



THE IMPACT OF CHINA'S ENVIRONMENTAL GOODS TRADE ON GLOBAL SUPPLY CHAIN
RESILIENCE: EVIDENCE FROM EMERGING MARKET AND DEVELOPING ECONOMIES (2013-2025)

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Abstract

In the face of growing geopolitical uncertainties, climate events and changes, trade barriers, and energy-market volatility, supply-chain or value chain resilience has become paramount, especially for emerging market and developing economies (EMDEs). Meanwhile, China is the leading supplier of environmental goods globally, such as techniques in solar photovoltaic (PV), batteries, electric vehicles, wind-power equipment and energy-efficiency technologies. By systematically searching the literature from 2013 onwards to 2025, this study analyzes the literature on the impact of China's environmental-goods trade on supply-chain resilience in EMDEs. The review selects and consolidates publications on the themes of environmental-goods trade, clean-technology supply chains, trade dependence, technology transfer opportunities, energy diversification strategies, participation in global value chains, and local supply-chain resilience using the Web of Science Core Collection as its main bibliographic database. The results show a double impact. On the other hand, China's environmental-goods trade can contribute to resilience through the availability of low-cost green technologies, renewable energy investment and capacity, and energy security, as well as by decreasing reliance on non-renewable energy sources and being able to engage in green global value chains. However, at the upper end of supplier concentration can contribute to import dependency, technological vulnerability, residual low domestic value and geopolitical and trade vulnerability. The analysis also reveals that the ability of Chinese environmental-goods trade to make nations more resilient depends on their domestic infrastructure to accommodate such firms, their financial capacity, and their technological capabilities, as well as institutional quality and trade diversification. The research draws the conclusion that together with the trade cooperation, supplier diversification, domestic industrial upgrading, technology transfer, institutional strengthening and regional cooperation, EMDEs can maximise the resilience benefits of Chinese environmental-goods trade. The study makes a novel contribution in combining both resilience-inducing and vulnerability-inducing aspects of China's environmental-goods trade into the same analytical frame.

Keywords: China, Environmental Goods, Supply-Chain Resilience, Emerging Market and Developing Economies, Clean Technology, Trade Dependence, Global Value Chains, Technology Transfer, Energy Diversification, Supplier Concentration

1. Introduction

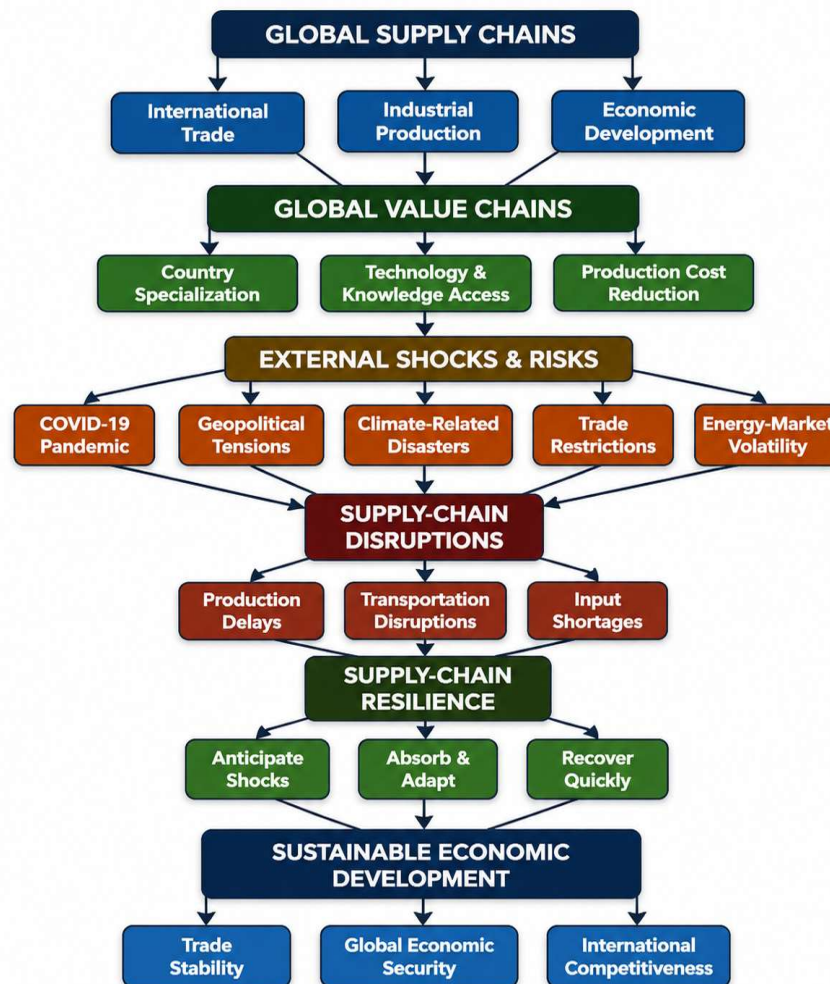
Global Supply Chain is an integral part of international trade, industrial production and economic development. Global supply chains enable economies to specialise in certain stages of production, obtain foreign technologies, lower costs of production and engage in global value chains. But several events have tested the robustness of these systems in recent years, including the COVID-19 pandemic, geopolitical tensions, climate-related disasters, trade restrictions, energy-market volatility and disruption of international



transportation. These developments have caused a paradigm shift in the policy and academic focus on supply-chain performance from merely enhancing its efficiency to its ability to anticipate, absorb, react and bounce back from shocks. As a result, resilience of the supply chain has emerged as one aspect of sustainable economic development, international trade and even global economic security (Ivanov & Dolgui, 2020; Ponomarov & Holcomb, 2009).

