



Research on the Impact of Green Innovation and Organizational Resilience on Firm Sustainable Development Performance

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Abstract. Based on innovation and sustainable development theory, it explores the relationship among green innovation(GI), organizational resilience(OR) and sustainable development performance(SDP). Through questionnaire survey and data analysis using SPSS and AMOS, the empirical results show that: (1) GI significantly positively affects OR. (2) OR has a significantly positive impact on SDP. (3) OR plays a mediating role between GI and SDP. (4) Environmental dynamism(ED) negatively moderates the relationship between green product innovation (GPdI) and OR, and positively moderates the relationship between green management innovation(GMI) and OR. It reveals the mechanism between GI and SDP, and enriches the theory of innovation and sustainable development. It suggests that firms should establish a culture and mechanism to encourage innovation internally, so as to achieve sustainable development and enhance the social image and reputation.

Keywords: Green innovation; Organizational resilience; Sustainable development.

1 Introduction

With the increasingly severe global environmental problems, sustainable development has become a global consensus. Green innovation(GI), as a key driving force to promote sustainable development, is gradually becoming an important path for firm transformation and upgrading. It not only involves the green transformation of products and technologies, but also covers the comprehensive innovation of organizational management and operation mode. Some scholars believe that GI helps firms achieve a win-win situation of economic and environmental benefits by reducing environmental pollution and improving resource utilization efficiency [1]. However, other scholars believe that although green innovation has a positive effect on the improvement of environmental performance, it may have a negative effect on economic performance [2]. This study will confirm this controversial conclusion in China's private manufacturing industry from an empirical perspective. In addition, in the era of global economic uncertainty and intensified environmental risks, organizational

resilience(OR) has become the core competitiveness for firms [3]. It has been suggested that GI not only improves the production efficiency and market competitiveness of firms, but also enhances the ability of firms to cope with environmental challenges by introducing new technologies, new materials and new models, which providing important support for the construction of organizational resilience [4]. What is the mechanism of organizational resilience between green innovation and firm performance? Will the impact of green innovation on firm performance change when the environment changes greatly? This study will discuss the above issues, hoping to provide some reference value for firms and policy makers.

2 Theory and Hypotheses

2.1 The Relationship Between Green Innovation(GI) and Firm Organizational Resilience (OR)

GI is a broad expression, and all related innovation activities involving "innovation-value creation-environmental protection" can be regarded as green innovation [5]. Compared with general innovation, GI needs to follow ecological laws [6], it is based on resource conservation, elimination of waste and pollution, it is driven by continuous improvement and innovation, and it aims at sustainable economic, environmental and social development. In the existing literature, GI is considered as a multi-dimensional construct. Following the research of most scholars, this paper analyzes GI from three dimensions, which includes green product innovation-GPdI, green process innovation-GPcI, and green management innovation-GMI.

Organizational resilience(OR) is considered as the ability of firms to recover from adversity [7], which can help firms quickly recover the expected performance when they suffer from external negative shocks, and it is used to explain how organizations survive and develop in adversity or turbulent environment. Although theoretical research on resilience has recently proliferated, empirical research has lagged behind [8]. In the context of increasingly turbulent external environment and more and more attention paid to security and stability, enhancing organizational resilience and achieving safe, stable and sustainable operation have become key issues in firm management.

GI can not only improve firms market competitiveness and anti-risk ability, but also promote their technological upgrading and organizational culture construction, thus enhancing their organizational resilience [9]. Specifically, GPdI reduces the impact of products on the environment in the whole life cycle. Firms can quickly adjust strategies and enhance the adaptability and resilience of organizations through environmentally friendly products Innovation. Through GPcI, firms optimize the production process and reduce environmental pollution and resource consumption, which helps firms to reduce operating costs and maintain market competitiveness, thus enhancing the resilience of the organization. In terms of management, GMI refers to the integration of green concepts into organizational management, strategic planning and corporate culture construction [10], which helps firms to quickly adjust their strategic direction and

maintain sustainable development capabilities when facing changes in the external environment. It also helps to form strong organizational cohesion within the firm, so that the internal members of firm can unite and cope with challenges together, thus enhancing the resilience of the organization.

Therefore, we propose the following hypothesis:

H1: Green innovation plays a positive role in promoting organizational resilience.

Specifically, the impacts of different dimensions of green innovation on organizational resilience are shown in the sub-hypotheses.

H1-1: GPdI plays a positive role in promoting OR.

H1-2: GPcI plays a positive role in promoting OR.

H1-3: GMI plays a positive role in promoting OR.

