** |
| RSC2 | 0.118 | 64.521 |
| RSC3 | 0.119 | 62.541 |
| RRC  Importance: **0.496**  Performance: 67.776 | RRC1 | **0.202** | **67.946** |
| RRC2 | 0.197 | 64.604 |
| RRC3 | 0.194 | 67.698 |

Note: See Table 1 for all abbreviations in column ‘Item’.

As can be seen from Table 8, compared with green production, the business model can play a more important role in cultivating and improving green dynamic capability (importance = 0.559). In the business model, key resources (KR) can play the most important role in adjusting business models to improve the green dynamic capabilities of an enterprise, although its performance is the lowest. In the business model, customer value proposition (CVP) ranked second in importance to green dynamic capability, and key process (KP) and value capture (VC) ranked the lowest in importance. At the indicator level of different sources, KP3 is the most important indicator for the business model. In the customer value proposition, CVP2 has the greatest impact on the business model, and its performance is much higher than other indicators in key resources and value capture. KR3 and VC3 are the most important indicators for the business model.

In terms of green production, green production practice (GPP) has the highest influence (importance) and performance on fostering green dynamic capability. In the green production practice, GPP3 is the most important to green production, while GPP4 has higher performance. In terms of the green production principle, GGPR3 is far more important to green production than other indicators, and its performance is also the best.

Finally, it can be seen that resource reconstruction capability is an important factor in green dynamic capability (importance = 0.496), while environmental sensing capability has a better performance (performance = 67.824).

# 5. Discussion

This research study has examined the factors influencing green dynamic capability of construction enterprises. It has also explored the impact of the business model (BM) and green production (GP) on green dynamic capability (GDC). The study found reliable evidence confirming the positive effects of the BM and GP on GDC. As highlighted in Section 4 at 95% of the significant level, the parameters path coefficients of the measurement and structural models were not zero. The major interpretations of the numerical results are described below.

## 5.1 Effect of business model on green dynamic capability

Hypothesis H1, which suggested that the business model is positively related to green dynamic capability, was supported. This result is consistent with current scholars’ view of encouraging enterprises to adjust their business models towards more sustainable development practices. For example, Teece (2010) pointed out that in the process of fostering green dynamic capability, enterprises need to fully mobilize their internal and external resources, and sustainable business models can help in this process.

At the same time, this study provided a detailed analysis of how and to what extent business model components influence green dynamic capabilities (see Table 8). Firstly, in the business model, key resources can have the most important impact on green dynamic capabilities (importance = 0.185). In most studies, key resources have become the basis for enterprises to support the achievement of the sustainable development goals (Dangelico et al. 2017). From the perspective of the business model, this discovery explains why enterprises can immediately rely on and properly use their key resources.

Secondly, customer value proposition can have a positive impact on the development of green dynamic capability (importance = 0.175). With the deterioration of the global environment, the impact of low-carbon and environmental protection initiatives in society have become stronger. On this matter, there has been an increasing raise of awareness of the advantages of green buildings. In many cases, customers are even willing to pay more for green buildings. Therefore, the customer value proposition can be considered as one of the key factors for enterprises to improve green dynamic capability (Lindic and da Silva 2011).

Thirdly, the key processes for enterprises to conduct business activities are also considered to be an important factor affecting the development of green dynamic capability (importance = 0.164). This is consistent with the conclusions of Jiang et al. (2018) and Teece (2016). When construction enterprises focus on the improvement of key processes when carrying out construction activities, they will be able to promote further development of their green dynamic capabilities.

Finally, regarding the value capture of enterprises, Scholars generally believe that high profits can greatly stimulate the enthusiasm of enterprises to cultivate and improve green dynamic capability (importance = 0.162). However, previous research has emphasized that value (or benefit) can be the direct driving force for enterprises to implement changes (Barnett and Salomon 2012; Eyring et al. 2011). Nevertheless, one matter that needs to be emphasized in this study is that the advantage of an enterprise's higher profitability is not only their healthier finances, but also other intangible benefits, such as improvements of its market competitiveness and social responsibility image.

## 5.2 Mediator role of green production

This study confirmed the hypothesis that green production is positively related to green dynamic capability. This is consistent with the conclusions of previous studies (Augusto de Oliveira et al. 2019; Severo et al. 2018).

