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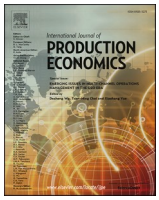

Decarbonisation and firm financial performance: The roles of supply chain transparency and resilience

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ABSTRACT

The main purpose of this study is to examine how decarbonisation affects a firm's financial performance through sustainable supply chain practices, focusing on the role of supply chain transparency and supply chain resilience. While opinions differ on the relationship between firm's environmental performance, sustainable business practices, and financial performance, empirical research has not yet reached a consensus. In this research, we adopted the institutional theory (INT), transaction cost economics (TCE), and the practice-based view (PBV) to develop our conceptual model and attempt to decipher the relationship. The empirical data was collected from 264 UK manufacturing companies and was analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The findings reveal that decarbonisation efforts positively and significantly influence financial performance. More importantly, the impact of decarbonisation is mediated sequentially through both supply chain transparency and supply chain resilience. The study highlights the dual benefits of integrating decarbonisation strategies with transparent and resilient supply chain practices, which not only support environmental sustainability but also drive financial success in organisations.

1. Introduction

Decarbonisation has become a critical focus for organisations aiming to reduce their environmental impact and comply with increasingly stringent regulations (Wang et al., 2020a; Kumar et al., 2024). Notably, the United Kingdom has established a robust framework of carbon regulations to combat climate change and promote sustainability (Pielke, 2009). The UK's Climate Change Act was the world's first legally binding climate change legislation, and in 2019, this target was updated to achieve net-zero emissions by 2050. Similarly, other countries and regions are implementing carbon regulations to combat climate change and reduce greenhouse gas emissions. The European Green Deal, for example, sets a goal for climate neutrality by 2050, with a target of a 55% reduction in emissions by 2030 compared to 1990 levels. The EU Emissions Trading System (ETS) caps emissions from power stations and industrial plants, while the proposed Carbon Border Adjustment Mechanism (CBAM) seeks to impose tariffs on carbon-intensive imports to prevent carbon leakage. Equally, as the world's largest manufacturing country, China introduced the National Carbon Trading Scheme in 2021, targeting power plants with the objective of reducing carbon intensity, which aims to peak carbon emissions by 2030 and achieve carbon neutrality by 2060.

Companies must incorporate sustainability criteria into their production and management systems to help meet these targets (Zhang et al., 2022; Matos et al., 2024) as manufacturing is a major contributor to global carbon emissions (Wang et al., 2020a). Supply chain transparency and resilience have emerged as key strategies to help them do this (Wieland and Durach, 2021; Sodhi and Tang, 2019; Sheffi, 2015) and these practices have gained increasing attention, particularly in an era marked by rising uncertainty, as trade tensions around the world escalate (e.g., the U.S.-China trade war) (Wang et al., 2024a) and the increasingly extreme whether events created by climate change are

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starting to be felt (Choi et al., 2021).

Supply chain transparency and resilience are practices now more commonly adopted by companies seeking to build more sustainable and resilient supply chains, in the context of Industry 5.0 (Leng et al., 2023). As supply chain transparency enhances the visibility and accountability across all the partners in the supply chain, and enables them to identify and reduce carbon-intensive activities that are often difficult to measure and eliminate by only one partner (Sodhi and Tang, 2019; Singh, 2025). Supply chain resilience, on the other hand, ensures that decarbonisation strategies remain viable under conditions of uncertainty and disruption, which are increasingly common in global supply chains (Sheffi, 2020). From this perspective, supply chain transparency and resilience are not merely outcomes of decarbonisation but essential mediators in translating it into improved firm performance. These supply chain practices are also recognised as vital for mitigating supply chain risks and managing disruptions, both of which are key contributors to overall firm performance (Sheffi, 2015; Sodhi and Tang, 2019). Moreover, the transition toward transparency and resilience is often driven not only by ethical imperatives but also by the potential for significant financial benefits too (López et al., 2007; Aastvedt et al., 2021).

Despite their increasing importance, the interrelationships between decarbonisation, supply chain transparency, resilience, and financial performance remain underexplored. Additionally, an important area that remains insufficiently addressed is the direct financial impact of decarbonisation initiatives. The adoption of corporate environmental strategies has sparked considerable scholarly debate, particularly around the question of how these environmental strategies can be integrated in ways that also drive financial success. Much of the literature focuses on environmental and operational benefits, yet few studies have assessed how decarbonisation impacts financial metrics such as profitability and financial performance (Ghosh and Gupta, 2023). Bridging these gaps is essential to offer firms clearer insights into the alternative decarbonisation strategies.

Furthermore, an ongoing debate exists around sustainability, encompassing environmental protection, corporate social responsibility (CSR), and company financial performance (Ameer and Othman, 2012; López et al., 2007; Miroshnychenko et al., 2017; Aastvedt et al., 2021; Gimenez et al., 2012). While sustainability serves as an overarching framework, decarbonisation represents a key environmental strategy within it. Similarly, environmental protection and CSR often encompass decarbonisation, as they reflect a firm's commitment to environmental responsibility and ethical business practices. However, previous studies have reported mixed results regarding the relationship between environmental or sustainable practices and financial performance. Some suggest a positive impact, while others find negligible or no clear effects (Ameer and Othman, 2012; López et al., 2007; Aastvedt et al., 2021; Horváth et al., 2022; Gimenez et al., 2012). For example: Ameer and Othman (2012) found that companies in some industries that focused on sustainability had higher sales growth, better returns on assets, more profit before tax, and stronger cash flow from operations. In contrast, Horváth et al. (2022) suggest that there was no clear link between reduced emissions and profitability changes.

These mixed findings further underscore the need for empirical studies that more clearly elucidate the relationship between decarbonisation initiatives and financial performance. A deeper understanding of this connection can enable firms to make better decisions regarding sustainability investments, thereby encouraging a broader adoption of decarbonisation across different industries. This need leads to the central research question (RQ) of this study:

> RQ: How does decarbonisation influence a firm's financial performance through supply chain practices, specifically supply chain transparency and supply chain resilience?

We developed our conceptual model based on institutional theory (INT), transaction cost economics (TCE), and practice-based view (PBV). These three complementary perspectives provide a robust theoretical foundation for understanding how decarbonisation can enhance corporate financial performance through alternative supply chain mechanisms.

INT posits that firms respond to institutional pressures, including regulatory, normative, and cultural-cognitive, to gain legitimacy (Scott, 2013). From this standpoint, decarbonisation initiatives reflect firms' responses to external pressures, such as environmental regulations and stakeholder expectations. By aligning with these institutional forces, companies not only improve legitimacy but also strengthen their market position and financial performance.

TCE focuses on minimising the costs associated with economic exchanges (Williamson, 1998). Applied in our context, TCE helps explain how decarbonisation, facilitated through supply chain transparency and resilience, can reduce uncertainty, mitigate risk, and lower transaction costs. Transparent and resilient supply chains enable firms to detect and respond to disruptions more efficiently, thus enhancing operational efficiency and cost-effectiveness (Sheffi, 2015).

PBV extends the resource-based perspective by emphasizing the role of organizational practices as sources of competitive advantage (Bromiley and Rau, 2014). Our study highlights supply chain transparency and resilience as critical decarbonisation practices that can be embedded into day-to-day operations. These practices support the implementation of low-carbon strategies, build adaptive capabilities, and ultimately improve financial outcomes (Wang et al., 2020a).

To empirically examine these relationships, we collected data from manufacturing firms in the UK and applied Partial Least Squares Structural Equation Modelling (PLS-SEM), to analyse the proposed conceptual model and its underlying mechanisms.

The remainder of the paper is organised as follows: Sections 2 and 3 review the relevant literature and develop five hypotheses. Section 4 details the research methods, including measurement development, sampling, and data collection. Section 5 presents the data analysis and results. Section 6 addresses the findings and their implications. Finally, Section 7 concludes our study, and discusses its limitations, and opportunities for future research.

