Original Paper

Research on the Impact of Executives' Green Cognition on Corporate Green Transformation

Du Xue[1]

[1] Qilu Medical University, Zibo, 255300, China

Abstract

The green transformation of enterprises is an important way to achieve the dual goals of environmental protection and economic growth. This paper uses the panel data of A-share listed companies in Shenzhen and Shanghai from 2003 to 2023 to explore how executive green cognition (EGP) affects the green transformation of enterprises (Gre). The following conclusions are found: ① There is a positive relationship between executive green cognition (EGP) and the green transformation of enterprises (Gre), that is, the higher the executive green cognition (EGP), the higher the green transformation of enterprises (Gre), ② In the positive impact of executive green cognition (EDP) on the green transformation of enterprises (Gre), the regression coefficient of enterprises with a larger number of employees is greater than that of enterprises with a smaller number of employees ; the regression coefficient of enterprises that use the Big Four accounting firms for auditing is greater than that of enterprises that do not use them.

Keywords

green recognition of senior executives, green transformation of enterprises, employee size

1. Introduction

Enterprises have always assumed the main responsibility in social and economic development and can effectively connect natural, economic and social elements. Enterprise green behavior directly supports the implementation of the national macro green development strategy (Wang, Qin, & Wang, 2014). Enterprise green transformation is an important way to achieve the dual goals of environmental protection and economic growth (Christos, & Lin, 2017; Eugenie & Marion, 2021). Existing studies have conducted a lot of research on the influencing factors and economic consequences of corporate environmental behavior (Hu, Wang, & Yu, 2021), but most of them choose single dimensions such as green patents, environmental investment and environmental management system certification to

indirectly describe corporate green transformation behavior. Green transformation is a comprehensive summary of corporate green development model, including but not limited to gradually improving management green concepts, continuous additional environmental investment, continuously optimized green production processes and innovative green products (Xie & Han, 2022). The degree of corporate managers' awareness of environmental issues and their judgment of future environmental trends will affect the formulation and deployment of corporate green strategies. Therefore, based on the high-level echelon theory, some researchers believe that senior corporate managers have a more profound impact on organizational behavior choices, strategic decisions and corporate performance (Yuan & Li, 2023). Therefore, this study explores the impact of executive green cognition on corporate green transformation.

2. Study Design

2.1 Sample Data and Sources

This paper uses the panel data of A-share listed companies in Shenzhen and Shanghai from 2003 to 2023 to explore how executive green cognition (EGP) affects corporate green transformation (Gre). The basic data of enterprises comes from the Guotai An Database (CSMAR), and the sample data is processed as follows: samples in ST and *ST status are eliminated; enterprises in the financial industry are eliminated; missing values are eliminated; continuous variables are winsorized at the 1% and 99% levels.

2.2 Variable Definition

Explained variable: Enterprise green transformation (Gre). With reference to relevant studies, 113 keywords for enterprise green transformation were selected from five aspects: publicity and advocacy, strategic concepts, technological innovation, pollution control, and monitoring and management. Then, the frequency of each keyword in the annual report text of listed companies was counted to form the frequency of green transformation words. The natural logarithm of the frequency of the word plus 1 was used to characterize the green transformation of enterprises (Zhou, Wang, Tao et al., 2022).

Explanatory variables: Executive green cognition (EGP). With reference to existing studies, the following keywords were selected based on three dimensions: green competitive advantage awareness, corporate social responsibility awareness, and external environmental pressure awareness: energy conservation and emission reduction, environmental protection strategy, environmental protection concept, environmental management agency, environmental education, environmental technology development, environmental audit, energy conservation and environmental protection, environmental protection policy, environmental protection department, environmental protection inspection, low-carbon environmental protection, environmental protection work, environmental protection governance, environmental protection and environmental governance, environmental protection facilities, environmental protection-related laws and regulations, and environmental protection pollution control. The frequency of each keyword in the annual report text of listed companies was

counted to form the frequency of executive green cognition words, and the natural logarithm of the word frequency plus 1 was used to characterize executive green cognition (EGP) (Yuan & Li, 2023; Li, Xia , & Zhao, 2023)

Control variables. Based on the research in existing literature, variables such as enterprise size (Size), debt-to-asset ratio (Lev), net profit on assets (ROA), cash flow ratio (Cashflow), growth ability (Growth), equity balance (TOP10), board size (Board), and enterprise age (FirmAge) are selected as control variables.

