

## Trade liberalization and green supply chains: impacts on sustainability and energy transition

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**Annotation.** Global economic integration and sustainability challenges underscore the need to examine trade liberalization, green supply chains, and energy transitions. Using a mixed-methods framework, this study addresses the limitations associated with single-method approaches, combining thematic qualitative analysis with quantitative correlation analysis. Data were gathered from 427 participants in Chengdu, encompassing surveys and 30 semi-structured interviews. The mixed-method approach offers a more reliable assessment of policy effectiveness. Notably, this method combines quantitative analysis with real-world market insights. The study results highlight that both trade liberalization and governmental policy measures result in higher adoption of eco-friendly supply chains and energy transition efforts. Hence, the study findings put forward practical guidance to policymakers and industrial stakeholders to develop successful sustainability programs that will help advance sustainable economic growth. Based on this, policymakers must enhance regulatory frameworks and incentives for green technologies, while industries should proactively adopt flexible and sustainable supply chain strategies, in order to support long-term competitiveness and environmental performance.

**Keywords:** Trade liberalization; Sustainability; Policy interventions; Mixed-method approach; Green supply chain

**JEL classification:** F18, Q56, Q42, O44.

## Introduction

Trade liberalization, changing trade barriers, and global trade regulations that control goods and services and capital movement constitute the key elements that shape the present-day global economy (Mirzaye *et al.*, 2025). Meanwhile, the industrial changes that take place due to these factors produce new competitiveness conditions for markets while developing global value networks that connect emerging economies with established markets (Gawusu *et al.*, 2022; Gereffi *et al.*, 2021). The world is switching from fossil fuels to renewable energy solutions which leads to both economic development and environmental sustainability benefits (Kabeyi *et al.*, 2022). Specifically, the need for policymakers to balance between economic growth and environmental conservation stems from the need to determine how trade liberalization and green supply chains and energy transition interact with each other (Batra, 2023).

Noticeably, the interaction of these factors generates an interdisciplinary policy domain where trade policy, technological innovation, and environmental sustainability must be addressed concurrently (Leal-Arcas *et al.*, 2024). Such a perspective supports the development of effective policy interventions while also uncovering the trade-offs between rapid economic growth and long-term environmental sustainability, thereby, stressing the need for global cooperation (Capano, Howlett 2021). Moreover, trade liberalization and green supply chain practices extend opportunities to optimize a wide range of sectors, including energy-intensive and manufacturing industries (Valiyeva, & Garashli 2025; Pathiranage, 2024). Increasingly, organizations employ eco-friendly supply chain practices worldwide to realize three fundamental goals, which consist of resource conservation, pollution reduction, and global environmental standards compliance (Gholami *et al.*, 2022).

Cima & Esty (2024) and Baah *et al.* (2022) highlight that regulatory bodies use renewable energy subsidies and carbon tariffs as potential tools to link trade to ecological effect to realize sustainable development. In particular, international trade agreements support international renewable energy projects, which allow countries move towards sustainable energy solutions (Deed *et al.*, 2025). Therefore, the present connections between trade liberalization and green supply chains and worldwide market systems must be comprehended to propose effective ecological and economic strategies (Yu *et al.*, 2021). Evidently, policy-driven methods have the power to not only attract investments but also create green job opportunities while pacing up the establishment of low-carbon energy systems (Pasqualino *et al.*, 2024; Eicke *et al.*, 2022).

The extant studies on trade liberalization and sustainability has not examined their combined effects with policy interventions and global market dynamics (Deed *et al.*, 2025; Gholami *et al.*, 2022; Baah *et al.*, 2022). Thus, this research studies how trade liberalization and policy measures and market forces influence green supply chain implementation and energy transition outcomes. Accordingly, the researchers point out that sustainability outcomes improve through trade liberalization and policy interventions while green supply chain implementation demonstrates decreased effectiveness due to global market dynamics. Consequently, this study examines three key research questions; (1) how trade liberalization impacts international trade relationships; (2) how policy measures affect these effects; (3) how global market trends create additional influence. Accordingly, this study postulated different hypotheses which tested two core research elements: the positive influences of trade liberalization and policy measures, and the connection between green supply chain practices and environmental sustainability results.

- ❖ **RQ1:** How does trade liberalization affect the adoption of green supply chain practices among business enterprises?
- ❖ **RQ2:** What role do policy interventions play in promoting sustainable economic growth and energy transition?
- ❖ **RQ3:** How do global market dynamics influence the effectiveness of green supply chains in different industries?
- ❖ **RQ4:** What is the relationship between trade liberalization, green supply chain adoption, and environmental sustainability outcomes?
- ❖ **H1:** Trade liberalization positively affects the adoption of green supply chain practices among firms.
- ❖ **H2:** Policy interventions exert a positive impact on sustainable economic growth and energy transition.
- ❖ **H3:** Global market dynamics (competition, trade regulations, and consumer demand) moderate the effectiveness of green supply chain implementation.
- ❖ **H4:** There existence a positive association between green supply chain adoption and environmental sustainability outcomes.

This study is organized as follows: Section 1 introduces the study. Afterward, Section 2 reviews the extant literature and research frameworks. Subsequently, Section 2 outlines the theoretical relationships between trade policies, openness, and sustainability outcomes. Thereafter, Section 3 details out the research methodology, including the conceptual framework, Chengdu-based survey, and analytical techniques. Thereafter, Section 4 presents results and discussion. Lastly, Section 5 concludes the study findings and points out future research directions.