2. Literature review

2.1. Decarbonisation

Decarbonisation is an emerging concept that has garnered increasing attention due to the growing motivation for low-carbon emission production (Wang et al., 2020a). Decarbonisation involves reducing greenhouse gas emissions across various activities. It represents a key aspect of environmental performance, driven primarily by the need to address climate change (de Sousa Jabbour et al., 2019). Manufacturing is a critical focus area due to its substantial carbon footprint, which includes emissions from energy use, industrial processes, and supply chain activities (Singh et al., 2018; Xu et al., 2023).

Decarbonisation is no longer a nice-to-have; it's a necessity. Many companies must comply with new or impending legislation (Chan, 2009). Traditional supply chain design primarily focused on minimising fixed and operating costs, often neglecting considerations of carbon emissions (Elhedhli and Merrick, 2012). Therefore, companies must implement carbon emission management strategies to minimise their environmental impact and develop low-carbon supply chains. Zhang et al. (2022) identified four common barriers to decarbonisation, with financial constraints being one of the major challenges. However, the effectiveness and appropriateness of the alternative decarbonisation strategies is still unclear and an underdeveloped area of research (de Sousa Jabbour et al., 2019; Xu et al., 2023).

Supply chain carbon emissions can include Scope 1 emissions, which are direct greenhouse gas (GHG) emissions from sources that are owned or controlled by the company. These are emissions from the company's own operations and equipment. Scope 2 emissions are indirect GHG

emissions from the consumption of purchased electricity, steam, heating, and cooling consumed by a company. These are emissions from energy used by the company but produced by an external source. Scope 3 emissions refer to the indirect GHG emissions that occur in a company's value chain, excluding those from the firm's direct operations and energy use, which cover indirect emissions across the entire value chain, often represent a more significant challenge but are equally important for comprehensive carbon management (Wang et al., 2020a; Chan, 2009). In addition to manufacturing, transportation is a significant contributor to carbon emissions within supply chains (Meyer, 2020).

In this study, we adopt a holistic approach to reducing carbon emissions at the company level. Ameer and Othman (2012) emphasise that the benefits of adopting green practices are not solely determined by external factors such as regulations but are significantly influenced by internal variables shaped by management. Management plays a crucial role in decarbonisation, including: setting reduction targets, developing a carbon management policy, measuring emissions, regularly reviewing progress on emission reductions, and communicating the carbon management plan with suppliers (Chan, 2009). Thus, Decarbonisation refers to the strategic efforts and actions undertaken by a company to reduce its carbon emissions. This includes having a clear vision and policies in place, ensuring staff awareness, regularly measuring GHG emissions, and setting measurable targets to achieve net-zero carbon emissions within a defined timeframe. Kumar et al. (2024) emphasise that decarbonising supply chains should be a data-driven process supported by advanced analytics. This approach underscores the link between decarbonisation and supply chain transparency, as effective decarbonisation relies on access to relevant information such as carbon emissions from companies across the supply chain.

2.2. Supply chain transparency

Supply chain transparency is not a completely new concept but has gained increasing relevance in recent years (Sodhi and Tang, 2019; Montecchi et al., 2021; Morgan et al., 2023; Bag et al., 2023). Supply chain transparency can significantly contribute to sustainability by disclosing environmental footprints, such as carbon emissions, and demonstrating social responsibility, like ensuring workplace safety (Sodhi and Tang, 2019). Supply chain transparency is considered a foundational pillar of supply chain management (Morgan et al., 2018; Xu et al., 2021). It refers to the practice of disclosing information about a product's journey through the supply chain, including its origins, manufacturing processes, and environmental or social impacts (Greer and Purvis, 2016; Asif et al., 2023). Our study, drawing on the definition of supply chain transparency from Sodhi and Tang (2019), supply chain transparency refers to a set of organisational disclosure practices through which a company openly shares information with external stakeholders, including consumers, investors, and the public, about its upstream operations, sourcing practices, and the characteristics of the products it offers. These practices aim to enhance visibility, accountability, and trust across the supply chain.

Supply chain transparency is closely related to the visibility and openness of a supply chain's processes and practices to stakeholders (Sodhi and Tang, 2019). Supply chain transparency provides potential benefits to firms throughout the supply chain network (Xu et al., 2021), and transparency can also have negative consequences on supply chains (Morgan et al., 2018; Mollenkopf et al., 2022). Transparency entails providing clear, accessible information about sourcing, manufacturing, and logistics, shared among all participants in the supply chain (Xu et al., 2021; Sodhi and Tang, 2019). It builds trust among consumers and partners and helps mitigate risks (Wang et al., 2021). It is increasingly important due to consumer demand, regulatory requirements, and ethical considerations (Mollenkopf et al., 2022). Major drivers include regulatory pressures, consumer demand for ethical products, and the need for risk management (Li et al., 2023; Bag et al., 2023). Companies are incentivised to adopt transparent practices to enhance reputation and competitive advantage (Sodhi and Tang, 2019). Furthermore, decarbonisation may enhance supply chain transparency, as companies must collaborate and share carbon emission information with suppliers and customers to maximise the effectiveness of decarbonisation across the entire supply chain (Chan, 2009).

Implementing transparency can be complex due to fragmented supply chains, data privacy concerns, and the cost of technology investments. There is often resistance from suppliers reluctant to share proprietary information (Wang et al., 2023b). Studies indicate that greater transparency can lead to improved supply chain efficiency, better compliance with regulations, and enhanced brand loyalty. However, the benefits must be weighed against potential costs and operational challenges (Sodhi and Tang, 2019). Supply chain transparency is a vital practice in modern supply chain management (Morgan et al., 2023), propelled by external pressures and technological advancements (Ying et al., 2025; Yang and Lu, 2025). Despite the challenges (Sonar et al., 2025), its potential benefits make it a critical area for continued research and development.

2.3. Supply chain resilience

After the COVID-19 crisis, the business world has entered a new normal characterised by significant uncertainties, including geopolitical conflicts, climate change, and rising deglobalisation (Wang et al., 2024a). These factors present numerous challenges for business and supply chains (Wang et al., 2020b, 2022b). Companies are motivated to enhance resilience to protect against financial losses and maintain customer trust (Wang et al., 2020a). It is crucial to strengthen supply chain resilience in response to these evolving threats. Supply chain resilience is a multidimensional criterion. It has been widely viewed as the ability of a supply chain to withstand and recover from disruptions (Tukamuhabwa et al., 2015; Ivanov, 2024). Furthermore, authors argue that supply chain resilience involves not only the ability to respond to unexpected changes both internally and externally but also the capacity to maintain operational continuity at the desired level of connectedness (Wieland and Durach, 2021). Resilience may encompass the establishment of redundancy, which involves the deliberate and strategic allocation of spare capacity and inventory. This approach enables organisations to effectively manage and respond to crises, such as supply shortages or demand surges, by utilising these reserves as needed (Tukamuhabwa et al., 2015; Wang et al., 2025a). Ivanov (2024) emphasises the importance of the ability to recover after a disruptive event, and a company can achieve minimal harm by effectively predicting and preparing for disruptions. In PBV, practices are the focal unit of analysis, defined as things firms do that can lead to better outcomes (Bromiley and Rau, 2014). In this study, supply chain resilience is defined as the set of practices of anticipating, preparing for, responding to, and recovering from disruptive events in supply chains. It is crucial for maintaining operational continuity and competitiveness, and it primarily encompasses three major facets: readiness, response, and recovery (RRR) (Qader et al., 2022; Ivanov, 2024).

