How to Drive New Energy Vehicle Firms' ESG Performance through Organizational Resilience? The Role of AI & Innovation Network Embeddedness

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Abstract. Under the context of global uncertainty and energy transitions, enhancing ESG performance has become a strategic imperative for new energy vehicle (NEV) enterprises to gain long-term competitive advantage. However, how organizational resilience (OR) enhance ESG performance and what its boundary conditions are remain underexplored. Therefore, using Chinese listed NEV enterprises from 2016 to 2023 as examples, this study explores the impact of organizational resilience on ESG performance. The empirical results show that: (1) Organizational resilience exerts a significant positive impact on NEV firms' ESG performance. (2) AI negatively moderates the relationship between organizational resilience and ESG performance while innovation network embeddedness positively moderates this relationship. (3) The positive effect of organizational resilience on ESG performance is more pronounced in non-state-owned NEV enterprises and under conditions of high environmental uncertainty. These findings guide NEV enterprises to enhance ESG performance through targeted resilience-building, rational AI deployment, and optimized innovation network embeddedness.

Keywords: Organizational Resilience, ESG Performance, Artificial Intelligence, Innovation Network Embeddedness, New Energy Vehicle Enterprises

1 Introduction

Against the backdrop of climate change and deepening energy transitions, new energy vehicle (NEV) enterprises have emerged as pivotal forces in driving low-carbon development and achieving environmental sustainability goals. Within this context, enhancing ESG (Environmental, Social, and Governance) performance has become crucial for sustainable development of NEV firms[1]. Stakeholders including investors and consumers are placing growing emphasis on ESG performance[2]. NEV firms with superior ESG performance can have access to low-cost financing and cultivate consumer trust.

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Nevertheless, under the multiple risks and impacts, NEV firms face various challenges and obstacles in improving their ESG performance. In this setting, organizational resilience (OR) that is defined as a dynamic trait that facilitates firms' stable development in turbulent business environments[3] emerges as a vital capability for safeguarding ESG outcomes. It comprises enterprises' absorptive, adaptive, and restorative capabilities when confronting external shocks[4]. However, whether OR can enhance ESG performance in NEV enterprises remains unexplored.

Improving ESG performance relies on not only internal technological empowerment but also external resource integration. On the one hand, artificial intelligence (AI) plays an indispensable role. AI technologies, leveraging capabilities in data integration, precision analytics, and dynamic early warning, can enhance enterprises' capacity to deal with ESG risks, thereby strengthening core functions of OR and subsequently improving ESG performance. However, AI's attributes and application scenarios may also undermine resilience-driven ESG gains. Over-reliance on AI may diminish enterprises' autonomous perception and decision-making capabilities in complex environments, undermining proactive adaptation and sustained ESG advancement. Besides, amid corporate resource scarcity, heavy AI investments may crowd out key resources, exerting a notable resource crowding-out effect on ESG practices.

On the other hand, innovation network embeddedness determines NEV firms' access to external ESG-related resources. Enterprises occupying central network positions can not only prioritize acquisition of ESG innovation resources but also rapidly adopt industry best practices in social responsibility and align with prevailing ESG standards. Such external support amplifies the effect of OR on ESG performance. Nevertheless, existing studies examining the resilience-ESG relationship in NEV contexts predominantly focus on internal capabilities, largely overlooking the role of innovation network embeddedness as a critical external variable.

Although scholarly attention to OR and ESG performance is growing, three key research gaps still remain. Firstly, ESG research lacks a resilience perspective addressing multiple uncertain risks. Current studies emphasize direct pathways such as policy drivers[5][6], internal characteristics like executive attributes[7][8] and technological innovation[9], failing to systematically incorporate organizational resilience as a foundational role in enhancing ESG performance under complex conditions. Second, boundary conditions influencing the resilience-ESG relationship remain underexplored. Specifically, the AI's dual effects and the differential impacts of innovation network embeddedness have not been integrated into analytical frameworks. Furthermore, in the heterogeneity analysis of the impact of OR on ESG performance, existing research has failed to simultaneously account for the heterogeneous impacts arising from ownership types and external environments (e.g., environmental uncertainty).

Considering these gaps, this study focuses on 2016-2023 NEV listed enterprises to explore how to improve corporate ESG performance through OR. The core research questions are: RQ1: Whether organizational resilience can enhance ESG performance? RQ2: What are the roles of AI and innovation network embeddedness? RQ3: Does the impact of organizational resilience on ESG performance vary across ownership types and levels of environmental uncertainty?

This research offers three key contributions. First, it enriches ESG driver studies by innovatively introducing organizational resilience as an antecedent variable. Second, it reveals critical boundary conditions by exploring the roles of AI and innovation network embeddedness. Moreover, it offers valuable ways to improve ESG performance, thereby increasing enterprises' abilities of sustainable development.