## **2. Literature Review**

Reportedly, Wang *et al.* (2025) explored the value chain upgrading and its feedback loop, and indicated that improved local value creation accelerates further ambitious renewable energy policies through green growth to fully develop a strengthening, thereby, reinforcing feedback loop. Parallel to this, Mamadiyarov *et al.* (2025) examined the interactions between green growth policies and renewable energy policies with fully described feedback loops and upgrading with value chains. The socio-economic actors of the value chain are established as stakeholder actors of the energy transitions of energy systems.

Furthermore, Sart *et al.* (2025) investigated the scope and introduced the Kernel Recursive Least Squares (KRLS) estimation and prediction models. They intended to understand the demand on the global supply chain and how it impacts the regional energy diversification. Zhang *et al.* (2024) on analyzed the digital supply chains and university English instruction, and confirmed the green economy expansion. Besides, Li (2020) ascertained how technology and linguistic skills support global communication through digital supply chains in university English education. This also highlights the role of skilled human resources in advancing a green economy. Additionally, Zhou *et al.* (2023) analyzed the Central Asia region to study how the transition of trade structure changes the energy performance, especially through the diversification of imports.

Although renewable energy and technology transfer support sustainability, environmental advancement may be hindered by industrial expansion (Zhou *et al.*, 2023). Moreover, Gast *et al.* (2024) investigated the impact of trade liberalization on medical supply chains. They discovered that increased competition and reduced trade barriers lower costs, thus, increasing the accessibility and affordability of essential

medicines and technologies. In addition to this, Bu et al. (2024) exposed how uneven global access to renewable energy shapes green value chains. Their study implications accentuated the global cooperation and adaptable technologies for balanced and sustainable industrial transformation. Likewise, Wang (2024) scrutinized supply chain management and digital financial inclusion, exhibiting that digital banking supports innovation, resilience, and financial access, consequently fostering sustainable economic growth as well as competitiveness.

Qi (2024) established that the integration of energy efficiency measures considerably reduces emissions in the long run by promoting cleaner technologies and sustainable practices although trade liberalization initially increases carbon emissions due to industrial expansion. On the same note, Pham (2024) posited that effective governance is essential for aligning trade policies with sustainability goals. These research implications highlight that both technological advancement and institutional quality play a vital role in lowering environmental degradation. Further, Wang *et al.* (2024) scrutinized the influences of trade openness on environmental quality, and concluded that increased trade can result in ecological degradation in emerging economies with weak regulatory bodies.

The current literature on trade liberalization, green supply chains, energy transition analyze these three areas independently without combining them to investigate how governmental policies and global markets impact sustainability outcomes (Wang & He, 2024). Prior studies reflect that trade openness promotes technology transfer and sustainable development, but its environmental effects remain uncertain, particularly in developing nations where enforcement of ecological regulations differs substantially (Pham, Nguyen, 2024; Wang *et al.*, 2024). Public policy must comprehend how market forces work in conjunction with government rules and financial rewards (Tirole, 2015). Hence, the research gap requires researchers to identify all factors that influence sustainability outcomes through their examination of trade liberalization, policy interventions, and global market behavior. Accordingly, this study attempts to address this gap by using a mixed-method approach to generate a rigorous analytical framework.

***H1: Trade liberalization positively affects the adoption of green supply chain practices among firms.***

Prominently, trade liberalization reduces trade obstacles, offering business organizations access to resources, new technology, and global best practices (Yan *et al.*, 2023). Green trade standards give firms a competitive advantage by promoting efficiency in resource use, waste reduction, and sustainable sourcing.

***H2: Policy interventions demonstrate a positive impact on sustainable economic growth and energy transition.***

Various policy interventions such as carbon taxes, ecological policy support, and subsidies on renewable energy lower regulatory and financial burdens, promoting investment in green infrastructure and clean energy (Yan *et al.*, 2023).

***H3: Global market dynamics (competition, consumer demand, and trade regulations) moderate the effectiveness of green supply chain implementation.***

Noticeably, global market factors, such as competition, international trade regulations, and consumer preference for sustainable products, hinder the efficient implementation of corporate green supply chains. Within a fiercely competitive marketplace, corporations are motivated to implement green practices to not only stand out from their rivals but also secure a distinct market share (Letunovska *et al.*,

2023). In certain, the consumers' demand for sustainable products drives enterprises to manufacture eco-friendly commodities and incorporate eco-friendly approaches.

**H4: There is a positive relationship between green supply chain adoption and environmental sustainability outcomes.**

Tetteh et al. (2025) suggest that green supply chain practices encompass different activities including waste reduction, efficient logistic, and sustainable sourcing, jointly fostering desired ecological outcomes. Meanwhile, enterprises that integrate eco-friendly processes limit pollution, reduce carbon emissions, and minimize resource consumption.