Supply chain resilience plays a vital role in modern supply chains. Supply chain resilience is crucial for addressing uncertainties (Ivanov, 2024; Wang and Jie, 2020). As previously mentioned, with increasing global uncertainty and growing supply chain complexity, resilience has become essential (Wang et al., 2024a; Gunasekaran et al., 2015). Beyond being a necessary component of modern supply chains, a key objective of supply chain resilience is to achieve stability in operations (Ivanov, 2024; Wang et al., 2025b). There are several strategies for building resilience. For example, 1) diversification: using multiple suppliers and alternative logistics options to mitigate risks (Wang, 2018); 2) flexibility: developing adaptable manufacturing processes and supply chain networks (Wang et al., 2018; Gunasekaran et al., 2015; Liao et al., 2025); 3) technology and collaboration: leveraging technologies to enhance supply chain processes and reinforcing partnerships with

suppliers and stakeholders to improve communication and risk-sharing (Wang et al., 2021; Pettit et al., 2013; Agarwal et al., 2025). Based on a holistic approach, Wang et al. (2024c) proposes a three-stage circular model that enables companies to learn, respond, and reconfigure their supply chains to achieve stability across different partners. This model also provides clear instructions for attaining supply chain resilience across various supply chain partners from a supply chain integration perspective. Building resilience can be costly and complex (Ivanov, 2024). Challenges may include aligning resilience strategies with existing supply chain processes and managing trade-offs between efficiency and redundancy.

2.4. Financial performance

Financial performance is an important parameter in business operations, and managers must weigh financial factors carefully before making decisions. This performance is closely linked to supply chain management, Wagner et al. (2012) indicate that a higher supply chain fit correlates with an increase in the firm's return on assets (ROA). According to the resource-based view (RBV), firms gain performance advantages by effectively integrating various resources to enhance organisational capabilities (Wernerfelt, 1984). Supply chain management is vital in building these capabilities (Liu et al., 2017), which in turn leads to improved financial performance (Shi and Yu, 2013).

When analysing the financial performance of companies, profitability indicators are crucial (Horváth et al., 2022). We assess financial performance using widely recognised metrics from the literature, such as profit margin, market share growth, return on sales, and sales growth rate (Molina-Azorín et al., 2009; Horváth et al., 2022). While some studies, such as Surroca et al. (2010), have not found a significant relationship between sustainable practices and corporate financial performance, other research suggests that sustainable environmental practices are generally associated with improved financial performance (Tamayo-Torres et al., 2019). Horváth et al. (2022) suggest that while no significant relationship was found between changes in GHG emissions and changes in profitability, a multidirectional relationship between environmental and financial performance was identified. Aastvedt et al. (2021) suggest that a company's financial performance influences its environmental performance, with a positive correlation between the two. Companies with strong financial performance are better positioned to invest in environmental protection and corporate social responsibility (CSR) initiatives, as they have the resources to support these efforts. Chan (2009) suggests that numerous businesses achieve substantial cost savings by cutting their carbon emissions, primarily by enhancing energy efficiency.

3. Theories and hypotheses development

3.1. Institutional theory, transaction cost economics, and practice-based view

INT provides the contextual backdrop, explaining why firms engage in decarbonisation efforts. According to Scott (2014) organisational legitimacy is shaped by regulatory, normative, and cultural-cognitive institutional forces. While these institutional forces are not the central focus of this study, they establish the legitimacy-driven environment in which decarbonisation strategies are pursued. As climate change becomes a critical global concern, regulatory bodies are increasingly enforcing carbon reduction targets, and firms are expected to conform to these standards to maintain legitimacy (Chan, 2009). Moreover, by enhancing supply chain transparency and resilience, firms not only respond to these institutional pressures but also align themselves with stakeholder expectations and societal norms (Montecchi et al., 2021). There is also a growing societal expectation for businesses to operate sustainably (Montecchi et al., 2021). Consumers, investors, and other stakeholders demand transparency regarding environmental practices. For example, consumer pressure is driving a shift in organisational strategies from focusing solely on profit to aiming for a wider range of sustainability outcomes (Mollenkopf et al., 2022). Building on this, TCE highlights the efficiency challenges that arise when firms seek to coordinate decarbonisation across multiple supply chain partners.

TCE is a theoretical framework used to understand and analyse the costs associated with economic transactions (Tadelis and Williamson, 2013; Williamson, 1998). In addition, TCE focuses on the costs incurred when engaging in economic exchanges, governance, resources and the mechanisms firms use to minimise these costs (Williamson, 1998). By improving supply chain transparency and resilience, firms can meet these normative expectations, thus gaining trust and support from stakeholders (Montecchi et al., 2021; Freeman et al., 2021). However, adopting supply chain practices - supply chain transparency and resilience, may involve additional costs. Aligning with these normative expectations can also improve brand reputation and customer loyalty, which are crucial for long-term financial success (Williamson, 1998). As industry standards evolve, firms are increasingly incorporating decarbonisation practices (Horváth et al., 2022). Embracing supply chain transparency and resilience may not only help mitigate risks related to environmental disruptions but may also align with the growing recognition of resilient and sustainable practices as essential to modern business operations.

PBV focuses on the practices within organisations that contribute to their capabilities and performance. This perspective emphasises the micro-foundations of organisational behaviour, looking at how specific activities and processes impact outcomes. As mentioned before, supply chain transparency and supply chain resilience are viewed as supply chain practices. Supply chain transparency strategies guide organisations in determining the appropriate level of disclosure, increasing both internal and external scrutiny, and improving perceptions of openness among stakeholders (Montecchi et al., 2021). Supply chain transparency helps identify and address inefficiencies, environmental impacts, and social issues within the supply chain (Sodhi and Tang, 2019). It drives companies to adopt supply chain practices, such as reducing carbon emissions, ensuring fair labour practices, and minimising waste/costs. Ultimately, supply chain transparency may support long-term sustainability by aligning business operations with broader environmental and social goals, promoting a more ethical and responsible approach to supply chain management.

Supply chain transparency mitigates information asymmetry and opportunism, while supply chain resilience reduces the transaction costs associated with uncertainty and disruptions. Finally, PBV positions supply chain transparency and supply chain resilience as specific organisational practices through which firms operationalise decarbonisation strategies. Supply chain resilience focuses on the ability of a supply chain to adapt to and recover from disruptions, ensuring continuity and stability (Ivanov, 2024). This resilience is essential for sustainability as it helps maintain consistent operations while minimising negative impacts on the environment and society (Tukamuhabwa et al., 2015). This study combines these three theories to develop a model that addresses the archetypal problem of linking decarbonisation, supply chain transparency and resilience, and financial performance.

3.2. Decarbonisation and supply chain practices

According to INT, an organisation's practices may be shaped by the values and beliefs of the society in which it operates. In the era of a net-zero economy, decarbonisation has become a strategic necessity (Kumar et al., 2024). Supply chain has become a major source of carbon emissions in business operations, making the implementation of supply chain practices crucial for long-term success (Lou et al., 2024). Decarbonisation can foster supply chain practices. For instance, as previously discussed, decarbonisation can enhance supply chain transparency by requiring companies to collaborate closely with suppliers to reduce Scope 3 carbon emissions (Wang et al., 2020a). Additionally,

decarbonisation necessitates meticulous measurement and monitoring of supply chain performance to manage carbon emissions effectively (Chan, 2009). This process often works closely with supply chain practices, enabling companies to proactively address potential uncertainties and risks (Xu et al., 2023), thereby increasing supply chain transparency, reducing disruptions, and improving supply chain resilience. The following hypotheses are proposed.

H1a. Decarbonisation is positively associated with supply chain transparency.

H1b. Decarbonisation is positively associated with supply chain resilience.

3.3. Supply chain practices and financial performance

Based on TCE and PBV, supply chain transparency and resilience may add significant value and costs to a company. For instance, increased transparency enhances visibility, mitigates risk, and simultaneously boosts efficiency (Sodhi and Tang, 2019). Nevertheless, there is ongoing debate about the impact of supply chain practices on financial performance. With the growing emphasis on regulatory requirements for sustainability from governments globally, there will be substantial effects on the global supply chain. While businesses primarily aim to generate profit and remain competitive, sustainability often becomes a secondary goal once financial stability is achieved.