Table 1. Variable Definition Table

Variable Types	Variable Name	Variable Symbols	Variable Definition
Explained variable	Green transformation of enterprises	Gre	The natural logarithm of the word frequency plus 1
Explanatory variables	Executives' green awareness	EGP	The natural logarithm of the word frequency plus 1
	Enterprise scale	Size	Logarithm of total assets
	Debt-to-asset ratio	Lev	Debt-to-asset ratio
	Net profit from assets	ROA	Net profit margin of total assets
	Cash flow ratio	Cashflow	Cash flow ratio
	Growth Capacity	Growth	Operating income growth rate
Control variables	Equity Balance	TOP10	Number of shares held by the top ten shareholders/total number of shares
	Board size	Board	Percentage of independent directors
	Company age	FirmAge	Years of Establishment

2.3 Model Construction

This paper uses the panel data of A-share listed companies in Shenzhen and Shanghai from 2003 to 2023 in China to explore how executives' green cognition (EGP) affects corporate green transformation (Gre). According to the results of the Hausman test, this paper selects a fixed effect model, and the specific model settings are as follows:

$$Gre_{it} = \alpha_0 + \alpha_1 EGP_{it} + \delta X_{it} + \lambda_j + \mu_t + \varepsilon_{it} \tag{1}$$

In the above model, i and t in the following table represent the enterprise and year respectively; X is the control variable; λ_j is the industry fixed effect, j is the industry to which enterprise i belongs; μ_t is the year fixed effect; ε_{it} is the random disturbance term, and robust standard errors are used to solve the heteroskedasticity problem.

3. Empirical Analysis

3.1 Descriptive Analysis

Table 2 Descriptive analysis shows the results of descriptive analysis of the explanatory variable executive green cognition (EGP), the explained variable enterprise green transformation (Gre), and the control variables. The explanatory variable executive green cognition (EGP) has a mean of 0.911, a standard deviation of 0.900, a minimum of 0, and a maximum of 5.994. Overall, the distribution of executive green cognition shows great differences. Most executives have a low level of green cognition (mean 0.911), but some executives have a very high level of cognition (maximum 5.994). The large standard deviation (0.900) means that the difference in cognition level is significant. Some executives have almost no green cognition (minimum 0), while some executives have a high level of green cognition. The overall distribution may be "right-skewed" (biased towards low values) because most of the data are concentrated near the mean.

The explained variable, enterprise green transformation (Gre), has a mean of 1.750, a standard deviation of 0.952, a minimum of 0, and a maximum of 6.001. Overall, the distribution of enterprise green transformation is quite different. Although the mean is 1.750, the standard deviation is 0.952, indicating that the level of green transformation among enterprises is significantly different; the overall level of green transformation of enterprises is low (mean is 1.750), and most enterprises may be in the initial or primary stage of green transformation; at the same time, there are also some enterprises with very high green transformation (maximum value is 6.001), and these enterprises may have achieved relatively mature results in green transformation. The descriptive situation of the control variables is shown in Table 2 Descriptive Analysis.

Table 2. Descriptive Analysis

Variable	Obs	Mean	Std.	Min	Max
Gre	50,125	1.750	0.952	0	6.001

EGP	50,125	0.911	0.900	0	5.994
Size	50,125	22.05	1.310	15.58	28.70
Growth	50,125	3.312	605.0	-1.445	134607
Lev	50,125	0.424	0.214	0.00708	9.699
ROA	50,125	0.0401	0.0765	-1.859	1.285
Cashflow	50,125	0.0473	0.0769	-0.744	0.876
Board	50,125	2.130	0.209	0	2.944
Top 10	50,125	0.587	0.154	0.0131	1.012
FirmAge	50,125	2.838	0.409	0	4.190