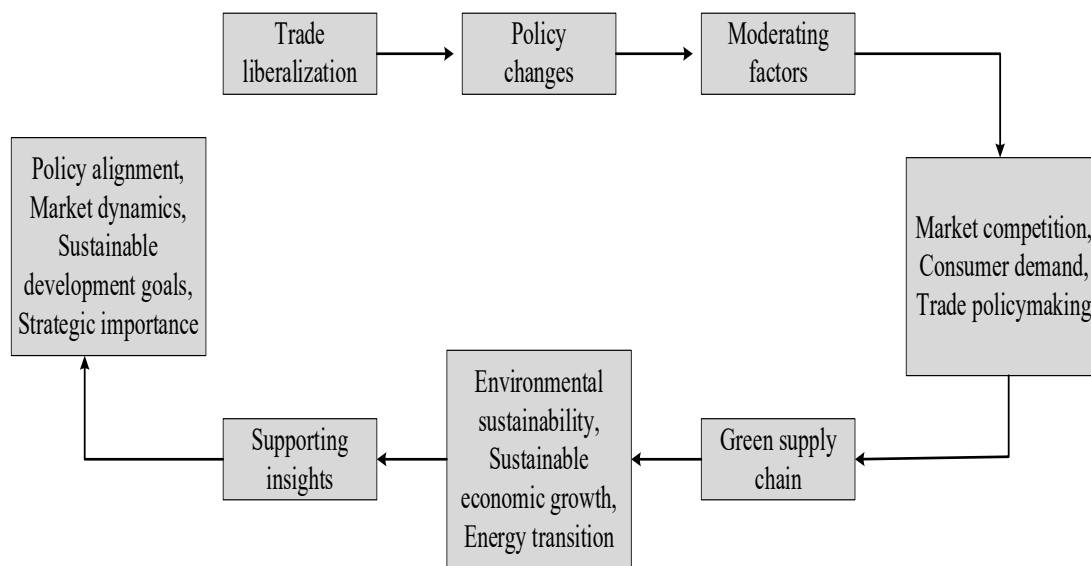
**1.1 Problem Statement**

A radical disruption of supply chains is caused by trade liberalization, creating a need to develop new sustainability approaches (Sandul, 2023). In exchange for greater openness to trade, a country has the benefit of new technology and competitive advantages, but it must address related ecological challenges (Liu et al., 2021; Rapson & Muehlegger, 2023). Certainly, state policy and the sustainability of a country's low-carbon development and sustainable economic growth are closely related, despite the growing focus on sustainable supply chains (Ngo et al., 2024).

**3. Methods and Data**

**3.1 The Study Purpose and Conceptual Model**

This paper analyses how trade liberalization and policies affect green supply chains in emerging economies. A model is proposed where these factors drive adoption, with market forces as moderators.



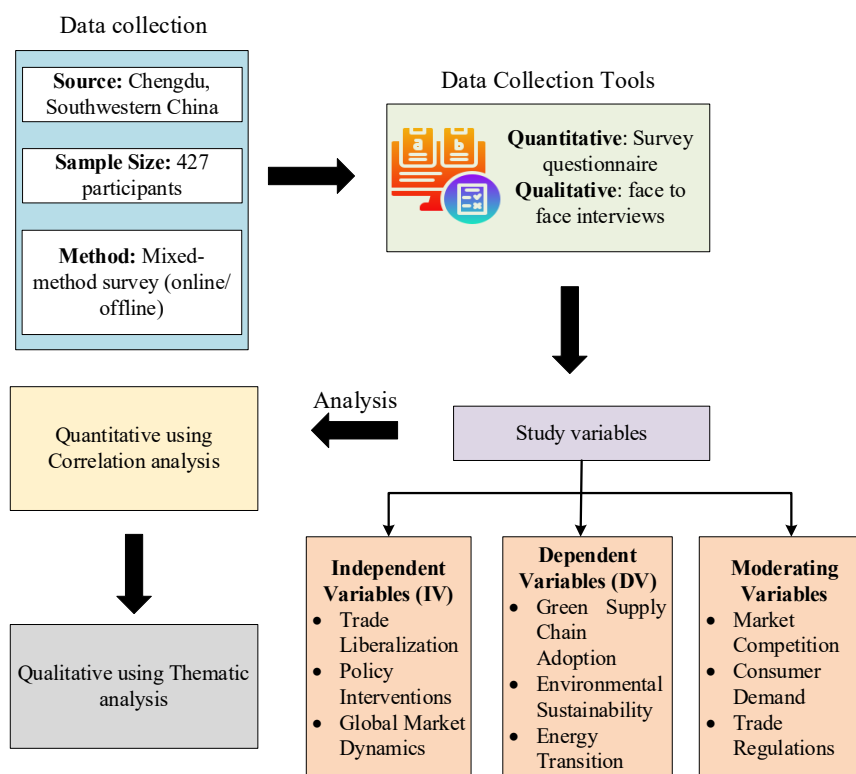
Source: Created by the authors.

Figure 1. Conceptual Framework for Trade Liberalization, Green Supply Chains, and Policy for Sustainable Energy Transition

The framework is shown in Figure 1.

### 3.2 Methods

A mixed-method approach is used in this study, combining surveys and interviews with 427 participants in Chengdu. This study examines how trade liberalization, policies, and market dynamics affect green supply chains and sustainability outcomes. Accordingly, quantitative Likert-scale data are supported by qualitative insights from open-ended responses. Furthermore, the mixed-method approach is apprehended due to the complex and multidimensional nature of the research problem involving trade, policy, and sustainability interactions. A purely quantitative approach can identify statistical relationships but cannot capture contextual insights and stakeholder perceptions. Nevertheless, the qualitative component offers an in-depth comprehension of real-world experiences and underlying mechanisms. As a result, combining both approaches augment the validity and reliability of study findings. Hence, the integrated method provides a more holistic and comprehensive analysis than a single-method approach to gain an in-depth comprehension of the sustainable economic growth frameworks.



Source: Created by the authors.

Figure 2. Overall Framework for Proposed Research

Figure 2 shows the overall diagram of proposed method.

### 3.3 Data Collection

Using online and offline surveys, data were collected from 427 professionals, managers, and policy actors in Chengdu. Table 1 represents the summary of data collection.

**Table 1. Details of Data Collection and Participant Engagement**

Component	Description
<b>Sample Size</b>	427 participants
<b>Participant Type</b>	Professionals, managers, and policy actors
<b>Location</b>	Chengdu, Southwestern China
<b>Survey Method</b>	Structured survey conducted both online and offline
<b>Questionnaire Type</b>	Mixed-method: quantitative (Likert-scale) and qualitative (open-ended)
<b>Quantitative Data</b>	Captured perceptions, practices, and attitudes on trade liberalization, green supply chain adoption, and energy transition
<b>Qualitative Data</b>	Collected views on policy effectiveness and global market dynamics
<b>Participant Recruitment</b>	Through professional networks, industry associations, and local business communities

Source: created by the authors.

