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ORIGINAL PAPER

FORGING A SUSTAINABLE PATH: UNLEASHING COLLABORATIVE INNOVATION TO EXPEDITE THE INTEGRATION OF GREEN TECHNOLOGIES INTO SUPPLY CHAINS

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ABSTRACT. Background: The imperative for green innovation within global supply chains, driven by environmental concerns related to rapid industrialization, is widely recognized. Governments strategically integrate green innovation into economic plans to align growth with sustainability. However, complexities in adoption, such as relative advantage, compatibility, and government policies, remain. This study aims to comprehensively examine the adoption of green innovations within supply chains, addressing a notable gap in the existing literature. It focuses on elucidating the challenges associated with the adoption of green innovation within supply chains, emphasizing a proactive response to environmental challenges. Key factors, including relative advantage and compatibility, are explored in the context of challenges related to resource constraints and integration complexities. The study underscores the role of cooperative innovation in enhancing the attractiveness of green innovation adoption, with a crucial moderating influence attributed to government policies.
Methods: A comprehensive literature review and quantitative research utilizing a questionnaire form the basis of this study. The research model evaluates factors influencing the willingness to adopt green innovations, encompassing external (government policy, competitive pressure), internal (collaborative innovation), and systemic factors (relative advantage, compatibility), with a specific focus on collaborative innovation. Structural Equation Modeling (SEM) using SPSS 26.0 and AMOS 25.0 was employed to identify directional influences in the analysis.
Results: The findings of this study reveal that both relative advantage and compatibility have a direct impact on cooperative innovation, subsequently influencing adoption intention through the mediation of cooperative innovation. Moreover, the study highlights a moderating effect of government policy on the relationship between cooperative innovation and the intention to adopt green supply chain innovations.
Conclusions: By integrating the Technology-Organization-Environment (TOE) theoretical framework into the Diffusion of Innovation (DOI) model, this study addresses critical gaps in research on organizational-level innovation adoption. The conclusions drawn, along with theoretical implications and managerial recommendations derived from the statistical results, contribute to fostering the implementation of green innovation in supply chain management.

Keywords: sustainability, green technology, supply chain management, relative advantage, compatibility, cooperative innovation

INTRODUCTION

The increasing environmental impact of rapid industrialization has made green innovation in supply chains critically important. Governments globally have recognized the need to balance economic growth with environmental sustainability, incorporating green innovation strategies into their economic and corporate plans. However, adopting green innovations is complex, influenced by factors like relative advantage, compatibility, cooperative innovation, adoption intention, competitive pressure, and government policies. China's "Fourteenth Five-Year Plan" [Zhao et al. 2023] highlights the significance of green development in this context.

Relative advantage, or the perceived superiority of an innovation, is crucial for green supply chain innovation. Firms recognizing the benefits of eco-friendly practices are more

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inclined to adopt them, but they face challenges such as resource limitations and insufficient incentives. Compatibility, the degree to which an innovation fits into existing systems, is also significant. Firms prefer innovations that can be smoothly integrated into their current processes, yet green innovations are often associated with incentive issues and alignment complexities.

Cooperative innovation involves supply chain partners working together to develop sustainable solutions. It enhances the attractiveness of green innovations through knowledge sharing and joint problem-solving, influencing organizations' willingness to adopt these innovations. Competitive pressures in the market and government policies also significantly impact green innovation adoption, with policies providing incentives and setting standards for sustainability.

Most existing research focuses on green innovation within individual enterprises, with less attention on collaborative innovation in the broader supply chain. This study aims to fill this gap by exploring how relative advantage and compatibility influence green supply chain innovation adoption intentions through cooperative innovation. It also examines the moderating effects of competitive pressure and government policy on this relationship. The research aims to help organizations integrate green innovations into their supply chains effectively and guide policymakers in creating supportive regulations.

THEORETICAL BACKGROUND

Literature Review

Green innovation

Green innovation distinguishes itself through environmental benefits, generating dual externalities: technology spillovers and knowledge externalities, and externalities from external environmental costs. Its outcomes align with the triple bottom line principle, influencing corporate performance and providing social benefits by reducing negative externalities and enhancing societal well-being [Bocken et al. 2014, Niesten et al. 2017].

Relative advantage

Relative advantage, defined as the perceived superiority of an innovation over existing ideas, significantly influences the adoption of technological and green innovations. It is assessed in terms of economic cost-benefits and drives willingness to adopt IT innovations among business owners and consumers [AlBar and Hoque 2019, Lin 2022, Wong et al. 2020, Zhang et al. 2020].

