**Equilibrium. Quarterly Journal of Economics and Economic Policy**
**Volume 19 Issue 3 September 2024**
p-ISSN 1689-765X, e-ISSN 2353-3293
www.economic-policy.pl

**ORIGINAL ARTICLE**

**Citation:** Chatzoudes, D., Kadłubek, M., & Maditinos, D. (2024). Green logistics practices: The antecedents and effects for supply chain management in the modern era. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *19*(3), 991–1034. https://doi.org/10.24136/eq.2864

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Article history: Received: 18.01.2024; Accepted: 16.08.2024; Published online: 27.09.2024

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# Green logistics practices: The antecedents and effects for supply chain management in the modern era

**JEL Classification:** *M11; L25*

**Keywords:** *supply chain management; green supply chain; environmental regulatory pressure; government support; social reputation*

**Abstract**

**Research background:** Green logistics has become a focal point of interest for researchers and practitioners across diverse sectors, including operations, logistics, and supply chain management, over the past two decades. As global sustainability pressures intensify, the significance of green logistics continues to rise, driving a surge in empirical studies aimed at uncovering its far-reaching organizational impacts.

**Purpose of the article:** This empirical study seeks to bridge a gap in the literature by consolidating key organizational elements that have not been collectively explored. At the core of this research is an original conceptual framework, meticulously developed and validated through a comprehensive empirical survey. The framework captures nine distinct factors, grouped into three critical dimensions: (a) drivers of green logistics practices, (b) the implementation of green logistics practices, and (c) firm performance as measured by the outcomes of these practices. Notably, four factors — customer pressure, economic pressure, environmental regulatory pressure, and government support — act as independent variables, while green logistics practices serve as both an independent and dependent factor. The dependent variables span four key aspects of firm performance: operational performance, financial performance, market performance, and social reputation. More explicitly, the aim of this study is to explore the key drivers and outcomes of green logistics practices, focusing on how factors like regulatory pressures and customer demands influence their adoption, and how these practices impact different measures of firm performance.

**Methods:** The conceptual framework introduced in this study, organized across three dimensions, represents a novel approach that has been scarcely explored in the existing literature. To evaluate this framework, a newly developed, structured questionnaire was distributed to a carefully selected sample of Greek manufacturing companies. Respondents, including supply chain managers, operations managers, and chief executive officers, were chosen for their specialized knowledge and strategic insights. The empirical data were rigorously analysed using Structural Equation Modeling (SEM), a robust and well-established multivariate technique. This study is grounded in primary data, it is explanatory in nature as it examines cause-and-effect relationships, it is deductive as it tests (eight) research hypotheses, and quantitative through its statistical analysis of data gathered via a structured research instrument.

**Findings & value added:** This study contributes significant empirical insights into the implementation and impact of green logistics practices within supply chain management. Unlike previous studies, it consolidates critical organizational elements into a comprehensive framework that reveals the influence of regulatory, economic, and customer pressures on green logistics adoption. The empirical results demonstrate that environmental regulatory pressure is the strongest driver of green logistics, underscoring the importance of regulatory compliance in shaping sustainable practices. This finding is particularly relevant, as stricter environmental regulations are expected in the coming years, making it timely and impactful for both academics and practitioners. The research also highlights the tangible benefits of green logistics practices on operational, financial, and market performance, as well as social reputation. This multi-dimensional approach offers more depth into the current body of research, indicating how green logistics practices can align with broader sustainability goals, while also enhancing business competitiveness. The value added of this study lies in the integration of three sets of factors, proposing a framework that can be used by future empirical research and business executives in the future. Finally, this empirical research offers practical guidance for state policymakers that aim to promote the adoption of green logistics and maximise their positive impact for business and society. Its findings suggest that enhancing the regulatory framework and, at the same time, offering better access to government support can really enhance the adoption of green logistics.

## Introduction

According to contemporary research (e.g., Kim *et al.*, 2024; Sharma *et al.*, 2023), the significance of green logistics has emerged under the context of increasing concerns about global warming, climate change, scarcity of natural resources, dependency on fossil fuels, environmental degradation etc. (Mesjasz-Lech, 2016). Baah *et al.* (2020) argues that the manufacturing and logistics sectors have been tasked with addressing these great challenges, since their core activities are considered to significantly contribute to environmental degradation, especially in terms of CO2 emissions (Luu *et al.*, 2023).

In the last decade, integrating green practices into logistics operations has become a crucial step towards achieving various sustainable development goals (SDGs) across many economic sectors (Afum *et al.*, 2022; Agyabeng-Mensah *et al.*, 2023). Green logistics focus on increasing sustainability in logistics operations, including practices such as sustainable transportation, utilization of reusable and recyclable materials, carbon footprint reduction, waste minimization and reverse logistics. The main objective of green logistics practices is to minimise the environmental impact that is associated with transportation and warehousing (Baah *et al.*, 2021).

As indicated by recent previous studies published in established journals (e.g., Agyabeng-Mensah *et al.*, 2023; Baah *et al.*, 2021; Prataviera *et al.*, 2024), the positive impact of green logistics adoption extends far beyond environmental affairs, since it is also found to increase operational performance and strengthen company reputation. As important stakeholders, like governments, consumers and investors, place more emphasis on sustainability, organisations become increasingly keen to adopt green practices in their logistics operations (Ding *et al.*, 2023; Jayarathna *et al.*, 2024; Jum'a *et al.*, 2022; Nikseresht *et al.*, 2024). Furthermore, the regulatory landscape is growing increasingly complex, with stricter environmental standards and policies, further emphasizing the need of organisations to implement green logistics practices (Agyabeng-Mensah *et al.*, 2021; Roy & Mohanty, 2024). Given the increasing role of logistics in global supply chains and its potential impact on sustainability that is highlighted above, the empirical examination of green logistics practices is not only relevant, but also critical in the context of modern business operations (Karaman *et al.*, 2020).

Recent studies in the field of green logistics have examined, in most cases separately, the drivers and outcomes of green logistics practices, focusing on both internal and external factors influencing their adoption. Key

drivers identified in the literature include regulatory pressure, customer demand, and economic incentives (e.g., Karunakaran *et al.*, 2023; Tan *et al.*, 2024; Yang & Wang, 2024). Environmental regulatory pressure has emerged as a major determinant of green logistics adoption, with stricter regulations urging organisations to integrate more sustainable practices into their logistics activities (Yang & Wang, 2024). Other studies have explored the role of customer preferences in driving companies to adopt green logistics practices (e.g., Jum'a *et al.*, 2022). According to the recent bibliometric analysis of Nikseresht *et al.* (2024), despite considerable pressure from regulatory authorities and consumers, the relatively low adoption rates of green logistics practices are mostly due to the unwillingness of the senior management to accept the costs of incorporating these practices in logistics operations.

On the outcomes side, research has shown that green logistics practices positively impact various dimensions of firm performance, including operational efficiency, financial outcomes and social reputation (Sharma *et al.*, 2023; Karaman *et al.*, 2020). Green logistics practices, such as optimising transportation routes, adopting eco-friendly packaging, and reducing waste, have been linked to improvements in operational performance (Agyabeng-Mensah & Tang, 2021; Nikseresht *et al.*, 2024). Moreover, it has been concluded that firms that embrace green logistics can attract environmentally conscious customers and investors, further enhancing their market reputation and financial performance (Baah *et al.*, 2021).

Despite that, there are empirical studies that failed to find a positive impact of green logistics on certain measures of firm performance (e.g., Ahmad *et al.*, 2022; Yildiz Çankaya & Sezen, 2019; Laari *et al.*, 2018; Younis *et al.*, 2020), while few studies found a negative impact of these practices on financial performance (e.g., Agyabeng-Mensah *et al.*, 2021). Agyabeng-Mensah *et al.* (2020) argued that this ambiguity requires further studies to examine the outcomes of green logistics adoption and, thus, contribute to the ongoing debate in both academia and business.