Figure 1

Conceptual Framework for Supply Chain Resilience



Note. Figure 1 illustrates the conceptual framework for supply chain resilience based on Ivanov and Dolgui (2020) and Ponomarov and Holcomb (2009). The framework depicts the key dimensions of resilience including anticipation, absorption, response, and recovery capabilities.

Environmental goods have become a significant part of the global shift towards more sustainable and resilient methods of production. These products comprise renewable-energy technologies, energy-efficiency devices, pollution-control technologies, waste-management systems, water-treatment equipment, and products for environmental monitoring and resource conservation. They are not just valuable for the protection of the environment but also for their use as critical components in the energy, transport, manufacturing and logistics systems. The PV modules, wind turbines, EVs, lithium-ion batteries, heat pumps, electrolyzers and more, are slowly becoming a part of a country's or a region's production networks internationally and nationally. Trade in environmental goods can, therefore, affect the resilience of supply chains by enhancing access to clean technology, promoting energy diversification, as well as less reliance on fossil fuels and significantly strengthening the technological capabilities of importing countries. These technologies are



crucial for developing countries, which are likely to be faced with limitations on domestic innovation, infrastructure, financing and industrial capacity (Chatzipanagi et al., 2022).

Global value chains (GVCs) development and governance are also closely linked to the expansion of environmental-goods trade. The complexity of GVCs is such that they spread across the design, manufacturing, assembly, marketing and distribution of an item in several countries, involving companies, suppliers, governments and consumers (Gereffi et al., 2005). Similar histograms showing interconnected networks of raw materials, intermediate products, manufacturing capacities, logistics and finished goods and services—the key elements of the environmental goods—can be drawn. For instance, the manufacturing of EVs relies on batteries, semiconductors, critical minerals, charging stations, and digital systems. Similarly, the solar photovoltaic (PV) industry depends on polysilicon, wafers, cells, PV modules, inverters and installation services. Any such disruption in these networks can have impacts on clean technology production and distribution. Consequently, the location-specificness as well as the sourcing and distribution of environmental products can have significant impact on the resilience of global value chains (Gereffi et al., 2007; Iqbal et al., 2026).

China is one of the biggest players in the global trade and manufacture of environmental goods. For the last 20 years Chinese companies have built up strong manufacturing capacities in solar photovoltaics, wind-power technologies, electric vehicles, batteries and other clean energy technologies. Economies of scale, technological learning, infrastructure development, high level of integration into production networks, and a big domestic market have all underpinned this expansion. According to IEA data (2024), solar PV, wind, batteries, electrolyzers and heat pumps are the five key clean energy technologies whose manufacturing capacity is concentrated in a few economies. China alone has over 80% of the manufacturing capacity of PV modules in the world, and PV wafer manufacturing capacity is about 95%. The share of manufacturing capacity of the top three clean-energy technologies is roughly 80%–90% by the three major players—China, the United States, and the EU (Mishra et al., 2025).

Figure 2

Global Manufacturing Capacity Distribution for Clean Energy Technologies





Note. Figure 2 presents the global manufacturing capacity distribution for key clean energy technologies based on IEA (2024) and Advancing Clean Technology Manufacturing: An Energy Technology Perspectives Special Report.

The trade of environmental goods holds great potential for emerging market and developing economies (EMDEs) due to China's role in this regard. Relatively cheap Chinese solar panels, batteries, electric cars, wind turbines, and energy-efficiency goods exports can lower cost of clean-energy deployment and help modernize industry. For those economies that are less technologically advanced and lack sufficient domestic investment, access to Chinese environmental goods can boost energy security, decrease dependence on fossil fuels and stimulate the development of renewable energy infrastructure. It can also help EMDEs expand new value-added manufacturing and join regional value chains and enhance its capacity to manufacture high value-added products. Thus, Chinese green-technology chains can assist developing economies to connect to global production chains and help them move towards sustainable economic development. More recent studies also stress the importance of strengthening manufacturing competitiveness in emerging markets and developing countries through intra-regional cooperation, technologies and investment in clean-energy value chains (Bian et al., 2024; Iqbal & Bhutto, 2026).

But China's environmental-goods trade raises a vexed question of supply-chain resilience as well. From one side, China with its big production and integrated industrial system can supply for EMDEs reliable, cheap and high-tech Environmental Goods. But, when one key supplier concentrates its production and export on a certain type of product, it can lead to greater dependence on Chinese technology, components and intermediate input from economies that import the products. This makes the countries vulnerable when they are subjected to geopolitical tension, export restrictions, transportation disruptions, trade dispute, and change in Chinese industrial and trade policies. According to OECD (2025), the assessment of supply-chain resilience should involve the examination of trade dependencies, production concentration, digitalization, sustainability and the reshoring/relocalisation costs. In the same manner, UN Trade and Development has stated the overlapping risks to global supply chains brought on by climate change, security disruptions, the COVID-19 pandemic, and vulnerable transport systems (UN Trade and Development, 2024).