### 3.4 Study Variables

In the context of trade liberalization and sustainable supply chains, the relationships between independent, dependent, and moderating variables are analyzed in this study.

**Table 2. Study Variables and their Roles in the Conceptual Framework**

Type of Variable	Variables	Description
<b>Independent Variables</b>	Trade Liberalization	Measures the extent of openness in trade, reduction of tariffs, and access to international markets and technologies.
	Policy Interventions	Captures government policies, regulations, subsidies, and incentives promoting green practices and sustainable growth.
	Global Market Dynamics	Represents factors such as market competition, consumer demand for sustainable products, and international trade regulations.
<b>Dependent Variables</b>	Adoption of Green Supply Chains	Assesses the organizations integrate environmental practices in procurement, logistics, and production.
	Environmental Sustainability Outcomes	Evaluates the impact of organizational practices on carbon footprint reduction, resource efficiency, and ecological performance.
	Energy Transition	evaluates the uptake of low-carbon technologies, renewable energy, and energy-efficient practices.
<b>Moderating</b>	Market Competition	Captures the intensity of competition in the market and its influence on green supply chain practices.
	Consumer Demand	Represents demand for eco-friendly products and services, influencing organizational sustainability strategies.
	Trade Regulations	Includes international standards, carbon border taxes, and environmental compliance requirements affecting organizational decisions.

Source: created by the authors.

The study variables along with their functions in the conceptual framework are presented in Table 2.

### **3.5 Survey Components**

#### **3.5.1 Demographic information: age, gender, education, role, & experience**

The demographic information portion of survey gathers the required background information, including job title, education level, age, gender, and years of work experience. Essentially, this section sets the stage for the interpretation of the study variables.

#### **3.5.2 Perceptions of trade liberalization: competitiveness, technology, & green practices**

The perceptions of trade liberalization section accesses how participants perceive the suggested business practices and sustainability influences of reducing trade barriers and enhancing global integration. This section assesses the impacts of international trade policies on both business and ecological outcomes.

#### **3.5.3 Green supply chain adoption: sustainable sourcing, waste reduction, energy efficiency, & certifications**

This section highlights the modifications and adaptations enterprise implement in their routine activities concerning waste reduction, recycling, and eco-friendly procurement. Further, the direct effects of adopting a green supply chain on accomplishing the established environmental and financial targets is also studied in this section.

#### **3.5.4 Policy interventions effectiveness: subsidies, incentives, & renewable strategies**

Prominently, effectiveness of policy Interventions, respondents' views are gathered related to the impact of government rules, such as subsidies. This study emphasizes how the sound governance and efficient policy execution impact the adoption of green supplier chains as well as the improvement of CSR environmental performance.

#### **3.5.5 Global market dynamics: competition, consumer demand, & trade regulations**

The global market dynamics section investigates the effectiveness of eco-friendly supply chain practices in the context of international competition and consumer demand for sustainable products. Additionally, this section also takes into account how global market conditions influence the attainment of sustainability metrics.

#### **3.5.6 Sustainability and energy transition outcomes: carbon reduction, energy efficiency, renewable adoption, & performance**

Simultaneously, sustainability and energy transition outcomes assess the economic- and ecological-supply-side advantages of implementing green supply chain management policies. In other words, this section illustrates the outcomes of collective efforts towards achieving sustainability as well as a successful energy transition.

### **3.6 Quantitative Analysis using Correlation Analysis**

In this study, the quantitative approach is adopted based on a structured survey conducted using a closed-ended questionnaire with 427 respondents. To examine the relationship and strength of the trade geopolitics versus sustainability outcome variables, this research adopted a correlation analysis.

### 3.7 Qualitative Analysis using Thematic Analysis

The thematic analysis constitutes the qualitative method of this study, given that a subset of 427 respondents was examined. Out of the 427 respondents, 100 were randomly chosen for the interviews, whereas 30 of those participated in offline, semi-structured, and in-person interviews. Reportedly, each respondent participated in the interview for about 30 minutes, which helped the researchers investigate perceptions and experiences in greater detail.

## 4. Results

The study results indicate that when a nation relaxes its trade regulations, there is a greater chance that corporations will use green supply chain techniques. In short, a mixture of policy actions and international agreements are needed to effectively manage the economic growth, sustainable development, and energy transition on a national and global levels.

### 4.1 Quantitative Findings

The quantitative results exhibit that there exists a significant positive influence of trade liberalization on the implementation of green supply chains. To sum up, the quantitative data stress the value of coordinated policy and market incentives in simultaneously promoting sustainability and economic development.

#### 4.1.1 Correlation Analysis

Table 3 presents Pearson correlations (-0.079 to 0.032) for variables Q6–Q10, reflecting very weak associations. For example, Q6 depicts insignificant correlations with Q7 and Q9, reflecting trade liberalization perceptions.

**Table 3. Correlation between Perceptions of Trade Liberalization**

		Correlations				
		Q6	Q7	Q8	Q9	Q10
Q6	Pearson Correlation	1	0.007	-0.008	0.032	0.017
	Sig. (2-tailed)		0.883	0.869	0.511	0.719
	N	427	427	427	427	427
Q7	Pearson Correlation	0.007	1	-0.043	-0.079	-0.019
	Sig. (2-tailed)	0.883		0.372	0.104	0.692
	N	427	427	427	427	427
Q8	Pearson Correlation	-0.008	-0.043	1	-0.053	-0.062
	Sig. (2-tailed)	0.869	0.372		0.274	0.200
	N	427	427	427	427	427
Q9	Pearson Correlation	0.032	-0.079	-0.053	1	0.034
	Sig. (2-tailed)	0.511	0.104	0.274		0.483
	N	427	427	427	427	427
Q10	Pearson Correlation	0.017	-0.019	-0.062	0.034	1
	Sig. (2-tailed)	0.719	0.692	0.200	0.483	
	N	427	427	427	427	427

Source: created by the authors.