Compatibility

Compatibility, the degree to which innovation aligns with adopters' values, experiences, and needs, affects the adoption and integration of new technologies. It encompasses technical compatibility (knowledge and technology congruence), value compatibility (alignment with organizational culture), and practicality compatibility (suitability for current practices). High compatibility facilitates adoption, while incompatibility serves as a barrier [Rogers 2010, Tortorella et al. 2021, Zhang et al. 2020].

Cooperative innovation

Collaborative innovation, underpinned by synergy theory, involves acquiring external knowledge and insights through partnerships. This approach yields greater impacts than individual efforts, fostering innovation efficiency, reducing risks, and facilitating high-quality knowledge spillovers. It includes radical innovation (enhancing R&D and market entry) and incremental innovation (improving supply chain efficiency) [Bai et al. 2023, Jimenez-Jimenez et al. 2019, Yu et al. 2021].

Adoption intention

Technology adoption intention, driven by models like TRA, DOI, TAM, TOE, and UTAUT, varies across individual, group, and organizational levels. It is influenced by technological characteristics, organizational factors, and environmental factors. Recent emphasis on organizational technology adoption has led to increased use of the TOE framework, which systematically examines internal and external adoption factors [Zhang et al. 2020].

Hypothesis Development

In examining innovation adoption, Rogers [2010] identifies five key attributes: relative advantage, compatibility, complexity, trialability, and observability. He emphasizes the critical role of relative advantage, particularly its economic aspects, in determining the adoption rate among specific groups. This advantage, as Wejnert [2002] notes, not only offers economic benefits but also enhances social status. Lai et al. [2018] further assert a positive correlation between an innovation's perceived relative advantage within a social system and its adoption rate.

Arthur [1989] suggests that companies can shape their technological trajectory by adopting strategies that capitalize on relative advantage, economies of scale, and the learning and synergy effects of technology. Maroufkhani et al. [2020] and Wong et al. [2020] argue that by leveraging their relative advantage in a particular technological domain, firms can drive technology adoption and development, fostering innovation through scale expansion and investment. This encourages continuous refinement and optimization of technology to meet market needs, underlining the incentive for ongoing investment and improvement to maintain competitive market positioning. Saunila et al. [2018] conclude that relative advantage drives innovation by providing opportunities for competitive advantage and promoting continuous technological advancement, leading to the hypothesis that relative advantage is a significant driver of innovation adoption and development.

H1: Relative advantage has a positive impact on cooperative innovation.

The second facet of innovation is compatibility, and its perceived congruence among members of a social system also exerts a positive influence on the adoption rate [Rogers 2010]. A research investigation focused on business cocreation and service innovation concluded that compatibility, which configures and facilitates cocreation dynamics across organizational boundaries, assumes a pivotal role in nurturing innovation [Chen et al. 2017]. Compatibility forms the foundational underpinning for cooperative innovation [Liao et al. 2017, Shahzad et al. 2020]. It empowers organizations to collaborate efficiently, seamlessly share information, minimize friction, integrate resources effectively, align objectives, mitigate risks, cultivate an innovation-oriented culture, sustain collaboration, and augment creativity. These components collectively contribute to the success of cooperative innovation initiatives, leading to the following hypothesis.

H2: Compatibility has a positive impact on cooperative innovation.

Innovation, described as the introduction of new ideas, processes, products, or procedures within an organization [Lê and Schmid 2022], thrives on the successful adoption of cooperative innovation. This requires firms to implement systems without causing conflicts with partner firms [Hausman et al. 2005]. The presence of innovative opportunities fosters a company's willingness to engage in such activities [Liu and Liu 2017]. When firms recognize these opportunities through collaboration, their motivation to adopt cooperative innovation increases [Zhou et al. 2020]. This prospect, coupled with the desire to remain competitive, encourages businesses to pursue cooperative innovation. Recognizing the benefits and possibilities of cooperation is key to an enterprise's commitment to these endeavors. This leads to the hypothesis that the perception of innovative opportunities through cooperation significantly influences a firm's intention to adopt cooperative innovation.

H3: Cooperative innovation has a positive impact on the intention to adopt green supply chain innovations.

The indirect impact of relative advantage and compatibility on the intention to adopt green supply chain innovations is mediated by cooperative innovation. This indirect impact (H4 and H5) is a consequence of the above three hypotheses (H1, H2 and H3).