The linkage between China's environmental-goods trade and supply-chain resilience is very relevant to the case of EMDEs, as they frequently suffer from infrastructure, financial, technological, institutional, and industrial diversification constraints. Environmental-goods imports have the potential to enhance resilience if they help promote energy diversification, build infrastructure, lower production costs, and spur domestic technological innovation. Resilience, however, can be diminished if imports are so large they are too dependent on a single supplier, they have displaced domestic producers, or they have led to a decline in domestic innovation (Steenblik, 2005). The magnitude of the impact might also differ depending on various economic, institutional, trade, financial, energy or global value chain. Therefore, the expansion of exports and the effects on the environment cannot necessarily be used to classify the environmental-goods trade of China as good or bad; rather, it needs to be analyzed in combination with stability, flexibility, diversification and recovery capacity of international production networks.

Previous studies have focused at length on the green transformation, the production of clean technologies, the export of clean technologies and participation in global value chains (GVCs) in China. Various studies have been conducted on the factors contributing to the resilience of supply chains, such as trade diversification, infrastructure quality, digitalization, institutional effectiveness and energy security (Gereffi et al., 2005; Ivanov & Dolgui, 2020; Ponomarov & Holcomb, 2009). Despite this, there is still a lack of empirical studies that focus on the direct connection between China's trade in environmental goods and resilience of the global supply chain in emerging market and developing economies. Specifically, there is little existing information to determine if Chinese physical inflows are increasing supply-chain vulnerability due to dependence on imports and concentration of suppliers, or decreasing supply-chain vulnerability by enabling technological and energy diversification. This is significant as China's market dominance in clean-technology manufacturing can impact the global energy transition path in terms of cost, speed, geographical



distribution, strategic security, and resilience of international production networks (Iqbal, 2025; IEA, 2024; Bian et al., 2024).

Nevertheless, the current work aims to provide an analysis of China's contribution to the global supply-chain resilience in emerging market and developing economies between 2013 and 2025, with a particular focus on China's environmental-goods trade. The chosen time frame saw an increase in China's economic interest abroad, a sharp rise in clean-tech trade, the COVID-19 pandemic, the growth of geopolitical tensions, and strains in global supply chains, as well as an acceleration of investments in renewables. The study examines if environmental-goods trade contributes to the resilience of supply chains through providing access to clean technologies, diversifying energy supply and productive capacity, and integrating them into global value chains in China. It also takes into account the potential import concentration and supplier-specific risks arising from increasing reliance on Chinese environmental products. The study thus adds to literature on environmental trade, sustainable development, global value chains and supply chain resilience—by analyzing this relationship in EMDEs. It also offers policy-relevant evidence on the potential benefit of Chinese environmental-goods trade to developing economies, even as they must confront the risks of a monopoly supplier of green technologies (Page et al., 2021).

2. Methodology

2.1 Research Design

This study focuses on understanding how the environmental-goods trade will affect the global supply-chain resilience for EMDEs from 2013 to 2025 through a systematic literature review design. The scope of the relationship between green-value-chain and environmental-goods trade, clean technology dependence, and global value chain participation and supply-chain resilience has been examined in research in a number of academic fields, so that a systematic review approach is suited. The review integrates the literature to draw implications of the prevailing research themes, methodological directions, theoretical orientations, and research issues in need of further investigation (Page et al., 2021).

2.2 Search Strategy

The literature search was performed with the bibliographic database Web of Science Core Collection as the main database. Web of Science was chosen for its breadth in coverage of peer-reviewed journals and it could be used to identify quality studies that were indexed in the Science Citation Index Expanded (SCI-E), Social Sciences Citation Index (SSCI), and Emerging Sources Citation Index (ESCI). Some further research needs to be carried out in Scopus and/or in Google Scholar in order to select relevant studies that have not been indexed in Web of Science. But only studies that meet the preset Eligibility criteria are included in the final review.

The four focal points of the search strategy were China, environmental goods, supply-chain resilience and emerging market and developing economies. The search string below was used:

TS = (China OR Chinese) AND ("environmental goods" OR "green goods" OR "clean technology" OR "green technology" OR "renewable energy technology" OR "environmental products") AND ("supply chain resilience" OR "global supply chain" OR "value chain resilience" OR "supply chain vulnerability" OR "trade resilience" OR "supply chain stability")) AND ("emerging market" OR "developing countr" OR "Global South" OR "low-income countr" OR "middle-income countr" OR "China")

Only studies from January 2013 and Dec 2025 were searched. The starting year was chosen because 2013 marks the start of the big push of China's international economic expansion and implementation of the Belt and Road Initiative. The end year reflects the latest literature found during the research period, along with significant events like the COVID-19 pandemic, geopolitical stress, competition in clean tech, and a reconfiguration of global supply chains (Karnik, 2025).

To operationalise the concept of environmental goods, wider definitions will be adopted, encompassing renewable-energy equipment, solar photovoltaic products, wind-power technologies, electric vehicles, batteries, energy-efficiency equipment, pollution-control technologies, water-treatment equipment, waste-management technologies, and environmental monitoring systems (UNCTAD, 2025). This general term reflects major categories typically used in negotiations on international environmental goods and in