In general, despite the growing body of literature on green logistics, several gaps remain unaddressed (Nikseresht *et al.*, 2024; Jayarathna *et al.*, 2023). One notable gap is the limited focus on the comprehensive examination of the combined effects of different drivers on the implementation of green logistics practices. Many studies (e.g., Agyabeng-Mensah & Tang, 2021; Sharma *et al.*, 2023; Umar *et al.*, 2022; Van Vo & Nguyen, 2023) tend to isolate individual drivers, such as regulatory pressure or customer de-

mand, without considering how multiple drivers interact to influence green logistics adoption (Baah *et al.*, 2021). Another gap is the insufficient attention given to the role of government support in driving green logistics practices, with mixed findings in the literature regarding its effectiveness (Kim *et al.*, 2024; Zhang *et al.*, 2024).

On the same vein, while previous empirical research has explored the outcomes of green logistics practices (Sharma *et al.*, 2023), there is a lack of empirical studies that systematically examine the full spectrum of performance outcomes, including operational, financial, and reputational impacts. According to Agyabeng-Mensah *et al.* (2020), the impact of green logistics on different measures of firm performance and the interactions among these dimensions have been understudied. The same authors suggest that future research should expand performance measurement to better cover both financial and nonfinancial measures, like market and social performance.

The present study aims to fill these literature gaps, by providing a holistic understanding about the antecedents and effects of green logistics practices. More specifically, its main objective is to investigates both the key drivers (antecedents) and the outcomes (effects) of green logistics practices within the supply chain operations of manufacturing organisations.

In this context, the impact of customer pressure, economic pressure, environmental regulatory pressure and government support on the adoption of green logistics practices is being examined. By developing and empirically testing a conceptual framework that integrates these drivers, new insights into how different forces collectively influence green logistics implementation are being offered. This is especially relevant in today's economy, in which business decisions are rarely influenced by a single factor, but by a complex network of indicators. Understanding the drivers and inhibitors towards adopting eco-friendly practices in the supply chain, enables organisations and policymakers to design and implement targeted interventions and policies for increasing the level of green logistics adoption.

Additionally, this study attempts to enhance the existing literature by examining the impact of green logistics practices on four different measures of firm performance. More specifically, it evaluates not only the operational and financial benefits, but also the social reputation and market effects, thus offering a more complete picture of the benefits associated with enhanced green logistics adoption. This is particularly important in

the modern economy, in which organisations are increasingly evaluated for their social and environmental responsibility (Agyabeng-Mensah *et al.*, 2023; Chhabra & Kr Singh, 2022; Van Vo & Nguyen, 2023; Zhang *et al.*, 2024). This study demonstrates how green logistics practices can enhance a company's social status, providing evidence that adopting these practices is not only an operational necessity, but a strategic initiative towards building a positive public image.

The study's focus on the Greek manufacturing sector provides valuable insights into green logistics practices in a specific setting. Much of the previous research on green logistics practices has focused on large economies or specific industries (Baah *et al.*, 2021; Sharma *et al.*, 2023). By studying a relatively smaller and less frequently analysed economy, this research provides evidence that green logistics practices are not limited to large, developed markets, but are also relevant in smaller economies that face several structural challenges. The results of this study can be used to draw comparisons between research conducted in similar settings, further expanding the geographical applicability of green logistics research.

The proposed conceptual framework of this study was examined with the use of an empirical survey, i.e., collection of primary data. In that context, a structured questionnaire was developed and targeted at executives of Greek manufacturing companies. Hypothesis testing was conducted using multivariate techniques, i.e. Structural Equation Modeling, an established method for examining complex causal relationships. The study adopts a quantitative approach, aiming to test several research hypotheses and provide an understanding of their underlying causal dynamics.

The remainder of this paper is organized as follows. Section 2 presents the hypotheses and the proposed conceptual framework of this study. The research methodology is discussed in Section 3, while Section 4 provides the empirical results. Finally, the last sections offer the discussion (Section 5), and the conclusions (Section 6), including the implications of the study, its limitations and the directions for future research.

## Literature review and research hypotheses

### *Customer pressure and green logistics practices*

In this study, customer pressure refers to the demands from customers for a company to adopt environmentally sustainable practices, including green transportation and ISO 14000 certification. Failure to meet these expectations may result in contract termination, since environmentally conscious customers might seek other, more sustainable ("greener") suppliers (Chu *et al.*, 2019; Choudhary & Sangwan, 2022).

Customer demands from manufacturers and suppliers concerning issues of environmental awareness and green supply practices are steadily increasing during the last decade (Dai *et al.*, 2021; Lai & Wong, 2012; Huang *et al.*, 2016). When a customer seeks an environmentally conscious supplier, it is reasonable to prefer the most conscious over its main competitors; this is expected to motivate suppliers to adopt environmentally friendly measures and practices. Such a cooperation will increase the efficiency of production and product transportation, while, at the same time, mitigating the environmental impact of the organisation, increasing its ecological performance and its acceptance by customers and other external partners (Kim *et al.*, 2022; Sarkis *et al.*, 2011). Thus, customer preferences and demands are driving suppliers to adopt green logistics practices in order to avoid losing market share.

According to the institutional theory (Chu *et al.*, 2018), organisations seek external approval, while their decision-making process is strongly affected by external forces. In that context, firms adopt green logistics practices on the basis on external environmental pressures and concerns (Vidal *et al.*, 2023). This is done in their effort to gain environmental legitimacy and satisfy the environmental requirements of their associates in the supply chain (Chu *et al.*, 2019). In that respect, green logistics are used to signify the alignment of the organisation with global expectations for sustainability and protect the firm competitor criticism. According to Choudhary and Sangwan, (2022), this rationale has forced manufacturers to seek "green" certifications, implement reverse logistics operations and conduct environmental audits. Given the above, the following hypothesis emerges:

Hypothesis 1. *Customer pressure has a positive impact on the implementation of green logistics practices.*

*Economic pressure and green logistics practices*

Economic pressure refers to the external financial forces that influence a company's decision to adopt green logistics practices. These include rising transportation costs, government subsidies for adopting sustainable processes, cost-saving benefits from green initiatives, waste reduction, and competitive advantages gained through green logistics management (Barut *et al.*, 2023; Lai & Wong, 2012).

Increased global demand has led to severe shortage of materials, leading construction and manufacturing companies to invest large sums of money to acquire them, which results in decreased profits (Wong, 2010). The need to recycle materials and manage waste more efficiently is becoming increasingly imperative to avoid these economic burdens, paving the way for green intervention in production and greener management of logistics operations (Barut *et al.*, 2023). According to Ghisellini *et al.* (2016), there are two ways in which you can mitigate the economic pressure: dematerialization and decoupling. The first is about producing products with as few environmental resources and waste as possible and the second is about decoupling from natural resources to produce and perform company operations. To achieve these objectives, relevant green resource management, maintenance and product design initiatives should be implemented, while alternative fuels and reusable materials should also be used (Jazairy *et al.*, 2024). In this context, economic pressure to reduce the costs of materials, warehousing, and transportation drives manufacturing companies to adopt green initiatives, which include implementing green logistics practices.

Economic pressures, such as rising transportation and energy costs, create a strong incentive for manufacturers to adopt green logistics practices to further reduce their operational costs (Sharma *et al.*, 2023; Jayarathna *et al.*, 2023). For example, as transportation costs increase, especially during periods of crisis (e.g., covid-19), companies are encouraged to optimise their routes and utilise energy-efficient vehicles, which ultimately lead to cost savings. The positive relationship between economic benefits and the adoption of green logistics has also been supported by previous studies (e.g., Barut *et al.*, 2023), which argue that implementing environmentally friendly practices can lead to significant reductions in both transportation and material waste, thus enhancing cost efficiency.

Moreover, government subsidies and other incentives for companies adopting green logistics further strengthen the argument that economic pressures drive greater adoption of these practices. Subsidies significantly reduce the financial cost of adopting sustainable practices and technologies, making them more economically feasible for manufacturing organisations (Barut *et al.*, 2023). Finally, rival companies may gain financial benefits by reducing costs through green initiatives, putting pressure on other companies to follow on the same route. Given the above, it is hypothesised:

Hypothesis 2. *Economic pressure has a positive impact on the implementation of Green logistics practices.*

*Environmental regulatory pressure and green logistics practices*

Environmental regulatory pressure refers to the external pressures imposed by governmental or legal regulations that require companies to modify their operations to comply with strict environmental standards. These regulations often involve restricting the use of hazardous materials, minimizing waste, and ensuring adherence to environmental laws and standards (Baah *et al.*, 2020; Lai & Wong, 2012).

