Risk Management as a Mediator in Innovation Performance of Chinese New Energy Enterprises: A Mixed-Methods Analysis

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Abstract

The Research objective To investigate how technological innovation, market changes, and policy evolution collectively influence innovation performance in rapidly growing new energy enterprises. To explore the interactions between technological innovation, market changes, and policy adjustments in shaping corporate innovation outcomes during the expansion of new energy industries. To determine whether risk management mediates the relationship among technological innovation, market dynamics, policy adjustments, and innovation performance in new energy enterprises.As the global energy transition accelerates, Chinese new-energy enterprises must navigate volatile markets, shifting policies, and technological uncertainties that challenge effective innovation management. Grounded in Schumpeter's innovation theory, open-innovation theory, and risk-management theory, this study investigates how technological innovation, market dynamics, and policy adjustment collectively affect innovation performance, with risk management serving as a mediating factor. Quantitative data from 330 professionals were analyzed. Structural equation modeling reveals that technological innovation, market dynamics, and policy adjustment each have significant positive impacts on innovation performance. Moreover, risk management partially mediates these relationships by transforming external uncertainty into organizational learning and adaptive capability. Overall, the study extends theoretical understanding of innovation performance under uncertainty and provides practical guidance for enhancing resilience and competitiveness in China's evolving new-energy industry.

Keywords: Technological Innovation, Market Dynamics, Policy Adjustment, Risk Management, Innovation Performance, New Energy Industry.

Introduction

1. Background of the Study

In the 21st century, the global energy system stands at a critical turning point, facing escalating challenges arising from fossil-fuel dependence, environmental degradation, and energy insecurity (Zou et al., 2016). Traditional resources such as coal, oil, and natural gas are finite and increasingly strained by rapid industrialization and population growth, leading to resource depletion and price instability. Their combustion also generates substantial greenhouse-gas emissions, accelerating climate change and posing severe risks to ecosystems, economies, and human health. Furthermore, heavy reliance on a few exporting regions heightens geopolitical and market vulnerabilities, making energy supply fragile and unpredictable.

Amid these constraints, the new energy industry encompassing solar, wind, hydro, biomass, geothermal, and low-carbon nuclear power has emerged as a cornerstone of sustainable development (Asif et al., 2007). Characterized by cleanliness, renewability, and low carbon emissions, new energy represents an essential alternative to fossil fuels. However, its growth has not been without challenges, including technological bottlenecks, high costs, and limited market acceptance. To remain competitive in this dynamic landscape, enterprises must continuously strengthen technological, managerial, and market innovation.

Technological innovation drives breakthroughs in efficiency, cost reduction, and safety of renewable-energy systems (Plank et al., 2018). Management innovation enables flexible organizational structures and strategic adaptation to industry transformation (Quitzow, 2015). Market innovation, guided by evolving policies and consumer demand, helps firms expand market share through effective research, branding, and distribution strategies (Tabrizian, 2019). Collectively, these innovation mechanisms determine firms' ability to sustain growth in an uncertain policy and market environment.

From a theoretical perspective, this study draws upon three interrelated frameworks. Schumpeter's innovation theory highlights "creative destruction," where technological progress drives industrial renewal (Schumpeter, 1934). Open innovation theory emphasizes knowledge collaboration across organizational boundaries, underscoring the importance of partnerships with universities, research institutes, and supply chains in enhancing innovation capacity (Chesbrough, 2003; West & Bogers, 2014). Risk management theory adds a vital dimension, addressing how firms identify, assess, and mitigate uncertainties in technology, policy, and market environments to optimize innovation outcomes (Miller, 1992; Tidd & Bessant, 2020).

Integrating these perspectives, this research proposes an analytical framework where technological innovation, market dynamics, and policy adjustment act as antecedent factors; risk management functions as a mediating mechanism; and innovation performance serves as the

ultimate outcome. To examine this complex relationship, a mixed-methods approach is adopted—combining quantitative analysis through Structural Equation Modeling (SEM) and qualitative interviews. This integration allows for both statistical validation and contextual interpretation of how risk management transforms external uncertainty into innovation advantage.

Research question

1. How do technological innovation, market changes, and policy adjustments influence innovation performance new energy enterprises?

