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THE CONVERGENCE OF ENVIRONMENTAL INNOVATION, STAKEHOLDER PRESSURE, OPEN INNOVATION IN LOGISTICS FIRMS: PATHWAY TO RENEWABLE ENERGY IN THE PRESENCE OF MANAGERIAL COGNITION & COMPETITIVE ADVANTAGE

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Abstract. The logistics industry has recently been pressured to adopt sustainable practices due to increasing environmental concerns and regulatory mandates. This study investigates the nexus between ecological innovation, stakeholder pressure, open innovation, and renewable energy adoption in logistics firms, emphasizing the moderating role of managers' cognition of sustainable opportunities and competitive advantage. In this regard, stakeholder pressure compels organizations to adopt renewable solutions. On the other hand, open innovation and eco-innovation are pivotal in taming firms' internal limitations and advancing the adoption of renewable technologies. Thereby, analyzing empirical data from China's logistics firm, the present study demonstrates how open innovation, eco-innovation, and stakeholder pressure affect renewable energy adoption and the firm's competitive advantage. In addition, the study explicitly outlines the critical role of managers' cognition of sustainable opportunities and competitive advantage as a moderator. Through SEM, the study reveals a positive and significant relationship between open-innovation, eco-innovation, and stakeholders' pressures regarding renewable energy adoption. The moderation of managers' cognition in the case of eco-innovation and open innovation proved significant, whereas, in the case of stakeholder pressure, it is insignificant. Competitive advantage, another moderator, failed to moderate the proposed relationship. Findings explain that managers can realize strategic significance in terms of sustainability. They may shift toward green strategies aligned with market apprehensions and environmental regulations. This cognitive factor enhances the usefulness of open and eco-innovation during renewable adoption. Overall, the study's findings underscore the significance of managerial insights in leveraging these factors to accelerate the industry toward a sustainable future.

Keywords: eco-innovation, stakeholder pressure, open innovation, manager's cognition, competitive advantage.

JEL Classification: O36, F64, O13, Q42, P18.

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1. Introduction

China has one of the largest logistics industries in the world. The infrastructure of logistics in the country is expanding (Li & Wang, 2022). According to an estimate, the Chinese government will invest almost 181.6 billion yuan in the logistics industry in 2021. The market value of logistics firms and industry has also doubled (Statista, 2023a). In 2014, the logistics cost of China was almost 16.6% of the country's GDP. The government aimed to reduce this logistics

cost to 12% by 2025. In 2021, the logistics cost became 14.6% of the country's GDP. However, it is still considered a slow progress. If the country and logistics firms keep working with the same strategies and practices, reducing and maintaining it below 12% will seem difficult by 2025 (Statista, 2023b).

Figure 1 shows the logistics costs in China's GDP. In the past few years, China has also been concerned about the pollution created by logistics firms, such as plastic pollution, carbon emissions, etc. The concerns about plastic pollution raised in the past few years, as observed in the growing logistics industry, produced nearly 8 billion plastic packaging to deliver parcels (Vu et al., 2023; Xinhua, 2018). For this purpose, logistics firms in China are now adopting sustainable green practices, such as packaging to be recyclable (Moshood et al., 2022). This is why China is trying to opt for environmental innovation (Konadu et al., 2022), which is related to the safety of natural resources and sustainable practices and others. According to Anshari and Almunawar (2022), open innovation can also be a significant factor in this matter as it allows organizations and firms to take help in innovation from outside the organization's boundaries, such as vertical and horizontal integration. The most crucial thing is adopting renewable energy in logistics firms, as using non-renewable energy sources might be harmful.

For example, the purpose of shipping solar photovoltaics or biofuels can be used to reduce the issue of carbon emissions (Khan et al., 2022). Another essential thing observed in this matter is the stakeholder pressure and the willingness and knowledge of the firm's manager to bring these sustainable practices (Adomako & Tran, 2022). Since they are essential parts of the organization, managers and stakeholders can be significant in bringing these practices and innovations to sustainability in logistics firms. Moreover, these sustainability practices can also give the firm a competitive advantage as, nowadays, everyone praises sustainable

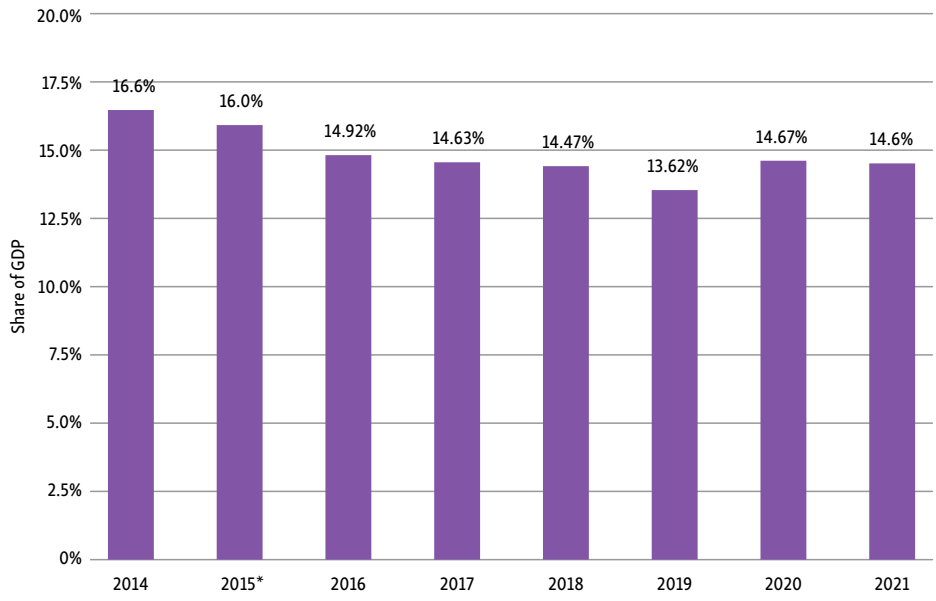

Figure 1. Logistics costs in China's GDP (2014–2021) (Statista, 2023b)

practices and incredibly rational customers (Afum et al., 2022). Different researchers, Guo and Wang (2022), Nguyen and Adomako (2022), and Singh et al. (2022), have worked on the relationship between stakeholder pressure, green innovation, and environmental innovation. Unfortunately, few research studies have discussed the relationship between open innovation and renewable energy adoption.