The regulatory framework, whether it is the government, a certification body (e.g., ISO), or, nowadays, social media stakeholders, is a significant factor for the adoption of environmental practices, mainly because organisations wish to avoid the bad reputation that may result from not complying with certain rules and procedures (Baah *et al.*, 2020). In order to avoid "scandals" and legal processes that would result in fines and long-term litigation, companies are often forced to implement certain practices in order to remain within the limits of the regulatory framework (Yang *et al.*, 2008). As highlighted by Zhu and Sarkis (2007), regulatory bodies and diverse social entities typically possess the capacity and authority to compel companies to adopt environmental initiatives and embrace green logistics practices.

The hypothesis that environmental regulatory pressure has a positive impact on the implementation of green logistics is further supported by the introduction of an increasing number of local and international regulatory frameworks and environmental laws (Kazancoglu *et al.*, 2021). These regulations compel companies, particularly those involved in international op-

erations, to adopt sustainable practices to meet legal requirements and avoid penalties or sanctions (Jayarathna *et al.*, 2023).

Additionally, by aligning their logistics operations with various environmental standards, organisations not only meet regulatory requirements, but also gain operational efficiencies and improve their competitive standing in "green" markets (Huge-Brodin *et al.*, 2020). Finally, companies that operate or trade in highly regulated markets are more likely to adopt green logistics practices to avoid the financial and reputational risks associated with non-compliance (Gündoğdu *et al.* 2023). Therefore, it is hypothesised:

Hypothesis 3. *The environmental regulatory pressure has a positive impact on the implementation of Green logistics practices*.

*Government support and green logistics practices*

Government support refers to the active and deliberate role of official governments and governmental bodies in promoting and facilitating the adoption of green logistics practices. This support includes providing financial aid for green initiatives, encouraging organisations to propose sustainable logistics projects, offering training to develop green logistics skills, and setting environmental regulations for logistics operations (Lee, 2008; Zhou *et al.*, 2023).

In addition to setting the regulatory framework that imposes fines for non-compliance with regulations, the government has a second intervening role, that of the incentive provider. Through providing financial incentives and tax breaks and sponsoring training programs on green logistics for companies, it can trigger firms to adopt green practices (Lin & Ho, 2011; Zhou *et al.*, 2023). Moreover, the government can impose tariffs on products and materials that do not fit into the concept of green production, aiming to discourage companies from using them and replacing them with more "responsible" ones (Hadi *et al.*, 2020).

While providing financial support is significant (Barut *et al.*, 2023), non-financial government support is also critical in helping companies offset the costs associated with adopting green logistics practices. Such support indirectly reduces the financial cost of investing in sustainable technologies. For example, training programs provided by the government enable manufacturers to build the necessary workforce and expertise to effectively execute these green initiatives (Zhou *et al.*, 2023). In conclusion, the combi-

nation of financial and non-financial support provided by governments creates a favourable environment for the adoption and implementation of green logistics practices (Leung *et al.*, 2023). It is, thus, reasonable to assume that government actions will encourage the adoption of greener solutions and enhance the implementation of Green logistics practices.

Hypothesis 4. *Government support has a positive impact on the implementation of green logistics practices.*

*Green logistics practices and operational performance*

Operational performance refers to a company's effectiveness in managing key operations, including timely delivery, inventory management, product / service quality, capacity utilization, product development time, flexibility, and responsiveness to customer demands. It reflects the ability to optimize resources and processes to better meet customer expectations and maintain high efficiency in operations (Abdallah *et al.*, 2023; Huo *et al.*, 2021).

As underlined by Lai and Wong (2012), integrating green logistics practices can substantially augment the ecological efficiency of a company. Moreover, these practices can improve product flows and resource consumption in such a way that operational efficiency is also improved. Barbiroli and Raggi (2003) argue that green practices improve the operational efficiency of a company, since they optimize production times and improve the transportation of resources and finished products (Tayyab *et al.*, 2020). There are many green logistics practices that lead to increased operational efficiency, like optimizing transportation routes, adopting alternative energy sources that are less prone to disruptions, and minimizing waste. For example, the use of energy-efficient vehicles and the optimization of loading and unloading processes, can contribute to better resource utilization.

There used to be a common belief, mostly among practitioners, of a trade-off between the implementation of environmental practices and productivity / operational efficiency. According to that point of view, pursuing environmental goals reduces efficiency, due to the need to dedicate significant resources for making the necessary changes in business operations. In the opposite of that, the eco-efficiency perspective suggests that pollution is a form of economic inefficiency and if reduced, productivity can be significantly improved (Yu *et al.*, 2023).

According to Lai and Wong (2012), green logistics aims at achieving eco-efficiency, while limiting environmental degradation. This includes preventive measures, like green material sourcing, reuse of parts and components and end-of-life product acquisition and processing. Enhanced upstream and downstream with green supply chain partners helps to improve productivity and reduce waste (Yu *et al.*, 2023), as especially demonstrated by Zhu *et al.* (2010). Under that context, it is hypothesised:

Hypothesis 5. *Green logistics practices have a positive impact on Operational performance.*

*Green logistics practices and financial performance*

Financial performance refers to a company's financial health over a specific period, measured by indicators such as sales, profit margins, net profits, return on investments (ROI) and return on equity (ROE). It provides insight into the ability of the organisation to generate revenue, manage costs, and utilize resources effectively, in order to achieve profitability and financial stability (Agyabeng-Mensah *et al.*, 2020; Baah *et al.*, 2020).

Implementing green logistics practices improves financial performance, since it helps companies attract ecologically conscious customers, suppliers, investors and other stakeholders (Lin & Ho, 2011). More customers lead to more orders, resulting in higher profits. According to Aguilera-Caracuel and Ortiz-de-Mandojana (2013), organisations that embrace innovative green practices get to enhance their financial performance by leveraging cost reductions and product differentiation, resulting from quality enhancements. Product differentiation attracts new customers and leads to better financial results.

As stated by Zailani *et al.* (2012), the implementation of green practices can be costly in the initial investment stages, but with proper management and planning it can bring about many positive results in the financial indicators of the organisation. Organizations that allocate resources towards green practices, with the dual objective of enhancing production process efficiency and product/service quality, demonstrate superior performance in key financial indicators, such as Return on Investment (ROI) and Return on Equity (ROE). This assertion is supported by the research of Przychodzen and Przychodzen (2015), which underscores the tangible benefits derived from investments in environmentally sustainable initiatives.

Recent research (i.e., Baah *et al.*, 2020; Kim *et al.*, 2024; Agyabeng-Mensah and Tang, 2021) also indicates that green logistics practices positively impact financial performance, primarily by reducing operational costs. These practices focus, among others, on optimizing energy use and reducing emissions and, thus, contributing to significant cost savings, particularly in fuel and utilities, which leads to improved financial outcomes. Moreover, their adoption, when combined with public disclosures through Environmental, Social, and Governance (ESG) reports and government certifications, creates a synergistic effect that further enhances financial efficiency. This is achieved by increasing transparency and credibility among stakeholders (Kim *et al.*, 2024).

In addition, Industry 4.0 technologies, such as AI and IoT, are crucial enablers of green logistics practices, since they allow better resource management. These technological advancements help overcome traditional adoption inhibitors, like high upfront costs, making green logistics more financially viable in the long term (Umar *et al.*, 2022). Thus, the combination of green logistics and emerging technologies can lead to enhanced profitability, supporting the hypothesis that green logistics practices have a positive impact on financial performance.

Hypothesis 6. *Green logistics practices have a positive impact on financial performance.*

*Green logistics practices and market performance*

Market performance refers to a company's success in the market, measured by its ability to grow market share and sales, improve customer loyalty, enhance its reputation and image, align products with consumer expectations, and successfully introduce new products (Dangelico, 2017).

Adopting green practices shows a serious commitment to environmental responsibility. This resonates positively with environmentally conscious consumers, leading to an enhanced brand image and reputation. More specifically, adopting green practices strengthens relationships with existing customers and attracts new ones; the enhanced loyalty of both groups of customers results in better sales (Agyabeng-Mensah *et al.*, 2020).