H4: Cooperative innovation mediates the positive impact of relative advantage on the intention to adopt green supply chain innovations.

H5: Cooperative innovation mediates the positive impact of compatibility on the intention to adopt green supply chain innovations.

In today's highly competitive business environment, the demand for goods and services aligns with competitive strength [Yalabik and Fairchild 2011]. Competitive pressure, though sparingly studied, moderates various business strategies. For instance, it influences social media adoption for marketing [Ali Abbasi et al. 2022], affects e-marketing adoption under top management support [Sheikh et al. 2017], and moderates the impact of technology on e-procurement [Marei 2022].

Furthermore, competitive pressure drives firms to seek innovative strategies for competitive advantage [Lisi et al. 2020]. In highly competitive markets, firms often collaborate on innovations, accessing new ideas and technologies. This environment fosters a willingness to adopt collaborative innovations to gain a competitive edge [Najafi-Tavani et al. 2018].

Additionally, competitive pressure is a key moderator in green supply chain management, enhancing the link between these practices and environmental performance [Ghosh 2019, Moreira et al. 2022]. Firms under competitive stress are more open to innovations from cooperative efforts, recognizing the need to stay competitive. This leads to the hypothesis that competitive pressure encourages the adoption of innovative, collaborative solutions to maintain market competitiveness.

H6: Competitive pressure moderates the positive impact of cooperative innovation on the intention to adopt green supply chain innovations.

Government policies significantly influence the competitiveness and growth of small and medium-sized enterprises (SMEs) by affecting innovation, financing, and management practices [Lee 2023, Mohd Shariff et al. 2010, Zhu and Sarkis 2007]. However, strict regulations can lead to risk aversion, particularly in construction, hindering cooperative innovation and technological adoption [Ji and Miao, 2020, Taofeeq et al. 2020]. Additionally, the implementation of contract governance mechanisms is vital in managing risks in asymmetric R&D alliances, especially regarding intellectual property and resource sharing. Such mechanisms encourage the adoption of cooperative innovations by ensuring the protection of partners' interests and alignment with their goals [De Jesus and Mendonça 2018, Zhen et al. 2021].

H7: Government policy moderates the positive impact of cooperative innovation on the intention to adopt green supply chain innovations.

Based on the above hypotheses, the following theoretical framework was developed.

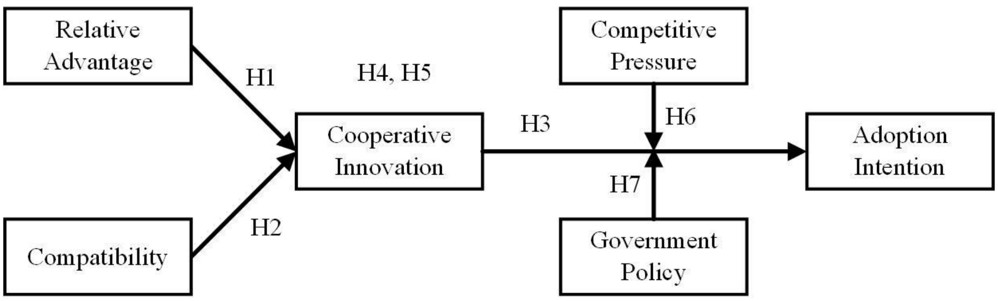

Fig. 1.Theoretical framework

RESEARCH METHODOLOGY

Construct Measurement

The research population comprises workers in the manufacturing sector's supply chain in China. A questionnaire was created on the SurveyMonkey online survey platform, and the link to the questionnaire was distributed to the sample through WeChat in September 2023. Out of the 342 questionnaires received, 337 responses were deemed valid for subsequent data analysis.

Each item was assessed using a 7-point Likert scale. The specific questionnaire employed in this study is presented below.