Moreover, many studies have not discussed the moderating role of a manager's cognition of sustainable opportunities. The current research study aims to bridge this gap and address these variables and relationships. Hence, this research study examines the nexus between environmental innovation, stakeholder pressure, open innovation, and renewable energy adoption in Chinese Logistics Firms. Moreover, the research study will also analyze the moderating effect of managers' cognition of sustainable opportunities and competitive advantage. As the current research study discusses the variables understudy and, most importantly, the variables such as open innovation and renewable energy adoption, this will contribute to the existing literature. This study will also strengthen the empirical evidence by presenting a conceptual framework and empirical evidence. The current research study will also be helpful for the managers of logistics firms as it discusses the importance of managers' cognition of sustainable opportunities. The remaining research paper is divided into 4 Sections: the Section 2 includes the detailed literature of this research study, the Section 3 describes the methodology, the Section 4 includes the analysis and results, and the last section includes the discussion of the findings.

2. Literature review

2.1. Theoretical background

The proposed model of the study is predicated upon the adoption of renewable energy resources, which are highly dependent on various eco-friendly practices within the organization and moderated by some specific conditions, which various logistic firms thus incorporate. To support the conceptual framework (see Figure 2), the researcher has used the *"Theory of planned behavior* (*TPB*)*"* based on seminal work of Ajzen (1991), which states that the behavioral intentions of an individual determine their behavior where individuals think first before undertaking a behavioral adoption which directs them to desirable results (Irfan et al., 2021). This theory will support the current research in a way that the behavioral aptitudes of stakeholders regarding sustainability and the desire to be competent, as well as managers' perception regarding sustainable opportunities, will allow a significant and feasible renewable energy adoption within logistic firms.

The adoption of renewable energy is directly dependent on eco-innovation, stakeholder pressure, and open innovations because these are the sustainable practices that prioritize renewable energy adoption (Zhu & Wang, 2023). In addition, the influence of the above-stated green practices is significantly moderated by the perceptions of the firms' managers regarding the choice of sustainable opportunities and their decisions to use them for enhancing renewable energy adoption. Moreover, competitive advantage significantly moderates the association between independent and dependent variables because the firms willing to achieve a competitive advantage will try their best to incorporate sustainable practices within the company, an ultimatum for adopting renewable energy (Chen et al., 2023).

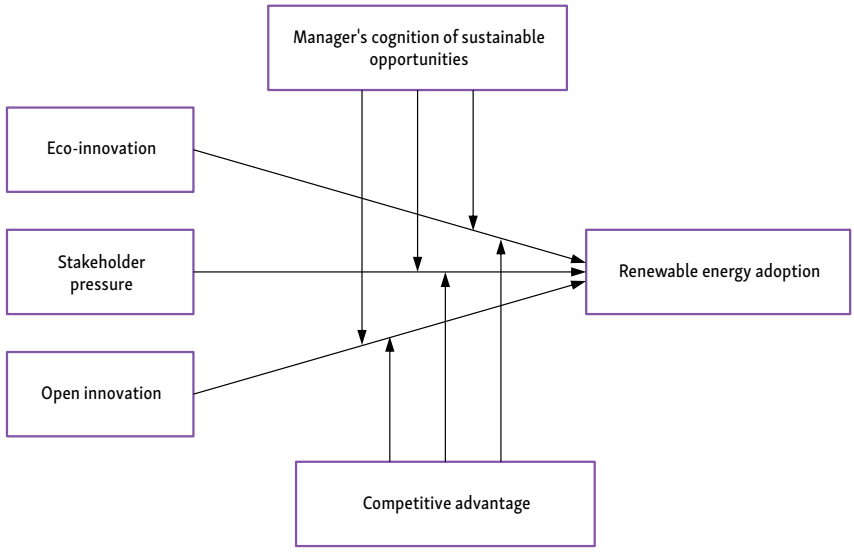

Figure 2. Conceptual framework

2.2. Eco-innovation and renewable energy adoption

The environmental impact in this modern-day world has changed how organizations operate worldwide. When green perspective is aligned with the principles of innovation, eco-innovation surfaces as a critical factor in business and management literature. This concept emerges from mounted pressure on businesses to modify their existing models in a way that incorporates sustainable principles into environmental and socio-economic objectives (He et al., 2018; Xu et al., 2024). Eco-innovation represents the strategic decisions of diverse stakeholders related to novel ideas, avent-grade behaviors and innovative products and processes. These endeavours are celebrated to address environmental concerns by achieving sustainability goals (Pereira et al., 2020; Wang et al., 2024). In addition, it could also be defined at a broader scope as traditional kinds of innovation, i.e., it can occur at the product, processes, services, and organizational management levels. However, it is still necessary to understand the significance of eco-innovation and its impact on renewable energy adoption, which is the primary concern of the current research.

The researcher believes that eco-innovation will significantly and positively influence the adoption of renewable energy because it promotes sustainable innovations crucial for enhancing renewable energy usage within logistic firms. In addition, the countries working on non-renewable energy consumption methodology have stable economic growth, but this increases the carbon dioxide footprint in the country because of enhanced energy consumption, which should be treated by bringing innovations (Pata, 2018; Zhao et al., 2024). In addition, renewable energy resources also play a considerable and vital role in promoting and enhancing the country's economic growth. Therefore, keeping in view the global changes in the climate and environment, innovations that could be eco-friendly and cost-effective are needed (Li et al., 2020). Furthermore, eco-innovations, such as environmental innovations that

have resulted from continuous investment, have paved the way toward using and adopting renewable energy resources. This has evidenced the importance of eco-innovation for adopting renewable energy within logistic firms, a crucial aspect of the current research.