The remainder of this paper is structured as follows: Chapter 2 reviews theories and hypotheses development; Chapter 3 outlines the research design; Chapter 4 presents and discusses panel regression results; Chapter 5 shows the conclusion.

2 Theories and Hypotheses Development

Based on the dynamic capability theory[10], OR is a core dynamic capability for enterprises to respond to environmental uncertainty, manifested in resource reconfiguration and strategic adaptation. In the NEV industry with rapid technological iteration and policy fluctuations, enterprises with high OR can quickly integrate internal and external resources to optimize environmental governance, social responsibility fulfillment, and governance structure, thereby improving ESG performance. Therefore, this study puts forward Hypothesis 1:

H1. Organizational resilience has a positive effect on ESG performance.

The Dynamic Capability Theory emphasizes enterprises' initiative in independent resource reconfiguration and environmental adaptation. Excessive AI investment may cause the resource crowding-out effect, weakening the redundant resource reserve required for dynamic capabilities, and inducing "resilience inertia" to reduce the flexibility of independent decision-making, hindering the transformation of OR into ESG performance via dynamic capabilities. Therefore, this study puts forward Hypothesis 2:

H2. AI negatively moderates the relationship between organizational resilience and ESG performance.

The exertion of dynamic capabilities depends on the efficiency of external resource integration. innovation network embeddedness provides NEV enterprises with ESG-related resources such as technology, standards, and practices. Enterprises with innovation network embeddedness can leverage network embeddedness advantages to enhance the external resource acquisition and transformation efficiency of dynamic capabilities, amplifying OR's driving effect on ESG performance. Therefore, this study puts forward Hypothesis 3:

H3. Innovation network embeddedness positively moderates the relationship between organizational resilience and ESG performance.

The conceptual framework is shown in Figure 1.

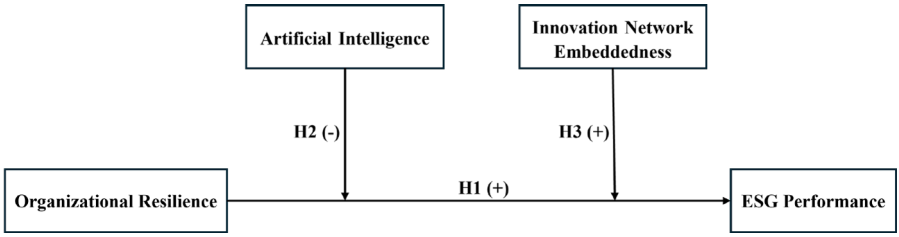

Fig. 1. Conceptual Framework

3 Research Design

3.1 Samples and Data Source

This study selects listed new energy vehicle (NEV) enterprises as samples, with the list of NEV enterprises sourced from the official website of China's iAskCai. Furthermore, based on the patent status of these listed NEV enterprises, 443 enterprises during 2016-2023 were finally selected. ESG performance data are from Wind financial terminals. Patent citation data are collected from the IncoPat database. Other data are from China Stock Market & Accounting Research (CSMAR) database. All continuous variables were winsorized at the 1 % and 99 % levels.

3.2 Measurement of Main Variables

ESG performance (ESG). It refers to a firm's practical performance in environmental, social, and governance aspects, reflecting its sustainable development capabilities. Consistent with prior research[11], this study converts these categorical ratings into numerical values, with the lowest grade "C" assigned a value of 1 and the highest grade "AAA" assigned a value of 9.

Organizational Resilience (OR). It refers to the ability of an organization to quickly adapt, recover, maintain normal operations, and even achieve development in the face of various disturbances and impacts. This study employs cumulative operating income growth over three years to measure performance growth; it uses the standard deviation of monthly stock returns within one year to assess volatility. Subsequently, the entropy weight method is applied to these two dimensions to calculate organizational resilience.

Artificial intelligence (AI). It refers to the level of artificial intelligence application in enterprises. This study measures artificial intelligence (AI) variable by firms' AI investment level, with the data sourced from the CSMAR Database.

Innovation network embeddedness (DU). It reflects the firm's resource acquisition capability, measured by network centrality. Innovation networks are built with co-applicants of invention patents as nodes and their joint-patent ties as edges.

Control variables. The regression model included the following control variables: supervisory board size (SUPER_B_SIZE), proportion of independent directors (INDE_DIRECTOR), big 4 audit (BIG4), firm size (LNSIZE), firm age (AGE), two positions in one (DUAL), major shareholder's shareholding ratio (LARGETH).

3.3 Empirical Model

3.3.1 Direct Effect Model.

To test the impact of organizational resilience on ESG performance, the fixed effect regression model is established, as shown in the following Formula (1):

$$ESG_{i,t} = C_0 + \beta_1 OR_{i,t} + \eta_1 Z + \mu_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

where the coefficient β_1 can be used to determine the impact of organizational Resilience on ESG performance.

