# How does top management's environmental awareness influence green innovation: The moderating role of absorptive capacity and slack resources

***Ying Yang[1], Jiaxin Zhao[2], Xiu-e Zhang[3]***

[1] *Northeast Electric Power University, Economics and Management School, Department of Management, China, ORCID: 0000-0002-4213-2832, yangying20088@163.com;*
[2] *Northeast Electric Power University, Economics and Management School, Department of Management, China, ORCID: 0000-0002-2326-7854, zhaojiaxin0211@163.com;*
[3] *Jilin University, Business and Management School, Department of Strategic Management, China, ORCID: 0000-0002-1758-9291, zhangxe@jlu.edu.cn.*

***Abstract:*** *Based on the upper echelons theory, dynamic capability theory, and resource-based view, this study explores the impact of top management's environmental awareness (TMEA) on green innovation (GI), the moderating role of absorptive capacity (AC) and slack resources (SR). Using the data of A-shared listed manufacturing firms in China from 2010–2023, this study finds that TMEA has a significant positive effect on GI. Furthermore, AC and unabsorbed slack resources (USR) strengthen the effect of TMEA on GI, whereas absorbed slack resources (ASR) weaken the effect of TMEA on GI. The results provide a more comprehensive understanding for enterprises to implement GI, expand boundary conditions between TMEA and GI, and contribute to the improvement of research on GI.*

***Keywords:*** *Top management's environmental awareness, green innovation, absorptive capacity, unabsorbed slack resources, absorbed slack resources.*

***JEL Classification:*** *M140.*

***APA Style Citation:*** Yang, Y., Zhao, J., & Zhang, X. (2025). How does top management's environmental awareness influence green innovation: The moderating role of absorptive capacity and slack resources. *E&M Economics and Management*, *Vol. ahead-of-print*(No. ahead-of-print). https://doi.org/10.15240/tul/001/2025-5-003

***Early Access Publication Date:*** *January 10, 2025.*

## Introduction

With the deterioration of global environmental problems, China announced the goals of "peak carbon dioxide emissions" and "carbon-neutral" to the world, giving unprecedented attention to green innovation (GI). GI refers to the innovation aimed at reducing the impact on the environment in the process of enterprise operation, including energy saving, pollution prevention, waste recycling, green product design, and enterprise environmental management technology (Chen et al., 2006). GI cannot only promote enterprises to speed up the transformation of production mode, but also promotes the manufacturing industry to effectively control pollution and rationally use resources (Li & Lu, 2022). In addition, through GI, the reputation of enterprises is improved due to the spillover

effect, thus increasing the demand for enterprise products (Eiadat et al., 2008). Although GI is an economic behavior centered on improving environmental performance, it has the characteristics of high risk, high input and external duality, which leads to the phenomenon that the company's GI motivation is insufficient (Xing & Yu, 2019). Therefore, it is of great theoretical and practical significance to explore the driving factors of GI in enterprises.

As for the research on the driving factors of GI in enterprises, most scholars have studied the influence of external driving factors, such as environmental regulation, financial subsidies and environmental pressure of stakeholders on GI (Hojnik et al., 2016; Porter et al., 1999; Xie et al., 2020). However, the above research cannot explain the performance differences of GI of different enterprises in the same external environment, so scholars began to focus on the internal driving factors of enterprises, such as enterprise scale, R&D level and executive characteristics, which will affect enterprises' GI (Liao & Cheng, 2014). Especially the top managers who are the strategists and resource allocators of enterprises, their understanding of the environment plays a decisive role in GI. Top management's environmental awareness (TMEA) is their perception of environmental protection and sustainable development based on their personal knowledge structure and values (Xing & Yu, 2020). According to the upper echelons theory, managers with environmental awareness can eliminate obstacles in the process of GI (Hambrick, 2007), promote enterprises to carry out green product innovation and enhance their green competitive advantage (Cao et al., 2021; El-Kassar & Singh, 2019; Patrick, 2019).

Although these studies are helpful for us to understand the driving factors of GI, there are still some shortcomings in existing studies. First, most studies focus on the influence of external driving factors such as environmental regulations and government subsidies on GI, relatively few studies have investigated the internal driving factors. However, whether an enterprise can carry out GI ultimately depends on its own cognition and strength, especially on top management's cognition and interpretation of environmental policies. Therefore, TMEA determines the strategic choice of the enterprise and is an important determinant of GI. However, the research on how TMEA affects enterprises' GI is not sufficient. Second, there is a lack of discussion on boundary conditions of how TMEA affects GI from the perspective of internal resources and capabilities of organizations. Although GI of enterprises is supported by external resources such as financial subsidies, what is more important is that the internal resources and capabilities are owned by enterprises themselves. If the internal resources and capabilities are insufficient, the effect of market demand and environmental regulations on GI will not be obvious (Zailani et al., 2015). Therefore, organizational resources and capabilities may also affect the relationship between TMEA and GI.

Based on upper echelons theory, resource-based view and dynamic capability theory, this study explores how TMEA affects GI, and finds that slack resources (SR) and absorptive capacity (AC) are moderating variables in the relationship between TMEA and GI in order to contribute to GI theory.

## 1. Theoretical analysis and hypotheses development

### 1.1 Top management's environmental awareness and green innovation

Top managers' in-depth understanding of environmental risks and benefits enables them to pay more attention to environmental issues, thus discovering more business opportunities and responding more quickly and actively by implementing environmental solutions such as GI activities. Because GI has the characteristics of high risk, high investment and long payback period, enterprises lack the priority in allocating resources to GI. However, executives have the right to control enterprise resources, and their willingness to use organizational resources for GI often depends on their understanding of environmental protection. Managers' perceptions will guide the subsequent strategic choices and actions (Kaplan, 2011), which will further affect the development of GI. The stronger the environmental awareness, the more executives can discover the potential benefits and opportunities in the market, so as to allocate the resources and capabilities within the enterprise more reasonably. In the literature, TMEA can be divided into general awareness and environmental awareness. General awareness refers to the top management's understanding of the company's environmental impact,

environmental measures and environmental practice. Out of a sense of social responsibility, senior executives aim to reduce the negative impact on the environment through GI. Environmental awareness refers to the top manager's awareness that GI can reduce costs, increase income and improve environmental performance (Gadenne et al., 2009).