H1: *Eco-innovation significantly and positively influences renewable energy adoption.*

2.3. Stakeholder pressure and renewable energy adoption

Stakeholders are crucial actors within several logistic firms. They are responsible for the measures and strategic actions of the company as it is necessary to fulfill the stakeholder's requirements regarding the organization, its sustainability, and the environment. According to research (Helmig et al., 2016; Hsu, 2024), stakeholder pressure is defined as "the power and capability of stakeholders to change and innovate a firm's decision" (Singh et al., 2022). In addition, stakeholder pressure has been characterized as the critical feature within logistic firms by which corporate efforts can be converted into corporate social responsibility and sustainability. Moreover, research has mentioned stakeholder pressure as a key to incorporating green management practices within logistic firms, such as "green human resource management, supply chain management, green marketing, and many other management practices" (Zhang et al., 2023). However, researchers have yet to research a broader scope of stakeholder pressure, where it enhances and facilitates renewable energy adoption within logistic firms.

The current research has focused on the paradigm of stakeholder pressure because the researcher believes that demand from the stakeholders of any particular organization will not only promote the sustainability of the company but also incorporate renewable energy adoption within the organization to eradicate the depletion of natural resources and to lessen the carbon dioxide footprint from the country. According to Gouldson and Sullivan (2013), the policymakers must devise a strategic plan for the organization which could overcome environmental changes, stimulate eco-innovations, and measure the progress of mitigation efforts (Wang & Sueyoshi, 2018; Wang & Li, 2024). In addition, the organization's strategic plan should focus on using renewable energy because it is necessary to implement it within the organization per the stakeholders' requirements. Persson and Rockström (2011) has elaborated that stakeholder pressure has enhanced the willingness of business managers to mitigate GHG emissions by utilizing renewable resource and improving eco-efficiency (Wang & Sueyoshi, 2018). Therefore, stakeholder pressure is a significant concern for business researchers regarding renewable energy adoption.

H2: *Stakeholder pressure significantly and positively impacts renewable energy adoption.*

2.4. Open innovation and renewable energy adoption

Open innovation is defined as "the firm's capability to utilize the knowledge regarding the inflows and outflows of the company and make it more innovative than before" (Bogers et al., 2018). In addition, firms can use open innovation to comprehend external knowledge and incorporate it within the organization to improve and innovate internal practices (Barham et al., 2020). However, in the case of logistics firms, open innovation plays a pivotal role in enhancing the internal innovations within the company based on external knowledge as well

as it also supports the usage and adoption of renewable energy within the logistics firms to lessen the consumption of energy and carbon dioxide footprints worldwide.

The current researcher believes that open innovations could significantly and positively influence renewable energy adoption within logistic firms. This could be evidenced by research (Rogelj et al., 2013), which elaborates that due to the rise in global warming, all the organizations thus operating in various countries are focusing on the usage of renewable energy resources, which can lessen the consumption of energy and help the organization to achieve the goal of net zero carbon (Solarin et al., 2022). In addition, this energy revolution has been facilitated by technological innovations across the globe, which helps incorporate the decarbonization agenda within firms, and investors are trying their best to shift toward the usage of energy driven technological advancements that can help design intelligent energy grids. Furthermore, this technological development has given rise to the usage of renewable energy, which ultimately enhances its adoption. This is why the current research has supported the incorporation of open innovations, which may be technological or in any other form, within the logistic firms, thus operating in various countries worldwide (Banelienė & Strazdas, 2023). Moreover, these open innovations are the key aspect behind renewable energy adoption, which will ensure the sustainability of logistic firms and the achievement of net zero carbon goals.

H3: *Open innovation significantly and positively influences renewable energy adoption.*

2.5. Manager's cognition of sustainable opportunities as a moderator

Managers play an essential role in shaping the policies and strategies within an organization, according to the demands of stakeholders, to enhance the firm's sustainability. The present study relies on this concept that managers' perceptions regarding sustainable opportunities, thus working within logistic firms, play a central role in enhancing sustainable logistics performance by implementing eco-friendly practices, which will eventually be favorable for renewable energy adoption. According to research by Helfat and Peteraf (2015), managerial cognitive capabilities refer to "the capability of a manager to perform one or more mental activities based on cognition" (Cao et al., 2020). In addition, this is also helpful in bringing innovations within organizations to achieve sustainability. In this modern business environment, the managers' decisions within any particular firm are checked by the stakeholders (Khavul & Bruton, 2013), which compels the company to focus on the concerns of stakeholders (Schaltenbrand et al., 2018). In addition, it has been observed that stakeholder pressure has a considerable and significant impact on a firm's decisions. The stakeholders exert significant pressure on applying and adopting renewable energy within logistic firms. Therefore, managers within logistic firms operating worldwide must be able to incorporate eco-friendly practices by availing various sustainable opportunities. This will ultimately and significantly moderate the nexus between stakeholder pressure and renewable energy adoption in logistics firms.

H4: *The manager's cognition of sustainable opportunities significantly moderates the relationship between stakeholder pressure and renewable energy adoption.*

Despite this, the decisions and policies thus formulated by the managers of logistic firms are highly dependent on their perspectives regarding sustainable opportunities. This cog-

nition will significantly enhance the adoption of renewable energy to achieve less energy consumption within the firm's processes by innovating the products, processes, and services thus manufactured by the firm. However, a sharp and effective manager's cognition of sustainable opportunities will significantly moderate the association between eco-innovation and renewable energy adoption (Tran-Thi-Thanh & Nguyen-Thi-Phuong, 2023).