Sodhi and Tang (2019) highlight that achieving supply chain transparency involves costs. Similarly, Ivanov (2024) points out that building supply chain resilience requires proactive planning and associated investments. However, supply chain transparency and resilience can enhance a company's confidence, reputation, and ability to manage disruptions, which are increasingly prevalent in modern supply chains.

Transparency enhances the monitoring and management of supply chain processes, leading to improved efficiency and cost savings through streamlined operations and reduced waste (Wang et al., 2021). Additionally, resilient supply chains can recover more swiftly from disruptions, minimising downtime and production interruptions, which in turn reduces financial losses and maintains revenue flow interruptions (Ponomarov and Holcomb, 2009; Wieland and Durach, 2021). Greater transparency also enables companies to anticipate and manage potential disruptions more effectively (Sodhi and Tang, 2019).

Companies with resilient supply chains are better equipped to respond to market changes and competitive pressures, gaining a competitive advantage that can lead to increased market share and profitability. Moreover, transparency supports compliance with regulatory requirements related to sustainability, labour practices, and safety, thereby reducing the risk of fines and legal issues (Wang et al., 2022a). Resilient supply chains contribute to steady production and delivery, resulting in more predictable cash flow and financial stability (Ivanov, 2024). Therefore, these supply chain practices can positively impact financial performance. Based on this, the following hypotheses are proposed:

H2a. Supply chain transparency is positively associated with financial performance.

H2b. Supply chain resilience is positively associated with financial performance.

3.4. Decarbonisation and financial performance

Decarbonisation is an important sustainable environmental effort (Zhang et al., 2022). Based on TCE, previous literature often associates sustainable environmental practices with strong financial performance (Tamayo-Torres et al., 2019; Ameer and Othman, 2012; Wagner, 2007; Gimenez et al., 2012). Wagner (2007) proposed an integration framework that incorporates social and environmental aspects into business management. By integrating social and environmental management with core processes, this approach leads to cost savings, innovative products, increased market share, improved profit margins, and a reduction in work-related accidents and injuries. Gimenez et al. (2012) demonstrate that internal environmental management programmes positively influence not only environmental performance but also economic and social outcomes. Horváth et al. (2022) emphasise that environmental performance positively impacts a company's financial results. Positive actions in environmental (and social) responsibility tend to enhance stakeholder satisfaction, social acceptance, and employee engagement, thereby improving the company's image and reputation (Aastvedt et al., 2021; Gimenez et al., 2012). This may also improve financial performance. Thus, we propose the following hypothesis.

H3. Decarbonisation is positively associated with financial performance.

3.5. Supply chain transparency and resilience

Supply chain transparency refers to a company's set of information disclosure practices that make its upstream operations and products visible to external stakeholders, including consumers, investors, and regulatory bodies. This transparency provides organisations with enhanced visibility into their entire supply chain, encompassing both upstream and downstream activities (Sodhi and Tang, 2019). Such visibility is particularly critical in the context of decarbonisation, as it enables firms to monitor environmental, ethical, and operational practices, thereby ensuring compliance and fostering trust.

This enhanced visibility may aid in the early identification of potential risks and disruptions (Ivanov, 2024; Gunasekaran et al., 2015). For instance, monitoring the environmental compliance of suppliers or their operational quality can alert companies to emerging issues before they escalate into significant problems or scandals. Additionally, transparent supply chains enable faster decision-making by offering information on supply chain activities and disruptions (Wang et al., 2024b; Sodhi and Tang, 2019). This agility allows firms to respond promptly to changes such as sudden shifts in demand and supply shortages, and achieve sustainability (Wang and Wang, 2023; Tukamuhabwa et al., 2015; Wang and Li, 2025). For example, if a supplier faces a delay, having transparency can help in quickly finding alternative sources or adjusting production schedules. Furthermore, transparency promotes better communication and collaboration among partners, leading to more coordinated efforts in addressing issues and enhancing overall performance (Wang et al., 2021; Morgan et al., 2023). Joint initiatives to improve production processes or tackle quality issues can further bolster the supply chain's resilience (Tukamuhabwa et al., 2015). Integrating the PBV, we argue that supply chain transparency is a foundational practice that fosters resilience. Therefore, we propose the following hypothesis:

H4. Supply chain transparency is positively associated with supply chain resilience.

3.6. Mediating effects

Implementing decarbonisation involves reducing GHG emissions and adopting supply chain practices within a company's operations (Wang et al., 2020a). For example, procuring materials and products from environmentally responsible sources and enhancing energy efficiency to lower energy consumption across the supply chain. As companies pursue decarbonisation, they often collaborate closely with supply chain partners to enhance transparency (Chan, 2009). This involves more thorough reporting on emissions, detailed monitoring of supply chain practices, and greater openness regarding environmental impact. Improved transparency enables stakeholders - such as consumers, investors, and regulators - to better assess and understand the company's environmental initiatives and performance (Sodhi and Tang, 2019). Greater supply chain transparency fosters increased trust and enhances

the company's reputation, which may lead to higher market shares and sales, and reduce transaction costs (Wang et al., 2023a; Mollenkopf et al., 2022). Moreover, Aastvedt et al. (2021) suggest that environmental performance positively affects a company's financial performance. By serving as a conduit for realising the benefits of decarbonisation, enhanced transparency from these efforts can boost stakeholder confidence, reinforce the company's reputation, and offer a competitive advantage, ultimately positively impacting financial performance. Thus, we propose the following hypothesis:

H5a. Supply chain transparency mediates the relationship between decarbonisation and financial performance.

As companies adopt decarbonisation, this may strengthen the resilience of their supply chains. Decarbonisation efforts typically involve close collaboration with supply chain partners, which can include diversifying suppliers, investing in effective infrastructure, improving risk management, and adopting new technologies to make the supply chain more robust against disruptions (Zhang et al., 2022). These efforts lead to better preparedness and adaptability in the face of environmental and operational risks, thereby enhancing the supply chain's ability to withstand and recover from disturbances (Wieland and Durach, 2021). Supply chain resilience may act as an intermediary through which the benefits of decarbonisation are realised. Specifically, by enhancing supply chain resilience, decarbonisation efforts positively influence financial performance through improved operational efficiency and reduced transaction costs (Xu et al., 2023). Consequently, the enhanced resilience resulting from decarbonisation contributes to better financial performance by increasing efficiency and minimising costs associated with disruptions. Given this, we propose the following hypothesis:

H5b. Supply chain resilience mediates the relationship between decarbonisation and financial performance.

We also proposed a serial mediation model, involving a sequence of mediators linking the independent variable to the dependent variable (MacKinnon, 2008). In this model, each mediator in the sequence partially mediates the effect of the independent variable on the dependent variable and often influences the subsequent mediator. Specifically, this study examines how the effect of decarbonisation on financial performance is mediated sequentially through supply chain transparency and supply chain resilience. Based on these proposed relationships, we have formulated the following hypothesis:

H5c. The relationship between decarbonisation and financial performance is serially mediated by supply chain transparency and supply chain resilience.

Overall, Fig. 1 depicts the proposed relationships between company-level decarbonisation efforts, supply chain practices - including supply chain resilience and transparency - and financial performance.

4. Methods

4.1. Sampling and data collection

We used our Qualtrics online survey to collect empirical data in the UK manufacturing industry. The research data for our study was collected at the firm level. For each firm included in the survey, we selected one respondent. Our participants were primarily focused on individuals holding managerial positions, ensuring that the responses reflected insights and perspectives from those with a comprehensive understanding of their firm's operations and strategic direction. Table 1 presents the demographic information from this survey, indicating that over 80% of respondents held managerial positions, suggesting the quality of the research data is high. Company size was assessed based on the number of employees in the UK, revealing that a majority of the companies are large, which aligns with the typical characteristics of manufacturing firms in the UK (Kitson and Michie, 2014). The questionnaire was carefully crafted (Dillman, 2011), with all measurement items adapted or developed from previous studies. To ensure content validity, we invited three academics and five managers to evaluate the survey. A pilot study was conducted to test reliability and validity before we commenced large-scale data collection.