2. What impact does risk management have on innovation performance management of new energy enterprises

3. Does risk management play a mediating role between technological innovation, market changes, policy adjustments, and innovation performance in new energy enterprises?

Research objective

1. To investigate how technological innovation, market changes, and policy evolution collectively influence innovation performance in rapidly growing new energy enterprises.

2. To explore the interactions between technological innovation, market changes, and policy adjustments in shaping corporate innovation outcomes during the expansion of new energy industries.

3. To determine whether risk management mediates the relationship among technological innovation, market dynamics, policy adjustments, and innovation performance in new energy enterprises.

Literature Review

The rapid expansion of the new-energy industry is transforming how enterprises manage innovation, compelling firms to address technological advancement, market volatility, and shifting policy environments simultaneously. To interpret these dynamics, this study draws on three complementary perspectives—Schumpeter's innovation theory, open-innovation theory, and risk-management theory—which together provide an integrated framework for understanding how firms enhance innovation performance under uncertainty.

Schumpeter's (1934) concept of "creative destruction" emphasizes that innovation through new combinations of knowledge, processes, and products is the primary driver of industrial transformation. Later developments distinguish incremental from radical innovation and product-based from process-based innovation (Damanpour & Gopalakrishnan, 2001). Building on this, open-innovation theory (Chesbrough, 2003) highlights that firms increasingly depend on

collaboration with external partners such as suppliers, research institutes, and competitors to share resources, access complementary knowledge, and accelerate commercialization. This approach is particularly relevant in technology-intensive industries like renewable energy, where global cooperation and cross-sector partnerships are essential for overcoming high R&D costs and technical uncertainty.

Risk-management theory (Miller, 1992; Hopkin, 2018; ISO 31000, 2018) complements these innovation frameworks by emphasizing how organizations identify, evaluate, and mitigate uncertainty to ensure strategic resilience. It recognizes that firms operating in dynamic environments such as the new-energy sector must not only pursue innovation but also manage the risks associated with technological disruption, regulatory change, and market volatility. Effective risk management transforms uncertainty into opportunity by institutionalizing proactive governance and adaptive learning mechanisms.

"New energy" encompasses renewable and low-carbon sources including solar, wind, biomass, geothermal, ocean, hydrogen, and nuclear energy. These alternatives were developed to alleviate environmental degradation and the resource constraints of fossil fuels (Kalyani et al., 2015). Since the 1980s, the global industry has evolved from small-scale solar and wind initiatives into a diversified system integrating storage, smart grids, and digitalized energy management (Li et al., 2022). Emerging trends such as the rise of distributed energy systems (Zia et al., 2020), hybrid energy networks (Li et al., 2020), green hydrogen development (Tiwari, 2022), and cross-industry collaboration—linking energy firms with automotive, construction, and agricultural sectors demonstrate how technological innovation is driving systemic change.

Technological advancement remains the central force shaping innovation in this industry. Breakthroughs in photovoltaic efficiency, battery storage, and data-driven optimization have enhanced energy conversion rates and reduced costs, enabling large-scale commercialization. Integration with information and communication technologies has given rise to smart grids and IoT-enabled systems that improve monitoring, control, and energy utilization (Thellufsen et al., 2017). Such developments reinforce that technological innovation directly enhances firm competitiveness and innovation performance (Khan et al., 2022).