H5: *The manager's cognition of sustainable opportunities significantly moderates the relationship between eco-innovation and renewable energy adoption.*

Top management, which is highly aware of environmental changes and their damages, can implement innovative strategies and technologies within the organization, enabling the company to allocate its internal responsibilities and incorporate the innovative strategy thus devised by the managerial staff (Cao & Chen, 2019). Therefore, the researcher has focused on the managers' cognition of sustainable opportunities within logistics firms because it will significantly moderate the correlation between open innovation and renewable energy adoption.

H6: *The manager's cognition significantly moderates the relationship between open innovation and renewable energy adoption.*

2.6. Competitive advantage as a moderator

Competitive advantage involves the factors that enable an organization to produce services and products better than its competitors. These competitive factors include cost structure, branding, product quality, customer service, distribution network, and intellectual property. In addition, it makes the products and services of an organization more desirable to the consumer within the local and global context. The researcher believes that the desire to be competitive within the logistics industry worldwide will significantly enhance renewable energy adoption by incorporating green, sustainable, and eco-friendly innovations within the firm, such as eco-innovations, open innovations (which may be technological innovations), and the pressure of stakeholder is also the reason behind the competency of any particular logistic firm.

According to research by Gupta and Agrawal (2018), it has been elaborated that various organizations are shaping their policies and strategies regarding the sustainability of their products and services according to the external knowledge regarding their stakeholders because it is necessary for the organization to work on the stakeholder demands (Liao & Tsai, 2019). Therefore, the logistics firms that are trying to achieve competency are focusing on the desires of stakeholders, and the stakeholder pressure will enable the company to bring eco-innovations that are responsible for enhancing the consumption of renewable energy resources within the firm, which are responsible for mitigating the energy consumption and carbon emission within the environment. This evidence the importance of competitive advantage as a moderator between eco-innovation, stakeholder pressure, and renewable energy adoption because the logistics firms that have the desire to achieve competency will significantly enhance the utilization of renewable energy as it is the demand of stakeholders by incorporating eco-innovations within the firm.

H7: *Competitive advantage significantly moderates the relationship between eco-innovation and renewable energy adoption.*

H8: *The relationship between stakeholder pressure and renewable energy adoption is significantly moderated by competitive advantage.*

Research has elaborated that when organizations work on the principle of open innovation, they focus on incorporating the most sustainable and eco-friendly innovations, which can enhance the quality of their product (Tsinopoulos et al., 2018). This will ultimately enhance the firm's adoption of renewable energy resources. However, this nexus between open innovation and renewable energy adoption is still dependent on the competitive nature of the firm. Therefore, competitive advantage considerably enhances the correlation between open innovations and renewable energy adoption.

H9: *Hence, it is proposed that competitive advantage significantly moderates the relationship between open innovation and renewable energy adoption.*

3. Methodology

3.1. Sample and data collection

The present study used a convenience sampling approach to collect data from Chinese logistic companies as it is considered an appropriate method to connect with firms accessible through corporate portals and online archives. Additionally, the practical challenges of random sampling create obstacles for researchers in gathering data from the vast and diverse logistics industry. Since there is an absence of a centralized database of logistics firms, convenience sampling is adequate for this study as it is well-aligned with prior literature, where managerial perspectives within the specific sectors were explored due to the need for targeted access.

In line with a quantitative and deductive approach, the data for this research was acquired via a questionnaire survey conducted among logistics companies in China. These companies are responsible for carrying out various logistics activities such as warehousing, transportation, inventory management, order processing, and packaging on behalf of their customers. China is considered a significant player in the global manufacturing hub, and therefore, the focus is on strengthening the logistics industry through energy-saving practices, innovation, and environmental strategies (Yu et al., 2023). The present study focused on targeting logistics companies in mainland China. For this purpose, the researcher utilized company websites and online databases to draw a sample of 100 logistic companies.

The researcher contacted 500 managers from the logistics companies through the company website. The managers were provided with information about the research project and its agenda. The researcher invited the managers to participate by completing an online survey. The managers were notified of the ethical considerations that would be upheld during the research process. Data confidentiality and participants' privacy would be prioritized.

Following the approach of Ali et al. (2019), informed consent was obtained from the managers, and only when the managers showed their willingness to participate was an online

survey link shared with the participants. In order to increase the response rate, two reminders were sent after two weeks. The researcher relied on the guide by Weston and Gore (2006) and aimed to obtain a minimum sample of 200 respondents. The logistics department was chosen due to its increasing focus on innovation and environmental practices (Amling & Daugherty, 2020). Of the 500 questionnaires distributed via the survey link, 412 were returned. Nevertheless, 100 questionnaires were discarded and excluded from the sample due to insufficient information. The final sample comprised 312 respondents.

Before collecting the primary data, a pilot survey was carried out with 20 firms to confirm that logistics industry managers could comprehend the questionnaire. No significant issue was reported by any manager while attempting the questionnaire, according to the pilot study's findings. In addition, the survey questionnaire was also reviewed by three university professors and two logistics company managers to improve the items' precision. The respondents' official language was Chinese; therefore, the English questionnaire was translated. The validity of the translated version was established with the support of three Chinese bilingual instructors.

3.2. Measures of constructs

The main variables incorporated in the study framework include environmental innovation, stakeholder innovation, and open innovation, which are the three independent variables (see Appendix). Five items were used to measure the adoption of renewable energy adapted from Wall et al. (2021) and modified as per the context of the present study. Based on previous research, Adomako and Tran (2022) utilized six items to measure stakeholder pressure (Shubham et al., 2018). The present study adopted the six items from Adomako and Tran (2022) to measure the construct. Six items were adopted from the research study by Al-Belushi et al. (2018) to evaluate open innovation. The adaptation of Cai and Li (2018) based on the scale of Chen et al. (2006) was utilized, and five items were adopted to measure environmental innovation. Four items were adopted from the study of Xu et al. (2022), inspired by the previous studies of Liu et al. (2013b) and White et al. (2003), to measure manager's cognition of sustainable opportunities. A total of six items were utilized from Chang's scale (2011), which was based on previous studies, to measure competitive advantage (Barney, 1991; Coyne, 1986; Porter & Van der Linde, 1995).