Table 1. Research questionnaire

Variable	Code	Description of Indicator Item	Source
Relative Advantage	RA01	Adoption of supply chain green innovation will enable our companies to increase productivity.	[Liu and Cao 2022]
	RA02	Adopting supply chain green innovation will enable our company to improve work performance.	
	RA03	Adopting supply chain green innovation will enhance the image of our company.	
	RA04	Adopting supply chain green innovation will increase our company's profitability.	
Compatibility	CO01	Supply chain green innovation is compatible with the business operating model in my company.	[Li et al. 2022]
	CO02	Supply chain green innovation is compatible with the management requirements of the company.	
	CO03	Supply chain green innovation fits with the existing values of my company.	
	CO04	Supply chain green innovation is compatible with my company’s existing infrastructure.	
Cooperative Innovation	CI01	Ability to quickly deal with problems in cooperation with external organizations.	[Luo et al. 2018]
	CI02	Possess the quality of quickly identifying new internal and external information and new technologies.	
	CI03	Possess the ability to quickly integrate new knowledge acquired from outside with its own technology	
	CI04	Cooperation with external parties can achieve the goal of maximizing the benefits of "1+1>2".	
Competitive Pressure	CP01	Our company believes that the adoption of supply chain green innovation has an impact on the competition in the industry.	[Liu and Cao 2022]
	CP02	Our company is facing pressure from competitors. It is challenging to survive in the fierce competition without using supply chain green innovation.	
	CP03	Some of our competitors have started to adopt supply chain green innovation.	
Government Policy	GP01	There is financial support offered by the Government for implementing supply chain green innovation.	[Lin et al. 2020]
	GP02	There are training opportunities provided by the government to adopt supply chain green innovation.	
	GP03	The government has given technical support for adopting supply chain green innovation.	
Adoption Intention	AI01	Our organization intends to adopt supply chain green innovation in the near future.	[Kumar Bhardwaj et al. 2021]
	AI02	I believe that my organization intends to adopt supply chain green innovation in the future.	
	AI03	Our organization is likely to adopt supply chain green innovation on a regular basis in the near future.	

Questionnaire Reliability and Validity

All constructs exhibit strong composite reliability and AVE, meeting recommended standards [Chin 1998, Fornell and Larcker 1981, Hair et al. 2019]. The standard deviations and composite reliabilities range from 0.843 to 0.931. These results confirm acceptable convergent validity as shown in Table 2. Discriminant validity, assessed following Fornell and Larcker's [1981] method, confirms that all AVE values exceed correlation coefficients (see Table 3), demonstrating strong discriminant validity among constructs.

RESULTS

Sample profile

The research encompasses a sample size of 337 individuals. The majority were female (58.50%), 31-35 years old (60.83%), and had an educational level equivalent to a 4-year university degree or under (70%), as shown in Table 3.

Table 1. Means, SD, CR, AVE of each construct.

Construct	Item	Mean	Std Dev	Std.	CR	AVE
RA	RA01	6.16	1.19	0.731	0.857	0.601
	RA02	5.99	1.37	0.848		
	RA03	6.01	1.36	0.820		
	RA04	6.08	1.34	0.691		
CO	CO01	6.15	1.32	0.866	0.931	0.770
	CO02	5.90	1.52	0.842		
	CO03	6.05	1.46	0.868		
	CO04	6.12	1.33	0.932		
CI	CI01	5.82	1.45	0.780	0.866	0.618
	CI02	5.90	1.33	0.813		
	CI03	6.05	1.31	0.747		
	CI04	5.62	1.47	0.804		
AI	AI01	5.49	1.55	0.843	0.843	0.642
	AI02	5.87	1.46	0.745		
	AI03	5.96	1.40	0.812		

Std., Standardized factor loadings; CR, Composite Reliability; AVE, Average Variance Extracted. RA, Relative Advantage; CO, Compatibility; CI, Cooperative Innovation; AI, Adoption Intention

Table 2. Results of discriminant validity by AVE.

	AVE	RA	CO	CI	AI
RA	0.601	**0.775**			
CO	0.770	0.565	**0.877**		
CI	0.618	0.628	0.716	**0.786**	
AI	0.642	0.475	0.542	0.756	**0.801**

RA, Relative Advantage; CO, Compatibility; CI, Cooperative Innovation; AI, Adoption Intention; The items on the diagonal in bold represent the square roots of the AVE; off-diagonal elements are the correlation estimates.

Table 3. Sample profile

Variables	Categories	n	%
Gender	(1) Male	140	41.50
	(2) Female	197	58.50
Age	(1) Under 30	44	13.06
	(2) 31-35	205	60.83
	(3) 36-40	57	16.91
	(4) over 41	31	9.20
Educational	(1) 4-year University degree or under	237	70.00
	(2) Graduate school	100	30.00
	Sum	337	100.00

Model fit

Nine widely accepted fitness metrics were calculated to assess model fit, as recommended by Tiffany and Schumacker [2022]. A good model fit typically results in a chi-square value/degrees of freedom ratio below 3. Additionally, Hu and Bentler [1999] recommend evaluating each fitness metric independently and simultaneously controlling for type I errors with more stringent model fit metrics, such as the Comparative Fit Index (CFI) > 0.90, Standardized Root Mean Square Residual (SRMR) < 0.08, and Root Mean Square Error of Approximation (RMSEA) < 0.08.