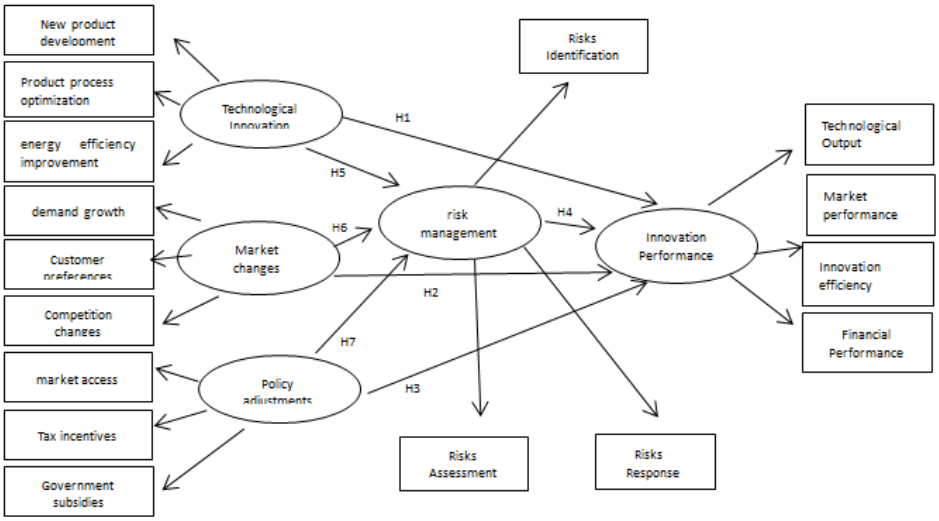
At the same time, market dynamics and consumer behavior increasingly influence innovation outcomes. The renewable-energy market has diversified, with segmented demand patterns reflecting varied priorities such as environmental consciousness, product intelligence, and long-term value (Wang et al., 2020). For example, in the electric-vehicle industry, consumer focus has expanded from price and range to connectivity, comfort, and brand experience. In the photovoltaic market, the growing adoption of distributed and building-integrated systems has created new niches across residential, industrial, and public infrastructure applications. These

evolving market structures compel firms to remain agile and to adapt innovation strategies that align with differentiated consumer expectations and competitive intensity (Teece, 2007; Jansen et al., 2006).

Policy adjustment is another crucial external force shaping innovation behavior. Government initiatives such as subsidies, tax incentives, environmental regulations, and industrial development programs reduce investment uncertainty and stimulate R&D efforts (Nesta et al., 2014; Zou et al., 2016). Stable, transparent, and well-coordinated policy frameworks encourage long-term strategic planning and facilitate collaboration across public and private sectors. Conversely, inconsistent or short-term policies can hinder innovation by increasing compliance costs and limiting firms' willingness to take risks. In the Chinese context, targeted policies for renewable energy development and international cooperation have created favorable conditions for technological advancement and global competitiveness (Sun et al., 2020; Li et al., 2022).

Risk management serves as the bridge linking these forces technology, market, and policy to innovation performance. Advances in digital technologies such as big data analytics, artificial intelligence, and predictive modeling allow firms to monitor risks in real time, anticipate disruptions, and develop adaptive responses (Pisano, 2015). By embedding enterprise risk management (ERM) systems into innovation processes, organizations can align strategic objectives with risk tolerance, improving resource allocation and innovation efficiency (Oehmen et al., 2014; da Silva Etges et al., 2017). Market volatility, technological uncertainty, and regulatory change thus become manageable conditions rather than barriers, supporting sustainable innovation in complex environments.

Overall, the literature reveals that innovation performance in the new-energy sector depends on an intricate interplay of technological, market, and policy factors, moderated by effective risk governance. Firms that integrate technological capability with market awareness, policy adaptability, and structured risk management achieve superior innovation outcomes and greater resilience in an increasingly competitive and uncertain global energy landscape.



Research Conceptual framework

Research Methodology

The quantitative analysis was employed in this research with a structured questionnaire based on validated scales from previous studies. The instrument covered five constructs, technological innovation, market change, policy adjustment, risk management, and innovation performance, measured on a five-point Likert scale. To ensure validity, three academic experts reviewed all items using the Item–Objective Congruence (IOC) index, retaining those scoring between 0.67 and 1.00. Reliability was confirmed through Cronbach's alpha, with all constructs exceeding 0.84, demonstrating strong internal consistency.

The target population comprised Chinese firms operating in solar, wind, and new-energy-vehicle sectors, including both producers and service providers affected by energy transition policies. Participants were mid- to senior-level managers with at least three years of innovation-related experience. Using stratified purposive sampling, firms were selected across different sizes and supply-chain positions to ensure diversity. The sample size, calculated using Yamane's formula (1967) for a population of about 3,000 professionals and a 5% error margin, indicated a minimum of 353 participants. In total, 330 questionnaires were distributed and 324 valid responses were retained, representing a 98.2% effective response rate.