Likewise, the correlation between other variable pairs such as Q7 and Q8, Q8 and Q9, and Q9 and Q10 is similarly minimal, with the majority of p-values lacking statistical significance. The absence of significant correlations implies that the variables do not seem to exhibit strong linear correlations.

**Table 4. Correlation between Green Supply Chain Adoption**

Correlations						
		Q11	Q12	Q13	Q14	Q15
Q11	Pearson Correlation	1	-0.040	0.006	-0.068	0.049
	Sig. (2-tailed)		0.407	0.897	0.159	0.317
	N	427	427	427	427	427
Q12	Pearson Correlation	-0.040	1	-0.005	0.048	-0.012
	Sig. (2-tailed)	0.407		0.926	0.319	0.805
	N	427	427	427	427	427
Q13	Pearson Correlation	0.006	-0.005	1	0.033	-0.037
	Sig. (2-tailed)	0.897	0.926		0.501	0.449
	N	427	427	427	427	427
Q14	Pearson Correlation	-0.068	0.048	0.033	1	-0.053
	Sig. (2-tailed)	0.159	0.319	0.501		0.271
	N	427	427	427	427	427
Q15	Pearson Correlation	0.049	-0.012	-0.037	-0.053	1
	Sig. (2-tailed)	0.317	0.805	0.449	0.271	
	N	427	427	427	427	427

Source: created by the authors.

Table 4 demonstrates Pearson correlations (-0.068 to 0.049) for Q11–Q15, confirming very weak, statistically insignificant relationships ( $p > 0.05$ ). Evidently, no meaningful linear associations were found despite 427 responses.

**Table 5. Correlation between Policy Interventions Effectiveness**

Correlations						
		Q16	Q17	Q18	Q19	Q20
Q16	Pearson Correlation	1	0.018	0.078	-0.007	0.022
	Sig. (2-tailed)		0.709	0.109	0.893	0.656
	N	427	427	427	427	427
Q17	Pearson Correlation	0.018	1	.121*	-0.086	-0.012
	Sig. (2-tailed)	0.709		0.012	0.077	0.812
	N	427	427	427	427	427
Q18	Pearson Correlation	0.078	.121*	1	-0.007	-0.035
	Sig. (2-tailed)	0.109	0.012		0.880	0.474
	N	427	427	427	427	427
Q19	Pearson Correlation	-0.007	-0.086	-0.007	1	0.076
	Sig. (2-tailed)	0.893	0.077	0.880		0.114
	N	427	427	427	427	427
Q20	Pearson Correlation	0.022	-0.012	-0.035	0.076	1
	Sig. (2-tailed)	0.656	0.812	0.474	0.114	
	N	427	427	427	427	427

Source: created by the authors.

Table 5 represents Pearson correlations for Q16–Q20. Explicitly, only Q17–Q18 is significant (0.121,  $p=0.012$ ); others are weak and insignificant ( $p>0.05$ ). At large, policy effectiveness reflects minimal correlation across 427 responses.

**Table 6. Correlation between Global Market Dynamics**

		Correlations				
		Q21	Q22	Q23	Q24	Q25
Q21	Pearson Correlation	1	-0.066	-0.018	-0.029	-0.081
	Sig. (2-tailed)		0.173	0.708	0.555	0.094
	N	427	427	427	427	427
Q22	Pearson Correlation	-0.066	1	-0.055	0.022	-0.012
	Sig. (2-tailed)	0.173		0.256	0.650	0.810
	N	427	427	427	427	427
Q23	Pearson Correlation	-0.018	-0.055	1	-0.029	0.068
	Sig. (2-tailed)	0.708	0.256		0.552	0.163
	N	427	427	427	427	427
Q24	Pearson Correlation	-0.029	0.022	-0.029	1	0.060
	Sig. (2-tailed)	0.555	0.650	0.552		0.218
	N	427	427	427	427	427
Q25	Pearson Correlation	-0.081	-0.012	0.068	0.060	1
	Sig. (2-tailed)	0.094	0.810	0.163	0.218	
	N	427	427	427	427	427

Source: created by the authors.

Table 6 populates Pearson correlations for Q21–Q25, highlighting very weak relationships. For example, Q21–Q22 depicts a  $-0.066$  correlation with  $p=0.173$ , revealing no statistically significant connection ( $p>0.05$ ).

**Table 7. Correlation between Sustainability and Energy Transition Outcomes**

		Correlations				
		Q26	Q27	Q28	Q29	Q30
Q26	Pearson Correlation	1	0.046	0.040	0.002	0.005
	Sig. (2-tailed)		0.343	0.408	0.962	0.918
	N	427	427	427	427	427
Q27	Pearson Correlation	0.046	1	-0.085	-0.029	-0.036
	Sig. (2-tailed)	0.343		0.081	0.544	0.452
	N	427	427	427	427	427
Q28	Pearson Correlation	0.040	-0.085	1	-0.019	-0.016
	Sig. (2-tailed)	0.408	0.081		0.689	0.743
	N	427	427	427	427	427
Q29	Pearson Correlation	0.002	-0.029	-0.019	1	0.031
	Sig. (2-tailed)	0.962	0.544	0.689		0.524
	N	427	427	427	427	427
Q30	Pearson Correlation	0.005	-0.036	-0.016	0.031	1
	Sig. (2-tailed)	0.918	0.452	0.743	0.524	
	N	427	427	427	427	427

Source: created by the authors.