Executives with strong environmental awareness can identify the green resources or needs of stakeholders, put resources into GI, and actively allocate enterprise resources to make the production and operation of enterprises green, thus meeting the existing green needs in the market. Managers should also realize the importance of GI in dealing with environmental risks, building environmental capacity and creating first-mover advantages (Peng & Liu, 2016). These advantages are lasting and difficult to imitate, which gives enterprises a priority in the competition and contributes to the long-term development of enterprises. Therefore, TMEA will stimulate the green process innovation and green product innovation of enterprises. Therefore, the following hypothesis is proposed:

*H1: TMEA positively influences GI.*

### 1.2 Moderating role of absorptive capacity

According to the dynamic capability theory, enterprises need to continuously establish, reorganize and allocate internal and external resources in order to achieve competitive advantage (Teece, 2007). Cohen and Levinthal (1990) first put forward the concept of AC, which refers to the ability of enterprises to identify and acquire new external information value, absorb information and apply it to commercial purposes. Zahra and George (2002) divide AC into potential absorptive capacity (PAC) and actual absorptive capacity (AAC). PAC includes knowledge acquisition and digestion, while AAC includes knowledge transfer and application. If PAC of enterprises is weak, it is difficult for organizations to understand and absorb external resources and information (Duan et al., 2020). Otherwise, the company can acquire and absorb external resources sufficiently, producing green products that meet market demand. AAC means that an enterprise obtains new insights from existing knowledge, and applies them to daily production and operation (Duan et al., 2020). If AAC is weak, an enterprise cannot grasp the industry technology, thus ignoring the potential opportunities in the market. On the contrary, it will help enterprises to integrate internal and external resources, promoting GI of enterprises.

AC can help enterprises overcome organizational inertia and break institutional conventions, so as to gain market competitive advantage (Miroshnychenko et al., 2021). Through AC of enterprises, from the identification and acquisition of external resources to the integration, digestion and application of internal resources, GI is promoted by the joint effect of internal and external knowledge and resources. Therefore, the following hypothesis is proposed:

*H2: AC positively moderates the relationship between TMEA and GI.*

### 1.3 Moderating role of slack resources

According to the resource-based view, only valuable, unique, difficult to imitate and hard to replicate resources are the key sources for enterprises to obtain sustainable competitive advantages (Bowen et al., 2010). Therefore, enterprises need to provide sufficient resources to ensure the implementation of innovation. The necessary resource support is the foundation for the success of GI. SR refers to the difference between the resources that an enterprise can have and the resources that it actually needs to maintain the status quo. SR can solve the problem of resource conflicts within the organization, acting as a "buffer" to protect the technological core of the organization from the impact of the external environment. It can also promote the implementation of new strategies to introduce new products and enter new markets (Tan & Peng, 2003). SR can be divided into unabsorbed slack resources (USR) and absorbed slack resources (ASR).

USR refers to idle flowing resources that can be applied to other projects quickly and flexibly. When enterprises have sufficient resources, they have the ability to invest in R&D, and are more inclined to invest in GI projects with environmental protection effects. Because GI has the characteristics of high risk and high investment, enterprise executives pay little attention to R&D technology and product development when enterprises cannot freely allocate resources. They are more inclined to pay attention to the short-term performance of enterprises (Xie & Wei, 2016). Therefore, their willingness and ability to carry out GI in R&D activities are very low. USR can alleviate the negative impact

caused by the failure of GI and provide a guarantee for enterprises. It can also improve the ability of enterprises to resist risks, which is conducive to the development of GI (Long & Chai, 2021). USR can help enterprise executives transform their environmental awareness into enterprise innovation behavior, that is, the more USR an enterprise has, the more resources it can provide for managers to carry out GI. Therefore, the following hypothesis is proposed:

*H3: USR positively moderates the relationship between TMEA and GI.*

ASR refers to the resources that have been used and absorbed by enterprises in production, operation and management. ASR has poor fluidity and activity. When an enterprise holds more ASR, managers will spend a lot of energy searching and disposing of them, which will increase the holding costs and management expenses (Xiao & Li, 2018). Excessive ASR makes it more difficult for enterprises to identify and utilize these resources. In this case, enterprises usually maintain the original development path, resulting in an increase in the time and cost of enterprise transformation and upgrading, which is not conducive to the development of GI (Li et al., 2018). ASR occupies more fixed assets of enterprises and makes it more difficult to obtain stable cash flows, which will have a negative impact on managers' decisions. In addition, managers perceive ASR as necessary to maintain existing production activities, but not sufficient to implement new strategies (Iyer & Miller, 2008). ASR is implicit and usually exists in the production processes within the enterprises. Because it is hard to search, it is rarely used for GI. Therefore, the following hypothesis is proposed:

*H4: ASR negatively moderates the relationship between TMEA and GI*.

Therefore, the theoretical framework is proposed and shown in Fig. 1.