3.2 Correlation Analysis

Table 3 shows the correlation analysis results of the explanatory variable executive green cognition (EGP), the explained variable enterprise green transformation (Gre) and the control variable, which includes the correlation coefficients between the variables and their significance. The correlation analysis in Table 3 shows that the correlation coefficient between the explanatory variable executive green cognition (EGP) and the explained variable enterprise green transformation (Gre) is 0.650, and is significant at the 1% level, indicating that the relationship between executive green cognition (EGP) and enterprise green transformation (Gre) is positively correlated, preliminarily proving that enterprises with higher executive green cognition (EGP) also have higher enterprise green transformation (Gre) ; there may also be certain correlations between other variables, proving the rationality of the selection of control variables.

In order to further ensure the reliability of the data, the multicollinearity test was conducted on the explanatory variables of executive green cognition (EGP), enterprise green transformation (Gre) and control variables. The test results showed that the VIF value of Size was 1.50, the VIF value of Lev was 1.54, the VIF value of ROA was 1.45, the VIF value of Cashflow was 1.17, the VIF value of Growth was 1.00, the VIF value of Board was 1.00, the VIF value of Top10 was 1.13, the VIF value of FirmAge was 1.10, the VIF value of EGP was 1.11 and the average VIF value was 1.24, all of which were less than 5. The VIF values of all variables were less than 5, and most of the VIF values were close to 1, indicating that there was no significant multicollinearity problem between the independent variables in the model, further ensuring the reliability of the data.

Table 3. Correlation Analysis

	Gre	EGP	Size	Growth	Lev	ROA	Cashflow
Gre	1						
EGP	0.650***	1					
Size	0.299***	0.252***	1				

Growth	-0.00600	-0.00500	-0.00100	1			
Lev	0.019***	0.050***	0.416***	0.00500	1		
ROA	0.011**	0.015***	0.014***	0	-0.395***	1	
Cashflow	0.026***	0.051***	0.072***	-0.00100	-0.140***	0.376***	1
Board	-0.065***	0.012***	0.205***	0.00200	0.150***	0.009*	0.041***
Top 10	0.023***	0.017***	0.074***	0.00300	-0.142***	0.247***	0.109***
FirmAge	0.329***	0.221***	0.250***	0.00300	0.102***	-0.093***	0.00500

	Board	Top 10	FirmAge
Board	1		
Top 10	0.011**	1	
FirmAge	-0.078***	-0.218***	1

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

3.3 Main Effect Analysis

Before analyzing the main effect, it is necessary to test the sample data, which helps to select the appropriate model for analysis and ensure the reliability of the sample data results. This study uses the Hausman test to test the sample data. The result of the Hausman test is chi2(8)=675.12; Prob>chi2=0.0000, so the fixed effect model is selected.

In the main effect analysis of Table 4, column (1) is the result without adding control variables and fixed effects; column (2) is the result without adding control variables and fixed effects; column (3) is the result without adding control variables and fixed effects; column (4) is the result with adding control variables and fixed effects. The regression coefficients are all positive and significant at the 1% level, proving that there is a positive relationship between the explanatory variable executive green cognition (EGP) and the explained variable enterprise green transformation (Gre), that is, the higher the executive green cognition (EGP), the higher the enterprise green transformation (Gre), which verifies how executive green cognition (EGP) affects enterprise green transformation (Gre).

Table 4. Main Effect Analysis

	(1)	(2)	(3)	(4)
	Gre	Gre	Gre	Gre
EGP	0.6877 ***	0.6110 ***	0.4849 ***	0.4663 ***
	(191.4230)	(171.0722)	(124.7736)	(118.5083)
Size		0.1198 ***		0.0758 ***
		(41.9386)		(27.4172)
Growth		-0.0000		-0.0000 ***