The initial sample frame comprised 1000 UK manufacturing firms, selected based on the categories outlined in the UKSIC 2007. These included various types of manufacturers, such as those producing food products, beverages, plastic products, machinery, and equipment, among others. We contacted their managers via LinkedIn, inviting them to participate in our online survey. A cover letter introducing our research project accompanied the invitations. Companies that declined

Table 1
Demographic information (n = 264).

	Category	Frequency	Percentage %
Position	CEO/Senior Managers/ Owners	134	51%
	Middle managers/ Supervisor	82	31%
	Staff/Employee	48	18%
Firm size - number of employees	between 1 and 9	35	13%
	between 10 and 49	56	21%
	between 50 and 249	60	23%
	More than 250	113	43%

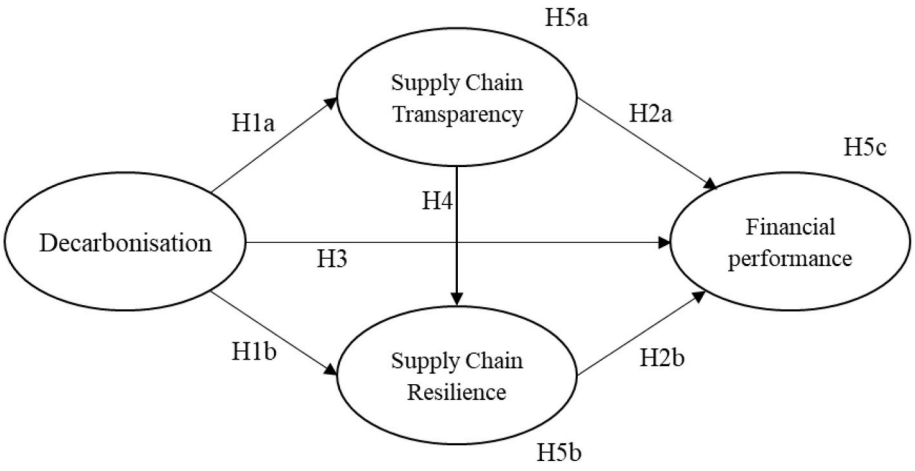

Fig. 1. Research conceptual framework.

our invitation were removed from our list. We sent the survey link through LinkedIn messages to the managers and followed up with a reminder message after two weeks if we had not received a response. The data collection period began at the end of 2023 and concluded in February 2024. During data collection, our survey received praise from managers for addressing significant issues in the current UK manufacturing industry. At the end of the data collection period, we removed incomplete responses; a total of 264 valid survey responses were used in our data analyses, resulting in an approximate response rate of 26% for this study.

4.2. Measures

In this study, measures were adopted from existing literature or research. A measurement scale in research refers to a set of items or statements designed to quantify concepts or variables of interest (Bryman and Bell, 2011). It serves as a structured tool to collect data systematically and reliably, allowing researchers to assess and analyse phenomena in a standardised manner. In this study, all measurement items were assessed using a 7-point Likert scale, which offers several advantages over other types of Likert measures (Joshi et al., 2015). Table 3 summarises the scales used in the research framework.

The independent variable is decarbonisation, which assesses the degree to which firms reduce carbon emissions in their operations. Originally developed in our research project on port decarbonisation in China, several academics and practitioners have contributed to the development of the measurement items to ensure they comprehensively cover the construct's domain and establish content validity. For this study, we have slightly revised the statements to align with UK manufacturing operations. According to our results from factor analyses, the measurement scale demonstrates reliability and validity in this study.

In this study, supply chain transparency and resilience serve as mediators. They may help us understand the mechanisms connecting environmental performance, supply chain practices, and financial performance (Sodhi and Tang, 2019; Wieland and Durach, 2021). Supply chain transparency measures assess how organisations openly and easily disclose their product/service and supply chain information. The construct was inspired and developed based on prior studies on supply chain transparency (Sodhi and Tang, 2019). Supply chain resilience measures were adopted from previous studies (Qader et al., 2022). In this model, financial performance is the dependent variable, evaluating a company's overall financial outcomes, with all measurement items drawn from previous studies (Molina-Azorín et al., 2009; Eller et al., 2020). We have also included the control variable of company size to gain a clearer understanding of the relationships among the constructs in this model.

4.3. Common methods bias and non-response bias

Since self-reported data were used in this study and the same respondents answered questions on both performance and its determinants, there was a potential for common method bias (CMB) (Podsakoff et al., 2003). Several methods were used to test for CMB in this study. First, we have implemented several recommendations on research design and process from Podsakoff et al. (2012) to minimise the impact of common method bias. For example: we maintain survey anonymity to ensure respondents that their answers are anonymous and will be kept confidential, thereby reducing social desirability bias. Separate the measurement of the variables to make it less likely that respondents will use a common method to answer all questions. We also ensure that questions are clear, concise, and specific to avoid confusion and misinterpretation.

In addition, we conduct an exploratory factor analysis (EFA) on all items of the variables to assess the presence of CMB in our study. This Harman's Single-Factor test evaluates whether a single factor accounts for the majority of the variance in the data, which would indicate potential CMB. Principal component analysis (PCA) was used as the extraction method, and no rotation was applied. The analysis was conducted using SPSS software. The results of Harman's Single-Factor Test revealed that the first largest factor accounted for 34.9% of the variance, which is below the commonly accepted threshold of 50%. We conclude that common method bias is unlikely to be a significant concern in this study.

To assess the potential impact of CMB, we also included a marker variable, "work-life balance," which is theoretically unrelated to our primary variables (Williams et al., 2010). We conducted a partial correlation analysis to control for this marker variable. After controlling for the marker variable, the correlations ranged from 0.19 to 0.29, with a maximum change of 0.05. The minimal changes in the correlations suggest that common method bias is unlikely to significantly affect the relationships among the primary variables in this study. This approach provides a robust test of the presence and impact of CMB in the study.

Testing for non-response bias is crucial in research because it helps ensure the validity and generalisability of study results. Non-response bias occurs when the individuals who do not respond to a survey or study differ significantly from those who do respond, potentially skewing the results and leading to inaccurate conclusions (Sheikh and Mattingly, 1981). We conducted a wave analysis by comparing early and late respondents. The analysis revealed no significant differences between early and late respondents in key variables. Furthermore, the comparison of respondents and non-respondents showed no significant differences in their positions.

5. Analyses and results

5.1. Exploratory factor analysis

Although several constructs in this study were drawn from established scales, some items were newly developed or adapted to reflect the specific context of decarbonisation. To ensure the validity and reliability of these items, we first conducted Exploratory Factor Analysis (EFA) to examine the underlying factor structure, followed by Confirmatory Factor Analysis (CFA) to validate the measurement model. This two-step approach ensures that both established and newly adapted items accurately capture the intended constructs.

We employed Partial Least Squares Structural Equation Modeling (PLS-SEM) for hypothesis testing. PLS-SEM was chosen for several reasons: (1) our study is predictive and exploratory in nature, focusing on explaining variance in firm performance rather than strictly confirming theory; (2) the model includes multiple mediators and complex relationships, which PLS-SEM handles efficiently; and (3) some indicators did not fully meet the assumptions of multivariate normality, and PLS-SEM provides robust estimates under such conditions. Overall, this approach provides a rigorous and appropriate framework for examining the relationships in our conceptual model.

The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was 0.872, indicating that the sample was suitable for factor analysis (values above 0.80 are considered meritorious). Bartlett's Test of Sphericity was significant, $\chi^2(210) = 3651.061$, $p < 0.001$, suggesting that the correlations between items were sufficiently large for factor analysis. EFA is a statistical technique designed to identify the underlying relationships between variables. It helps uncover the structure of observed variables by grouping them into factors, which represent common dimensions that explain the correlations among the variables (Fabrigar, 2012).