Results

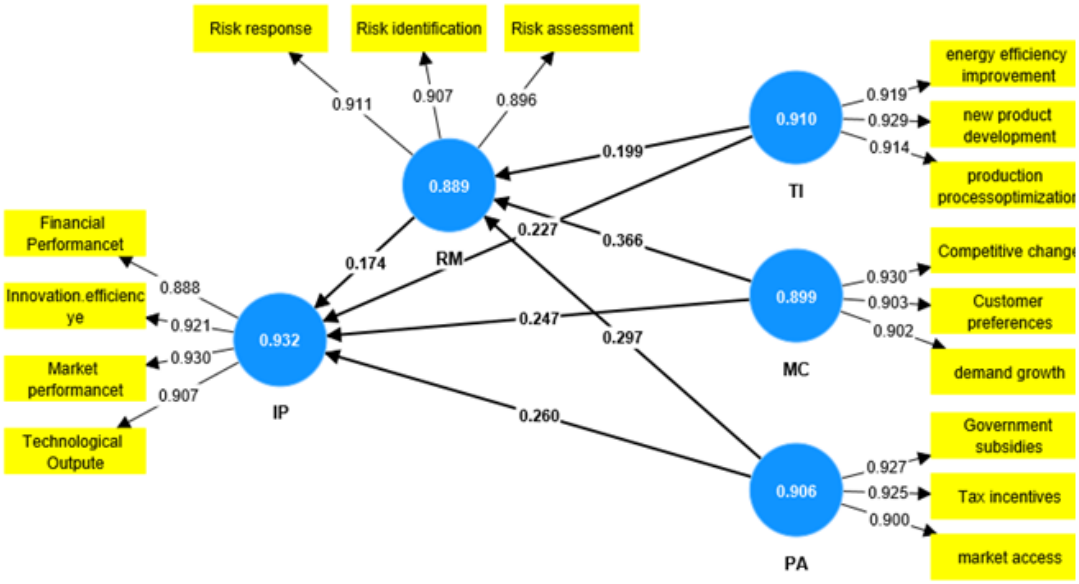
Using PLS-SEM with bootstrapping, all theorized paths were statistically significant. The structural model confirmed positive effects of the three antecedents on innovation performance (IP): **technological innovation** ⟶ **IP** (β = **0.312**, t = 4.79, p < .001), **market changes** ⟶ **IP** (β = **0.284**, t = 3.92, p < .001), and **policy adjustments** ⟶ **IP** (β = **0.267**, t = 3.58, p < .001).

Risk management (RM) functioned as a mediating capability. Antecedents significantly increased RM—**technological innovation ⟶ RM** (**β = 0.355**, $t = 4.63$, $p < .001$), **market changes ⟶ RM** (**β = 0.338**, $t = 4.21$, $p < .001$), **policy adjustments ⟶ RM** (**β = 0.322**, $t = 3.96$, $p < .001$)—and **RM ⟶ IP** was positive and significant (**β = 0.299**, $t = 4.05$, $p < .001$). These results indicate that firms with stronger risk-governance practices more effectively translate external shifts and internal innovation into superior innovation outcomes.

Model quality indicators were satisfactory. Endogenous **R^2** values were high (e.g., **R^2 = 0.601** for innovation performance), underscoring the explanatory power of the framework. Overall, the findings align with prior work on dynamic capabilities and integrated risk governance in policy-sensitive, high-uncertainty settings (e.g., Teece, 2007; Zhao et al., 2022; Hair et al., 2021).

Table 1 Results of Hypothesis Testing

Path Relationship	Hypothesis	Coefficient (O)	Mean (M)	Std. Dev.	t-value	p-value	supported
Technological Innovation ⟶ Innovation Performance	H1	0.227	0.23	0.07	3.249	0.001	yes
Market Changes ⟶ Innovation Performance	H2	0.247	0.247	0.075	3.301	0.001	yes
Policy Adjustments ⟶ Innovation Performance	H3	0.26	0.257	0.073	3.547	0	yes
Risk Management ⟶ Innovation Performance	H4	0.174	0.175	0.072	2.395	0.017	yes
Technological Innovation ⟶ Risk Management	H5	0.199	0.198	0.063	3.168	0.002	yes
Market Changes ⟶ Risk Management	H6	0.366	0.365	0.065	5.591	0	yes
Policy Adjustments ⟶ Risk Management	H7	0.297	0.299	0.075	3.975	0	yes



Discussion and Conclusion

Grounded in Schumpeter's theory of innovation, the open-innovation paradigm, and risk-management theory, this study quantitatively examined how technological innovation, market dynamics, and policy adjustments influence innovation performance in China's new-energy sector, with risk management serving as a mediating variable. Using Partial Least Squares Structural Equation Modeling (PLS-SEM) based on 330 valid responses, the results provide empirical evidence for the integrated framework.