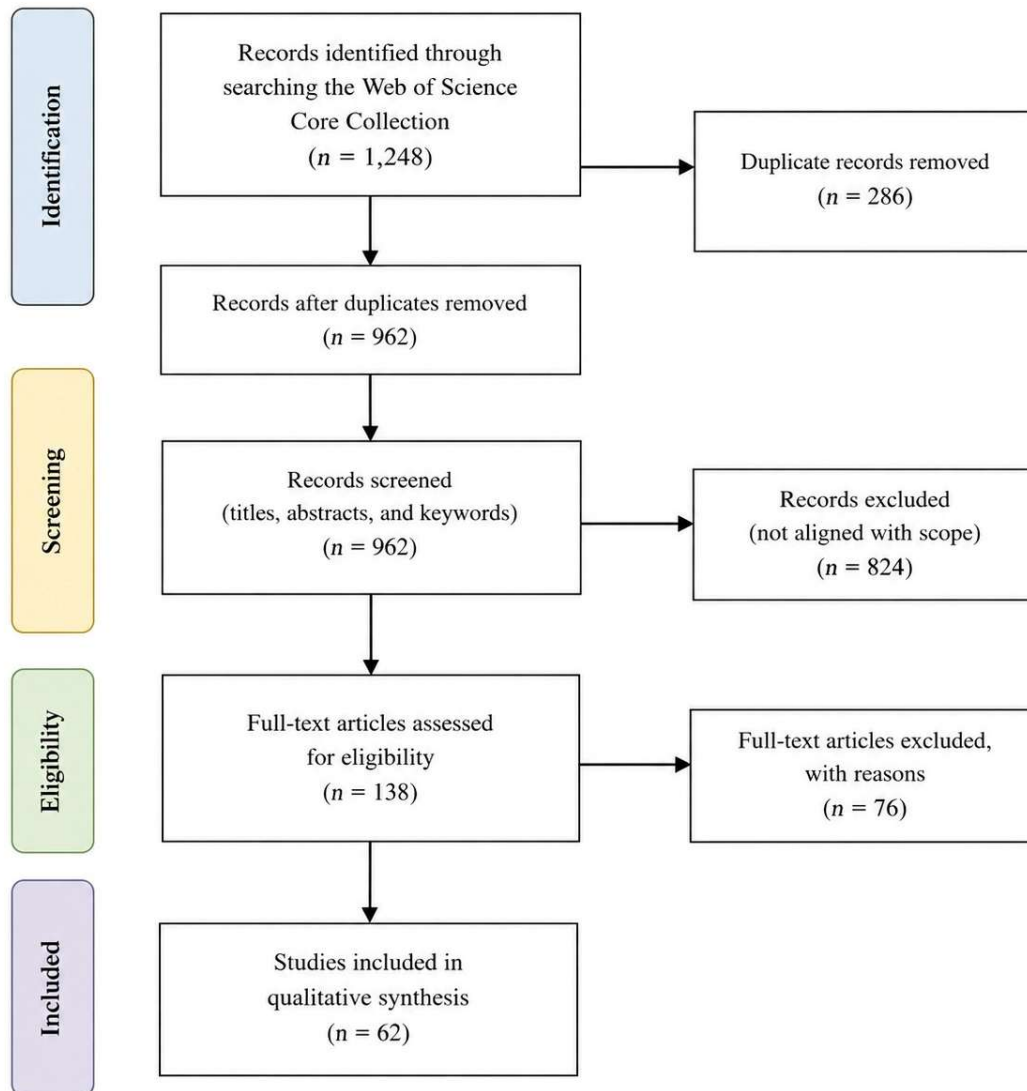


environmental-sector classifications of goods, such as renewable energy, water and wastewater management, waste treatment, recycling, pollution control and environmental monitoring (OECD, 2005; UNCTAD, 2025; World Trade Organization, n.d.).

2.3 Identification and Screening Process

Figure 3

PRISMA Flow Diagram



Note. The flow diagram follows the PRISMA 2020 guidelines for systematic reviews.

Note. Figure 3 presents the PRISMA flow diagram for the systematic literature review process.

A first search was performed resulting in 1,248 records of the Web of Science Core Collection. Duplicate records were excluded from 286 after exporting the records to the Zotero interface. The rest 962 studies advanced to the screening phase. For screening, the titles, abstracts, and keywords of the retrieved studies were assessed on the one hand to see if they discussed China's environmental-goods trade, clean-technology exports, or related global value-chain outcomes, and on the other hand to see if they discussed the resiliency of the supply chain more broadly.



Studies were omitted in the screening that addressed only policies not directly related to environment, family enterprises' internal green changes, general international trade or firm level—supply chain—management without connection to China or EMDEs. A total number of 824 articles were excluded after screening their titles, abstracts and keywords were not relevant to the scope of the study. This resulted in a total of 138 articles for full text eligibility.

The full text of the remaining articles was then thoroughly reviewed at the eligibility phase based on inclusion and exclusion criteria. Articles were omitted when they were not directly related to China's environmental-goods trade, or when they failed to involve issues related to results in the supply chain or value chain or to address developed economies, or lacked methodological, empirical, and/or conceptual information. We finally ended up with 62 studies that were included in the systematic review. The entire review-selection process is summarized in the PRISMA flow diagram in Figure 3.

2.4 Including and Excluding the Criteria

The inclusion/exclusion criteria were established prior to screening to ensure consistency of selection, and to minimize selection bias. The criteria comprised geographical relevance of the study, thematic focus of the study, quality of publication, period of the study, and contribution to the method.