Agyabeng-Mensah *et al.* (2020), Laari *et al.* (2018) and Jia and Wang (2019) argue that companies are implementing green strategies to improve their image and market share, both nationally and internationally. Green

strategies, such as material reusage and efficient waste management, help the environment and this enhances employee and customer loyalty, leading to increased market share (D'Souza *et al.*, 2020). Also, by showcasing unique environmentally friendly initiatives, companies can differentiate from their competitors. The development of a distinctive market identity may lead to increased market visibility, recognition and market share.

More specifically, by implementing green practices, manufacturing organisations can appeal to environmentally conscious consumers, thus enhancing brand image, increasing customer loyalty and improving customer satisfaction (Agyabeng-Mensah *et al.*, 2020). For example, practices such as green packaging and reverse logistics enhance environmental sustainability, which particularly resonates with modern consumers. As a result, manufacturers can more easily attract new customers who are drawn to such eco-friendly practices. Finally, the financial savings from implementing green logistics allow companies to offer competitive pricing, which further boosts sales and increases market share. Therefore, the increased focus on sustainability leads to stronger market performance, as firms appeal to the growing demand for eco-friendly products and services (Baah *et al.*, 2020).

Hypothesis 7. *Green logistics practices have a positive impact on market performance.*

*Green logistics practices and social reputation*

Social reputation refers to the perception of a company's commitment to social responsibility and ethical practices. It is measured by the company's involvement in philanthropic activities, investment in employee skills and employee safety, initiatives to improve job satisfaction, and contributions to the community where the company operates (Baah *et al.*, 2020).

One of the main reasons for companies to implement green logistics practices is to reduce greenhouse gas emissions that results from global transportations. Therefore, when a company chooses to implement environmental practices, it is essentially ensuring the well-being of the society it operates in, promoting social responsibility (Baah & Jin, 2019). Thus, it has been established that adopting green practices positively affects company social reputation, both because it showcases its ecological face and, also,

because it shows that it cares about the safety and quality of life and skills of its employees (Agyabeng-Mensah *et al.*, 2020).

When a company prioritises environmentally responsible strategies, it demonstrates its hard commitment to addressing pressing ecological challenges. This commitment fosters positive perceptions among stakeholders (e.g., consumers, investors, the public), leading to a favourable social reputation (Baah *et al.*, 2020). Companies that embrace green logistics actively participate in global sustainability efforts. Such strategies position them as socially responsible entities that work towards fighting climate change and preserving natural resources. The positive coverage and word-of-mouth these actions gather, further enhance the social reputation of companies.

In summary, green logistics practices underline the alignment of the organisation with environmental / societal goals, thus showcasing its dedication to sustainability and ethical practices. Such a dedication increases the reputation of the organisation, while also enhancing the company's public image and social standing. This is why manufacturers publicly disclose their green initiatives (Karaman *et al.*, 2020). Therefore, it is reasonable to hypothesise that:

Hypothesis 8. *Green logistics practices have a positive impact on social reputation.*

Figure 1 diagrammatically presents the proposed conceptual framework (research model) of this study, which includes nine factors (categorised into three dimensions): (a) Drivers of Green logistics practices (Customer pressure, Economic pressure, Environmental regulatory pressure, Government support), (b) Green logistics practices, and (c) Measures of firm performance (Operational performance, Financial performance, Market performance, Social reputation). To the best of the researchers' knowledge, such a framework has not been previously explored in the existing literature.

As mentioned above, the present study aims to expand the findings of the existing body of literature, investigating the drivers and outcomes of green logistics practices. While the relevant literature has explored these relationships in the past (e.g., Barut *et al.*, 2023; Kim *et al.*, 2024; Panghal *et al.*, 2024), several challenges persist. First, there is limited focus on examining the combined implications of both drivers and outcomes, thus adopting a more holistic approach. Second, from the drivers' side, the role of government support has attracted limited attention, while, from the outcomes'

side, few studies have adopted an approach that incorporates both financial and non-financial measures. Third, very few studies have been conducted on smaller countries facing certain structural and economic challenges. The next section will detail the methodological approach used to face these challenges, including the population of the study and the data collection process, the measurement of the nine research factors and the test for their overall validity and reliability.

## Method

### *Population / data collection*

The population of this study consists of Greek manufacturing organizations, regardless of their location, size, year of establishment and ownership. According to the latest available data, the manufacturing sector in Greece comprises of 57.903 registered companies (Hellenic Statistical Authority, 2019).

ICAP, a reputable 'Business Service Group' that provides dependable information, provided the researchers with a list containing the contact details of 4.125 manufacturing enterprises operating in Greece. Employing an online random number generator, a thousand of these companies were randomly selected from this dataset. Subsequently, initial contact was established, via telephone calls, with 894 of these manufacturing entities. Following this outreach, the questionnaire was dispatched to 361 organizations who expressed willingness to participate in the survey.

To procure the necessary primary data, an online questionnaire was meticulously crafted. Managers who had consented to participate in the online survey were provided with the corresponding link. The web-based questionnaire was engineered utilizing Google's suite of services. The introductory section presented the primary research objectives, while ensured the confidentiality of all gathered information. Key respondents included Supply Chain managers, Logistics managers, Procurement managers, Production managers, and Chief Executive Officers (CEOs). Spanning a rigorous three-month research period during the final months of 2022, a total of 189 completed and valid questionnaires were finally retrieved. These questionnaires were entered in IBM SPSS, version 25.

*Measurement*

In order to collect empirical data, the research team meticulously fashioned a structured questionnaire, tailored to the study's unique requirements. Divided into two distinct sections, it unfolded as a roadmap guiding respondents through the survey. In the first section, personal and organizational information were being collected. In the second section, the nine factors of the proposed research model (conceptual framework) were being measured.

The measurement of the nine (9) research factors was conducted through a comprehensive assessment, utilizing previously validated measurement scales. Respondents were prompted to indicate their level of agreement on a five-point Likert scale, ranging from one, representing total disagreement, to five, indicating complete agreement. Utilizing validated scales to measure research factors is essential for ensuring the reliability and validity of the study (Hunziker & Blankenagel, 2024). Validated scales have undergone rigorous testing in previous studies, which guarantees that they accurately measure the constructs they are intended to assess. Additionally, the use of validated scales helps to minimize measurement error, thereby improving the internal consistency of the research. In this study, the use of validated scales across the nine research factors provides a solid foundation for interpreting the results, grounded in established scientific methodology.

Table 1 presents the nine research factors along with the corresponding number of items used for their measurement. Additionally, the table provides an overview of the relevant literature supporting each factor. Lastly, Appendix 1 offers a detailed breakdown of all the measurement items employed in this study.

*Validity and reliability*

To test the content validity of the research instrument (i.e., questionnaire), a rigorous pre-testing procedure was conducted, in line with the suggestions of Zikmund (2003). This process involved discussions with key respondents and experienced academics of the relevant field. More specifically, six (6) brief unstructured interviews were conducted, in which executives and academics were invited to offer their insights on the clarity and comprehensibility of the items included in the structured questionnaire.

Their feedback provided invaluable guidance that was pivotal in refining the research instrument, ensuring its effectiveness in accurately measuring the nine factors included in the proposed research model. Furthermore, special attention was given to the challenges that were inherent in translating the questionnaire to its target language, Greek. This process of refinement enhanced the suitability of the questionnaire for its intended context, the Greek manufacturing sector.

Moreover, to assess the construct validity of the research instrument, an examination of the unidimensionality and reliability of each research factor was conducted. For the evaluation of the unidimensionality of each factor, Explanatory Factor Analysis (EFA), using Principal Component Analysis and Varimax Rotation techniques, was conducted. Moreover, the reliability of each research factor was assessed using "Cronbach's Alpha", an established the statistical indicator of internal consistency. In total, nine distinct analyses were conducted, corresponding to each research factor of the proposed model. In the same vein, Cronbach's Alpha was also computed nine times.