		(-0.8160)		(-4.6303)
Lev		-0.4011 ***		-0.0126
		(-22.6355)		(-0.7724)
ROA		-0.2495 ***		0.0527
		(-5.1909)		(1.2286)
Cashflow		-0.2650 ***		-0.1098 ***
		(-6.1490)		(-2.8051)
Board		-0.3576 ***		-0.0151
		(-23.5763)		(-1.0961)
Top 10		0.2027 ***		0.0358 *
		(9.5525)		(1.8544)
FirmAge		0.3924 ***		-0.0850 ***
		(47.9422)		(-9.6516)
_cons	1.1233 ***	-1.7274 ***	1.3080 ***	-0.0851
	(244.1913)	(-27.6969)	(281.1596)	(-1.3386)
N	50125	50125	50125	50125
adj. R^2	0.422	0.483	0.603	0.612

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

3.4 Robustness Analysis

In order to ensure the reliability of the sample data, it is necessary to conduct a robustness test on the sample data. According to the existing methods, this study selected the methods of adding fixed effects, adding control variables, lagged one period, and removing special samples for robustness testing. In order to solve the omitted variable bias, control the interference of all time-invariant and unobservable individual characteristics on the relationship between the explanatory variables executive green cognition (EGP) and corporate green transformation (Gre); provide a cleaner identification, use the changes within individuals over time to estimate the effect, and reduce the influence of confounding factors. Therefore, the method of adding individual fixed effects is used for robustness testing. Table 5 The first column (1) of the robustness analysis is the analysis result of the method of adding individual fixed effects. Its regression coefficient is 0.4388 and is significant at the 1% level. It is the same as the result before adding individual fixed effects. Both are normal and significant, which preliminarily illustrates the robustness of the sample data.

Affected by the control variables, the analysis results may change due to the variables not added. The hollowing out of company resources by major shareholders (such as occupying funds) will weaken the financial capacity of the enterprise and directly restrict green investment (such as technology upgrades and environmental protection equipment purchases); the shareholding of management binds the interests of senior executives to the long-term value of the enterprise, which may motivate them to

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promote green transformation (because green investment has long-term benefits) ; high management expense ratio may reflect that management squanders resources, squeezes out green investment budgets, and organizational redundancy reduces transformation execution. Therefore, the method of adding control variables is used for testing. This study adds three variables: major shareholder capital occupation (Occupy), management shareholding ratio (Mshare), and management expense ratio (Mfee). The first column (2) of Table 5 Robustness Analysis is the analysis result of the method of adding control variables. Its regression coefficient is 0.4674 and is significant at the 1% level, which is the same as the result before adding control variables. Both are normal and significant, further verifying the robustness of the sample data.

By cutting off the reverse causal chain through time sequence and eliminating the interference of the same period, more credible evidence is provided for the causal relationship of "executives' green cognition drives corporate green transformation". Therefore, a one-period lag method is used for robustness test. The first column (3) of Table 5 Robustness Analysis is the analysis result of the one-period lag method. Its regression coefficient is 0.3646 and is significant at the 1% level, which is the same as the result before the one-period lag. Both are normal and significant, which once again verifies the robustness of the sample data.

The existence of special samples may affect the general results and cause a certain degree of deviation. Therefore, the method of removing special samples is used for robustness test. However, the four municipalities directly under the Central Government of China, namely Beijing, Tianjin, Shanghai, and Chongqing, have administrative privileges, policy biases, and regional extreme values that interfere with the estimation, affecting the universality of the impact of executives' green cognition (EDP) on corporate green transformation (Gre) in general areas. Therefore, the sample data of the four municipalities directly under the Central Government are removed. The first column (3) of the robustness analysis in Table 5 is the analysis result of the method of removing special values. Its regression coefficient is 0.4627 and is significant at the 1% level, which is the same as the result before removal. Both are normal and significant, verifying the robustness of the sample data.