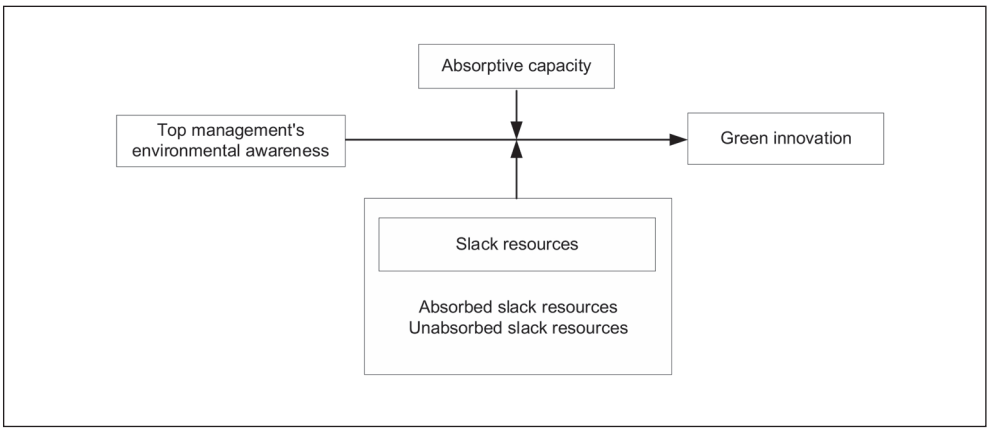


**Fig. 1: Proposed theoretical framework**

Source: own

## 2. Methodology

### 2.1 Sample and data collection

The research samples are from listed manufacturing companies in the A-share market of China. Compared with other industries, the manufacturing industry engaged in production activities has a greater impact on the environment. Under external pressure, there are more GI in manufacturing companies, and the number of patents is easier to collect. Given the availability of data, this paper selects Chinese manufacturing enterprises from 2010–2023 as the sample. According to the research of Hao et al. (2019) and Chen et al. (2018), the initial sample processing is as follows. First, eliminate special treatment listed companies (ST and *ST). Second, delete the companies with missing variables. Third,

the missing data of variables are manually filled with the average value of the previous year and the next year. A total of 816 valid observations were obtained. The data sources are as follows. GI comes from the CNRDS database, and TMEA comes from Wingo's financial text data platform. AC, SR and control variables are from the CSMAR database.

## 2.2 Measurements

We measured GI based on the study of Jiang et al. (2022) with the number of green patents applied by enterprises in the current year. The number of green patent applications includes the number of green inventions and the number of green utility models. The larger the number, the stronger the GI. In order to make the GI index more in line with the normal distribution, this paper adds 1 to the number of green patent applications and takes the natural logarithm.

TMEA was measured by the total word frequency of keywords add 1 and take the natural logarithm in corporate social responsibility reports adopted from Short et al. (2010). According to the definition of environmental awareness (Peng & Liu, 2016) and the questionnaire items (Gadenne et al., 2009), five keywords were extracted: environmental protection, environmental problems, environmental protection measures, environmental responsibility, and environmental policy. Through the deep learning function of similar words on WinGo's financial text data platform, keywords were found, and then similar words with similarity less than 0.5 were removed to get the keywords list. The total word frequency of the keywords appearing in CSR reports from 2010–2023 was counted.

AC was measured by R&D intensity according to Cohen and Levinthal (1990) and Rothaermel and Alexandre (2009) because considering the scales of enterprises. The formula is: R&D investment/operating revenues.

Referring to Wu and Hu (2016), we used ((selling expense + administrative expense)/ operating revenues) as a measure of ASR. This indicator reflects the amount of specific resources invested by the enterprise in sales and management activities.

Latham and Braun (2008) used the current ratio to measure USR, but enterprises with high indicator may not have strong short-term

**Tab. 1: Variable descriptions**

| Variable type | Variable name | Abbreviation | Measurement |
|---|---|---|---|
| **Dependent variable** | Green innovation | *GI* | Add one to the number of green patents applied by the enterprise in that year, and take the natural logarithm. |
| **Independent variable** | Top management's environmental awareness | *TMEA* | Add one to the total word frequency of five keywords and take the natural logarithm. |
| **Moderating variables** | Absorptive capacity | *AC* | R&D investment/operating revenues |
| | Absorbed slack resources | *ASR* | (selling expense + administrative expense)/ operating revenues |
| | Unabsorbed slack resources | *USR* | Quick assets/current liabilities |
| **Control variables** | Firm age | *AGE* | The natural logarithm of the number of years since the firm's establishment |
| | Firm size | *SIZE* | The natural logarithm of the total assets of the firm at the end of the year |
| | Ownership type | *TYPE* | State-owned enterprises = 1<br>Non-state-owned enterprises = 0 |
| | Financial leverage | *LEV* | Asset-liability ratio |

Source: own

solvency. Therefore, we used the quick ratio as a measure of USR referring to Shimizu (2007). The formula is: quick assets/current liabilities. This indicator can more accurately reflect the ability of enterprises to repay short-term debts.

**Control variables**

Based on the related research, firm age, firm size, ownership type, and financial leverage were selected as control variables (Deng et al., 2021; Li et al., 2020; Nie et al., 2008; Xie, 2021; Xie & Zhu, 2021). We used the natural logarithm of the number of years since the firm was founded and the total assets at the end of the year to measure firm age and firm size, respectively. Ownership type was measured using a dummy variable (state-owned enterprises = 1, non-state-owned enterprises = 0). Financial leverage was measured by the asset-liability ratio. The descriptions of the variables are shown in Tab. 1.

### 2.3 Regression models

To explore the influence of TMEA on GI, the following regression equation was established.

$$GI_{it} = \alpha_0 + \alpha_1 TMEA_{it} + \alpha_2 X_{it} + \mu_{it} \quad (1)$$

where: $GI_{it}$ – GI of *i* industry in *t* year; $TMEA_{it}$ – TMEA of *i* industry in *t* year; $X_{it}$ – the control variables; $\mu_{it}$ – the random error.