3.3. Data analysis

The data analysis was divided into two parts, where descriptive analysis and data screening tests were performed using SPSS in the first phase. In the second part, the researcher intended to evaluate the hypotheses. The sample size 304 was sufficient to perform structural equation modeling (SEM), as suggested by prior scholars (Weston & Gore, 2006). AMOS 24.0 was utilized for the discussion on measurement and structural model. Various indicators were utilized to show the model's fitness. SEM is a robust technique for complicated models with an interaction term (Collier, 2020). Therefore, hypotheses were investigated using SEM, and conclusions were drawn based on the p-value and standardized regression coefficients.

4. Results

4.1. Profile of respondents

The present research aimed to collect data from employees of Chinese Logistic companies. After the data cleaning, there were 312 questionnaires finalized for data analysis. When data were analyzed, the first test was performed to assess the demographic characteristics of respondents. For this purpose, the age, gender, and working experience of employees were assessed. Among 312 employees, 136 had an experience of 2 to 5 years, and 104 had a sufficient experience of 5 to 8 years. Although some new employees joined the company two years ago, thirty-five senior employees have over eight years of experience.

Table 1. Demographics profile

Gender		
	Frequency	Per cent
Male	163	11.9
Female	149	43.6
Working experience		
	Frequency	Per cent
Less than 2 Years	37	11.9
2 to 5 years	136	43.6
5 to 8 years	104	33.3
More Than 8 years	35	11.2
Age		
	Frequency	Per cent
21–30 years	75	24.0
31–40 years	91	29.2
41–50 years	97	31.1
More than 50 years	49	15.7
Total	312	100.0

Table 1 also presents the age summary of respondents. It is evident from the results that 97 employees aged 41–50 were retained by the logistics company. Similarly, 75 employees were aged between 21 and 30, 91 were between 31 and 40, and 49 were older than 50. Diversity was observed regarding the age distribution of respondents. Moreover, gender distribution was assessed among 312 respondents. As specified in Table 1, out of 312 respondents, 163 were male and 149 were female respondents, with a frequency of 52.2 and 47.8, respectively. It showed that Chinese logistics companies recruit male employees significantly more than female employees.

4.2. Descriptive statistics

Table 2 presents the descriptive summary of variables. The outlined minimum and maximum values suggest that there is no outlier issue within dataset. It is due to observed ranges that

are well aligned with the threshold set by instrument scale. In addition, normality of data is also confirmed as values of skewness are within range (–1 to +1). The average value of eco-innovation suggests that participants favoured the adoption of renewable adoption, however, a slightly negative skewness value highlights that responses were generally concentrated on upper end of scale. Open innovation also followed the similar trend, suggesting that most of the respondents perceived open innovation in a positive manner. In case of stakeholder pressure, distribution seems to be balanced based on skewness value where mean value suggests the consistency among responses. On the other hand, perspective of respondents toward competitive advantage is lower compared to other constructs. Whereas, the moderate agreement can be seen through RE adoption mean and standard deviation values. Lastly, in case of MOSC, fair distribution pattern can be seen due to positive skewness value.

Table 2. Descriptive summary

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
ECO	312	1.00	5.00	3.5216	1.06884	–0.700	0.138
OP	312	1.00	5.00	3.4994	1.09439	–0.684	0.138
SP	312	1.00	5.00	3.4974	0.93781	–0.485	0.138
MOSC	312	1.00	5.00	3.4159	1.06743	–0.238	0.138
CA	312	1.00	5.00	2.8397	1.08832	0.212	0.138
RE	312	1.00	5.00	3.2821	1.12519	–0.274	0.138

Notes: ECO – Eco-innovation, SP – Stakeholder pressure, OP – Open innovation, MOSC – Manager's cognition of sustainable opportunities, CA – Competitive advantage, RE – Renewable Energy Adoption.

4.3. Reliability and validity tests

A series of tests were performed to assess validity and reliability, including the KMO and Bartlett test (see Table 3), factor loadings, and validity test by construct validity. Table 3 shows the results for sample adequacy through the KMO and Bartlett test. The resultant value of this test was .906, which ascertained that the sample was adequate. Through this test, whether the sample for the study was adequate, corresponding to the number of variables selected, was studied. The significant results of this test indicated that factor loading would yield significant results.

The next test assessed the significant factor loadings by attaining the "rotated component matrix." Table 4 presents the results of factor loading for the measurement model. Each variable's item has been loaded in an individual column, indicating no cross-loading or duplication of values. Furthermore, no identity matrix was formulated, indicating a stronger correlation among variables. Factor analysis results were also obtained to be significant.

Validity testing was the next step to assess the measurement model's construct validity. The internal consistency of variables was studied through CR and AVE and reported through "Convergent Validity." CR values threshold range are assumed to be significant if greater than 0.7; for AVE, these values must be greater than 0.5. Table 5 shows that both AVE and CR meet the threshold criteria, so internal consistency in the measurement model is established.