Table 5. Robustness Analysis

	(1)	(2)	(3)	(4)
	Gre	Gre	Gre	Gre
EGP	0.4388 ***	0.4674 ***		0.4627 ***
	(91.3428)	(119.0828)		(105.9191)
Size	0.0910 ***	0.0816 ***	0.0878 ***	0.0741 ***
	(16.9142)	(28.5094)	(27.5416)	(23.0757)
Growth	-0.0000	-0.0000 ***	0.0004	-0.0000 ***
	(-0.0679)	(-4.4389)	(1.4434)	(-12.2425)

Lev	0.0284	-0.0032	0.0059	-0.0001
	(1.3817)	(-0.1851)	(0.3159)	(-0.0078)
ROA	0.0994 **	0.0200	0.0874 *	0.0683
	(2.3452)	(0.4649)	(1.7769)	(1.4235)
Cashflow	-0.0004	-0.0978 **	-0.0868 *	-0.1428 ***
	(-0.0117)	(-2.5011)	(-1.9062)	(-3.2424)
Board	-0.0170	-0.0052	-0.0108	-0.0206
	(-0.8536)	(-0.3808)	(-0.6700)	(-1.3202)
Top 10	0.1544 ***	-0.0048	0.0558 **	0.0341
	(4.9743)	(-0.2446)	(2.5216)	(1.5754)
FirmAge	0.0720 **	-0.0736 ***	-0.0985 ***	-0.0706 ***
	(2.5146)	(-8.2929)	(-9.1068)	(-7.1944)
Occupy		0.0149		
		(0.5457)		
Mshare		0.0015 ***		
		(9.6300)		
Mfee		0.0002 ***		
		(5.8886)		
L.EGP			0.3646 ***	
			(82.6725)	
_cons	-0.9330 ***	-0.2684 ***	-0.2026 ***	-0.0680
	(-6.7183)	(-4.0309)	(-2.7344)	(-0.9312)
N	49814	50125	43259	40345
adj. R^2	0.750	0.612	0.546	0.610

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

3.5 Heterogeneity Analysis

In order to explore the results of different enterprises and provide some guidance for enterprises to make more reasonable decisions according to their own conditions, heterogeneity analysis is conducted. Table 6 shows the results of different enterprises divided by employee size and whether they are audited by the Big Four accounting firms. Table 6 Heterogeneity Analysis (1) is the sample data result of larger employee size, with a regression coefficient of 0.4803, which is significant at the 1% level; Table 6 Heterogeneity Analysis (2) is the sample data result of smaller employee size, with a regression coefficient of 0.4471, which is significant at the 1% level; Table 6 Heterogeneity Analysis (3) is the sample data result of audited by the Big Four accounting firms, with a regression coefficient of 0.5192, which is significant at the 1% level; Table 6 Heterogeneity Analysis (4) is the sample data result of not

audited by the Big Four accounting firms, with a regression coefficient of 0.4564, which is significant at the 1% level.

Through comparison, it is found that in the positive impact of executives' green cognition (EDP) on corporate green transformation (Gre), the regression coefficient of enterprises with larger employee scale is greater than that of enterprises with smaller scale. The reasons may be: enterprises with larger employee scale usually have more abundant cash flow and human resource reserves, which can provide sufficient trial and error costs for green transformation (such as clean technology research and development, equipment renewal); green technology (such as photovoltaic equipment, carbon capture) has significant economies of scale, and large enterprises have lower unit transformation costs due to their large output; large-scale employee groups contain cross-domain knowledge diversity (such as engineers + legal affairs + marketing personnel collision), and executives' green cognition (EDP) can stimulate internal innovation (such as green product design), while small enterprises have a single knowledge base and a low innovation conversion rate.

Through comparison, it is found that in the positive impact of executives' green cognition (EDP) on corporate green transformation (Gre), the regression coefficient of enterprises that adopt the Big Four accounting firms for auditing is greater than that of enterprises that do not. The reasons may be that: the Big Four audits symbolize high reliability of financial information, and their audit reports can enhance the credibility of executives' green cognition (EDP) -related decisions (such as green investment plans); the strict audit procedures of the Big Four can restrain management opportunism (such as cutting environmental protection investment to beautify short-term profits).