To test the moderating effect, the following regression equation was further developed.

$$GI_{it} = \alpha_0 + \alpha_1 TMEA_{it} + \alpha_2 AC_{it} + \\ + \alpha_3 TMEA_{it} * AC_{it} + \alpha_4 X_{it} + \mu_{it} \quad (2)$$

where: $GI_{it}$ – GI of *i* industry in *t* year; $TMEA_{it}$ – TMEA of *i* industry in *t* year; $AC_{it}$ – AC of *i* industry in *t* year; $X_{it}$ – the control variables; $\mu_{it}$ – the random error.

$$GI_{it} = \alpha_0 + \beta_1 TMEA_{it} + \beta_2 USR_{it} + \\ + \beta_3 TMEA_{it} * USR_{it} + \beta_4 X_{it} + \mu_{it} \quad (3)$$

where: $GI_{it}$ – GI of *i* industry in *t* year; $TMEA_{it}$ – TMEA of *i* industry in *t* year; $USR_{it}$ – USR of *i* industry in *t* year; $X_{it}$ – the control variables; $\mu_{it}$ – the random error.

$$GI_{it} = \alpha_0 + \gamma_1 TMEA_{it} + \gamma_2 ASR_{it} + \\ + \gamma_3 TMEA_{it} * ASR_{it} + \gamma_4 X_{it} + \mu_{it} \quad (4)$$

where: $GI_{it}$ – GI of *i* industry in *t* year; $TMEA_{it}$ – TMEA of *i* industry in *t* year; $ASR_{it}$ – ASR of *i* industry in *t* year; $X_{it}$ – the control variables; $\mu_{it}$ – the random error.

Equations (2–4) will test whether *AC* and SR play a moderating role between *TMEA* and *GI*.

## 3. Results

### 3.1 Descriptive statistics and correlation analysis

As shown in Tab. 2, we find that there are large differences in *GI* and *TMEA* among enterprises. From the maximum and minimum values of *AC* and SR, it can be concluded that the abilities of enterprises to transform external superior resources and knowledge, as well as the resources they own, are very different. From the mean value of *AGE*, *SIZE*, *TYPE* and *LEV*, we conclude that the enterprises have a long duration. There is little difference in the assets owned by the enterprises. Non-state enterprises are in the majority. The overall operation of the enterprises is relatively stable.

The correlation coefficient of each variable is less than 0.7, which preliminarily indicates that there is no multicollinearity problem among the variables. In addition, the maximum variance inflation factor is less than 3, which further indicates that multicollinearity was not a serious problem.

### 3.2 Regression results

We used a hierarchical regression analysis to test our hypotheses (Tab. 3). In Model 1, the control variables were entered first. The results reveal that *SIZE*, *TYPE* and *AGE* have significant positive effects on *GI*, but the relationship between *LEV* and *GI* was not significant. Next, *TMEA* was entered as an independent variable (Model 2), resulting in a positive and significant effect of *TMEA* on *GI* ($\alpha_1 = 0.692$, $P < 0.001$). Thus, *H1* was supported.

Then, the moderating effect of *AC* on the relationship between *TMEA* and *GI* was tested using Model 3. The interaction term (*TMEA*AC*) was positive and significant ($\alpha_3 = 0.132$, $P < 0.01$), indicating support for *H2*. To verify the moderating role of SR, we added *USR* and *ASR* into Models 4 and 5, respectively. The results showed that *USR* positively moderated the positive effect of *TMEA* on *GI* ($\beta_3 = 0.137$, $P < 0.01$) and *ASR* negatively moderated the positive effect of *TMEA* on *GI* ($\gamma_3 = -1.260$, $P < 0.01$). Thus, *H3* and *H4* were supported.

**Tab. 2: Correlations and descriptive statistics**

| Variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1. *GI* | 1.000 | | | | | | | | |
| 2. *TMEA* | 0.053*** | 1.000 | | | | | | | |
| 3. *AC* | 0.050*** | 0.016* | 1.000 | | | | | | |
| 4. *USR* | 0.076** | −0.043 | 0.089** | 1.000 | | | | | |
| 5. *ASR* | 0.172*** | 0.023* | 0.575*** | 0.122*** | 1.000 | | | | |
| 6. *SIZE* | 0.083** | 0.054** | −0.020 | −0.387*** | −0.184*** | 1.000 | | | |
| 7. *LEV* | 0.085** | 0.052 | 0.104*** | −0.671*** | −0.272*** | 0.621*** | 1.000 | | |
| 8. *TYPE* | −0.060* | −0.093*** | 0.230*** | −0.074** | 0.080 | 0.218*** | 0.117*** | 1.000 | |
| 9. *AGE* | 0.031** | −0.127*** | 0.024 | −0.203*** | −0.033 | 0.284*** | 0.298*** | 0.124*** | 1.000 |
| Mean | 1.782 | 3.001 | 5.962 | 2.156 | 0.166 | 22.330 | 0.390 | 0.218 | 2.698 |
| SD | 0.834 | 0.288 | 4.305 | 2.241 | 0.089 | 1.070 | 0.170 | 0.413 | 0.408 |

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: own

**Tab. 3: Regression results**

| Variables | *GI* | | | | |
|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| *SIZE* | 0.132* | 0.156*** | 0.184* | 0.172** | 0.186** |
| *LEV* | 0.612 | 0.160 | 0.181 | 0.188 | 0.167 |
| *TYPE* | 1.028** | 1.391*** | 1.106*** | 1.795** | 1.125*** |
| *AGE* | 0.915** | 0.712** | 0.713* | 0.710** | 0.851** |
| *TMEA* | | 0.629*** | 0.438*** | 0.575*** | 0.875*** |
| *AC* | | | 0.621** | | |
| *TMEA*AC* | | | 0.132** | | |
| *USR* | | | | 0.736** | |
| *TMEA*USR* | | | | 0.137** | |
| *ASR* | | | | | 0.610*** |
| *TMEA*ASR* | | | | | −1.260** |
| $R^2$ | 0.150 | 0.176 | 0.179 | 0.177 | 0.186 |
| Adjusted $R^2$ | 0.065 | 0.056 | 0.049 | 0.053 | 0.052 |
| *F* | 18.860 | 18.210 | 13.880 | 14.810 | 14.960 |

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: own

To interpret the interaction results, we plotted the moderation effect at one standard deviation above and below the mean for the moderating variables (Figs. 2–4). Fig. 2 and Fig. 3 showed that the relationship between *TMEA* and *GI* was stronger when *AC* and *USR* were stronger, which were in good agreement with *H2* and *H3*. Fig. 4 indicated that, compared with low *ASR*, the effect of *TMEA* on *GI* was weakened at a high level of *ASR*, supporting *H4*.