To ensure appropriate statistical scrutiny, the study examined several key measures, as advocated by Hair *et al.* (2014). These included: (a) the Kaiser-Meyer-Olkin (KMO) test, which was calculated for the entire dataset, and the Measure of Sampling Adequacy (MSA), which was computed for each individual variable (values above 0.7 are considered satisfactory, while values of 0.5 are deemed acceptable); (b) Bartlett's test of Sphericity, where statistical significance at the 0.05 level indicates adequacy; (c) The criterion of eigenvalue, selecting factors with eigenvalues over one (1); (d) The percentage of total variance explained by the proposed factor(s), with Total Variance Explained (TVE) exceeding 50%; (e) The significance of factor loadings, with loadings exceeding 0.5 deemed statistically significant; (f) The assessment of Cronbach's Alpha, with values greater than 0.7 being indicative of validity. The results, presented in Table 2, affirm the validity and reliability of all nine research factors.

Additionally, the goodness of fit for each research factor to the proposed model was assessed using Confirmatory Factor Analysis (CFA). This evaluation incorporated several key metrics, including chi-square, p-value, Normed $X^2$, construct reliability (CR), variance extracted (VE), as well as the RMSEA, CFI, and GFI indices. All tests yielded satisfactory results (see Table 3 for a summary of the main results).

## Results

### *Demographics*

Table 4 presents a snapshot of the demographic characteristics of the surveyed sample. A majority of participants, constituting 64.4%, identified as male, while 35.6% identified as female. The average age of respondents was calculated at 39.6 years. Furthermore, a significant proportion of the participants, accounting for 40.6%, held a university degree, while an additional 43.8% reported attending a postgraduate program. This educational profile underscores the high level of academic attainment among respondents. In terms of work experience, the mean score among sample employees stood at 14.8 years, reflecting a wealth of professional expertise within the surveyed population.

Shifting focus to the organizational profile, the majority of manufacturing organizations within the sample exhibited characteristics typical of small to medium-sized enterprises (SMEs). Specifically, 6.2% of the surveyed companies employed less than 10 employees and 35% employed between 11 to 50 persons. Collectively, SMEs, defined as entities with less than 250 employees, comprised 82.5% of the final sample, indicative of the dominant presence of smaller-scale enterprises within the Greek manufacturing landscape.

### *Hypotheses testing*

Hypothesis testing in this study utilized the "Structural Equation Modeling" (SEM) technique, a type of multivariate analysis. SEM is particularly suitable for complex research models, like the one tester in this study, where factors can serve as both independent and dependent. Additionally, SEM provides various tools to assess the overall validity of the proposed model. Furthermore, it allows for the examination of both direct and indirect relationships between factors and offers modification indices to assist researchers in identifying potential additional causal pathways (Dash & Paul, 2021).

In this research, covariance-based SEM (CB-SEM) was applied using the IBM AMOS 22.0 software. CB-SEM was chosen over variance-based partial least squares SEM (PLS-SEM) for several reasons (Dash & Paul, 2021; Legate *et al.*, 2023): (a) CB-SEM is more appropriate for reflective measurement

scales, while PLS-SEM is typically used for higher-order models and formative scales; (b) CB-SEM is better suited for larger sample sizes, whereas PLS-SEM is ideal for smaller samples, typically under 100 observations; (c) CB-SEM is more effective in testing established theories or hypotheses, while PLS-SEM is better suited for exploratory research; (d) PLS-SEM does not offer the same model comparison and modification capabilities as CB-SEM; (e) CB-SEM provides more comprehensive model fit indices, while those for PLS-SEM are still evolving.

For examining the proposed research model, the Maximum Likelihood Estimation method was employed. The Covariance Matrix was used as the table of entry and the extraction of the Standardized Completely Solution was requested. When estimating the structural model (causal paths between factors), mean factor scores were used. These scores were calculated using the mean (average) of the items used for the measurement of each factor.

In order to evaluate the proposed research model (conceptual framework) and, subsequently, test the eight research hypotheses, the Structural Equation Modeling (SEM) technique was employed. In this multivariate analytical approach, the Covariance Matrix served as the primary input table, facilitating the extraction of a Standardized Completely Solution. SEM allowed a holistic exploration of the interrelationships between the research factors, while also offering indexes about the overall validity of the model.

Table 5 provides an exploration of the initial proposed model. Empirical findings offer support to six of the eight initial research hypotheses (H1, H3, H5, H6, H7, H8). However, in light of the modification indices provided by IBM AMOS, three new causal paths were incorporated into the model, in order to enhance its explanatory capacity.

Table 6 presents the outcomes of the modified structural model. Notably, the modified model demonstrates excellent data fit, while its explanatory power proves to be highly satisfactory. Specifically, the factors included into the modified model can explain a high percentage of the variance of its main dependent factors, as analytically depicted in Figure 2.

In-depth scrutiny of the overall model fit involved the estimation of the chi-square value ($X^2 = 31.242$ with 16 degrees of freedom) and its associated p-value ($p = 0.013$). However, recognizing the inherent sensitivity of the chi-square statistic to sample size, complementary indices were employed to provide a more comprehensive evaluation.

Supplementary measures, including the "Normed-$X^2$" index (1.953), the Root Mean Square Error of Approximation (RMSEA) index (0.077), the Comparative Fit Index (CFI) (0.965), and the Goodness-of-Fit Index (GFI) (0.956), were assessed. These indices, as recommended by Kelloway (1998) and Schumacker and Lomax (2010), collectively affirm a robust fit of the model. Their consistent indication of very good fit underscores the reliability and validity of the proposed model, enhancing confidence in its utility for successfully investigating the hypothesized relationships between the research factors of this study.

Figure 2 illustrates the results of the overall structural model, showcasing the extracted path coefficients (r) alongside the $R^2$ scores. In aggregate, the final model demonstrates a notable capacity to explain the variance of the dependent factors. Specifically, it accounts for 49% of the variance in "green logistics practices", 40% in "financial performance", 33% in "market performance", 29% in "social reputation", and 21% in "operational performance".

Table 7 provides a concise summary of the direct, indirect, and total effects observed between the factors comprising the research model. This tabulated presentation offers valuable insights into the intricate interplay among factors, shedding light on the relationships of the proposed model.

## Discussion

The results indicate that six of the eight research hypotheses are supported by the empirical data. Hypothesis 2 is rejected, since the relationship between "economic pressure" and "green logistics practices" is negative (r=-0.138) and not positive, as hypothesised. Hypothesis 3 is also rejected, since no statistically significant relationship was found between "government support" and "green logistics practices" ($p = 0.380 > 0.05$).

As seen on Figure 2, the factor that has the highest impact on the implementation of "green logistics practices" is the "environmental regulatory pressure" (r=0.521). This finding is in line with previous empirical attempts (e.g., Baah *et al.*, 2020; Lin & Ho, 2011). It seems that manufacturing organisations are encouraged to embrace sustainable supply chain practices by stringent regulations (fines, legal liabilities, reputational risks associated with non-compliance). Furthermore, clear guidelines simplify decision-making, guide investments, and promote innovation. As such, fear of

penalties and the desire to align with the expectations of external stakeholders drive companies to adopt green logistics practices. According to institutional theory, organisations submit to outside forces in order to obtain legitimacy and preserve stability. Environmental regulatory pressure, as a coercive force, compels companies to adopt green logistics practices. Firms feel pressure to conform to society and legal norms as a result of stricter regulations. Adopting green policies not only ensures conformance, but also strengthens organisational legitimacy, since it shows that companies care about the environment.

Moreover, "green logistics practices" have a direct impact on three of the four factors measuring firm performance ("operational performance": r=0.460, "financial performance": r=0.312, "social reputation": r=0.272), and an indirect impact (via "operational performance") on "market performance" (r=0.264). These results are also supported by previous empirical findings (e.g., Lai & Wong 2012; da Silva *et al.*, 2021; Lai *et al.*, 2012), that indicate that "green logistics practices" have the highest effect on "operational performance" (timely product delivery, optimization of inventory management and transportation capacity, flexibility of the production system, timely response to customer requirements, etc.). This conclusion is valid even after taking under consideration the total effects between the four research factors measuring firm performance.