3.3.2 Moderating Effect Model.

To examine the moderating mechanism, the following regression models was constructed:

$$ESG_{i,t} = \beta_0 + \beta_2 OR_{i,t} + \beta_3 AI_{i,t} + \beta_4 OR_{i,t} * AI_{i,t} + \eta_2 Z + \mu_i + \delta_t + \varepsilon_{i,t} \quad (2)$$

$$ESG_{i,t} = \alpha_0 + \alpha_1 OR_{i,t} + \alpha_2 \mathrm{DU}_{i,t} + \alpha_3 OR_{i,t} * \mathrm{DU}_{i,t} + \eta_2 Z + \mu_i + \delta_t + \varepsilon_{i,t} \quad (3)$$

4 Panel Regression Results

4.1 Baseline Regression Results

Columns (1) of Table 1 Baseline regression results and results of moderating effect. present the regression results regarding the impact of organizational resilience on ESG performance. Column (1) reveals that the coefficient of organizational resilience is statistically significant at the 10% level. These findings confirm that organizational resilience positively impacts ESG performance, providing empirical support for Hypothesis 1 (H1).

4.2 Moderating Effect Tests

4.2.1 The Moderating Effect of Artificial Intelligence.

The moderating effect of artificial intelligence is reported in Table 1. Specifically, Column (2) of Table 1 shows that the moderating role of AI in the relationship between OR and ESG performance is negative and statistically significant. These results thus provide empirical support for Hypothesis 2.

4.2.2 The Moderating Effect of Innovation Network Embeddedness.

The moderating effect of innovation network embeddedness is reported in Table 1. Specifically, Column (3) of Table 1 shows that the moderating role of innovation network embeddedness in the relationship between OR and ESG performance is positive and statistically significant. These results thus provide empirical support for Hypothesis 3.

Table 1. Baseline regression results and results of moderating effect.

	ESG	ESG	ESG
	(1)	(2)	(3)
OR	0.238*	0.319**	0.263**
	(1.82)	(2.38)	(2.06)
OR*AI		-0.168***	
		(-2.77)	
OR*DU			0.158***
			(2.85)
AI		0.156*	
		(1.67)	
DU			0.091**
			(2.12)
CONTROLS	YES	YES	YES
CONSTANT	-0.180	-0.151	-0.213
	(-0.90)	(-0.15)	(-1.19)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
N	566	502	566
R^2	0.6432	0.6540	0.6557

Notes: Standard errors are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. FE, fixed effects.

4.3 Heterogeneity Analysis

4.3.1 Heterogeneity of Firm'S Ownership.

This study classifies the enterprise samples into high and low groups according to firm's ownership. Column (1) and (2) in Table 2 show that coefficient of OR is positively significant in non-SOE enterprises (non-SOEs) while the coefficient of organizational resilience of SOE enterprises is not significant. The results indicate that OR plays a greater role in advancing the ESG performance of non-SOEs.

Table 2. Heterogeneity analysis.

	ESG		ESG	
	(1)	(2)	(3)	(4)
	NON-SOE	SOE	LOW_EPU	HIGH_EPU
OR	0.397**	-0.070	0.141	0.373*
	(2.18)	(-0.35)	(0.67)	(1.96)
CONTROLS	YES	YES	YES	YES
CONSTANT	-0.401***	-0.697	-0.231	-0.298
	(-3.39)	(-1.38)	(-0.73)	(-0.29)
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	347	219	270	249
R^2	0.6713	0.6394	0.6983	0.7199

Notes: Standard errors are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1. FE, fixed effects.

4.3.2 Heterogeneity of Environmental Uncertainty.

This study classifies the enterprise samples into high and low groups according to the level of environmental uncertainty. Table 2 shows that in the subgroup with high environmental uncertainty, the coefficient of organizational resilience is positively significant. Whereas, when firms with low environmental uncertainty, the coefficient is statistically insignificant. This indicates that the greater the environmental uncertainty faced by firms, the more pronounced the positive effect of OR on their ESG performance.

5 Conclusion

This study systematically examines the impact of organizational resilience on ESG performance in the context of NEV enterprises. The empirical results confirm that organizational resilience significantly enhances ESG performance. However, AI exerts a negative moderating effect while innovation network embeddedness has a positively moderating impact. Moreover, the effect of organizational resilience is more pronounced in non-state-owned enterprises and under conditions of high environmental uncertainty. Theoretically, this study contributes to the ESG and organizational resilience literature by introducing resilience as a core dynamic capability under uncertainties, thus bridging the gap in risk-responsive ESG research. It also unveils the moderating mechanisms of AI and innovation network embeddedness. Practically, the findings provide actionable insights for NEV firms to enhance ESG performance through building OR, strategically deploying AI technologies to avoid over-reliance, and actively embedding into innovation networks to secure external resources. This study has several limitations. First, the sample is limited to Chinese listed NEV companies. Second, the measurement of organizational resilience may not fully capture its multidimensional nature. Future research could extend the current framework to other high-tech or environmentally industry.

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