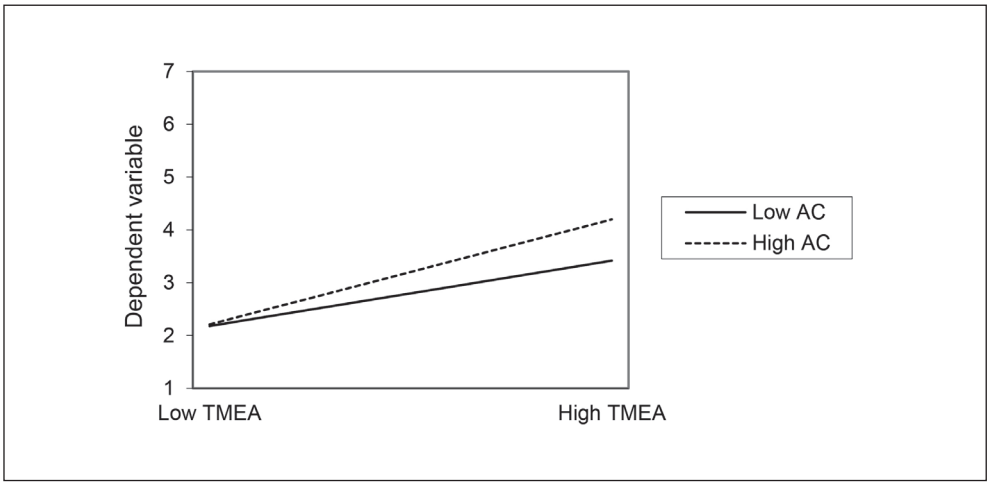


**Fig. 2:** **Moderating effect of AC between TMEA and GI**

Source: own

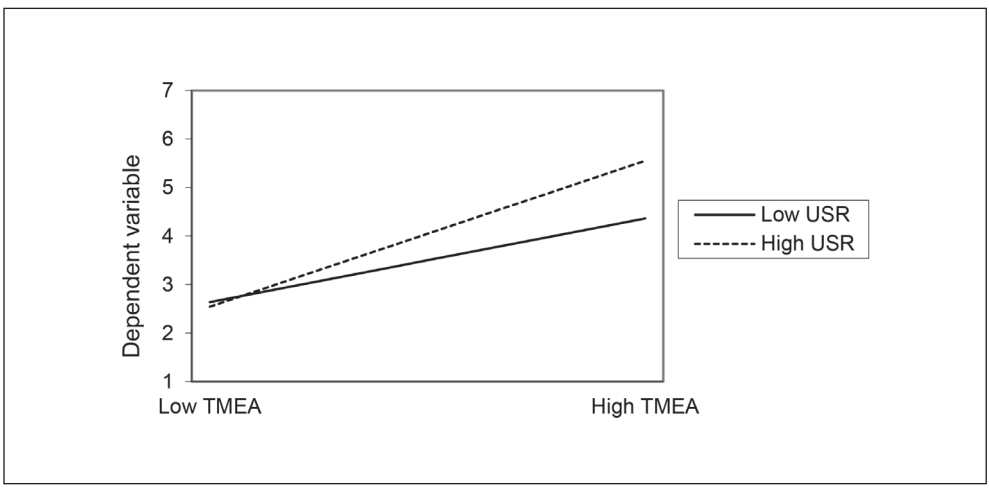


**Fig. 3:** **Moderating effect of USR between TMEA and GI**

Source: own

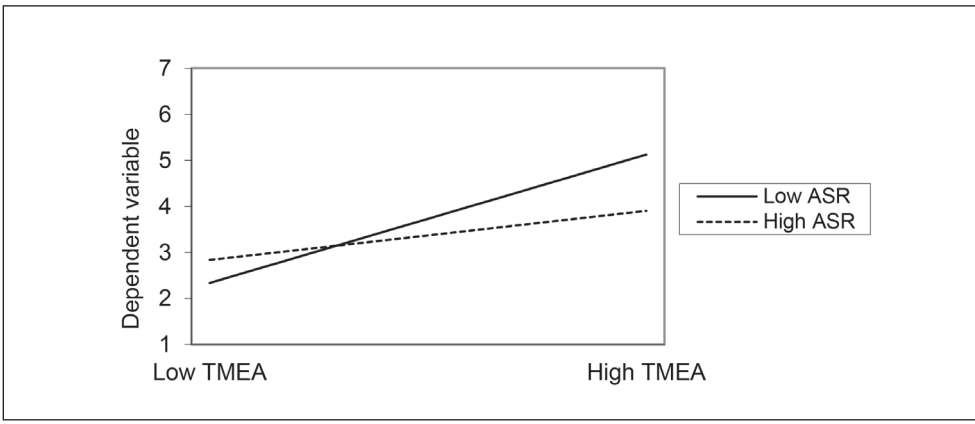


**Fig. 4:** **Moderating effect of ASR between TMEA and GI**

Source: own

### 3.3 Robustness test

We used two methods to test the robustness of the results. The first method is variable substitution. Referring to the previous studies, we used the ratio of the number of R&D personnel (Liu & Buck, 2007), the current ratio (Latham & Braun, 2008), and the ratio of administrative expenses to selling expenses (Yang et al., 2015) to measure *AC*, *USR* and *ASR*, respectively.