Table 7 confirms very weak, insignificant correlations between sustainability (Q26) and energy transition outcomes (Q27–Q30), with all p-values >0.05. Even though the highest (0.046) is negligible, signalling no meaningful relationships.

**4.1.2 Descriptive Statics**

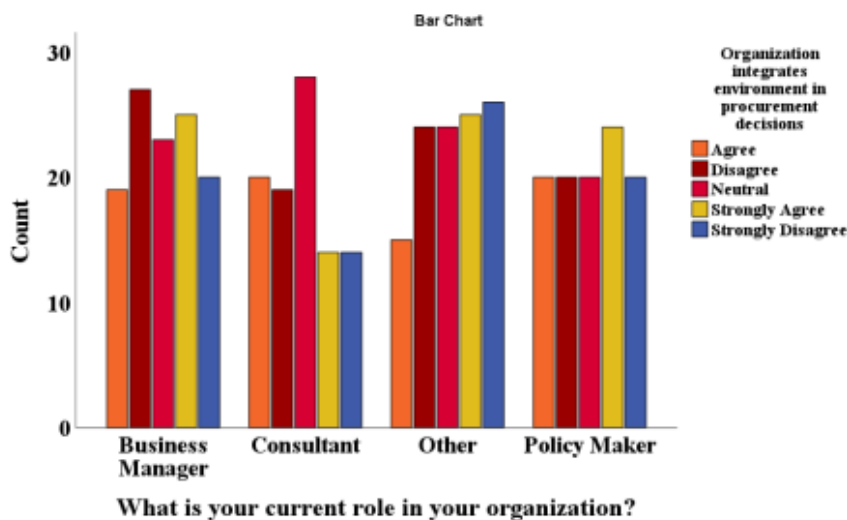
Table 8 reveals how the 427 participants are divided demographically. Meanwhile, the “N” confirms the sample size for all categories. The mean values of about 2.5 for all variables suggest a general inclination of the responses towards the scales’ centers.

**Table 8. Descriptive and Demographic Profile of Participants**

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
What is your age?	427	1	4	2.54	1.088
What is your gender?	427	1	4	2.48	1.118
What is your highest level of education?	427	1	4	2.58	1.086
What is your current role in your organization?	427	1	4	2.49	1.129
How many years of experience do you have in your field?	427	1	4	2.52	1.112
Valid N (listwise)	427				

Source: created by the authors.

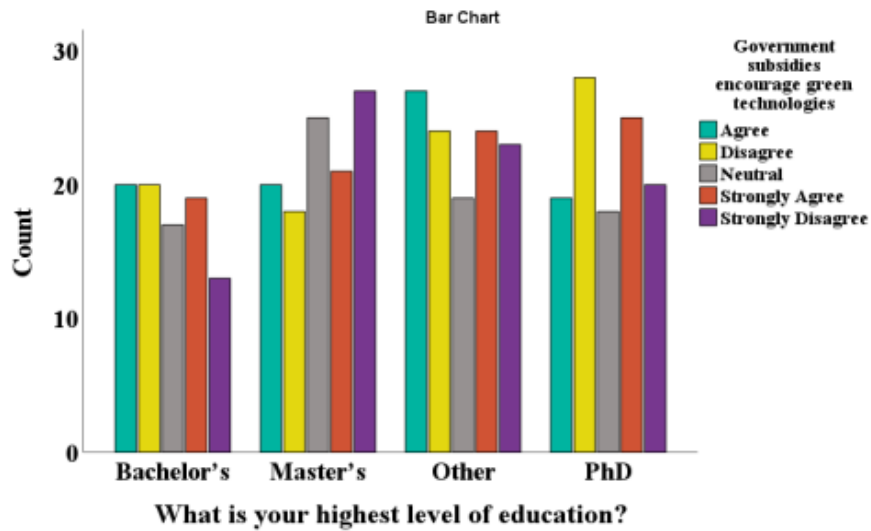
A certain level of conformity in participants’ responses is brought to the light by the standard deviations of 1.06 to 1.18, since these numbers indicate that there is modest variation but a majority of participants are clustered around the mean.



Source: created by the authors.

**Figure 3. Organization Integrates Environment in Procurement Decisions**

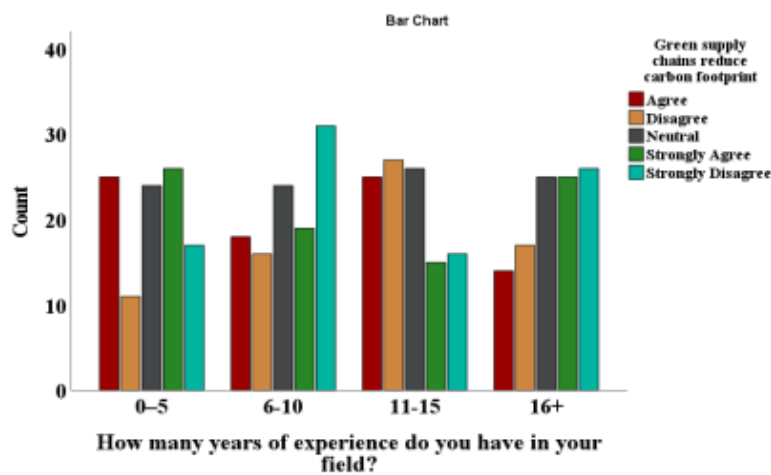
Figure 3 illustrates responses on a statement of organization factoring its environmental factors in procurement decisions. With minor exceptions, people from all the roles tend to agree or strongly agree to the statement.