During SEM analysis, model estimation often leads to an increase in the chi-square value, potentially affecting the model's fit. To address this, we corrected the chi-square value using the Bollen-Stine bootstrap p-value chi-square correction test [Bollen and Stine 1992]. The corrected chi-square value (χ^2) indicates that the model fit is 143.193, with 86 degrees of freedom, resulting in a chi-square to degrees of freedom ratio (χ^2/df) of 1.665. Moreover, the Tucker-Lewis Index (TLI) value is 0.979, the CFI value is 0.983, the Goodness of Fit Index (GFI) value is 0.959, and the Adjusted Goodness of Fit Index (AGFI) value is 0.949, all exceeding the threshold of 0.9. Furthermore, the RMSEA value is 0.044, and the SRMR value is 0.045, both falling below the 0.08 standard. These results collectively indicate a strong degree of model fit. Table 5 presents the goodness-of-fit metrics for the models analyzed in this study.

Table 4. Bollen-Stine bootstrap p-value chi-square

Model fit	**Criteria**	**Research Model**	**Bollen-Stine Model fit**
χ^2	The smaller the better	213.006	143.193
DF	The larger the better	86	86
χ^2/DF	1<χ^2/DF<3	2.477	1.665
RMSEA	<0.08	0.066	0.044
SRMR	<0.08	0.045	0.045
TLI (NNFI)	>0.9	0.954	0.979
CFI	>0.9	0.962	0.983
GFI	>0.9	0.922	0.959
AGFI	>0.9	0.891	0.949

Path analysis

The path analysis results in Table 6 demonstrate significant associations among the constructs. Relative advantage (RA) significantly influenced cooperative innovation (CI) (b=0.427, $p < 0.001$) and compatibility (CO) (b=0.525, $p < 0.001$), supporting H1 and H2. The combined influence of these values explained 58.6% of the variance of CI. And cooperative innovation (CI) (b=0.874, $p < 0.001$) significantly affected adoption intention (AI), supporting H3, with 58.6% of the variance of cooperative innovation explained by AI.

Table 5. Regression coefficient

DV	**IV**	**Unstd.**	**S.E.**	**Unstd./S.E.**	***Sig.***	**Std.**	**R^2**
CI	RA	0.427	0.079	5.424	***	0.328	0.586
	CO	0.525	0.060	8.695	***	0.531	
AI	CI	0.874	0.072	12.095	***	0.756	0.572

RA, Relative Advantage; CO, Compatibility; CI, Cooperative Innovation; AI, Adoption Intention