**Tab. 4:** **Variable substitution method**

| Variables | Model 6 | Model 7 | Model 8 |
|---|---|---|---|
| ***SIZE*** | 0.178** | 0.187** | 0.176** |
| ***LEV*** | 0.169 | 0.171 | 0.180 |
| ***TYPE*** | 1.089** | 1.061* | 1.078** |
| ***AGE*** | 0.758** | 0.872** | 0.836** |
| ***TMEA*** | 0.561*** | 0.585** | 0.682** |
| ***AC*** | 0.591** | | |
| ***TMEA*AC*** | 0.152** | | |
| ***USR*** | | 0.656** | |
| ***TMEA*USR*** | | 0.135** | |
| ***ASR*** | | | −0.627*** |
| ***TMEA*ASR*** | | | −0.258*** |
| $R^2$ | 0.187 | 0.196 | 0.206 |
| Adjusted $R^2$ | 0.046 | 0.054 | 0.059 |
| ***F*** | 13.520 | 14.720 | 15.010 |

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: own

**Tab. 5: Repeated random sampling**

| Variables | *GI* |
|---|---|
| *TMEA* | 0.629*** |
| | (6.160) |
| Company/code FE | Yes |
| Observations | 816 |

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: own

Tab. 4 shows that *AC* and *USR* have a positive moderating effect between *TMEA* and *GI*, while *ASR* has a negative moderating effect in this relationship, which is consistent with previous findings, indicating the robustness of the research results.

The second method is repeated random sampling. To alleviate sample selection bias, we used Bootstrap method to repeat random sampling 1,000 times. As shown in Tab. 5, the results are generally consistent with the previous regression results.

## Conclusions

This study explores the relationship between TMEA and GI using manufacturing companies in China. First, TMEA has a significant positive impact on GI. The extent to which an enterprise responds to external environmental pressure depends on the level of TMEA. The stronger the TMEA, the better they can identify the potential resources, benefits and opportunities in the external environment, reasonably allocate and apply the internal and external resources and opportunities, and promote enterprises to carry out GI activities. Second, AC enhances the positive effects of TMEA on GI. The stronger the AC, the more efficient the enterprise can obtain resources and information from the external environment, and absorb, transform and apply them to the R&D investment of the enterprise, thus responding to market changes and demands in time, helping the enterprise to create its own competitive advantage and realize GI. Third, TMEA has a greater impact on GI in firms with abundant USR compared to firms with few USR. USR can improve the ability of enterprises to resist risks, reduce the negative impact caused by environmental uncertainty, and provide security for enterprises. When senior managers realize the importance of GI, enterprises will invest enough resources and capabilities to carry out GI activities. Fourth, ASR weakens the positive effect of TMEA on GI. ASR has poor liquidity because it has been applied to various production and management activities of enterprises. When enterprise resources are in short supply, it is impossible to conduct flexible scheduling, which reduces the efficiency of GI.

First, this study integrates upper echelons theory, resource-based view and dynamic capability theory, and puts forward the theoretical model of the influence of TMEA on GI. It adds to our understanding of how TMEA influence GI. Most of the previous studies have discussed influencing factors of GI from the perspective of external institutional pressure (Xu et al., 2017). However, they have not paid enough attention to the role of TMEA in promoting GI. This paper analyzes the key factors affecting GI from the perspective of internal resources and capabilities of enterprises, and discusses the influence of executives' perception and interpretation of different policies on GI behavior. The stronger the environmental awareness of executives, the more inclined they can actively allocate organizational resources to meet the enterprises' environmental strategy and obtain sustainable green competitive advantages (El-Kassar & Singh, 2019). This study helps us to better understand the mechanism of promoting GI in enterprises, and also provides useful reference for enterprises to carry out GI more effectively.

Second, one contribution of this study is to verify the moderating effect of AC on the relationship between TMEA and GI. AC is the ability of enterprises to acquire, transform and utilize internal and external resources

and knowledge to improve GI (Duan et al., 2020). TMEA will make enterprises pay more attention to external environmental information, but how to transform external resources into GI ultimately depends on the enterprises' internal AC. Although previous studies believe that AC is a key factor for enterprises to integrate and transform knowledge effectively, there is still a lack of research on how AC affects the relationship between TMEA and GI. Given the importance of AC, we verified that AC positively moderates the relationship between TEMA and GI. This study provides a new insight into the research of how to increase GI by investigating the moderating role of AC.

Third, this study verifies the moderating effect of SR between TMEA and GI. Previous studies have found that SR can play a positive role in promoting GI as long as enterprises can effectively use these resources, whether it is USR or ASR (Xie et al., 2020). Redundant resources of enterprises can reduce the cost of GI, thus maintaining their sustainable development. However, there are few studies on how TMEA affects GI from the perspective of SR. This study fills this gap. It is found that USR has high flexibility and low switching cost, which can play a role at any time in dealing with unexpected events in the environment and contributing to GI. ASR will increase the cost of enterprises, which is not conducive to GI. TMEA can help to determine whether an enterprise can make full use of internal resources, and turn external institutional and market pressure into opportunities for GI. Therefore, when enterprises carry out GI, they should consider TMEA and internal resources comprehensively. The study enriches GI theories and helps us to understand the driving mechanism of GI in enterprises.

**Practical implications.** This study has three implications for enterprise management and practice. First, because top managers are the key driving forces to formulate enterprise strategy, the government and society should strongly advocate the belief of green development, increase executives' attention to meet the green expectations of society, and improve managers' level of environmental responsibility. Top managers should pay more attention to the benefits of stakeholders, formulating plans and implementing specific measures that meet environmental protection standards. In addition, top managers should put GI at a strategic level and integrate it into product production within enterprises.

Second, enterprises should pay more attention to AC. With the promotion of green development of enterprises, the ability of enterprises to transform knowledge into results has become an important source of green competitive advantages. Therefore, enterprises should strengthen the training of organizational members and improve their learning ability, knowledge acceptance and transformation ability.

Third, enterprises should make scientific and reasonable decisions, fully understand the risk resistance function and improve the utilization rate of USR, maintain the flexibility of resource allocation, and enhance the vitality of GI. In addition, enterprises should control ASR to some extent, thus reducing the management cost of enterprises and saving human and financial resources. We should not only pay attention to the strengthening of TMEA, but also pay attention to the integration of resources and the improvement of capabilities.