We conducted EFA using the SPSS software. This process involved initially loading all factors and extracting them from the correlation matrix with PCA. We then applied Varimax rotation to improve the interpretability of the factors. To decide on the number of factors to retain, we employed the Kaiser criterion (eigenvalues greater than 1). The results of the EFA are presented in Table 2. During the EFA, four constructs were identified. These factors perfectly align with our

Table 2
Rotated component matrix.

	Component			
	SCR	Decarb	FP	SCT
R4	.852			
R5	.852			
R3	.850			
R6	.840			
R2	.758			
R1	.749			
D2		.894		
D5		.838		
D1		.836		
D4		.825		
D3		.817		
F4			.823	
F5			.756	
F2			.748	
F1			.715	
F3			.712	
T3				.822
T4				.815
T6				.692
T5				.688
T1				.679

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
Rotation converged in 5 iterations.

construct measurement items. Only one item was removed due to cross-loading issues. The results demonstrate the validity of the instruments used in the study.

5.2. Measurement model

We further tested our measurement models using Confirmatory Factor Analysis (CFA) within structural equation modelling to confirm the dimensional structure identified through EFA and to ensure that the items adequately represented the latent constructs before proceeding to PLS-SEM. This process aligns with established methodological practices for construct validation in early-stage scale development (SEM) (Hair et al., 2014). Reliability and validity analysis involves assessing the quality and accuracy of measurement models and their ability to represent theoretical constructs (Bryman and Bell, 2011). Reliability refers to the consistency and stability of a measurement instrument. In SEM, it is typically assessed through several criteria. Cronbach's Alpha measures the internal consistency of a set of items within a construct, with a higher alpha (generally above 0.70) indicating that the items are reliably measuring the same underlying construct. Our results indicate that all constructs have a Cronbach's Alpha greater than 0.8. Composite Reliability (CR) evaluates the reliability of a latent variable by considering the factor loadings of its indicators, with values above 0.70 deemed acceptable. Our results show that all constructs have a CR greater than 0.8. Additionally, each indicator's loading on its corresponding factor reflects its reliability, with higher loadings (typically above 0.60) suggesting that the indicators effectively measure the latent construct (Hair, 2010). All our factor loadings are above 0.65, indicating satisfactory reliability.

Validity refers to how well a measurement instrument accurately measures what it is intended to measure (Hair, 2010). In this study, validity is assessed through several criteria. Convergent Validity is evaluated using the Average Variance Extracted (AVE), which measures the proportion of variance captured by a latent construct relative to the measurement error, with an AVE value above 0.50 indicating good convergent validity. Table 3 presents the results of the reliability and validity analysis in this study.

Discriminant validity ensures that a construct is distinct from other constructs (Hair, 2010). We assessed discriminant validity using both

Table 3
Results of reliability and validity analysis.

Constructs and items		Factor loadings	SD	T-statistics
Decarbonisation (Cronbach's α = 0.926; CR = 0.944; AVE = 0.773)				
D1	1. Our company has a clear vision of reducing carbon emissions.	0.877	0.018	48.289
D2	2. Our company has relevant decarbonisation policies.	0.910	0.021	43.409
D3	3. Our staff understand the decarbonisation policy.	0.860	0.019	44.621
D4	4. Our company regularly measures greenhouse gas (GHG) emissions.	0.867	0.022	39.524
D5	5. Our company has set targets to achieve net zero carbon within the announced timeframe.	0.879	0.019	46.816
Supply Chain Transparency (Cronbach's α = 0.827; CR = 0.878; AVE = 0.592)				
T1	1. Our company discloses relevant product/service and supply chain information to our customers.	0.704	0.048	14.660
T2	2. Our company operates transparently with other supply chain partners to ensure that all the transactions are visible quickly.	0.834	0.025	33.282
T3	3. Our company frequently shares information with supply chain partners	0.792	0.037	21.670
T4	4. Our company collaborates with its suppliers to improve transparency.	0.816	0.027	29.955
T5	5. Our company makes its supply chain operations (i.e., disclosing supplier information) more transparent to the public	0.690	0.037	18.648
Supply Chain Resilience (Cronbach's α = 0.929; CR = 0.944; AVE = 0.738)				
R1	1. Our company (prior to disruptions) can eliminate the source of potential disruptions before they occur.	0.827	0.023	35.752
R2	2. Our company (prior to disruptions) monitors supply chain processes in advance to prevent potential disruptions.	0.846	0.022	39.276
R3	3. Our company (immediately after disruptions) can rapidly respond to actual disruptions.	0.887	0.017	52.566
R4	4. Our company (immediately after disruptions) can quickly recognise supply chain resources immediately after an actual disruption breaks out.	0.897	0.018	49.577
R5	5. Our company (afterward until recovery) can recover from disruptions in the supply chain.	0.857	0.024	34.962
R6	6. Our company (afterward until recovery) can reconfigure supply chain resources after responding to disruptions in the supply chain.	0.838	0.028	29.572
Financial Performance (Cronbach's α = 0.834; CR = 0.879; AVE = 0.594)				
F1	1. We have a high market share growth.	0.835	0.026	32.068
F2	2. We have a high sales growth rate.	0.831	0.027	30.625
F3	3. Our products command a significant share of the market.	0.798	0.028	28.108
F4	4. We have a high -profit margin on sales.	0.680	0.067	10.092
F5	5. We have a high return on sales.	0.700	0.060	11.676

the Fornell-Larcker Criterion and the Heterotrait-Monotrait Ratio (HTMT) (Hair et al., 2014). According to the Fornell-Larcker Criterion, the square root of the AVE for each construct should exceed its correlations with other constructs (Fornell and Larcker, 1981; Fornell and Larcker, 1981). Additionally, HTMT measures the average correlations between indicators of different constructs relative to the average correlations within the same construct. HTMT ratios below the recommended threshold (<0.85) suggest good discriminant validity (Henseler et al., 2015). Our HTMT values are below this threshold, indicating that the constructs are sufficiently distinct. Table 4 presents the results of our discriminant validity analysis.

Table 4
Results of discriminant validity analysis.

Construct	FP	SCR	SCT	Decarb
Fornell-Larcker Criterion				
Financial Performance (FP)	0.771			
Supply Chain Resilience (SCR)	0.366	0.859		
Supply Chain Transparency (SCT)	0.299	0.416	0.769	
Decarbonisation	0.341	0.440	0.314	0.879
HTMT				
FP	–			
SCR	0.389			
SCT	0.337	0.451		
Decarb	0.356	0.470	0.354	–

5.3. Structural model

Testing for collinearity issues is crucial in SEM to ensure that predictors are not excessively correlated, which can lead to unreliable coefficient estimates (Hair, 2010). We assessed collinearity by calculating the variance inflation factor (VIF). High VIF values (greater than 5) indicate significant collinearity among predictors, potentially affecting the stability of the regression coefficients (Hair, 2010). Our results show that all VIF values are below 4, suggesting that collinearity is not an issue in this study.

An analysis of unobserved heterogeneity was performed using the FIMIX-PLS procedure in SmartPLS. Endogeneity in PLS-SEM occurs when there is a correlation between an explanatory variable (independent variable) and the error term in a model. This can lead to biased or unreliable estimates (Sarstedt et al., 2020). The results of the FIMIX-PLS analysis indicated that unobserved heterogeneity did not significantly impact the data within the model.