Source: created by the authors.

Figure 4. Government Subsidies Encourage Green Technologies

sorted by education level of respondents, Figure 4 analyzes the survey about government subsidies for green technologies. Generally, there are more people agreeing than disagreeing and their ratio is quite close in all groups.



Source: created by the authors.

Figure 5. Green Supply Chains Reduce Carbon Footprint

Figure 5 presents the data from responses to the statement "Green supply chains decrease carbon footprint" relation to the number of years worked in a particular area.

#### 4.2 Qualitative Findings

Face-to-face interviews show that the participants highlighted the possibilities that trade liberalization offers access to new technologies and sustainable practices.

### **Impact of trade liberalization on green supply chain adoption**

This section addresses RQ1: *How does trade liberalization affect the adoption of green supply chain practices among businesses?* Thematic analysis of qualitative data revealed three major themes:

1. Increased Competition and the Need for Efficiency
2. Access to Green Technologies and Knowledge Transfer
3. Regulatory Influence and Policy Alignment

#### **Theme 1: Increased competition and the need for efficiency**

Businesses identified that trade liberalization exposed them to more competition, which, eventually, motivated them to employ greener supply chain practices to remain competitive.

*“Maintaining a competitive edge requires action—failing to reduce the carbon footprint could lead customers to choose other options.” (Participant A, Manufacturing Executive)*

The theme posits that trade liberalization can lead to a push for more sustainable practices as a means to gain an economic advantage and meet consumer demand.

#### **Theme 2: Access to green technologies and knowledge transfer**

Trade liberalization has resulted in a greater access to international green technologies and expertise, facilitating the adoption of more sustainable supply chain practices.

*“I never thought it could implement solar-powered logistics, but with new trade agreements, were able to access this technology.” (Participant B, Logistics Manager)*

This theme illuminates the role of global trade in facilitating the transfer of technologies and sustainable practices that enterprises might otherwise not be able to afford or access.

#### **Theme 3: Regulatory influence and policy alignment**

Global trade agreements often come with regulations that encourage or mandate sustainability.

*“Having to meet EU carbon regulations pushed us to rethink how operate and look at greener suppliers.” (Participant C, Supply Chain Director)*

The theme reflects that trade liberalization not only opens up markets even if they were previously not inclined to adopt such practices.

### **The role of policy interventions in promoting sustainable economic growth and energy transition**

This section addresses RQ 2: *What role do policy interventions play in promoting sustainable economic growth and energy transition?*

#### **Theme 1: Government incentives and green innovation**

*“Government support was essential to afford the initial costs of implementing solar energy in the factories.” (Participant A, Renewable Energy Firm)*

**Theme 2: Policy stability and long-term investment**

*“The uncertainty about future regulations was a real problem, but once policies became stable, were able to make larger investments in clean energy.” (Participant B, Manufacturing Manager)*

**Theme 3: International cooperation and policy alignment**

*“Following the global push for sustainability becomes more effective when international standards align with local policies, making it easier to stay ahead in the transition to green energy.” (Participant C, Energy Policy Analyst)*

**How global market dynamics affect the effectiveness of green supply chains in different industries**

This section addresses RQ 3: *How do global market dynamics affect the effectiveness of green supply chains in different industries?* Accordingly, thematic analysis of qualitative data proposed three key themes:

1. Market Demand for Sustainability
2. Supply Chain Complexity and Global Sourcing Challenges
3. Industry-Specific Regulations and Standards

**Theme 1: Market demand for sustainability**

*“Due to customer demands for sustainability, the entire supply chain has been redesigned to meet those expectations.” (Participant A, Consumer Goods CEO)*

**Theme 2: Supply chain complexity and global sourcing challenges**

*“This work with suppliers all over the world, and some countries still don’t have the same environmental standards. It’s hard to control every link in the chain.” (Participant B, Electronics Manufacturing Executive)*

**Theme 3: Industry-specific regulations and standards**

*“The car industry is highly regulated in Europe, so It have been forced to create a sustainable supply chain. In other regions, the rules are more relaxed, and it’s tougher to implement.” (Participant C, Automotive Industry Manager)*

**The Relationship between trade liberalization, Green supply chain adoption, and Environmental sustainability outcomes**

This section addresses RQ 4: *“What is the relationship between trade liberalization, green supply chain adoption, and environmental sustainability outcomes?”* Thematic analysis of qualitative data presented three core themes:

1. Trade Liberalization as a Catalyst for Green Supply Chain Adoption
2. Multiplier Effect of Sustainable Practices Across Borders
3. Sustainable Supply Chains as a Competitive Advantage for Environmental Impact

**Theme 1: Trade liberalization as a catalyst for green supply chain adoption**

Trade liberalization is directly credited by numerous business entities for promoting the adoption of green supply chain practices.

*“With global trade agreements pushing sustainability, following suit became necessary to avoid losing market position.” (Participant A, International Trade Manager)*

**Theme 2: The multiplier effect of sustainable practices across borders**

*“Being able to tap into sustainable practices from other countries has been a game-changer, with a clear reduction in carbon emissions across all markets.” (Participant B, Global Supply Chain Manager)*

**Theme 3: The multiplier effect of sustainable practices across borders**

*“Involvement in trade liberalization enabled the implementation of green practices that significantly reduced waste and energy consumption.” (Participant C, Environmental Compliance Officer)*

**5. Discussion**

The trade structure and import diversification impact energy efficiency since effective system optimization results in improved performance (Doğan et al., 2022). Subsequent to that, Zhou et al. (2023) pointed out that organizations must balance their incorporation of renewable energy with their need to grow and minimize carbon emissions, suggesting that the implementation of advanced technologies can optimize performance. According to Zhou et al. (2023) global trade liberalization allows enterprise to adopt new technologies, thereby, improving their operational efficiency. Afterward, Gast et al. (2024) examined how different types of renewable energy production capacity impact both industrial operational efficiency and sustainable value chain development. The proposed method demonstrates better flexibility and scalability than existing studies because this method uses adaptive mechanisms, which lead to both increased system efficiency and real-world implementation capabilities.