**Limitations and future directions.** There are some limitations in this study, which also provides a direction for future research. First, this paper investigates the influence of TMEA, AC and SR on GI of manufacturing enterprises, which supplements the application of GI research in manufacturing industry, but the research conclusions are not universal. Due to the particularity of GI, the specific situation of GI may be different in different industries. Therefore, whether the conclusions of this study are valid in other industries needs further discussion. Second, there are limitations in the research samples and measurement indicators. The selected samples only include listed manufacturing enterprises in China, and the sample size only meets the theoretical needs. The scope and sample size can be expanded in future research. Regarding the measurement indicator, TMEA measured by keywords may deviate from the actual environmental awareness of executives. Future research can be combined with questionnaires and secondary data measuring TMEA more accurately. Third, we only discuss the moderating roles of AC and SR in the relationship of TMEA and GI. In the future, we will explore other variables affecting this relationship, seeking to enrich the existing theories.

***Acknowledgments:*** *Supported by the National Social Science Foundation of China (No. 20BGL059).*

## References

Bowen, F., Cousins, P., Lamming, R. C., & Farukt, A. C. (2010). The role of supply management capabilities in green supply. *Production and Operations Management*, *10*(2), 174–189. https://doi.org/10.1111/j.1937-5956.2001.tb00077.x

Cao, C., Tong, X., Chen, Y., & Zhang, Y. (2021). How top management's environmental awareness affect corporate green competitive advantage: Evidence from China. *Kybernetes*, *51*(3), 1250–1279. https://doi.org/10.1108/k-01-2021-0065

Chen, X., Yi, N., Zhang, L., & Li, D. (2018). Does institutional pressure foster corporate green innovation? Evidence from China's top 100 companies. *Journal of Cleaner Production*, *188*(1), 304–311. https://doi.org/10.1016/j.jclepro.2018.03.257

Chen, Y.-S., Lai, S.-B., & Wen, C.-T. (2006). The influence of green innovation performance on corporate advantage in Taiwan. *Journal of Business Ethics*, *67*(4), 331–339. https://doi.org/10.1007/s10551-006-9025-5

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128–152. https://doi.org/10.2307/2393553

Deng, Y., Wang, L., & Zhou, W. (2021). Does environmental regulation promote green innovation capability? – Evidence from China. *Statistical Research*, *10*(7), 76–86 (in Chinese). https://doi.org/10.19343/j.cnki.11-1302/c.2021.07.006

Duan, Y., Wang, W., & Zhou, W. (2020). The multiple mediation effect of absorptive capacity on the organizational slack and innovation performance of high-tech manufacturing firms: Evidence from Chinese firms. *International Journal of Production Economics*, *229*(1), 107754–107765. https://doi.org/10.1016/j.ijpe.2020.107754

Eiadat, Y., Kelly, A., Roche, F., & Eyadat, H. (2008). Green and competitive? An empirical test of the mediating role of environmental innovation strategy. *Journal of World Business*, *43*(2), 131–145. https://doi.org/10.1016/j.jwb.2007.11.012

El-Kassar, A.-N., & Singh, S. K. (2019). Green innovation and organizational performance: The influence of big data and the moderating role of management commitment and HR practices. *Technological Forecasting and Social Change*, *144*(1), 483–498. https://doi.org/10.1016/j.techfore.2017.12.016

Gadenne, D. L., Kennedy, J., & McKeiver, C. (2009). An empirical study of environmental awareness and practices in SMEs. *Journal of Business Ethics*, *84*(1), 45–63. https://doi.org/10.1007/s10551-008-9672-9

Hambrick, D. C. (2007). Upper echelons theory: An update. *Academy of Management Review*, *32*(2), 334–343. https://doi.org/10.5465/amr.2007.24345254

Hao, Y., Fan, C., Long, Y., & Pan, J. (2019). The role of returnee executives in improving green innovation performance of Chinese manufacturing enterprises: Implications for sustainable development strategy. *Business Strategy and the Environment*, *28*(5), 804–818. https://doi.org/10.1002/bse.2282

Iyer, D. N., & Miller, K. D. (2008). Performance feedback, slack, and the timing of acquisitions. *Academy of Management Journal*, *51*(4), 808–822. https://doi.org/10.5465/amr.2008.33666024

Jiang, S., Liu, X., Liu, Z., Shi, H., & Xu, H. (2022). Does green finance promote enterprises' green technology innovation in China? *Frontiers in Environmental Science*, *10*(1), 1–18. https://doi.org/10.3389/fenvs.2022.981013

Kaplan, S. (2011). Research in cognition and strategy: Reflections on two decades of progress and a look to the future. *Journal of Management Studies*, *48*(3), 665–695. https://doi.org/10.1111/j.1467-6486.2010.00983.x

Latham, S., & Braun, M. (2008). The performance implications of financial slack during economic recession and recovery: Observations from the software industry (2001–2003). *Journal of Managerial Issues*, *20*(1), 30–50.