2.2 Relationship Between Organizational Resilience (OR) and Sustainable Development Performance(SDP)

SDP refers to the ability of a firm to meet current needs without compromising the ability of future generations to meet their needs, and to achieve a balanced development across the three dimensions of economy, society, and environment. The performance not only focuses on short-term economic benefits, but also underscores the importance of long-term social and environmental benefits.

OR equips firms with the capacity to manage risks, adapt to shifts, innovate, and sustain competitiveness, thus fostering balanced development across economic, social, and environmental dimensions. Specifically, OR allows firms to proactively anticipate and assess potential risks, devise response strategies, minimize losses, and ensure the realization of sustainable development objectives [11]. Additionally, OR allows firms to remain flexible and innovative when facing challenges. For instance, by engaging in learning and knowledge management, firms can develop a forward-looking mindset, continuously adapt their strategic initiatives, and update business planning to align with evolving market and technological conditions. Therefore, we propose the following hypothesis:

H2: OR plays a positive role in promoting SDP.

2.3 Mediating role of organizational resilience between green innovation and sustainable development performance

As illustrated above, green innovation positively influences organizational resilience, which then positively impacts sustainable development performance. Thus, we propose that organizational resilience serves as a mediator between green innovation and sustainable development performance, for the reasons outlined below:

Firstly, as firms embark on green innovation initiatives, they may face hurdles such as technological challenges, limited market acceptance, and policy uncertainties. OR enables firms to cope with these shocks, recover quickly by adjusting strategies and

optimizing resource allocation, and ensure the continuous progress of green innovation projects [12].

Secondly, green innovation frequently involves the introduction of new technologies and transformations in management models. Organizational resilience allows firms to adapt flexibly to these changes, continuously adapting to new market environments and policy requirements through learning and innovation.

Thirdly, from an internal perspective, green innovation requires close collaboration among different departments and teams. Organizational resilience fosters interconnectivity and interdependence among departments, allowing firms to create strong synergies.

Therefore, we propose the following hypothesis:

H3: Organizational resilience plays a mediating role between green innovation and sustainability development performance.

Specifically, the hypothesis includes the following sub-hypotheses.

H3-1: OR plays a mediating role between GPdI and SDP.

H3-2: OR plays a mediating role between GPcI and SDP.

H3-3: OR plays a mediating role between GMI and SDP.

2.4 The Impact of environmental dynamics

The dynamic environment challenges the green development of firms [13]. In terms of product innovation, environmental dynamism escalates the risks associated with green innovations and environmental upgrades, causing firms to cut back on innovation investments for fear of failure, thus hindering organizational resilience. Moreover, to address the challenges posed by environmental dynamism, firms may need to spread their resources across various fields, which could result in inadequate resources for green product innovation, subsequently impacting both its success and organizational resilience. From the standpoint of process innovation, firms' green process innovations is often accompanied by complex processes such as technological innovation, equipment upgrades, and process optimization, which requires firms to invest a lot of human, material and financial resources but fail to obtain the expected results, resulting in resource waste and confidence setback, thus weakening organizational resilience. From a management perspective, green management innovation involves the collaboration of multiple departments and fields, and the decision-making process may become complex and time-consuming, which makes it difficult for firms to make the right decision at the critical moment, thus affecting the successful implementation of green management innovation and the improvement of organizational resilience.

Therefore, we believe that environmental dynamism(ED) will negatively affect the relationship between green innovation(GI) and organizational resilience(OR), and make the following hypothesis:

H4: ED negatively moderates the relationship between GI and OR.

Specifically, the hypothesis includes the following sub-hypotheses.

H4-1: ED negatively moderates the relationship between GPdI and OR.

H4-2: ED negatively moderates the relationship between GPcI and OR.

H4-3: ED negatively moderates the relationship between GMI and OR.

The positive effect of organizational resilience on sustainable development performance will be enhanced when the environmental dynamism is high. On the one hand, the dynamic changing environment requires firms to constantly seek new solutions and coping strategies, which stimulates the innovation vitality of firms. Firms with strong organizational resilience can make better use of this innovation vitality to improve production efficiency, reduce costs, so as to improve the sustainable development performance [14]. On the other hand, the higher the environmental dynamics is, the more efficient the resource allocation ability must be. Firms with strong organizational resilience can flexibly adjust their resource allocation plans to ensure resource input in key areas and projects. This optimization of resource allocation helps firms to improve the efficiency of resource utilization, reduce waste and cost, and thus improve the sustainable development performance.

Therefore, we propose the following hypothesis:

H5: ED positively moderates the relationship between OR and SDP.

2.5 Conceptual Model

Based on the above assumptions, the conceptual model is illustrated in Figure 1.