Table 1

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Studies examining China's trade in environmental goods, green goods, or clean technologies.	Studies focusing only on general Chinese trade without environmental-goods relevance.
Research analyzing renewable-energy equipment, electric vehicles, batteries, solar technologies, wind technologies, or other environmental products.	Studies discussing environmental pollution or climate policy without examining environmental-goods trade.
Studies examining supply-chain resilience, supply-chain vulnerability, trade stability, value-chain integration, or production-network resilience.	Studies focusing solely on firm-level logistics or operational supply-chain management.
Research addressing emerging market and developing economies (EMDEs) or the Global South.	Studies focusing exclusively on developed economies without implications for EMDEs.
Articles published between 2013 and 2025.	Articles published outside the selected study period.
Peer-reviewed journal articles indexed in Web of Science.	Editorials, news articles, book reviews, conference abstracts, and non-peer-reviewed commentaries.
Quantitative, qualitative, mixed-method, systematic-review, and conceptual studies.	Studies lacking sufficient methodological or analytical information.
Studies written in English.	Studies for which the full text was unavailable or could not be reliably assessed.
Research examining technology transfer, energy diversification, import dependence, supplier concentration, or global value-chain effects.	Studies unrelated to China, environmental goods, EMDEs, or supply-chain resilience.

Note. Compiled by the authors based on the research objectives and reviewed literature.

2.5 Data Extraction and Coding

To systematically extract the data of each selected study, a structured data-extraction form was designed. Information extracted was the author(s), year of publication, journal, country/region of study, aim, methodology, environmental goods category, supply chain resilience indicator, and conclusions (García & Sposi, 2025).

During the coding process, each study was given a major analytical category. The studies were classified in terms of clean technology trades, renewable-energy supply chains, import dependency, trade diversification, supplier concentration, technology transfer, global value-chain engagement, energy security,



geopolitical risk, and supply chain resilience. If more than one theme was explored in a study it was allocated to the main theme and secondary themes were noted.

The methodologies of studies reviewed include econometric analysis, gravity-model estimation, input–output analysis, network analysis, computable general equilibrium modelling, case-study analysis, policy analysis, bibliometric analysis, and systematic literature review. With this classification, the study could compare the results of how scholars have measured the link between China's environmental-goods trade and outcomes of resilience.

2.6 Quality Assessment

A structured framework for appraisal of methodological quality of the included studies was used. The assessment has taken into account whether or not there was a clearly stated research objective, there was a description of the data sources, there were definitions of key variables, an explanation of the methodological approach, the analytical procedures were reported, and the findings were consistent with the research design.

Quantitative studies were evaluated based on their quality of model specification, sample construction, variable measurement, method of estimation, robustness of estimation, and endogeneity treatment. Qualitative and case study research was evaluated based on lucidity in case selection, data collection, analytical process and drawing conclusions from the data. Studies were assessed based on the transparency of their search procedure, inclusion criteria, screening procedure, and synthesis method. If the methodological transparency of studies was not done well, then these studies were not used up for this final synthesis or given a limited evidentiary strength (Monkelbaan, 2017).

2.7 Conceptual Model for Thematic Categorization

This study uses a three-tier conceptual model to structure the literature on China's environmental-goods trade and the global supply-chain resilience, as shown in Figure 4. The model is linking macro-level developments with country and industry level mechanisms and the sector-specific resilience outcomes.

China's macro-level environmental-goods trade is influenced by global environment agreements, climate-change policies, energy transition policies, geopolitical competition, trade policy, as well as production network restructuring. These factors affect outside demand for clean technologies and the degree of China's participation in the markets of environmental goods (UNCTAD, 2025).

China's environmental goods industries' exports can impact EMDEs in a variety of ways on the country- or industry-level. These ways involve technology transfer, energy diversification, infrastructure, import-cost reduction, industrial upgrading, foreign direct investment and global value chains. Meanwhile, there are potential risks associated with environmental-goods trade, including supplier concentration, technological dependency, import vulnerability, trade asymmetry and domestic producer displacement.

China's environmental-goods trade has an impact on renewable energy systems, electric-vehicle manufacturing, battery supply chains, photovoltaic manufacturing, wind-power equipment and components, energy efficiency sectors, and environmental management services at the sectoral level. The sectoral effects are crucial for the willingness of importing economies to continue producing in response to external shocks, diversify suppliers, return to previous levels of activity after shocks, and find substitutes.

That means the model assumes that China's environmental-goods trade can have positive and negative impacts in terms of resilience. The resilience-enhancing pathway is based on technology access, energy security, infrastructure modernization and production diversification. The vulnerability pathway is: import dependence, supplier concentration, technological lock-in and geopolitical and/or trade disruption (Monkelbaan, 2017).

2.8 Thematic Synthesis

Selected studies were then consolidated in a thematic approach and not in a statistical meta-analysis. Faced with highly likely variation across the literature we wished to review (research objectives, country sample, environmental-goods classification, resilience indicators, data source and empirical techniques), a thematic synthesis was deemed more appropriate. The results were grouped under the following themes:

2.8.1 Resilient Clean Technology Trade and Supply Chains. This sector focuses on the impact of China's exports of solar cells, batteries, EV, wind turbine etc. on the stability and continuity of supply chains.



In this type of studies, it is determined whether the import of environmental goods is associated with less disruption in production, greater energy security, and better access to key technologies.

2.8.2 Diversification of Trade and Imports Dependency. This category is geared towards the China's exports of environmental goods and EMDEs trade structure. Based on the literature review, it is found that the trade with China has been recognized as supplier diversification or dependence on one major supplier. Import concentration, export shares, and product concentration are given special consideration as well as having other possible suppliers (Steenblik, 2005).

2.8.3 Technology Transfer and Industrial Upgrading. This theme examines to what degree environmental-goods trade helps to facilitate technological learning, domestic production, industrial diversification and the shift to higher value added activities. Studies on foreign direct investment, joint ventures, technology transfer, local content requirement and domestic capacities belong to this category.