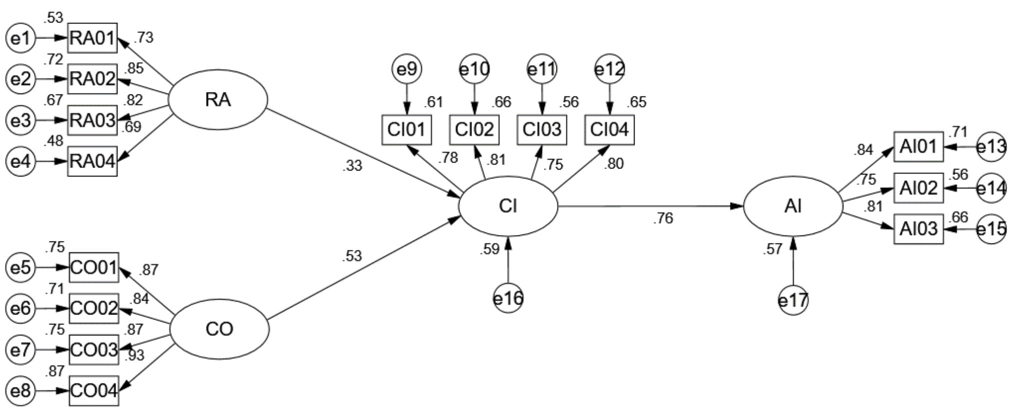

Fig. 2 SEM model

Mediating effects

The most commonly employed method to examine the indirect effect of intermediary variables is the bootstrapping method. It is statistically more powerful compared to causal path methods and coefficient product methods [MacKinnon et al. 2004, Williams and MacKinnon 2008]. Confidence intervals (C.I.) for indirect effects obtained through bootstrapping (preferably bias-corrected bootstrapping) are statistically robust when no "0" is found within the lower and upper bound of the confidence intervals [Briggs 2006, Williams and MacKinnon 2008]. In Table 7, the analysis shows no "0" within the confidence intervals, which reveals significant mediation effects. The indirect effects indicate mediation of RA→CI→AI (C. I. [0.179 to 0.687]) and CO→CI→AI (C. I. [0.313 to 0.612]), which supports hypotheses H4 and H5.

Table 6. Mediating effects.

Effect	Point Estimate	Bootstrap 1000 times	
		Bias-corrected 95%	
		Lower bound	Upper bound
Indirect effects			
RA→CI→AI	0.373	**0.179**	**0.678**
CO→CI→AI	0.458	**0.313**	**0.612**

RA, Relative Advantage; CO, Compatibility; CI, Cooperative Innovation; AI, Adoption Intention

Moderation effects

The moderating effects analysis assessed the effect of the moderator variables, namely, competitive pressure and government support, on the relationship between cooperative innovation and the intention to adopt green supply chain innovations. In Table 8, the moderating effect of competitive pressure on the relationship between collaborative innovation and adoption intention is -0.058 (S.E. = 0.03, p = 0.055), which is not statistically significant. However, the moderating effect of government support on the relationship between cooperative innovation and adoption intention is significant. The estimate is 0.0568 (S.E. = 0.028, p = 0.049). Therefore, when government support is greater, collaborative innovation increases the intention to adopt green supply chain innovations.

Table 7. Moderating effects.

Dependent variable	Independent variable	Estimate	S.E.	Estimate/S.E.	P
AI AVE	CI AVE	0.604	0.163	3.713	***
	GP AVE	0.021	0.160	0.134	0.893
	CP AVE	0.220	0.166	1.327	0.185
	CI CP AVE	**-0.058**	**0.030**	**-1.919**	**0.055**
	CI GP AVE	**0.056**	**0.028**	**1.972**	**0.049**

CI, Cooperative Innovation; GP, Government Policy; CP, Competitive Pressure; AI, Adoption Intention

DISCUSSIONS AND CONCLUSIONS

Discussions

The study has examined how relative advantage and compatibility positively influence cooperative innovation in green supply chains. Al Bar and Hoque [2019] argue that these factors not only individually contribute to the adoption of environmentally sustainable practices but also synergistically enhance each other's impact. Relative advantage is the perception that adopting eco-friendly practices offers clear benefits over traditional methods, encouraging collaborative endeavors in supply chains. Such collaboration is motivated by potential competitive advantages like cost reduction, brand reputation enhancement, and the capacity to meet consumer expectations. Additionally, enterprises are more willing to engage in cooperative innovation when they perceive a relative advantage, as this helps in distributing risks and fosters a culture of knowledge sharing [Jimenez-Jimenez et al. 2019, Wong et al. 2020].

The study further identified cooperative innovation as a mediating factor in the relationship between relative advantage, compatibility, and the intention to adopt green supply chain innovations. When firms perceive both relative advantage and compatibility in green innovations, there is an increased likelihood of engaging in knowledge sharing and collaborative learning with supply chain partners. This collaboration provides a structured platform for exchanging insights, sharing best practices, and understanding the benefits of innovation within the existing ecosystem [Liao et al. 2017]. Cooperative innovation also facilitates resource pooling, making the adoption of green innovations more feasible and attractive [Jimenez-Jimenez et al. 2019].

Moreover, government policies were found to moderate the positive impact of cooperative innovation on the the intention to adopt green supply chain innovations. Policies and regulations, covering aspects like environmental standards and incentives, can act as catalysts for firms engaged in cooperative green innovations [Lee 2023, Zhu and Sarkis 2007]. Incentives may include tax benefits, grants, or preferential treatment for collaborative sustainability efforts [De Jesus and Mendonça 2018]. Clear regulatory frameworks can mandate specific environmental standards and practices, promoting green practices [Ji and Miao 2020]. Additionally, market access and government contracts may depend on the adoption of certain green innovations, further motivating firms to engage in cooperative innovation. Government funding for R&D in green supply chain innovation can also significantly influence adoption [Mohd Shariff et al. 2010].