Concerning the negative impact of "economic pressure" on the implementation of "green logistics practices", this oxymoron might be explained in the light of the following arguments: (a) Initial Investment (Short-term focus): Green logistics practices can result in long-term cost benefits, but they frequently need a sizable initial investment in terms of process improvements, technology upgrades, and training. Even though they are aware of the potential advantages, businesses that might be grappling with budgetary restrictions or short-term economic challenges may be hesitant to devote resources to these efforts. Under that context, companies may emphasize short-term financial aims above long-term sustainability goals, due to economic pressures. The advantages of green logistics practices could take some time to manifest, and businesses might place more importance on short-term profitability, than on prospective gains that might be realized over a longer time frame; (b) Risk Aversion: Even when the potential advantages are acknowledged, there is some risk involved in implementing new techniques, technologies, or processes. Organisations under pressure may be more risk-averse, since they worry that the imple-

mentation process will disrupt ongoing operations or present unexpected difficulties, (c) Resource Allocation: Companies might allocate resources to initiatives believed to directly result in increased sales or cost savings. Although they might be advantageous in the long run, green logistics practices could not be as directly related to these results, making them less important when allocating resources.

Concerning the statistically insignificant impact of "government support" on "green logistics practices", it seems that the incentives provided by the Greek government are not able, by themselves, to increase the level of green logistics practices implementation. This may be because government support programs can, sometimes, involve complex and time-consuming application processes, extensive paperwork and strict eligibility criteria. Also, it is possible that not all manufacturing companies are aware of the available government support programs.

These findings align with similar challenges observed in previous research. For example, Kim *et al.* (2024) explored the influence of government policies on the financial efficiency of logistics companies. Their research revealed that, while government support enhances financial efficiency when combined with public reporting, government support alone is not sufficient to significantly affect financial performance. This is in line with the results of the present study, suggesting that government support may not effectively increase the adoption of green logistics practices when other conditions, like simple processes, are not met.

Moreover, Zhang *et al.* (2024) studied the role of government subsidies in promoting green logistics through an evolutionary game model involving local governments, platforms and logistics enterprises. Their study concluded that government subsidies can positively affect the adoption of green logistics practices, but also highlighted the importance of the proportion of subsidies and cost-sharing by platforms. Most importantly, Zhang *et al.* (2024) found that complicated or improperly scaled subsidies can have a negative impact on the adoption of green logistics. These findings agree with one of the main conclusions of the present study, concerning the complexity and ineffectiveness of Greek government incentives.

Both previous studies (Kim *et al.*, 2024; Zhang *et al.*, 2024) indicate that government intervention alone may not be sufficient for increasing the level of green logistics implementation, unless properly organised and supported by additional incentives. It seems that, while government policies are crucial for enhancing environmental sustainability, a more holistic

approach is needed. Under that context, government initiatives must be combined with simplified procedures, increased awareness and supportive corporate practices to maximise their impact on the adoption of green logistics. Hence, a common thread emerges across recent studies conducted in different regions and industries; government support alone may not be adequate and additional actions are needed in order to achieve the desired outcomes in green logistics.

## Conclusions

The main objective of the present empirical study was to develop and empirically test a novel conceptual framework that examines the antecedents and effects of green logistics practices. This framework is built on a three-dimensional perspective, comprising (a) drivers of green logistics practices (antecedents), (b) the implementation of green logistics practices, and (c) its impact on four measures of firm performance (outcomes). Notably, the adoption of this multidimensional approach is very rare within the relevant literature, rendering the investigation of the proposed conceptual framework an intriguing and novel research endeavour.

The proposed conceptual framework was tested with primary data collected from a structured questionnaire. The research instrument, comprising of 48 items designed to measure nine research factors, was disseminated among a sample of Greek manufacturing enterprises. Specifically, the questionnaire was targeted towards 894 companies selected as the study's target population. Following a three-month data collection period, a total of 189 completed questionnaires were received. The collected data underwent rigorous analysis, primarily employing the SEM technique.

In brief, the results indicate the following: (a) The environmental regulatory pressure is the factor with the highest effect on the implementation of green logistics practices. That indicates that imposing strict rules and regulations is the way for achieving greener supply chains. That finding is in line with the institutional theory; (b) Surprisingly, there is a negative impact of economic pressure on the implementation of green logistics practices. This might be due to manufacturers adopting a short-sighted approach, prioritising short-term financial aims over long-term financial benefits. Either way, future empirical studies should also look into that relationship, (c) The support offered by the government has no impact on green logistics

practices. Despite its potential benefits, government support may not have a substantial impact on green logistics practices, because of challenges including limited resources, complex application processes, and conflicting objectives. Conflicting policies and a lack of knowledge about available resources can also make it difficult to incorporate sustainable practices into the company operations; (d) The impact of green logistics practices on the four factors measuring firm performance (i.e., operational performance, financial performance, market performance, social reputation) is both direct and indirect, while these four factors strengthen each other (i.e., operational performance enhances market performance, market performance enhances financial performance and social reputation). Operational excellence fuels market traction, which in turn increases financial gains and enhances reputation. These interconnections underscore the multifaceted benefits of implementing green logistics, fostering a virtuous cycle of enhanced firm performance across various dimensions. Hence, the present study found that the implementation of green logistics practices is beneficial for many business areas, while it also has an impact on their financial bottom-line.

*Implications for policy makers and organisations*

This study offers implications for both policy makers and organisations.

The empirical results suggest that government support currently has no significant impact on the adoption of green logistics practices, highlighting the need for further efforts in this area. To encourage companies to adopt these practices, governments can take two key steps. First, they can simplify the application process for green incentives by developing a streamlined, user-friendly system. This could be achieved through a centralized online platform, where companies can easily apply for subsidies, tax breaks, and other incentives, as well as track the progress of their applications. Secondly, governments can implement procurement policies that prioritize companies meeting green logistics standards. This would require companies bidding for public contracts to demonstrate their existing green logistics initiatives or submit plans for future implementation. Thirdly, governments can offer tiered financial support based on green milestones. As companies achieve specific goals, such as completing energy audits or adopting electric vehicle fleets, they would qualify for increasing levels of financial assistance, thereby reducing the costs of transitioning to greener

practices. Additionally, governments can establish green logistics training and certification programs. By funding and organizing workshops on eco-friendly transportation, sustainable packaging, and supply chain waste reduction, they can equip businesses with the knowledge and skills needed to adopt green logistics practices. Finally, governments can provide subsidies and/or low-interest loans for the implementation of green technologies in logistics operations. These subsidies can significantly ease the financial burden of companies that wish to further green their supply chain and, thus, accelerate the adoption of environmentally friendly logistics solutions.

The study highlights that environmental regulatory pressure is the most influential driver of green logistics practices, followed closely by customer pressure. Policymakers can enhance this pressure by implementing and enforcing more rigorous regulations. This could involve introducing stricter environmental standards for emissions, waste management, and resource consumption in logistics operations. Regular and more comprehensive audits would ensure that companies adhere to these standards, helping them avoid fines, legal penalties, and reputational damage. In addition, certification bodies such as ISO, in collaboration with governments, can introduce mandatory green certifications for logistics companies. These certifications should establish rigorous criteria focused on eco-friendly practices, including emissions reduction and optimized transportation routes. Failing to meet these standards could result in escalated fines and legal actions, further motivating companies to comply. Moreover, governments can require companies to publicly disclose their environmental performance data, such as emissions and energy consumption. By making this information accessible to consumers, stakeholders, and the media, businesses would face added pressure to improve their sustainability practices in order to maintain public trust and market competitiveness.

To leverage the positive impact of customer pressure on the adoption of green logistics practices, governments can take several proactive steps. First, they should promote, or mandate standardized eco-labelling on products and services, making the environmental impact of supply chains transparent to consumers. This will help customers make informed decisions and favour businesses that prioritize sustainability. Additionally, governments can launch educational campaigns to raise public awareness about the environmental consequences of logistics practices. These campaigns would encourage consumers to seek out eco-conscious businesses,

further driving demand for green logistics. To further amplify this impact, policymakers could establish a prestigious, government-backed awards program that recognizes companies excelling in green logistics. Publicly celebrating these success stories would inspire customers to support businesses that win or participate in these programs, fostering healthy competition and motivating more companies to adopt environmentally friendly logistics practices. Finally, governments can mandate that companies publicly disclose their logistics-related carbon emissions, energy usage, and waste generation on an easily accessible online platform. This transparency would increase accountability and allow consumers and stakeholders to make sustainability a key factor in their purchasing and partnership decisions.