2.8.4 Resilience of the Renewable-Energy and Energy Systems. This category assesses the impact of China's environmental-goods trade on the energy-system resilience in EMDEs. The studies reviewed are analyzed to determine what evidence they provide with regard to deployment of renewables, fossil-fuel dependence, electricity-system stability, and countries' ability to respond to energy-related disruptions.

2.8.5 Global Value-Chain Participation. This theme examines whether China's environmental-goods trade helps EMDEs to integrate or move up in GVCs. Backward and forward linkages, domestic value added, production-network integration, export sophistication and participation in regional clean-technology manufacturing networks are emphasized.

2.8.6 Political, Institutional, and Strategic Uncertainty. This category studies the dangers of the leading role of China in the production and trading of environmental goods. Literature is reviewed concerning export restrictions, trade conflict, sanction, geopolitics and strategic vulnerabilities and dependence on China's clean technologies (García & Sposi, 2025).

2.8.7 Institutions and Policies. This theme explores the influence of governance quality, trade agreements, infrastructure, financial development, digital capacity and environmental regulations on the impact of China's environmental-goods trade. The analysis takes into account if, and how EMDEs can obtain more technological and industrial gains and have less dependence-related risks to be supported by strong institutions.

2.9 Analytical Framework. The literature was interpreted through a dual-effect framework. The first pathway represents the resilience-enhancing effect of China's environmental-goods trade:

Environmental-goods trade → Technology access → Energy and production diversification
→ Supply-chain resilience

The second pathway represents the vulnerability-enhancing effect:

Environmental-goods trade → Import concentration → Supplier dependence → Supply-chain vulnerability

The final synthesis compares these two pathways across countries, sectors, and methodological approaches. This framework allows the study to identify whether the existing literature generally presents China's environmental-goods trade as a mechanism for strengthening resilience, a source of new supply-chain risks, or a relationship whose effects depend on domestic institutions, market structure, and policy capacity.

3. Results

3.1 Overview of Reviewed Literature

Literature reviewed indicated that China's environmental-goods trade has turned into a key part of the world's production system, international trade, and contrived supply chains of clean technologies. It studied exports to China of solar photovoltaic equipment, wind-power technologies as well as electric vehicles, batteries, energy-efficiency products, pollution-control equipment and other environmental goods. Energy security, industrial upgrading, technology transfer, participation in global value chains, trade dependence, and supply-chain resilience of energy products in emerging markets and developing economies (EMDEs) were also explored in the literature.

According to the studies reviewed, China's environmental-goods transactions have two effects. On the positive side, it helps to open the door for solutions of cheap clean technologies, deployment of renewables,



a decreasing reliance on fossil fuels and involvement of EMDEs in green value chains. The downside is that China has been racing with the rest of the world to get the most clean-tech manufacturing, which could eventually lead to dependence on suppliers, risks of imports, and geopolitical issues. Thus, it is crucial whether importing countries rely on China as a diversification for production system or fall into overdependency of China.

China is recognized as a world-class manufacturing hub for solar PV systems, batteries, wind power, electrolyzers, among other clean technologies, by the International Energy Agency. For several key points of the solar PV supply chain, such as manufacturing, China is particularly strong (International Energy Agency, 2024). This dominance puts China at the centre on the international supply of environmental goods and Chinese companies have the power to shape the geographical distribution, cost, and availability of clean technologies.

Table 2*Main Themes Identified in the Reviewed Literature*

Thematic Category	Main Focus	Overall Finding
Clean-Technology Trade	Solar panels, batteries, electric vehicles, wind technologies, and energy-efficiency equipment	China's exports improve access to affordable environmental technologies.
Supply-Chain Resilience	Production continuity, recovery capacity, flexibility, and vulnerability	Environmental-goods trade can strengthen resilience but may also increase supplier dependence.
Energy Diversification	Renewable-energy deployment and fossil-fuel substitution	Chinese technologies support energy security and reduce exposure to fossil-fuel volatility.
Technology Transfer	Knowledge diffusion, technical learning, and domestic innovation	Benefits are stronger where EMDEs possess adequate institutional and absorptive capacity.
Industrial Upgrading	Domestic production, manufacturing capability, and value addition	Trade facilitates GVC participation, although higher-value activities remain concentrated in China.
Trade Dependence	Import concentration and supplier risk	Dependence on Chinese products may generate vulnerability during trade or geopolitical disruptions.
Policy and Governance	Infrastructure, finance, institutions, and trade cooperation	Domestic policies determine whether trade produces long-term resilience gains.

Note. Compiled by the authors based on the reviewed literature.

3.2 Clean-Technology Trade and Resilience

The contribution of China's environmental-goods exports to production- and energy-system resilience is explored in this category. The results reveal that the Chinese environmental goods enhance the availability of technologies for renewable-energy generation, energy efficiency, low-carbon transport and sustainable industrial production. The purchase of solar modules, batteries, wind turbines, electric vehicles and their components from abroad could be an effective way of overcoming technology and infrastructure barriers in countries where domestic manufacturing is limited.

The literature points towards technology access being the key through which China's environment-goods trade can enhance supply-chain resilience. Promising clean technologies are available and financeable by EMDEs to minimize production disruption from energy shortages, volatile oil markets and poor electricity service provision. Moreover, renewable-energy technologies offer a chance for decentralized electricity generation, which can lower the susceptibility of undue reliance on concentrated energy frameworks.