Li, H., & Lu, J. (2022). Temperature change and industrial green innovation: Cost increasing or responsibility forcing? *Journal of Environmental Management*, *325*(1), 116492–116501. https://doi.org/10.1016/j.jenvman.2022.116492

Li, J., Pan, Z., & Chen, J. (2018). The influence and outcome of expected performance feedback effect on the structure of organizational slack in manufacturing industry. *Management Review*, *30*(11), 198–208 (in Chinese).

https://doi.org/10.14120/j.cnki.cn11-5057/f.2018.11.019

Li, M., Su, J., & Hu, C. (2020). Research on the influence of enterprise network position and relationship intensity on technological innovation performance in IUR cooperation. *Science & Technology Progress and Policy*, *20*(14), 118–124 (in Chinese). https://doi.org/10.6049/kjjbydc.Q201908747

Liao, Z., & Cheng, H. (2014). The antecedents and outcomes of firm's environmental innovation – From the perspective of environmental policy and firm's background characteristics. *Studies in Science of Science*, *32*(05), 792–800 (in Chinese). https://doi.org/10.16192/j.cnki.1003-2053.2014.05.001

Liu, X., & Buck, T. (2007). Innovation performance and channels for international technology spillovers: Evidence from Chinese high-tech industries. *Research Policy*, *36*(3), 355–366.https://doi.org/10.1016/j.respol.2006.12.003

Long, D., & Chai, Z. (2021). Organizational redundancy, green technology innovation and corporate financial performance. *China Circulation Economy*, *30*, 36–39 (in Chinese). https://doi.org/10.16834/j.cnki.issn1009-5292.2021.30.021

Miroshnychenko, I., Strobl, A., Matzler, K., & De Massis, A. (2021). Absorptive capacity, strategic flexibility, and business model innovation: Empirical evidence from Italian SMEs. *Journal of Business Research*, *130*(1), 670–682. https://doi.org/10.1016/j.jbusres.2020.02.015

Nie, H., Tan, S., & Wang, Y. (2008). Innovation, firm size and market competition: A panel data analysis based on Chinese firm level. *The Journal of World Economy*, *10*(7), 57–66. https://doi.org/10.3969/j.issn.1002-9621.2008.07.005

Peng, X., & Liu, Y. (2016). Behind eco-innovation: Managerial environmental awareness and external resource acquisition. *Journal of Cleaner Production*, *139*, 347–360. https://doi.org/10.1016/j.jclepro.2016.08.051

Rothaermel, F. T., & Alexandre, M. T. (2009). Ambidexterity in technology sourcing: The moderating role of absorptive capacity. *Organization Science*, *20*(4), 759–780. https://doi.org/10.1287/orsc.1080.0404

Shimizu, K. (2007). Prospect theory, behavioral theory, and the threat-rigidity thesis: Combinative effects on organizational decisions to divest formerly acquired units. *Academy of Management Journal*, *50*(6), 1495–1514. https://doi.org/10.5465/amj.2007.28226158

Short, J. C., Broberg, J. C., Cogliser, C. C., & Brigham, K. H. (2010). Construct validation using computer-aided text analysis (CATA ) an illustration using entrepreneurial orientation. *Organizational Research Methods*, *13*(2), 320–347. https://doi.org/10.1177/1094428109335949

Tan, J., & Peng, M. W. (2003). Organizational slack and firm performance during economic transitions: Two studies from an emerging economy. *Strategic Management Journal*, *24*(13), 1249–1263. https://doi.org/10.1002/smj.351

Teece, D. J. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319–1350. https://doi.org/10.1002/smj.640

Wu, H., & Hu, S. (2020). The impact of synergy effect between government subsidies and slack resources on green technology innovation. *Journal of Cleaner Production*, *274*(1), 122682–122694.https://doi.org/10.1016/j.jclepro.2020.122682

Xiao, H., & Li, J. (2018). A dynamic test of the iron law of responsibility: Empirical evidence from a sample of Chinese listed companies' mergers and acquisitions. *Journal of Management World*, *34*(7), 114–135 (in Chinese). https://doi.org/10.19744/j.cnki.11-1235/f.2018.07.010

Xie, Q. (2021). Environmental regulation, green financial development and technological innovation of firms. *Scientific Research Management*, *10*(6), 65–72 (in Chinese). https://doi.org/10.19571/j.cnki.1000-2995.2021.06.009

Xie, W., & Wei, H. (2016). Market competition, organizational slack and corporate R&D investment: Evidence from China. *Chinese Soft Science*, *10*(08), 102–111 (in Chinese). https://doi.org/10.3969/j.issn.1002-9753.2016.08.009

Xie, X., Wang, R., & Huo, J. (2020). Green process innovation and corporate performance in the context of government's financial incentive: An empirical study based on content analysis. *Management Review*, *32*(5), 109–124 (in Chinese). https://doi.org/10.14120/j.cnki.cn11-5057/f.2020.05.010

Xie, X., & Zhu, Q. (2021). How can green innovation solve the dilemmas of harmonious coexistence? *Journal of Management World*, *10*(1), 128–149 (in Chinese). https://doi.org/10.19744/j.cnki.11-1235/f.2021.0009

Xing, L., & Yu, H. (2019). Influence of environmental regulation on green innovation

– The moderating role of green dynamic capability. *East China Economic Management*, *33*(10), 20–26 (in Chinese). https://doi.org/10.19629/j.cnki.34-1014/f.190529004

Xing, L., & Yu, H. (2020). Research on the impact of green dynamic ability on environmental innovation – The moderating effect of environmental regulation and top managers' environmental awareness. *Soft Science*, *34*(6), 26–32 (in Chinese). https://doi.org/10.13956/j.ss.1001-8409.2020.06.04

Xu, J., Guan, J., & Lin, Y. (2017). Institutional pressures, top managers' environmental awareness and environmental innovation practices: An institutional theory and upper echelons theory perspective. *Management Review*, *29*(9), 72–83 (in Chinese). https://doi.org/10.14120/j.cnki.cn11-5057/f.2017.09.007

Yang, J., Liu, Q., & Shi, J. (2015). The value of corporate green innovation strategy. *Science Research Management*, *36*(1), 18–25 (in Chinese). https://doi.org/10.19571/j.cnki.1000-2995.2015.01.003

Zahra, S. A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *The Academy of Management Review*, *27*(2), 185–203. https://doi.org/10.2307/4134351

Zailani, S., Govindan, K., Iranmanesh, M., Shaharudin, M. R., & Sia Chong, Y. (2015). Green innovation adoption in automotive supply chain: The Malaysian case. *Journal of Cleaner Production*, *108*(1), 1115–1122. https://doi.org/10.1016/j.jclepro.2015.06.039