Practical implications

Emphasizing Relative Advantage: Organizations should recognize and communicate the clear benefits of adopting green practices over traditional methods. This includes highlighting potential competitive advantages such as cost reduction, improved brand reputation, and the capacity to meet consumer expectations. By understanding these advantages, firms are more likely to engage in cooperative innovation, seeing it as a beneficial strategy.

Fostering Cooperative Innovation: The study underscores the importance of cooperative innovation as a key mediator in the adoption of green supply chain innovations. Firms should actively pursue collaborative relationships with supply chain partners to share knowledge, resources, and best practices. Such collaboration can lead to a more efficient and effective implementation of green innovations.

Leveraging Compatibility: Enterprises should assess how green innovations align with their current operations and culture. By ensuring compatibility, firms can integrate these practices more seamlessly, reducing resistance and increasing the likelihood of successful adoption.

Utilizing Government Policies and Incentives: The role of government policies in encouraging green supply chain practices is crucial. Firms should stay informed about relevant policies, incentives, and regulations, and leverage them to support their green initiatives. Engaging with policy frameworks can provide additional motivation and resources for the adoption of sustainable practices.

Encouraging Knowledge Sharing and Learning: The promotion of a learning culture within and across organizations is vital. Firms should invest in training and development programs that emphasize the importance of sustainability and the practical aspects of implementing green supply chain innovations.

Resource Pooling and Risk Distribution: Cooperative innovation allows for the pooling of resources, which can make the adoption of green technologies more feasible and cost-effective. Additionally, collaboration can help distribute risks associated with green innovation, making firms more willing to invest in these practices.

Conclusions

Green innovations, when perceived as compatible, integrate seamlessly into existing operations, enhancing their attractiveness for adoption. Firms should seek partners committed to sustainability, recognizing the advantages and compatibility of green practices. Collaborative relationships, crucial in this process, can be developed through strategic partnerships, joint research, and shared sustainability goals [Tortorella et al. 2021]. Raising awareness about the benefits of green innovations is essential to foster a conducive environment for their adoption [Shahzad et al. 2020].

Operationalizing these findings, companies are encouraged to cultivate collaborative relationships within their supply chains, emphasizing knowledge sharing, resource pooling, and joint problem-solving. Establishing cooperative innovation platforms and continuous learning cultures is vital [Liu and Liu 2017, Shahzad et al. 2020, Zhou et al. 2020]. Investment in education and training, alongside effective communication channels, is crucial for successful cooperative innovation and transparency.

Engagement with policymakers is also key for firms, which need to advocate for policies that incentivize green supply chain innovation. Collaborative efforts with industry associations and supply chain partners can highlight the importance of these policies. Staying abreast of government regulations and aligning with them enhances cooperative innovation and adoption intention. Exploring government-funded R&D opportunities can fortify these efforts, especially in international trade contexts. Firms should maintain transparency in their sustainability practices for compliance and credibility.

However, green innovation presents dual externalities. While it offers social benefits, their value often cannot be internalized by the enterprise, affecting the willingness to innovate. In competitive markets, green technologies may not significantly increase demand. Although green products can command higher prices, the marginal profit may not increase, and the adoption of green technologies can raise costs, reducing actual profits and dampening enthusiasm for green innovation.

Limitations of the study

The study's limitations primarily revolve around its scope and generalizability. Firstly, the research might be constrained by its focus on specific industries or regions, limiting its applicability to other sectors or geographic areas. Secondly, the reliance on certain theoretical frameworks or methodologies may restrict the breadth of insights, potentially leaving out alternative perspectives or variables. Additionally, the study's conclusions may be influenced by the quality and availability of data, which could affect the robustness of its findings. Lastly, as the research is based on current practices and policies, rapid changes in technology or regulations could render some findings less relevant over time.

Plans for future research

Future research should explore strategies to internalize the benefits of green innovations within enterprises, thereby enhancing their willingness to adopt such practices. This would involve investigating economic incentives and business models that balance environmental benefits with financial viability. Additionally, studying the impact of government policies and international regulations on green innovation adoption across different industries and global markets is crucial. Research should also focus on the development of technological advancements that reduce the cost of green innovations, making them more accessible and attractive to a wider range of companies. Finally, longitudinal studies to assess the long-term effects of green innovation on corporate performance and sustainability are essential.

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