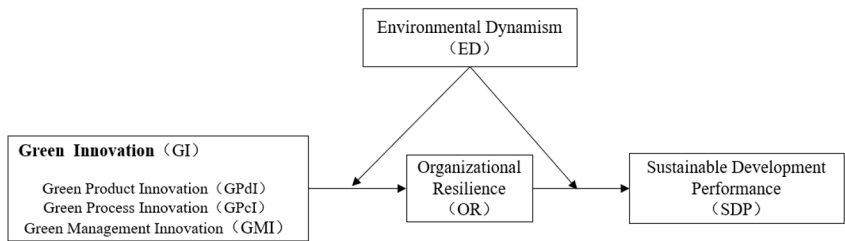


Fig. 1. Conceptual model

3 Methodology

3.1 Sample and Data Collection

The initial questionnaire followed the existing mature scale and adopted the Likert7 scale. In the question design, the green innovation of firms is measured from three dimensions including 12 questions, such as "We develop or use new products with less or no pollution/non-toxic raw materials". The measurement of organizational resilience is mainly carried out from three aspects: anticipation ability, response ability and adaptability [15], including four questions, such as "In the face of emergencies, firms can make emergency plans and implement them accurately and quickly."

Environmental dynamism mainly measures the competition from environmental protection or green products in the market, including three questions, such as "other competitive green products are easy to be introduced into the market." The dependent variable sustainable development performance is measured with four questions from three aspects: economic performance, environmental performance and social performance. In addition, this study included firm age and firm size as control variables.

3.2 Data Collection and Bias Analysis

A total of 585 questionnaires were distributed in this study, and 246 valid questionnaires were collected. We selected the first 40 and the last 40 samples received for independent T-test to test the non-response bias, and the test variables selected were firm age, industry and scale. The results show that under the assumption of equal variance (homogeneous), the Levene test of firm size shows that $F=1.999$ and the significance $p=0.161>0.05$, which indicates that the variance of the two groups of samples is homogeneous. In the corresponding t test, $t=0.826$, $df=78$, $p=0.250>0.05$. Therefore, there is no significant difference between the two sets of data in terms of firm size. Similarly, there is no significant difference between the two groups of data in terms of industry and firm age. This indicates that the non-response bias in this study is not obvious and can be ignored.

3.3 Reliability and Validity Tests

In this study, the SPSS software is used to test the reliability of internal consistency, and the results show that the Cronbach's α of each construct is above 0.8, indicating that the reliability of the scale is very good, and the internal consistency test is passed. The specific results are shown in table 1 below:

Table 1. Results of Confirmatory Factor Analysis of Construct Measures

Construct	Cronbach's Alpha value	Composite reliability	AVE
GPdI	0.851	0.877	0.641
GPcI	0.814	0.820	0.538
GMI	0.808	0.813	0.526
OR	0.813	0.812	0.520
SDP	0.839	0.842	0.571
ED	0.844	0.854	0.665

The validity test is carried out from two aspects: the convergent validity and discriminant validity. As shown in Table I, the AVE values of all constructs in this study are greater than 0.5, so the convergent validity test has passed. By comparing the square root of AVE of a construct with the correlation coefficient between the construct and other constructs, if the square root of AVE is greater than the correlation coefficient between the construct and all other constructs, the discriminant validity test passes.

Through calculation, this condition is met, so the discriminant validity of the scale is passed

4 Empirical Test and Result Analysis

4.1 Direct Path Test

AMOS26.0 is used to test the hypotheses of direct path in this study. The results reveal that all paths are significant as shown in figure 2. Therefore, hypotheses H1 and H2 are verified.

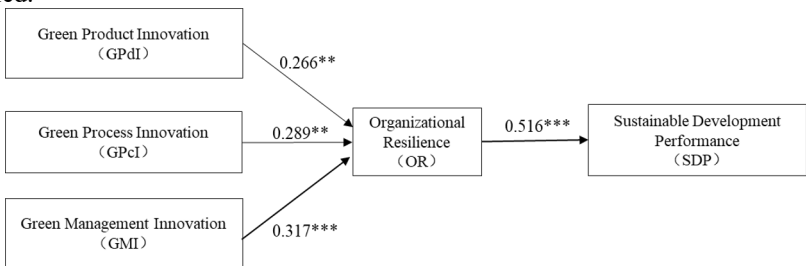


Fig. 2. Direct path test results. (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$)

4.2 Mediating effect test

This study verifies the mediating effect of organizational resilience between green innovation and sustainable development performance by establishing a structural equation model and using 5000 sample operations of Bootstrap in AMOS. The results are shown in Table 2.