Table 3. KMO & Bartlett test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.906
Bartlett's Test of Sphericity	Approx. Chi-Square	6531.484
	Df	351
	Sig.	0.000

Table 4. RCM results

	1	2	3	4	5	6
ECO1	0.705					
ECO2	0.737					
ECO3	0.801					
ECO4	0.763					
OP1						0.565
OP2						0.603
OP3						0.608
OP4						0.685
OP5						0.670
SP1					0.800	
SP2					0.848	
SP3					0.833	
SP4					0.824	
SP5					0.858	
MOSC1			0.733			
MOSC2			0.782			
MOSC3			0.811			
MOSC4			0.769			
CA1				0.628		
CA2				0.585		
CA3				0.915		
CA4				0.907		
RE1		0.660				
RE2		0.730				
RE3		0.787				
RE4		0.692				
RE5		0.618				

Notes: ECO – Eco-innovation, SP – Stakeholder pressure, OP – Open innovation, MOSC – Manager's cognition of sustainable opportunities, CA – Competitive advantage, RE – Renewable Energy Adoption.

Discriminant validity was also assessed to investigate those variables that are not related theoretically and are, in fact, not correlated. Table 5 demonstrated that the "inter-construct correlation" was smaller than "intra-variable correlations." The diagonal form of Table 5 showed the establishment of discriminant validity in the measurement model. As the KMO and Bartlett test, factor loadings, and construct validity provided significant results, it is evident that the sample size was accurate, variables inter-associations are significant, and the constructs are valid and reliable.

Table 5. Validity results "Discriminant and convergent validity"

	CR	AVE	MSV	MaxR(H)	ECO	RE	MOSC	CA	SP	OP
ECO	0.903	0.699	0.639	0.906	0.836					
RE	0.896	0.633	0.597	0.904	0.722***	0.796				
MOSC	0.903	0.698	0.474	0.905	0.616***	0.688***	0.836			
CA	0.813	0.566	0.074	1.001	0.233***	0.141*	0.178**	0.752		
SP	0.791	0.453	0.277	0.855	0.526***	0.490***	0.464***	0.235***	0.673	
OP	0.905	0.657	0.639	0.907	0.800***	0.773***	0.629***	0.273***	0.522***	0.811

Notes: ECO – Eco-innovation, SP – Stakeholder pressure, OP – Open innovation, MOSC – Manager's cognition of sustainable opportunities, CA – Competitive advantage, RE – Renewable Energy Adoption.

4.4. Goodness of fit

The model's fitness was measured through the evaluation of several fitness indices. The researcher computed CMIN/df, GFI, CFI, IFI, and RMSEA to assess the measurement model's fitness. The threshold and observed values against each index are shown in Table 6. It can be observed that the measurement model was fit, and all five indices computed values corresponding to the threshold limit. Therefore, the measurement model was fit, and structural equation modeling can be projected to yield significant results.

Table 6. Model fitness indices

	Threshold ranges	Observed values
CMIN/df	≤3	3.006
GFI	≥0.80	0.817
IFI	≥0.90	0.904
CFI	≥0.90	0.903
RMSEA	≤0.08	0.08

4.5. Hypothesis testing (SEM results for direct effects)

The hypothesized associations were tested through structural equation modelling. Table 7 shows that the hypothesis for the first association has been accepted. A one-unit increase in ECO influences RE with .252 units with a p-value of .009, which declares that the hypothesis has been accepted. Similarly, a one-unit increase in OP impacts RE with .440 units with a p-value of .012, which means that the association between OP and RE has also been accepted. The third association was also significant between SP and RE with a p-value of .018. Therefore, table 7 shows that all direct hypotheses were accepted (see Figure 3 and 4).

Moderation of MOSC and CA was also investigated in the measurement model. Table 8 shows that MOSC is a significant moderator between OP and RE, with a p-value of .051. However, CA resulted in being an insignificant moderator between OP and RE. The p-value for these moderations was .962, declaring that the hypothesis had been rejected.

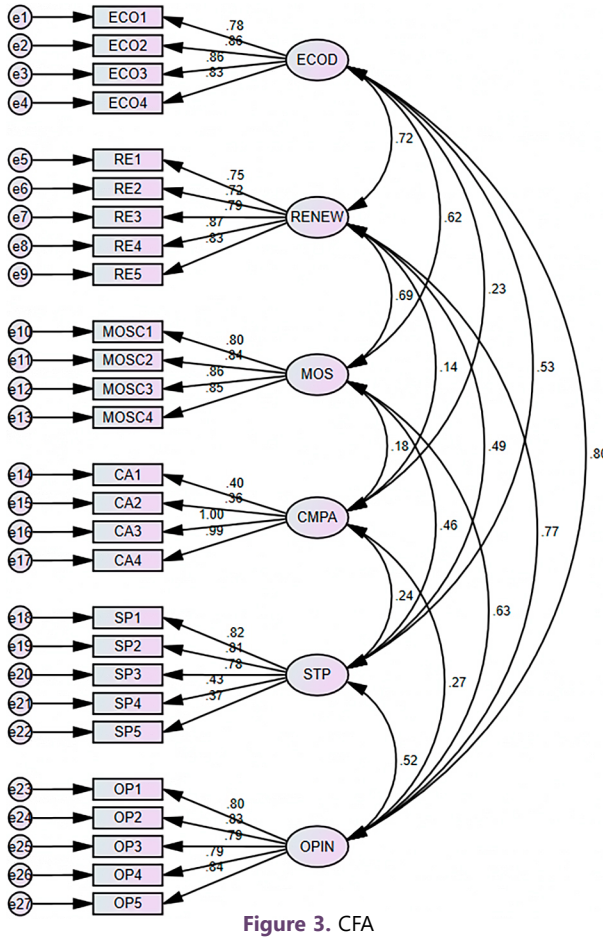

Figure 3. CFA

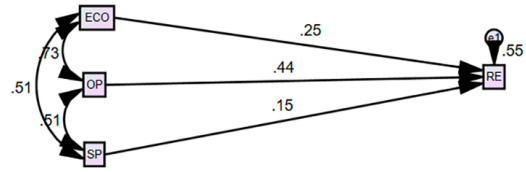

Figure 4. SEM

Table 7. Direct associations tested through SEM

Parameter	Estimate	Lower	Upper	P
RE <--- ECO	0.252	0.131	0.382	0.009
RE <--- OP	0.440	0.280	0.571	0.012
RE <--- SP	0.150	0.066	0.231	0.018

Notes: ECO – Eco-innovation, SP – Stakeholder pressure, OP – Open innovation, MOSC – Manager's cognition of sustainable opportunities, CA – Competitive advantage, RE – Renewable Energy Adoption.