The present study highlights the significant impact of green logistics practices on firm performance, emphasizing the importance for companies to implement actions to enhance their logistics operations in an environmentally sustainable manner. From a managerial standpoint, organisations aiming to further green their logistics should begin by optimising their transportation operations. This can be largely achieved by introducing energy-efficient vehicles, utilising alternative fuels and designing optimal routes, all of which are expected to reduce emissions and fuel consumption.

Next, companies should adopt sustainable packaging solutions by shifting to recyclable, biodegradable, or reusable materials, thus minimizing waste. Improving waste management is quite crucial and can be, also, achieved by embracing circular economy principles to reduce operational waste. In that context, it is essential to ensure the collaboration of suppliers. Organisations should work more closely with suppliers who also prioritise sustainability. Investment in technology is also critical, i.e., employing digital tools that can assist in route optimization and implement Internet of Things (IoT) solutions that can improve efficiency in operations, while also reducing the environmental footprint of the organisation. Further, the use of eco-labelling can further attract environmentally conscious consumers. Lastly, investing in employee training and development is crucial.

*Limitations of the study*

Since this study is based on primary data collected from Greek manufacturing organisations, its findings may not be directly applicable to or-

ganizations in different geographical or economic contexts. Factors such as local regulations, infrastructure, and market conditions could affect the adoption of green logistics practices in other countries / regions. Despite that, the study's findings can be generalized to other countries that share similar regulatory, economic, or industrial characteristics. For instance, countries within the European Union or other regions with strong environmental regulatory frameworks may experience similar pressures to adopt green logistics practices. Additionally, markets where customer preferences are shifting towards sustainable practices and where government support is growing could also see similar dynamics at play.

This research employed a cross-sectional survey, meaning data were collected at a single point in time. While this approach is effective for identifying correlations and testing hypotheses, it limits the ability to observe the evolution of green logistics practices over time. It is, also, advocated in the recent literature (e.g., Hunziker & Blankenagel, 2024) that cross-sectional studies can identify associations between factors, but they cannot establish a causal relationship with high levels of certainty.

Moreover, the reliance on survey responses and the subsequent use of a structured questionnaire with Likert scale responses can introduce response bias, especially social desirability bias. Managers may have been inclined to overstate their company's green logistics initiatives or their impact on firm performance to align with perceived best practices or societal expectations. This could have skewed the results, particularly on subjective measures like operational and financial performance. Finally, while SEM is a powerful tool for examining complex relationships among factors, it is quite sensitive to sample size and model complexity. In this case, with a sample size of 189 companies, there is a risk that the SEM results may be unstable or that certain relationships are over- or under-estimated.

Despite these methodological limitations, the study's design still provides valuable insights. The use of a structured questionnaire and SEM, even with the challenges of response bias and sample size, allows for a robust examination of complex relationships between green logistics practices and firm performance. Moreover, the sample of 189 companies, while modest, is still substantial enough to offer meaningful patterns, especially within the Greek manufacturing sector.

*Suggestions for future research*

While this study has contributed valuable insights into the antecedents and effects of green logistics practices, several areas require further exploration. First, longitudinal studies would provide more insight into how regulatory changes, ongoing economic pressures, and/or technological advancements affect the adoption and performance of green logistics over time. Additionally, studies conducted in multiple waves (e.g., Time 1, Time 2) would provide more robust causal support into the examined relationships. Second, as this study relied exclusively on quantitative data, future research should incorporate qualitative methods, such as case studies or interviews with key decision-makers. These qualitative insights could uncover the specific challenges, motivations, and decision-making processes behind green logistics practices, which are not easily captured in structured surveys. Third, future research could investigate additional performance metrics, such as employee satisfaction, customer loyalty, and long-term corporate sustainability. These additional dimensions could offer a more holistic understanding of how green logistics practices contribute to overall organizational success and sustainability. Fourth, future research should consider industry-specific studies (e.g., retail, automotive, or technology sectors) and extend the analysis to other countries with different regulatory environments, cultural norms, and market pressures. Comparative studies between countries with strong environmental regulations and those with emerging frameworks could yield valuable insights into the global implementation of green logistics practices. Fifth, the growing importance of digital tools such as Internet of Things (IoT) devices, artificial intelligence, and blockchain in optimizing supply chains, suggests that future research could focus on the integration of these technologies into green logistics practices. Studies could examine how technological advancements influence the adoption and success of green logistics, and the extent to which they mitigate the operational and financial challenges identified in the current study. Sixth, future studies could delve deeper into understanding how specific market trends, such as increasing consumer demand for sustainability and corporate social responsibility, affect the adoption of green logistics practices. Finally, this study found that government support had a limited impact on green logistics practices in the Greek context. Future research could investigate the effectiveness of many types of government

incentives, such as tax breaks, subsidies, or green certification programs, across various countries or sectors.

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**Compliance with ethical standards**

This article does not contain any studies with human participants or animals performed by the authors. Extracting and inspecting publicly accessible files (scholarly sources) as evidence, before the research began no institutional ethics approval was required.

**Data availability statement**

All data generated or analyzed are included in the published article. The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation. The raw anonymized data can be provided by emailing the primary author.

**Author contributions**

All listed authors have made a substantial, direct and intellectual contribution to the work, and approved it for publication. The authors take full responsibility for the accuracy and the integrity of the source analysis.

**Conflict of interest statement**

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# Annex

**Table 1.** Factor measurement

| Research factors | Sources | Number of items |
|---|---|---|
| Customer pressure | Chu *et al.*, 2019; Huang *et al.*, 2016; Lai and Wong, 2012 | 5 |
| Economic pressure | Lai and Wong, 2012 | 5 |
| Environmental regulatory pressure | Baah *et al.*, 2020; Lai and Wong, 2012 | 4 |
| Government support | Lee, 2008 | 4 |
| Green logistics practices | Agyabeng-Mensah *et al.*, 2020; Baah *et al.*, 2020 | 6 |
| Operational performance | Abdallah *et al.*, 2023; Huo *et al.*, 2021 | 7 |
| Financial performance | Agyabeng-Mensah *et al.*, 2020; Baah *et al.*, 2020 | 7 |
| Market performance | Dangelico, 2017 | 6 |
| Social reputation | Baah *et al.*, 2020 | 5 |
| ***Total:*** | | ***49*** |

**Table 2.** Validity and reliability

| Research factors | Mean | S.D. | MSA | Bartlett's Test of Sphericity | Eigen-value | TVE | Factor loadings | Cronbach alpha |
|---|---|---|---|---|---|---|---|---|
| Customer pressure | 2.763 | 0.888 | 0.838 | 372.08 | 3.304 | 66.07% | 0.836 / 0.791 / 0.826 / 0.826 / 0.783 | 0.868 |
| Economic pressure | 3.468 | 0.639 | 0.652 | 117.85 | 2.081 | 52.03% | 0.641 / 0.822 / 0.746 / 0.661 | 0.784 |
| Environmental regulatory pressure | 3.844 | 0.705 | 0.728 | 194.78 | 2.483 | 62.06% | 0.766 / 0.880 / 0.746 / 0.753 | 0.787 |
| Government support | 2.870 | 0.727 | 0.813 | 266.84 | 2.601 | 65.02% | 0.885 / 0.893 / 0.745 / 0.681 | 0.818 |
| Green logistics practices | 3.500 | 0.765 | 0.732 | 421.45 | 3.607 | 60.11% | 0.822 / 0.748 / 0.823 / 0.836 / 0.810 / 0.582 | 0.863 |
| Operational performance | 4.108 | 0.484 | 0.735 | 385.14 | 3.541 | 50.59% | 0.756 / 0.688 / 0.714 / 0.785 / 0.562 / 0.638 / 0.805 | 0.822 |
| Financial performance | 3.735 | 0.512 | 0.771 | 571.52 | 3.728 | 53.26% | 0.727 / 0.610 / 0.717 / 0.810 / 0.810 / 0.812 / 0.584 | 0.848 |
| Market performance | 3.938 | 0.467 | 0.717 | 334.54 | 3.015 | 50.24% | 0.783 / 0.664 / 0.742 / 0.679 / 0.732 / 0.643 | 0.794 |
| Social reputation | 3.772 | 0.747 | 0.723 | 326.81 | 3.087 | 61.73% | 0.636 / 0.870 / 0.726 / 0.808 / 0.863 | 0.838 |