In PLS-SEM, model fit indices are used to evaluate how well the proposed model represents the data (Hair et al., 2019). While PLS-SEM is more focused on prediction rather than strict model fit, we assessed the model's adequacy using several indices: Standardised Root Mean Square Residual (SRMR), Normed Fit Index (NFI), R^2 and Q^2. SRMR measures the difference between the observed and the predicted correlations in the model, standardised to account for differences in scale. An SRMR value below 0.08 is generally considered a good fit, indicating that the model's predictions are close to the observed data. Our model has an SRMR of 0.07, indicating a satisfactory fit. NFI compares the fit of the model to a null model. Values closer to 1 indicate a better fit. NFI values above 0.90 are often considered indicative of a good fit. Our model's NFI is 0.89, which is slightly below the recommended threshold but still acceptable in the context of our study. R^2 assesses the proportion of variance in the dependent variables that is explained by the independent variables. Our R^2 values range from 0.10 to 0.20. Additionally, we conducted a blindfolding analysis for all endogenous constructs. Q^2 evaluates the model's ability to predict the endogenous variables' values. It reflects how well the model can predict the observed data by comparing predicted values to actual values. The Q^2 values obtained were positive across the board (SCT = 0.054, SCR = 0.199, FP = 0.096), demonstrating that the structural model possesses adequate predictive relevance for the dependent variable. Given the exploratory nature of our model and the complexity of the phenomena studied, these values, along with other evaluation criteria, suggest that the model's performance is acceptable or good for this study.

After confirming the model fit in our study, we conducted a PLS-SEM analysis to test hypotheses H1 through H4, including the control variable. We examined the path coefficients to assess the strength and direction of the relationships between constructs, comparing these coefficients with our hypothesised directions and expectations. To determine the significance of the path coefficients, we employed bootstrapping with 5000 resamples, generating numerous bootstrap samples to estimate standard errors and significance levels. Paths with *p*-values less than 0.05 were deemed statistically significant. Our results reveal that all direct relationships—between decarbonisation, supply chain transparency, supply chain resilience, and financial performance—are statistically significant. This is confirmed by the 95% bias-corrected bootstrapped confidence intervals for the path estimates, which align with our expectations. Table 5 summarises the results of the direct effect testing and hypothesis tests.

5.4. Mediation analysis

Based on the results, all direct path coefficients are significant. In this study, we also examined the mediation effects within the research model (Hayes, 2018). Specifically, we investigated how two supply chain practices - supply chain transparency and supply chain resilience - mediate the relationship between decarbonisation and financial performance (i.e., H5a, H5b and H5c). These mediations may help elucidate the mechanisms through which decarbonisation impacts financial outcomes. The bootstrap resampling method was employed to test the mediating effects in the model. Additionally, this study calculated all path coefficients while simultaneously controlling for company size. The control variable did not show a significant relationship with the study variables.

To test the mediation hypotheses (H5a–H5c), a bootstrapping procedure with 5000 resamples was employed. The results demonstrate significant indirect effects for all three mediation paths. Hypothesis H5a posits that supply chain transparency mediates the relationship between decarbonisation and financial performance. The bootstrapped results confirm a significant indirect effect ($\beta = 0.047$, $t = 2.062$, $p < 0.05$, 95% BCa CI [0.006, 0.095]), thus supporting H5a. Hypothesis H5b suggests that supply chain resilience mediates the relationship between decarbonisation and financial performance. The indirect effect was also significant ($\beta = 0.075$, $t = 2.422$, $p < 0.05$, 95% BCa CI [0.022, 0.145]), thus supporting H5b. Hypothesis H5c proposes that the relationship between decarbonisation and financial performance is serially mediated by both supply chain transparency and supply chain resilience. The bootstrapped indirect effect for this path was significant ($\beta = 0.021$, $t = 2.194$, $p < 0.05$, 95% BCa CI [0.006, 0.044]), confirming support for H5c. The analysis reveals that the indirect effect of decarbonisation on financial performance through both mediators is significant. Consequently, the study accepts all the proposed hypotheses. Table 6 summarises the results of the mediation effect testing conducted in this study.

6. Discussion

Decarbonisation has emerged as a key focus in supply chain management (Wang et al., 2020a). However, as previously noted, there is a lack of empirical studies exploring the effects of decarbonisation on supply chain practices and corporate financial performance. Additionally, the literature presents ongoing debates regarding the interplay between environmental performance, supply chain practices, and financial outcomes. This study employed supply chain transparency and supply chain resilience as mediators between decarbonisation and financial performance, using the frameworks of INT, TCE, and the PBV to explore the underlying relationships. Our results indicate that all direct relationships in this model are significant and align with findings from previous studies (Horváth et al., 2022). Additionally, we conducted mediation analyses to unravel the complex causal chains and mechanisms through which decarbonisation impacts financial performance. The research suggests a serial mediation model, where decarbonisation first influences supply chain transparency, which then impacts supply chain resilience. Subsequently, both transparency and resilience together affect financial performance. In other words, decarbonisation enhances transparency, which improves resilience, and both factors collectively contribute to better financial outcomes.

Supply chain transparency involves the clear and open disclosure of information related to the sourcing, production, and distribution of

Table 5
Results of direct effect testing.

Hypothesis	Path	Coefficient	SD	T-statistics	p-value	Inference
H1a	Decarb→SCT	0.314	0.059	5.331	0.000	Supported
H1b	Decarb→SCR	0.442	0.059	5.780	0.000	Supported
H2a	SCT→FP	0.148	0.063	2.362	0.018	Supported
H2b	SCR→FP	0.228	0.076	2.966	0.003	Supported
H3	Decarb→FP	0.199	0.067	2.964	0.003	Supported
H4	SCT→SCR	0.309	0.064	4.826	0.000	Supported

Table 6
Results of mediating effect testing.

Hypothesis	Indirect paths	SD	T-statistics	p-value	Inference
H5a	Decarb→SCT→FP	0.023	2.062	0.040	Supported
H5b	Decarb→SCR→FP	0.031	2.422	0.015	Supported
H5c	Decarb→SCT→SCR→FP	0.010	2.194	0.028	Supported

products (Sodhi and Tang, 2019). This practice may foster trust and compliance, which may help companies enhance business integrity and reduce corruption. Consequently, it may improve a firm's market positioning and profitability. On the other hand, supply chain resilience is the ability of a supply chain to adapt to disruptions and maintain continuous operations (Wieland and Durach, 2021). A resilient supply chain mitigates risks associated with environmental regulations and climate change, thereby stabilising financial performance (Ivanov, 2024; Tukamuhabwa et al., 2015). In the serial mediation model, this study also confirms that supply chain transparency can enhance supply chain resilience. Developing transparency is crucial for maximising decarbonisation efforts, building resilience, and ultimately improving financial performance. Enhanced resilience resulting from decarbonisation measures may lead to improved operational efficiency, cost savings, and higher profit margins (Tukamuhabwa et al., 2015; Chan, 2009). In this paper, we argue that it is feasible to develop a transparent, resilient, and low-carbon supply chain, as supported by empirical results from UK manufacturing companies.

Decarbonisation is inherently complex, with no one-size-fits-all solution applicable across all companies and industries (Chan, 2009). However, this study suggests that enhancing transparency and strengthening supply chain resilience can facilitate the positive effects of decarbonisation, leading to improved financial performance. These supply chain practices align with effective carbon management. For instance, regulations mandate that companies calculate and report their emissions annually (Chan, 2009), which also necessitates close collaboration with supply chain partners, thereby enhancing supply chain resilience. The Climate Change Act 2008 positioned the UK as the first country to establish a legally binding framework for long-term carbon emission reductions. Our empirical findings from the UK manufacturing sector indicate that companies are adapting to these changes and demonstrate a strong positive relationship among the constructs in the model.

6.1. Theoretical implications

The theoretical significance of this research is threefold. First, as the global push towards decarbonisation intensifies, understanding the financial implications for firms becomes increasingly vital for both academia and industry (Kumar et al., 2024). Decarbonisation initiatives often signal a firm's long-term commitment to environmental sustainability. However, their effectiveness depends on the presence of complementary practices, particularly transparency. Without transparent communication and shared practices across the supply chain, decarbonisation efforts risk being ineffective or misunderstood, reducing their visibility, impact, and stakeholder engagement. This study contributes to the literature by providing empirical evidence that decarbonisation can positively influence financial performance when supported by robust supply chain practices. Furthermore, we offer a validated measurement instrument for assessing decarbonisation at the firm level, which can support future empirical research in this area.