Table 8. Moderation of MOSC and CA

Relationship	Estimate	UL	UB	P-value	Decision
RE <--- OP*CA	0.030	–0.507	0.432	0.962	Not significant
RE <--- OP*MOSC	0.476	0.049	0.950	0.051	Significant
RE <--- SP*MOSC	0.021	–0.188	0.209	0.884	Not significant
RE <--- SP*CA	–0.008	–0.208	0.159	0.880	Not significant
RE <--- ECO*MOSC	0.249	0.142	0.613	0.042	Significant
RE <--- ECO*CA	–0.012	–0.360	0.370	0.887	Not significant

Notes: ECO – Eco-innovation, SP – Stakeholder pressure, OP – Open innovation, MOSC – Manager's cognition of sustainable opportunities, CA – Competitive advantage, RE – Renewable Energy Adoption.

The moderation of MOSC between SP and RE has also been rejected with a p-value of .884. Moderation of CA between SP and RE has also been rejected with a p-value of .880. The moderating role of MOSC between ECO and RE has been accepted, and MOSC has resulted as a significant moderator between ECO and RE. The last moderation of CA between ECO and RE has also resulted in insignificant results with a p-value of .887. So, after SEM results for moderation, MOSC has only once resulted as a significant moderator. Other than this, the moderation of CA has been insignificant.

5. Discussion

The findings revealed that Eco-innovation, open innovation, and stakeholder pressure significantly and positively influence renewable energy adoption. This research shows that businesses are more inclined to adopt renewable energy options if they prioritize and invest in eco-innovation practices, such as creating cleaner and more energy-efficient products. It emphasizes how crucial it is to incorporate sustainability objectives and environmental concerns into the innovation process to accelerate the widespread use of renewable energy sources. Businesses collaborating with external stakeholders through collaboration, knowledge exchange, and collaborative development are more likely to use renewable energy sources. This research indicates that when businesses decide to implement renewable energy solutions, they are attentive to the needs and expectations of numerous stakeholders, including governmental organizations, consumers, and communities. It emphasizes how crucial it is to match company strategies with stakeholder needs and sustainability standards. According to Li et al. (2020), green investments in R&D produce technological advancements related to the environment that assist economies in shifting to REC sources. Enhanced technological development would result in a reduction in China's carbon footprint. These findings are supported by Li et al. (2020), who said that stakeholder pressure significantly impacts manufacturing companies' green practices. Stakeholders evaluate businesses to ensure they adhere to environmental standards and integrate sustainable development into their corporate cultures to produce sustainable learning for societies while utilizing the social method of knowledge mobilization (Singh et al., 2022).

According to the research, MOSC impacts how open innovation and the adoption of renewable energy technology are related. This conclusion implies that managers are more likely to use open innovation practices to promote the adoption of renewable energy solutions if they have a strong understanding and consciousness of the potential advantages and possibilities related to sustainability. It has been suggested by Cao et al. (2020) that a manager's cognitive capability is a significant element affecting how businesses make strategic adjustments and adapt to changing surroundings. Managers with a deep understanding of sustainable potential are more likely to support open innovation projects promoting renewable energy technology with resources like money and human capital. Yang et al. (2019) have found a favorable correlation between managers' perceptions of social and corporate challenges and their emphasis on proactive environmental planning, which supports the growth of innovative capabilities.

6. Conclusions

This research study examined the nexus between environmental innovation, stakeholder pressure, open innovation, and renewable energy adoption in Chinese Logistics Firms. Moreover, the research study also analyzed the moderating effect of managers' cognition of sustainable opportunities and competitive advantage. The data needed for this study was gathered by a questionnaire survey conducted among logistics organizations in China in keeping with a quantitative and deductive strategy. The target of the current investigation was mainland Chinese logistics firms. In order to accomplish this, the researcher used online databases and corporate websites to compile a sample of 100 logistic companies. The sample size was 304. According to the results, Eco-innovation, open innovation, and stakeholder pressure significantly and positively influence renewable energy adoption. Whereas MOSC was a significant moderator between OP and RE and ECO and RE, CA was an insignificant moderator between OP and RE. The moderation of MOSC between SP and RE and the moderation of CA between SP and RE were rejected.

7. Implications

7.1. Practical implications

The environment is another primary concern for China, a rapidly industrializing nation. Although the government has implemented an in-depth environmental policy, it still needs incentives for businesses that adhere to environmental norms to motivate other businesses to do the same and make EI a crucial component of their business plan. Eco-innovation ahead of rivals can deliver business managers not just improved productivity and decreased cost. However, it has an edge over rivals and an improved image as environmental challenges attract increasing stakeholder interest. By creating creative platforms, offering subsidies,

and simplifying organizational collaboration, public policy could encourage enterprises' resource-building and reconfiguring, which enhances environmental capabilities.

The results of this study can help Chinese logistics companies understand how critical it is to pursue environmental innovation strategies. It draws attention to the beneficial link between environmental innovation and the uptake of renewable energy, encouraging businesses to invest in sustainable practices and technologies. The study strongly emphasizes how stakeholder pressure influences processes for making sustainable decisions. It advises logistics companies on how crucial it is to interact with groups of stakeholders, including government agencies, clients, and communities, to align their operations with sustainability objectives and legal requirements.