Table 6. Heterogeneity Analysis

	(1)	(2)	(3)	(4)
	Gre	Gre	Gre	Gre
EGP	0.4803 ***	0.4471 ***	0.5192 ***	0.4654 ***
	(89.6782)	(76.9865)	(31.1389)	(111.2169)
Size	0.0906 ***	0.0861 ***	0.0946 ***	0.0702 ***
	(22.1238)	(16.0328)	(9.3743)	(22.2378)
Growth	-0.0000 ***	0.0006 ***	0.0006 ***	-0.0000 ***
	(-4.0754)	(4.0727)	(3.7875)	(-4.5077)
Lev	-0.0328	0.0320	0.0839	-0.0062
	(-1.2382)	(1.5428)	(0.9333)	(-0.3580)
ROA	0.0155	0.0911 *	0.3518	0.0974 **
	(0.2245)	(1.6501)	(1.4802)	(2.1486)
Cashflow	0.0455	-0.1673 ***	-0.3292 *	-0.1187 ***
	(0.7188)	(-3.3340)	(-1.6638)	(-2.8702)

Board	-0.0361 *	0.0246	-0.0858 *	-0.0147
	(-1.8729)	(1.2447)	(-1.6607)	(-0.9936)
Top 10	0.0150	0.0648 **	0.3267 ***	0.0319
	(0.5619)	(2.2529)	(3.5961)	(1.5318)
FirmAge	-0.0838 ***	-0.0943 ***	-0.0921 ***	-0.0797 ***
	(-6.4315)	(-7.7756)	(-2.7033)	(-8.4812)
_cons	-0.4084 ***	-0.3515 ***	-0.7115 ***	-0.0141
	(-4.2427)	(-2.8502)	(-2.8319)	(-0.1952)
N	25087	25036	2769	44373
adj. R^2	0.630	0.595	0.676	0.603

t statistics in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01.

4. Conclusions and suggestions

By selecting sample data of A-share listed companies in Shenzhen and Shanghai from 2003 to 2023, this paper studies the impact of executive green cognition (EDP) on corporate green transformation (Gre). The following conclusions are found through the analysis of sample data: ① There is a positive relationship between executive green cognition (EGP) and corporate green transformation (Gre), that is, the higher the executive green cognition (EGP), the higher the corporate green transformation (Gre), which verifies how executive green cognition (EGP) affects corporate green transformation (Gre). And a series of robustness tests such as adding individual fixed effects method, adding control variables method, lagged one period method and eliminating special values have been passed. ② In the positive impact of executive green cognition (EDP) on corporate green transformation (Gre), the regression coefficient of companies with larger employee scale is greater than that of companies with smaller employee scale; the regression coefficient of companies that use the Big Four accounting firms for audits is greater than that of companies that do not use them. Based on the above conclusions, the following suggestions are put forward:

⑴ Deepen the environmental awareness of senior executives and embed it into the strategic action decision-making mechanism

Incorporate executives' environmental awareness into the strategic investment evaluation process, and require the addition of an "environmental benefit-cost analysis" to all new project feasibility reports ; transform capacity building, carry out environmental technology and economic training, and jointly offer practical courses with universities to improve the accuracy of executives' green decision-making ; implement a benchmark factory secondment program, and arrange executives to conduct practical learning in industry environmental benchmark companies.

⑵ Customize the transformation path according to the size of the company's employees

For large enterprises, we will establish a professional environmental protection technical team and

assign full-time environmental protection engineers to transform the environmental protection strategies of senior executives into technical solutions ; we will activate the scale leverage effect and use the purchase volume advantage to implement the "Green Supply Chain Plan". For small and medium-sized enterprises, we will develop lightweight transformation tool kits, promote modular environmental protection equipment and shared testing platforms ; we will build a transformation mutual assistance alliance, and small and medium-sized enterprises in the same industry will jointly purchase environmental protection services.

⑶ Strengthen the role of audit in safeguarding environmental protection transformation

Expand the boundaries of audit functions. Add an environmental compliance audit module, and include verification of the authenticity of environmental investment in the annual report audit. Develop transformation progress certification services, with the audit agency issuing a "Green Transformation Progress Verification Certificate" every quarter as a basis for banks to renew green credit. Reduce costs for non-Big Four companies, establish a regional audit collaboration pool, and promote simplified environmental audit standards.

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About the author

Du Xue, born in December 1998, is a Han Chinese master and a teaching assistant at Qilu Medical
College.