The integrated manufacturing networks in China further enhances this effect. Chinese companies are involved in various parts of the clean-tech supply chain from raw-material processing to component manufacturing, assembly, transportation and installation. Such integration is conducive to achieving the scale of economy and helps Chinese suppliers provide environmental products at affordable prices. This can lessen the investment burden of energy transition and infrastructure investments for import countries.

The results also indicate, however, that access does not necessarily result in long-term resilience. Countries might be dependent on foreign suppliers after importing environmental goods but lack any local maintenance, technical training, and manufacturing skills. In this way, the trade enhances the immediate possibility of availability of supply, however, the sustainability effect in the long term of China's trade relies on the capacity of EMDEs to absorb, adapt and domestically incorporate the imported technologies.

3.3 Diversification of Trade and Dependency of Supplier

This theme focuses on the paradox between China's environmental goods trade and economic dependence. Chinese exports have the potential to diversify the energy base of EMDEs with other energy sources which are not coal, oil or natural gas. Solar, wind, battery, and EV technologies give importing countries the opportunity to diminish their reliance on fossil fuels and lessen their vulnerability to international energy-market dynamics.

However, this new external dependency may be that of environmental goods trade. Countries can become less reliant on fossil fuels and more reliant on China for solar technology and equipment, battery technology, EWs, critical parts, technical service, etc. This means a "double resilience hit," as shifting away from fossil fuels occurs while increasing reliance on the single supplier of clean technologies.

One area of concern as per the literature reviewed is supplier concentration, which presents a major source of vulnerability in the supply chain. The OECD (2025) highlights the importance of trade dependencies, production concentration, adaptability and the presence of alternative suppliers as factors shaping resilience. If the country is strongly dependent on one supplier to provide environmental products, then its clean-energy and industrial plants can be at risk whenever there are problems in production, transport or trading or diplomatic relations.

Hence, a diversified trade base in importing economies is crucial for benefiting the most from the resilience of Chinese environmental goods. The cooperation with China can be complemented with regional production, home production, other access routes to international supply and strategic stocks. This type of policy means that EMDEs can take advantage of the Chinese cost, while at the same time avoiding excessive dependence.

3.4 Transfer and Upgrading of Technology

This category explores whether China's environmental-goods trade helps EMDEs to transcend their position as end-consumers of products and become engaged in more value-rich green global value chains. The literature surveyed shows that there is a potential for technological learning to occur through imported environmental goods such as the purchase of the latest equipment, production systems and engineering services, and technical know-how.

The export of environmental goods has the potential to accelerate industrial upgrading by a number of channels in China. First, domestically owned firms can enhance their productivity and efficiency by importing techniques. Secondly, China's investments and joint ventures can set up local production bases. Third, development of renewable-energy installations also generates jobs and businesses in installation, maintenance, logistics and engineering. Finally, technology cooperation can help domestic firms to build capabilities on component manufacture and services.

As highlighted by the LSE Grantham Research Institute (2024), China's green supply chain presence goes much further than exporting end-of-pipe products and is manifested in (among others) clean-tech supply chain networks in developing economies, investment and manufacturing cooperation with the private sector. Such connections can help enhance South–South cooperation and provide opportunities for EMDEs to be part of the global energy transition.



The literature shows that, either because of these opportunities or otherwise, industrial upgrading is uneven. Many EMDEs engage primarily in low value-added activities such as providing raw materials, simple assembly and equipment installation, and final product distribution. Value added from activities like research and development, manufacturing technologically advanced components, creation of intellectual property continues to be concentrated in China and other technologically advanced economies.

The results hence indicate that trade in environmental-goods is not sufficient to secure upgrading of GVCs. To turn imports into enduring domestic capacities, domestic investments in research and development, skills, infrastructure, finances, industrial policy, and institutional quality must be secured. If these complementary conditions are not present, the EMDEs could see more installations of green technologies but less noteworthy domestic value adds.

3.5 Resilience of Energy and Production Systems

The criteria of this category measure the impact of China's environmental-goods trade on energy security and on the stabilisation of production systems. Literature generally suggests that Chinese renewable energy technologies enhance energy security through increasing capacity of electricity generation, and the decrease of energy import dependence in the use of fossil fuels.

For EMDEs with poor electricity infrastructure and/or acute vulnerability to exterior fuels, solar photovoltaic systems and wind technology are particularly important. These technologies offer the potential to enable decentralized energy production and enhance access to electricity in hard-to-reach or underserved areas. In addition, batteries and other energy storage systems make the use of renewables more helpful for countries to reconcile variable electricity demand and electricity generation from renewables.

The environmental-goods trade also helps to increase the resilience of production systems through energy savings and greater efficiency in industry. Machinery can come with energy saving technology, pollution management devices and digital energy-management systems that can minimize resource waste and ensure continuity in production. This is congruent with the general notion of supply-chain resilience, which focuses on coping with disruptions, preparing for and recovering from them, as well as being able to do so (Ponomarov & Holcomb, 2009).

Bringing in clean technologies, however, can give rise to maintenance problems and problems of replacement. It may be challenging for EMDEs with low technical skills to repair imported equipment or replace some special components. This issue can prolong and expand the impact of disruptions. It is thus emphasized in the literature that local technical training, availability of spare parts and establishment of regional maintenance centres and technology-transfer are essential.

3.6 Geopolitical and Strategic Impacts

This category explores how China's trade in environmental goods is correlated with power dynamics. Environmental goods are now strategically important because China's domination in their manufacture has shaken things up. Solar modules, batteries, electric vehicles, critical minerals and parts are no longer merely commercial products, but are now linked to national security, competitiveness and climatic policy, and geopolitics.