Table 2. Results of Mediating Effect Test

Test path	indirect effect	95% confidence interval		p value
		The lower bound	The upper bound	
① GPdI→OR→SDP	0.137	0.053	0.288	0.005
② GPcI→OR→SDP	0.149	0.039	0.314	0.011
③ GMI→OR→SDP	0.164	0.063	0.323	0.001

a. Level of Confidence for Confidence Intervals:95

b. Number of Bootstrap Resamples: 5000

The results show that the 95% confidence intervals under the three paths do not include 0, and the p-values are less than 0.05, so the indirect effects are significant. In other words, the organizational resilience of firms plays a mediating role between green innovation and sustainable development performance, H3 is verified.

4.3 Moderating effect test

SPSS is used to test the moderating effect of environmental dynamism. Firstly, we use two model to test whether the role of green innovation on organizational resilience has changed when the environment changes. It can be seen in table III, the cross term between green product innovation and environmental dynamism and the cross term between green management innovation and environmental dynamism are both significant (the values of ΔR^2 are 0.048*** and 0.379*** respectively), while the cross term between green process innovation and environmental dynamism is not significant, indicating that ED plays a moderating role in the relationship between GPdI and OR, it also moderates the relationship between GMI and OR. Among them, the moderating effect is negative between GPdI and OR (the coefficient is -0.157, $p < 0.01$), while it is positive between GMI and OR (the coefficient is 0.189, $p < 0.001$). Which supports Hypothesis H4-1 but contradicts Hypothesis H4-3. In addition, the regression results also show that ED has no significant moderating effect on the relationship between GPdI and OR.

Table 3. Results of Moderating Effect Test 1

Variables	Organizational Resilience	
	Model 1	Model 2
<i>Control variables</i>		
Firm age	0.019	0.006
Firm size	-0.116*	-0.099
<i>Independent Variables</i>		
① Green Product Innovation	0.264***	0.281***
② Green Process Innovation	0.282***	0.231***
③ Green Management Innovation	0.252***	0.300***
④ Environmental Dynamism	0.008	.024
①x④		-.157**
$\Delta R^2 = 0.048***$		
②x④		-.014
$\Delta R^2 = 0.001$		
③x④		.189***
$\Delta R^2 = 0.379***$		

a. * $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$

Secondly, we test the moderating effect of environmental dynamism on the relationship between organizational resilience and sustainable development performance. The results reveals that environmental dynamism has no significant moderating effect, so H5 is not verified.

5 Conclusion and Applications

5.1 Conclusions and Discussions

This study draws the following conclusions:

(1) the three dimensions of green innovation can positively and significantly affect organizational resilience. This reveals that green innovation is very important for firms, it can increase the ability of firms to resist risks and recover from adversity.

(2) Organizational resilience positively and significantly promotes the sustainable development performance, it also plays a mediating role between green innovation and sustainable development performance. The conclusion is consistent with most studies, revealing the positive effect of organizational resilience on firm performance. This conclusion also answers the different debates of scholars on the relationship between green innovation and economic performance, and confirms the positive effect of green innovation on sustainable development performance, especially economic performance.

(3) Environmental dynamism negatively moderates the relationship between green product innovation and organizational resilience. Environmental dynamism has no significant moderating effect on the relationship between green process innovation and organizational resilience, this is not consistent with our hypothesis, perhaps because the optimization, improvement and reorganization of internal processes reflect the hard power of firms, and their impacts on organizational resilience will not change with the change of the environment. The results also reveal that environmental dynamism positively moderates the relationship between green management innovation and organizational resilience, this is contrary to our hypothesis for the following reasons: first, rapid environmental changes may force firms to constantly seek new management methods to adapt to changes in the external environment; Second, in a dynamic environment, firms need to constantly learn and adapt to meet various challenges. The process of green management innovation is also a process of organizational learning. Through continuous trial and error and improvement, firms can accumulate valuable experience and knowledge, thus enhancing organizational resilience and adaptability.

5.2 Management Applications

First, firms should establish a culture and mechanism that encourages innovation, and support employees to propose and implement green innovation projects to enhance the organizational resilience of firms. In addition, multi-department cooperation is needed because green innovation often involves knowledge and technology in multiple fields. Therefore, firms should actively create cross-department or multi-team cooperation opportunities and establish a wide internal partner network.

Second, firms should focus on the role of green innovation in improving economic and environmental performance, as well as on its role in social performance. It is very important for firms to actively participate in environmental protection and public welfare activities and strengthen communication and cooperation with stakeholders.

5.3 Limitations and Future Research

This study has the following shortcomings, which provide opportunities and directions for our future research. (1) This study collects time-point data rather than time-period data, so it can only judge the performance changes brought by innovation in the early stage from a single time-point. (2) This study only chooses firm age and size as control variables for analysis. Our subsequent research can be considered under the condition of controlling more variables such as enterprise nature and manager orientation.

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