**6. Conclusion**

Green supply chains is subject to market conditions and policy support. This research presents valuable basic information on how trade liberalization and policy interventions affect sustainable supply chain practices. Nonetheless, this research entails multiple restrictions that limit its development. For instance, this study relies on data collected from a single geographic region (Chengdu, China), thus, restricting the ability to apply study results to different settings. Similarly, the cross-sectional survey design fails to measure changes that occur over time. Moreover, this study also depends on participants to provide their own information. Future studies should use comparative and longitudinal studies, focus on sectors, as well as explore technology and digital innovation for sustainability.

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## **PREKYBOS LIBERALIZAVIMAS IR ŽALIOSIOS TIEKIMO GRANDINĖS: POVEIKIS TVARUMUI IR ENERGETIKOS PERTVARKAI**

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*Santrauka.* Pasaulinė ekonominė integracija ir tvarumo iššūkiai pabrėžia poreikį kartu nagrinėti prekybos liberalizavimą, žaliąsias tiekimo grandines ir energetikos pertvarką. Šiame tyrime, taikant mišriųjų metodų sistemą, derinant teminę kokybinę analizę su kiekybine koreliacijos analize, nagrinėjami vieno metodo metodų apribojimai. Duomenys buvo surinkti iš 427 dalyvių Čengdu mieste, įskaitant apklausas ir 30 pusiau struktūruotų interviu. Mišriojo metodo metodas leidžia patikimiau įvertinti politikos veiksmingumą, sujungia kiekybinę analizę su realaus pasaulio rinkos įžvalgomis. Teigtina, kad tiek prekybos liberalizavimas, tiek vyriausybės politikos priemonės skatina didesnę aplinkai nekenksmingų tiekimo grandinių ir energetikos pertvarkos pastangų diegimą. Tyrimo rezultatai politikos formuotojams ir pramonės suinteresuotosioms šalims siūlo praktines gaires, kaip parengti sėkmingas tvarumo programas, kurios padėtų skatinti tvarų ekonomikos augimą. Remiantis išvadomis, politikos formuotojams rekomenduojama tobulinti žaliųjų technologijų reguliavimo sistemas ir paskatas, o pramonės įmonės turėtų aktyviai taikyti lanksčias ir tvarias tiekimo grandinės strategijas, kad būtų užtikrintas ilgalaikis konkurencingumas ir veiksminga aplinkosauga.

*Reikšminiai žodžiai:* prekybos liberalizavimas; tvarumas; politikos intervencijos; mišrus metodas; žalioji tiekimo grandinė.

## Appendix

### APPENDIX

#### Section A: Demographic Information

1. What is your age?  
 Under 25  25–34  35–44  45 and above
2. What is your gender?  
 Male  Female  Non-binary  Prefer not to say
3. What is your highest level of education?  
 Bachelor's  Master's  PhD  Other (please specify): \_\_\_\_\_
4. What is your current role in your organization?  
 Business Manager  Policy Maker  Consultant  Other (please specify):  
\_\_\_\_\_
5. How many years of experience do you have in your field?  
 0–5  6–10  11–15  16+

#### Section B: Perceptions of Trade Liberalization

6. Trade liberalization increases access to international technologies that improve business sustainability.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
7. Reducing tariffs and trade barriers encourages firms to adopt environmentally friendly practices.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
8. Open trade policies positively influence my organization's investment in green initiatives.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
9. Trade liberalization improves competitiveness by encouraging efficient and sustainable operations.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
10. International trade agreements support environmental standards and green supply chain adoption.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

**Section C: Green Supply Chain Adoption**

11. My organization integrates environmental considerations into procurement and sourcing decisions.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
12. Waste reduction and recycling practices are implemented throughout our supply chain.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
13. Energy-efficient logistics and transportation methods are adopted in our operations.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
14. Green certifications (ISO 14001, LEED, etc.) are pursued in supply chain management.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
15. Suppliers are evaluated based on their environmental performance and sustainability practices.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

**Section D: Policy Interventions Effectiveness**

16. Government subsidies and incentives encourage investment in green technologies.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
17. Environmental regulations positively influence my organization's sustainability practices.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
18. Tax incentives promote adoption of energy-efficient and low-carbon supply chain solutions.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
19. Policy frameworks for renewable energy support business transition toward clean energy.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
20. Public-private partnerships enhance the implementation of green supply chain initiatives.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

**Section E: Global Market Dynamics**

21. Global competition encourages firms to adopt environmentally sustainable practices.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
22. Consumer demand for eco-friendly products influences my organization's supply chain decisions.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
23. International trade regulations (e.g., carbon taxes) affect our green supply chain strategies.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
24. Global supply chain disruptions drive innovation in sustainable practices.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
25. Firms that adopt green supply chains gain a competitive advantage in international markets.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree

**Section F: Sustainability and Energy Transition Outcomes**

26. Adoption of green supply chains reduces the organization's carbon footprint.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
27. Sustainable supply chain practices improve energy efficiency in operations.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
28. Green supply chain adoption positively impacts environmental sustainability in my sector.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
29. Transition toward renewable energy is facilitated by sustainable business practices.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree
30. Implementing green supply chains strengthens long-term economic and environmental performance.  
 Strongly Disagree  Disagree  Neutral  Agree  Strongly Agree