The results show that technological innovation exerts a significant positive effect on innovation performance (β = 0.227, $p < 0.01$). Firms that actively engage in R&D, process optimization, and technological upgrading tend to achieve higher innovation efficiency and improved market performance. This finding aligns with the resource-based view (RBV) (Barney, 1991) and dynamic capability theory (Teece et al., 1997), indicating that technological resources and reconfiguration capabilities are key drivers of sustainable competitive advantage in a rapidly changing industry.

Market dynamics also demonstrate a significant positive impact on innovation performance (β = 0.247, $p = 0.001$), confirming that firms responsive to changing customer preferences, demand fluctuations, and competitive pressures achieve better innovation outcomes. The results are consistent with Schumpeter's concept of creative destruction, where market turbulence stimulates innovation. Furthermore, market changes positively influence risk management (β = 0.366, $p < 0.001$), which subsequently enhances innovation performance (β =

0.174, p = 0.017), confirming a partial mediation effect. This supports the premise that firms convert external volatility into structured innovation advantages through effective risk governance.

Policy adjustments significantly promote innovation performance (β = 0.260, p < 0.001), underscoring the pivotal role of government incentives, tax policies, and regulatory frameworks in supporting enterprise innovation. Policy shifts also positively influence risk management (β = 0.297, p < 0.001), highlighting the importance of institutional alignment and compliance structures in reducing innovation uncertainty. These findings echo prior research emphasizing that adaptive policy environments can amplify firms' innovation potential and enhance their competitiveness.

The model confirms that risk management functions as a crucial mediating mechanism linking technological innovation, market changes, and policy adjustments with innovation performance. Firms with robust risk identification, assessment, and mitigation capabilities can effectively transform external uncertainties into innovation-driven growth. This finding strengthens the theoretical connection between risk-management capability and innovation performance, extending the literature on dynamic risk capabilities (Mikalef et al., 2020).

Quantitative evidence substantiates the integrated framework in which technological, market, and policy drivers jointly determine innovation performance through the mediation of enterprise risk management. The model advances innovation theory by embedding risk management into the innovation–performance relationship, providing a comprehensive perspective on how external uncertainty interacts with internal capability development in emerging economies.

Conclusion

The quantitative findings confirm that technological innovation, market changes, and policy adjustments each exert significant direct and indirect effects on innovation performance through risk management. Firms that embed structured risk frameworks within innovation systems achieve stronger resilience and superior performance under uncertainty. The results contribute to the theoretical understanding of innovation under dynamic conditions and provide empirical guidance for developing risk-informed innovation strategies in China's rapidly evolving new-energy industry.

Reference

Barney, J. B. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120.

Chang, S. J., van Witteloostuijn, A., & Eden, L. (2010). From the editors: Common method variance in international business research. *Journal of International Business Studies, 41*(2), 178–184.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business School Press.

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In G. A. Marcoulides (Ed.), *Modern methods for business research* (pp. 295–336). Lawrence Erlbaum Associates.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39–50.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115–135.

Hillson, D. (2002). Extending the risk process to manage opportunities. *International Journal of Project Management, 20*(3), 235–240.

Li, Y., & Wang, K. (2021). Government policy and green innovation: Evidence from China's renewable energy sector. *Journal of Cleaner Production, 278*, 123944.

Miller, K. D. (1992). A framework for integrated risk management in international business. *Journal of International Business Studies, 23*(2), 311–331.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879–903.

Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology, 63*, 539–569.

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

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509–533.

Voorhees, C. M., Brady, M. K., Calantone, R., & Ramirez, E. (2016). Discriminant validity testing in marketing: An analysis, causes for concern, and proposed remedies. *Journal of the Academy of Marketing Science, 44*(1), 119–134.

Zhou, K. Z., & Li, C. B. (2012). How knowledge affects radical innovation: Knowledge base, market knowledge acquisition, and internal knowledge sharing. *Strategic Management Journal, 33*(9), 1090–1102.