Second, the study integrates three theoretical perspectives including INT, TCE, and the PBV, to offer a more comprehensive explanation of how decarbonisation strategies influence firm performance through supply chain practices. Previous studies have primarily relied on single-theory approaches, such as INT to examine institutional pressures or TCE to analyse the cost-efficiency of sustainability strategies.

- INT provides the contextual lens, explaining how external institutional forces such as regulatory, normative, and cognitive, shape firms' sustainability practices, including decarbonisation, as companies seek legitimacy and compliance in response to climate change regulations (Scott, 2014).
- TCE provides a lens to understand how decentralization reduces transaction costs and improves company efficiency through supply chain transparency and resilience, and enables more efficient coordination across the supply chain (Williamson, 1998).
- PBV highlights how specific practices, such as supply chain transparency and resilience, translate strategic initiatives like decarbonisation into operational and financial benefits (Bromiley and Rau, 2014).

By combining these perspectives, the framework offers a more comprehensive explanation than any single theory: it clarifies why firms act, how they navigate associated challenges, and through which practices performance outcomes are achieved. This theoretical integration advances our understanding of the mechanisms linking decarbonisation to firm performance. This integrated theoretical framework extends prior work. It also offers a richer understanding of the mechanisms through which decarbonisation efforts yield financial returns.

Third, the study contributes to the growing literature on the link between environmental and financial performance by identifying supply chain transparency and resilience as key mediating mechanisms. Building on the work of Molina-Azorín et al. (2009), we test a serial mediation model in which transparency and resilience jointly mediate the relationship between decarbonisation and financial performance. Transparency acts as the operational bridge, enabling an open flow of environmental information that builds trust, improves monitoring, and enhances supply chain coordination (Sodhi and Tang, 2019). This, in turn, strengthens resilience by equipping stakeholders with the necessary insights to manage and adapt to disruptions (Sheffi, 2015).

The findings underscore that transparent and resilient supply chains, underpinned by decarbonisation, are better positioned to maintain operational continuity and reduce the financial impact of disruptions.

Decarbonisation thus acts as a strategic catalyst, fostering internal changes that enhance both transparency and resilience. These interdependent practices collectively support stronger financial outcomes, revealing a pathway through which sustainability and profitability can coexist.

This study's theoretical contribution lies in clarifying the mechanisms linking decarbonisation to financial performance. It does so by demonstrating how transparency and resilience function sequentially to amplify the financial benefits of environmental strategies. By integrating INT, TCE, and PBV, we offer a comprehensive and multi-theoretic lens to understand the environmental-economic interface in supply chain management. This contributes to a more integrated understanding of how firms can achieve dual objectives: environmental sustainability and financial performance through complementary supply chain strategies.

6.2. Managerial implications

This study offers several important managerial insights into supply chain practices and strategic decision-making in the context of decarbonisation. First, it provides a practical roadmap for navigating institutional pressures related to environmental sustainability. By empirically demonstrating the positive effect of decarbonisation on financial performance mediated through supply chain transparency and resilience, this study reinforces the business case for adopting sustainability initiatives beyond regulatory compliance. The findings suggest that effective decarbonisation involves more than goal setting; it requires a comprehensive and embedded approach. Specifically, firms demonstrating high performance in decarbonisation tend to:

- Establish a clear vision and company-wide commitment to reducing carbon emissions.
- Develop and communicate formal decarbonisation policies across all organisational levels.
- Ensure that staff are aware of and understand these policies.
- Regularly monitor and measure GHG emissions.
- Set specific and time-bound targets to achieve net-zero carbon emissions.

These practices reflect not only regulatory compliance but also internal readiness and cultural alignment toward environmental goals. By integrating these elements, managers may position their organisations as proactive and responsible players in low-carbon transitions. Furthermore, managers in manufacturing sectors, especially in developed economies like the UK, can draw confidence from these findings when investing in decarbonisation strategies. Prior studies, such as Zhang et al. (2022), have highlighted a widespread lack of knowledge and direction as a key barrier to decarbonisation. This research helps address that gap by clarifying how decarbonisation contributes to financial outcomes, provided that it is embedded within transparent and resilient supply chain systems.

Practically, this means that managers should not view decarbonisation in isolation but as part of a broader, interconnected strategic framework. Effective implementation requires developing systems that enhance transparency and building resilience. Collaborating closely with upstream and downstream partners is essential to co-create a low-carbon supply chain that meets both environmental and performance goals. The findings highlight the crucial role of supply chain transparency and resilience as mediating mechanisms through which decarbonisation affects financial outcomes. Managers should not only focus on emissions reduction efforts but also prioritise transparency and resilience practices to maximise value.

Based on the validated items in this study, managers can enhance supply chain transparency by:

- Disclosing relevant product, service, and supply chain information to customers;
- Operating transparently with supply chain partners to ensure rapid visibility of transactions;
- Frequently sharing information with supply chain stakeholders;
- Collaborating with suppliers to enhance transparency;
- Making supply chain operations more transparent to the public.

These practices foster stakeholder trust, improve collaboration, and support regulatory compliance, which collectively strengthen legitimacy and performance outcomes.

In parallel, managers should strengthen supply chain resilience by focusing on three key phases of disruption management:

- Proactive preparation: eliminating sources of potential disruptions and monitoring supply chain processes in advance;
- Immediate response: responding rapidly and recognising supply chain resources immediately following a disruption;
- Post-disruption recovery: recovering operations effectively and reconfiguring supply chain resources after disruptions.

By institutionalising these practices, companies can reduce vulnerability to supply chain shocks and maintain performance continuity even during periods of uncertainty. This study offers a practical framework for aligning environmental and financial goals. Managers are encouraged to approach decarbonisation not as a standalone initiative but as part of a broader supply chain strategy that incorporates transparency and resilience. These interrelated practices not only support sustainable development goals but also contribute directly to financial success.

7. Conclusion

This study examined the impact of decarbonisation on firm financial performance, focusing on the mediating roles of supply chain transparency and supply chain resilience. Drawing on INT, TCE, and the PBV, we developed and tested a conceptual framework that explores how decarbonisation influences financial outcomes through supply chain practices. By integrating these theoretical perspectives, the research provides a comprehensive understanding of how decarbonisation efforts are operationalised through supply chain practices to generate economic value.

The empirical findings reveal that decarbonisation is positively and significantly associated with financial performance. Importantly, this relationship is mediated sequentially by supply chain transparency and resilience. These results contribute to the ongoing discourse on ESG practices by demonstrating that sustainability initiatives, when strategically embedded within supply chain operations, can enhance organisational performance. Furthermore, as the UK was the first country to introduce carbon legislation, our findings offer timely and relevant insights for manufacturing firms navigating regulatory environments and sustainability pressures.

Despite these contributions, the study has several limitations. First, the focus on UK manufacturing firms may limit the generalisability of the findings. Future research could extend the model to other industries and geographic regions to validate and compare the effects across different regulatory and cultural contexts. Second, while this study identifies a partial mediation effect of transparency and resilience, other potential mediators and moderators—such as leadership commitment, stakeholder engagement, or digital capabilities—could be explored in future work. Third, the study concentrates on decarbonisation from an internal organisational perspective. Future research could examine the role of external drivers, such as regulatory frameworks, market pressures, or institutional forces, to offer a more holistic view of decarbonisation dynamics. Finally, qualitative approaches could complement the quantitative findings by offering rich insights into the processes, capabilities, and challenges that underpin effective decarbonisation strategies.

In sum, this research highlights the importance of integrating environmental objectives with robust supply chain practices. By doing so, companies can not only respond to institutional and regulatory pressures but also achieve superior financial outcomes, positioning sustainability as a strategic enabler of long-term success.

CRediT authorship contribution statement

Michael Wang: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Yang Liu:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Duanyang Geng:** Writing – review & editing, Methodology, Conceptualization. **Manoj Dora:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Alex Hill:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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