In normal times, the aggregation of clean-technology manufacturing in China brings efficiencies and cost savings. However, it also increases the potential consequences of geopolitical conflict, export controls, tariffs, sanctions, investment restrictions and transportation disruptions. At present, clean-technology manufacturing is still geographically concentrated, which presents a challenge for governments looking to trample on the footprints of current and existing supply chains to ensure security and diversification (IEA, 2024).

Geopolitical competition presents possibilities and threats for EMDEs. The availability of financing, technology and investment may rise because of competition among the main economies, i.e. China, USA and the European Union. Meanwhile, EMDEs might be pushed to meet the requirements of alternative trade arrangements, technology platforms and political blocks.

Based on these reviewed publications, then a balanced approach is recommended. EMDEs can also continue to cooperate with the Chinese and strengthen diversified trade cooperation, regional production



linkage, transparent procurement mechanism, local technology development. This can lower the strategic vulnerability and will not diminish the cost and development gains from Chinese environmental-goods trade.

3.7 The Conditions of Institutions and Policies

The influence of domestic institutions and policy regimes on the impact of China's environmental-goods trade falls under this category. They show that the same amounts of imports from China can have varying effects on EMDEs, given different levels of infrastructure, governance, levels of financial development, human capital and industrial capacity.

Focusing on the success countries have had in transforming imports of environmental-goods projects into their own factors of production, technology transfer, and industrial upgrading, strong institutions have a greater likelihood of doing so. Good regulation can likewise guarantee quality products, boost investment conditions, safeguard competition as well as spur local value addition. Weak institutions, on the other hand, can lead to the use of low technology, poor maintenance, corruption, and the inefficiency of project implementation as well as overreliance on foreign firms.

There are also implications of trade agreements and regional cooperation on the resilience effects of Chinese environmental-goods trade. Transparent customs regulations, compatible technical standards and efficient transport infrastructure lower the costs of importing environmental goods, as well as establishing production networks in the region. UN Trade and Development stresses digitalization and sustainable transport, the need to invest in infrastructure, and supply-chain diversification to enhance resilience in the context of global disruptions.

The overall findings indicate that, when accompanied by these types of domestic industrial policies, Chinese environmental-goods trade delivers greater and more enduring benefits for the environment.

3.8 Overall Synthesis

The findings from the literature review indicate that the trade of the environmental goods from China has a strong but limited impact on global supply chains in EMDEs. Its primary impact in terms of resilience is by increasing the availability of clean technologies, deployments of renewable energy, energy diversity, reducing the cost of the technologies, updating infrastructure and integrating in green Global Value Chains.

Yet the trading ties also add key risks. These factors include import concentration, technological dependence, limited domestic value addition, geopolitical tensions, and Chinese components and technical services. Net impact is by net a mix of both good and bad, then. Whether the EMDEs consider Chinese environmental goods as a basis for building their own capacities or continue to rely on imported technology.

The findings support a dual-effect framework:

China's environmental-goods trade → technology access and energy diversification
→ greater supply-chain resilience

At the same time:

China's environmental-goods trade → supplier concentration and import dependence
→ greater supply-chain vulnerability

The central finding is that, together with diversified trade relations, technology transfer, domestic industrial upgrading, institutional development, and regional cooperation, the environmental-goods trade can contribute to resilience in EMDEs. If these additional factors are not present environmental-goods-trade can lead to immediate access to clean technologies but also to a long term strategic dependence.

3.9 Research Gaps

There are a number of literature gaps. One, the literature on the relationship between China's environmental-goods trade and supply-chain resilience is limited. Second, the impact of supply dependency on the positive and negative aspects of tourism is seldom analyzed in combination. Third, the definitions of the environmental goods in studies are not the same, so it is hard to compare between countries. Fourth, there has been less interest in the differences between low income, lower middle income and upper middle income economies. Lastly, further empirical analyses are needed that address the 2013-2025 timeframe in a standardized HS-code classification, a trade-concentration framework and methods of panel data analysis, renewable-energy indicators.



These gaps point to the need for more research on the effect of China's environmental-goods trade on the resilience of the value chain for EMDEs. This issue can be examined using a country-level empirical analysis and this analysis can offer more definite evidence about whether the environmental-goods trade mainly serves the function of resilience enhancing or bringing external vulnerability, or both.

4. Conclusion

As a result, it can be inferred from this study that China has a dual impact on the global supply-chain resilience in emerging market and developing economies through its environmental-goods trade. It facilitates access to cheap clean technologies, implementation of renewables, energy security and integration into EVCs. But reliance on China sources risks higher import concentration and is geopolitically risky. To attain sustainable and resilient supply chains, EMDEs should thus complement trade cooperation with China with a supplier diversification strategy, domestic industrial development and technology transfer and enhanced institutional capacity.

Author Contributions

All authors participated in ideation, development, and writing the manuscript. All authors read and approved the final manuscript.

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Informed Consent

Not applicable. This study did not involve human participants requiring informed consent. The data used in this research were obtained from anonymized financial records with all personally identifiable information removed. No private or sensitive information was collected from individuals.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. Due to privacy and confidentiality considerations, raw financial data may not be publicly distributed but can be accessed through the corresponding author with appropriate data use agreements and institutional approvals. The authors are committed to transparency and will provide detailed methodological information, model specifications, and analysis protocols upon request.

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