Besides, the results show that the importance of green production practice to green dynamic capability (importance = 0.162) is greater than that of the green production principle (importance = 0.156). Green production practices can effectively reduce the negative impact of enterprises on the surrounding environment, and bring higher socio-economic and environmental performance for enterprises (Subramanian and Gunasekaran 2015; Zhang et al. 2018). This does not necessarily mean that green production principles are not important. Indeed, without the guidance of green production principles for the production activities, the adoption of green production practices may not result in the expected outcomes in terms of sustainable development (Peng and Liu 2016). Also, as pointed out by (de Oliveira Santos et al. 2019), enterprises need to formulate corresponding guidelines (or principles) according to the needs of green production, which can help enterprises to undertake greener production practices.Consequently, if enterprises can strictly follow green production principles in production processes, then such enterprises can also actively promote green dynamic capability to cope with the challenges brought by turbulent business environments (Tseng et al. 2013). Finally, the mediator role of green production (mediating effect of 27.7%) shows that when construction enterprises adopt green production principles to restrict production activities, their production level can be greatly improved. This provides another prerequisite for nurturing dynamic capability.

## 5.3 Main components of green dynamic capability

The core elements of green dynamic capability were divided into environmental sensing capability, resource seizing capability and research reconfiguration capability.

First of all, the improvement of resource reconfiguration capability brings the major improvements in green dynamic capability (importance = 0.496). Resource reconfiguration capability requires the organization to adjust the current operation modes and management processes to maintain the adaptability of the enterprise to the business environment (Lin and Chen 2017). Hence, whether an enterprise can effectively reorganize and allocate its original resources and procedures is a major must when a company needs to improve its green dynamic capability.

Environmental sensing capability is the second most important component of green dynamic capability (importance = 0.488). Environmental sensing capability reflects the capability of construction enterprises to discover and pursue innovative opportunities (Stanovcic et al. 2015). For construction enterprises, environmental sensing capability requires to constantly scan the surrounding business environment to understand information (e.g. emergent market demands for technological development and industry trends). Furthermore, enterprises still lack relevant experience in sustainable development, so they need to make extensive use of various internal and external information sources to explore future development opportunities and risks (Horbach et al. 2012).

Finally, resource seizing capability is considered to be an important component of green dynamic capability (importance = 0.283). In other words, integrating the new knowledge into the existing enterprise knowledge base and promoting it is indispensable for improving green dynamic capability (Ben Arfi et al. 2018; Wong 2013). This further supports the importance of knowledge sharing and knowledge management.

# 6. Conclusions

This research study proposes a theoretical framework to analyze and enhance enterprises' green dynamic capability. The study applies the framework to the Chinese construction industry and provides guidance on some aspects that enterprises need to pay special attention to improve their green dynamic capability. The findings also verify the hypotheses proposed at the beginning of the article. The main conclusions are:

a) There is a positive relation between the business model and green dynamic capability. The transformation of existing business models to sustainable operation can help enterprises balance the relationship between social, economic and environmental benefits. This further helps enterprises to adapt to changes in turbulent business environments and ultimately achieve their sustainable development goals. In this regard rational allocation of resources is priority to enhance their green dynamic capability.

b) Enterprises should actively implement green production, which is the most direct means for enterprises to achieve sustainable development goals. Green production can effectively reduce the negative impact of production activities on the environment and bring more environmental benefits to enterprises. The green production principles and practices formulated by enterprises can promote the improvement of green dynamic capability, but need to be specifically implemented in the engineering process of the construction industry. Although most enterprises have responded to green production specifications, such rules and procedures are often not strictly enforced in the commercial process of construction projects.

c) Finally, the findings also reveal the mediating effect of green production in the business model and green dynamic capability. Green production can strengthen the positive correlation between the business model and green dynamic capability. In this process, green production practices can play a more important role than green production principles.

From the perspective of enterprise management, firstly, this research found that key resources are the most important for enterprises to foster green dynamic capabilities. It is suggested then that enterprises should continuously develop unique resources to enable enterprises to achieve sustainable development. This suggestion is also consistent with Mezger (2014). Hence, enterprises should focus on the renewal of resources and capabilities, as rare and inimitable resources are the source of sustainable competitiveness for enterprises. Secondly, regarding green production, the research results also show that green production practices can have an important impact on the promotion of green dynamic capability. In the production process, enterprises need to pay attention to the continuous improvement of production methods and update production technologies. They also need to improve the utilization efficiency of resources to reduce the negative impact on the surrounding environment.

This study inevitably has some limitations. First, although the study used the PLS-SEM method with a sufficient sample size to verify the hypotheses, a larger sample size would have been more representative. Second, the study focused on the driving factors of green dynamic capability of construction enterprises. However, it did not make a detailed distinction between the specific business scope and development stages of enterprises. Considering that the life cycle stage and the main business scope of the construction enterprises are different, the specific characteristics of the enterprises will also be different. Future research then should make a distinction between these factors.

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