Numerous Chinese businesses have come to understand how crucial it is to implement a green innovation strategy in order to address pressing environmental issues and the nation's severe environmental restrictions. Businesses are currently putting environmental protection strategies into practice. The study's findings can provide helpful information to Chinese regulators and policymakers. It emphasizes the relationship between adopting renewable energy, open innovation, stakeholder pressure, and environmental innovation, which can guide the creation of regulations and subsidies that support sustainability in the logistics industry. Research has highlighted the importance of stakeholder pressure in promoting EIN, which motivates researchers to consider how external forces may affect businesses' proactive environmental policies and sustainable development practices.

7.2. Theoretical implications

This study looks into how renewable energy adoption and environmental innovation are related to Chinese logistics companies. The results help interpret how environmental innovation practices affect businesses' interest in implementing renewable energy sources. The study contributes to environmental innovation by enhancing our comprehension of its causes. Even if there have been studies of EIN from various angles, there are few. The intrinsic motivation of enterprises to adopt EIN has not been adequately studied empirically. Theoretical implications can improve the knowledge of how stakeholder pressures, like governmental rules and public demands, affect businesses' decisions regarding renewable energy sources.

Thus, research done in developed economies could not accurately represent the situation in developing economies. In the setting of China's developing economy, this research examines these problems. This study adds to the theory of open innovation by examining the relationship between open innovation and environmental sustainability and its possible influence on encouraging sustainable practices in logistics companies. It explains how working together and exchanging expertise with outside partners can speed up the implementation of renewable energy technologies. Findings from the research improve the body of knowledge in green innovation and sustainable consumption. The study's results strengthen the claims made in the literature about how stakeholders pressurize businesses to implement green initiatives to remain current and viable in their respective industries.

The study looks at how managers interpret the potential for sustainability and competitive advantage concerning the uptake of renewable energy sources. Theoretical implications can

advance the comprehension of the cognitive mechanisms that affect managers' choices regarding strategy and decision-making processes concerning sustainable practices. The study offers theoretical understandings that can direct future research and assist in creating more successful tactics and regulations to encourage sustainability in the logistics sector.

7.3. Limitations

This research adds to the body of literature but has several limitations. First, as the sample only includes Chinese businesses, future research must examine how EIN implementation varies internationally. This study uses cross-sectional survey data, a method that is often used in business research. Nevertheless, future studies might use a longitudinal dataset to offer additional insight into the emergence of capabilities and their influence on environmental innovation because firms continually grow and alter their ability to innovate in response to ecological alterations. Future studies might explore the interactions or causal connections between additional factors that promote environmental innovations.

7.4. Future directions

Comparing the results of Chinese logistics companies with those of companies from other nations or areas might provide insightful comparisons. Future studies may expand on the precise technological innovations and methods Chinese logistics companies use to switch to renewable energy technologies. It will become evident with more research into stakeholder involvement and cooperation patterns in how logistics companies can effectively handle and address stakeholder pressures. Future studies could use longitudinal data to examine long-term company circumstances and operations patterns. The data is primarily self-evaluated. Although the respondents' opinions on stakeholder pressure and environmental innovation could be fair and trustworthy, the assessment of company efficiency should be enhanced.

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APPENDIX

Table A1. Scale

Item no.	Item	Adapted from	Source
	Open Innovation	Al-Belushi et al. (2018)	
1	New opportunities as new products and/or services/ process.		
2	We have been able to create more value because the new products and services jointly developed by us have opened up new market opportunities and expanded our customer base.		
3	We thoroughly collect industry information and new technologies.		
4	Our firm has used the new ideas and skills acquired from the partner to create value by improving its products and services.		
5	Our firm has used the knowledge gained about technology from the alliance experience to improve our technology.		
6	Within the alliance boundary, this alliance has led to more efficient deployment and utilization of resources leading to continuous improvement of the quality of products.		
	Stakeholder pressure	Adomako and Tran (2022)	Shubham et al. (2018)
1	Government/regulators put pressure on our company to pursue sustainable environmental practices.		
2	Customers/suppliers put pressure on our company to pursue sustainable environmental practices.		
3	There are pressures on our company from employees to embark on sustainable environmental practices.		
4	Competitors put pressure on our company to pursue sustainable environmental practices.		
5	Nongovernmental organizations/activists put pressure on our company to pursue sustainable environmental practices.		
6	The media put pressure on your company to pursue sustainable environmental practices.		
	Environmental innovation	Cai and Li (2018)	Chen et al. (2006)
1	Low energy consumption such as water, electricity, gas, and petrol during production/use/disposal.		
2	Recycle, reuse, and remanufacture material.		
3	Use of cleaner technology to create savings and prevent pollution.		
4	The manufacturing process of our firm effectively reduces the emissions of hazardous substances and waste.		
5	The manufacturing process of our firm reduces the use of raw materials.		
	MCSO	Xu et al. (2022)	Liu et al. (2013a), White et al. (2003)
1	I describe the overall natural and social environments confronting the company as opportunities for it.		
2	For the development of this company, I think confronting natural and social environments is positive.		
3	I have perceived the amazing promotion of natural and social environmental conditions for the future of the company.		
4	I think the natural and social environments confronting the company are controllable.		

End of Table A1

Item no.	Item	Adapted from	Source
	Competitive Advantage	Chang (2011)	Barney (1991), Coyne (1986), Porter and Van der Linde (1995)
1	The quality of the products or services that the company offers is better than that of the competitor's products or services.		
2	The company is more capable of R&D than the competitors.		
3	The company has better managerial capability than the competitors.		
4	The company's profitability is better.		
5	The corporate image of the company is better than that of the competitors.		
6	The competitors are difficult to take the place of the company's competitive advantage.		
	Renewable Energy Adoption	Wall et al. (2021)	Liu et al. (2013a)
1	We have the intention to adopt renewable energy.		
2	The energy-saving behaviour encourage us to adopt renewable energy.		
3	We are willing to be renewable energy adoption ambassador.		
4	We have the intention to spend more on renewable energy than other sources of energy,		
5	We strongly recommend others to adopt renewable energy		