**Table 3.** Estimation of the goodness of fit

| Research factors | Normed $X^2$ | C.R. | V.E. | RMSEA | CFI | GFI |
|---|---|---|---|---|---|---|
| Customer pressure | 2.69 | 0.74 | 62.2% | 0.092 | 0.97 | 0.93 |
| Economic pressure | 3.26 | 0.76 | 64.6% | 0.084 | 0.96 | 0.91 |
| Environmental regulatory pressure | 3.519 | 0.72 | 70.8% | 0.073 | 0.99 | 0.97 |
| Government support | 4.01 | 0.77 | 59.7% | 0.089 | 0.99 | 0.993 |
| Green logistics practices | 3.46 | 0.69 | 61.6% | 0.079 | 0.91 | 0.94 |
| Operational performance | 2.11 | 0.82 | 58.3% | 0.076 | 0.96 | 0.92 |
| Financial performance | 3.36 | 0.74 | 71.1% | 0.084 | 0.95 | 0.96 |
| Market performance | 4.14 | 0.77 | 74.9% | 0.082 | 0.97 | 0.99 |
| Social reputation | 1.97 | 0.83 | 78.3% | 0.072 | 0.97 | 0.97 |

**Table 4.** Demographics

| Question | Reply | Percent | | Reply | Percent |
|---|---|---|---|---|---|
| Gender | Male | 64.4% | Age | Less than 30 | 24% |
| | Female | 35.6% | | 31-35 | 15% |
| | Total | 100% | | 36-40 | 32.5% |
| Total experience (in years) | Less than 5 | 11.3% | | 41-45 | 20% |
| | 6-10 | 17.5% | | 46-50 | 10% |
| | 11-15 | 33.1% | | 51 and above | 9.4% |
| | 16-20 | 15% | | Missing values | 0.6% |
| | 21-25 | 15.6% | | Total | 100.0% |
| | 26 and above | 7.5% | Market share in comparison with main competitors | Very small | 0.6% |
| | Total | 100% | | Small | 5.6% |
| Number of employees | Less than 10 | 6.2% | | Average | 32.5% |
| | 11-50 | 35% | | Big | 46.3% |
| | 51-250 | 41.3% | | Very big | 15% |
| | 251 and more | 16.3% | | Total | 100% |
| | Missing values | 1.2% | | | |
| | Total | 100% | | | |

**Table 5.** Hypothesis testing (initial model)

| H | Causal paths | | | r | p | Result |
|---|---|---|---|---|---|---|
| H1 | Customer pressure | → | Green logistics practices | 0.284 | 0.000 | Supported |
| H2 | Economic pressure | → | Green logistics practices | -0.154 | 0.015 | *Rejected* |
| H3 | Environmental regulatory pressure | → | Green logistics practices | 0.514 | 0.000 | Supported |
| H4 | Government support | → | Green logistics practices | 0.054 | 0.380 | *Rejected* |
| H5 | Green logistics practices | → | Operational performance | 0.460 | 0.000 | Supported |
| H6 | Green logistics practices | → | Financial performance | 0.430 | 0.000 | Supported |
| H7 | Green logistics practices | → | Market performance | 0.245 | 0.001 | Supported |
| H8 | Green logistics practices | → | Social reputation | 0.371 | 0.000 | Supported |

**Table 6.** The modified structural model

| Hypothesised causal paths | | | r | p |
|---|---|---|---|---|
| Customer pressure | → | Green logistics practices | 0.289 | 0.000 |
| Economic pressure | → | Green logistics practices | -0.138 | 0.023 |
| Environmental regulatory pressure | → | Green logistics practices | 0.521 | 0.000 |
| Green logistics practices | → | Operational performance | 0.460 | 0.000 |
| Green logistics practices | → | Financial performance | 0.312 | 0.000 |
| Green logistics practices | → | Social reputation | 0.272 | 0.000 |
| **New causal paths** | | | **r** | **p** |
| Operational performance | → | Market performance | 0.574 | 0.000 |
| Market performance | → | Social reputation | 0.402 | 0.000 |
| Market performance | → | Financial performance | 0.477 | 0.000 |

**Table 7.** Direct (D), Indirect (I) and Total (T) effects between research factors

| | | Environmental regulatory pressure | Economic pressure | Customer pressure | Green logistics practices | Operational performance | Market performance |
|---|---|---|---|---|---|---|---|
| Green logistics practices | D | 0.521 | -0.138 | 0.289 | | | |
| | I | 0.000 | 0.000 | 0.000 | | | |
| | T | 0.521 | -0.138 | 0.289 | | | |
| Operational performance | D | 0.000 | 0.000 | 0.000 | 0.460 | | |
| | I | 0.240 | -0.064 | 0.133 | 0.000 | | |
| | T | 0.240 | -0.064 | 0.133 | 0.460 | | |

**Table 7.** Direct (D), Indirect (I) and Total (T) effects between research factors

| | | Environmental regulatory pressure | Economic pressure | Customer pressure | Green logistics practices | Operational performance | Market performance |
|---|---|---|---|---|---|---|---|
| Market performance | D | 0.000 | 0.000 | 0.000 | 0.000 | 0.574 | |
| | I | 0.138 | -0.037 | 0.076 | 0.264 | 0.000 | |
| | T | 0.138 | -0.037 | 0.076 | 0.264 | 0.574 | |
| Social reputation | D | 0.000 | 0.000 | 0.000 | 0.272 | 0.000 | 0.402 |
| | I | 0.197 | -0.052 | 0.109 | 0.106 | 0.231 | 0.000 |
| | T | 0.197 | -0.052 | 0.109 | 0.378 | 0.231 | 0.402 |
| Financial performance | D | 0.000 | 0.000 | 0.000 | 0.312 | 0.000 | 0.477 |
| | I | 0.228 | -0.060 | 0.127 | 0.126 | 0.274 | 0.000 |
| | T | 0.228 | -0.060 | 0.127 | 0.438 | 0.274 | 0.477 |

**Figure 1.** The proposed conceptual framework of the study

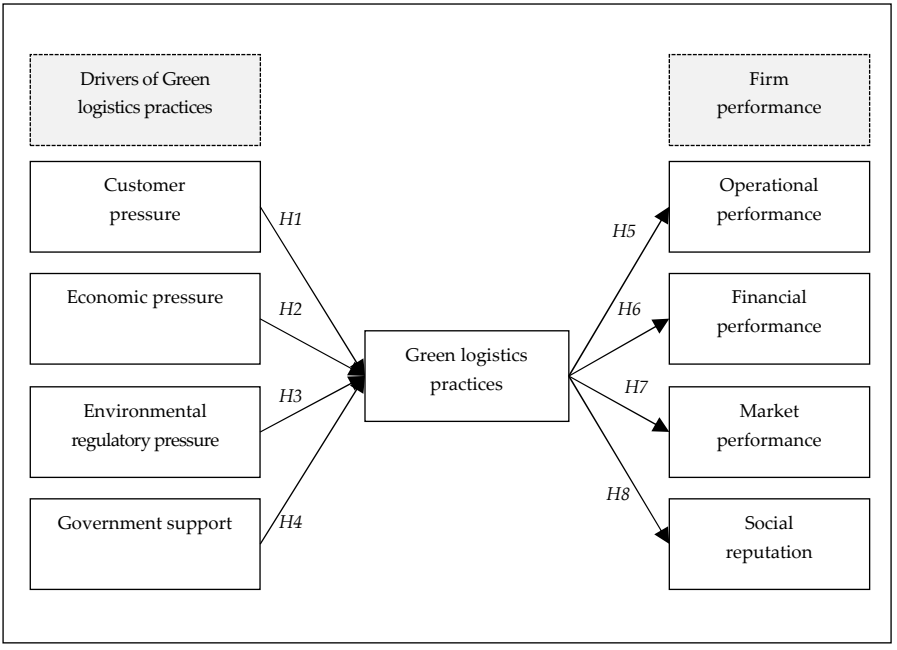
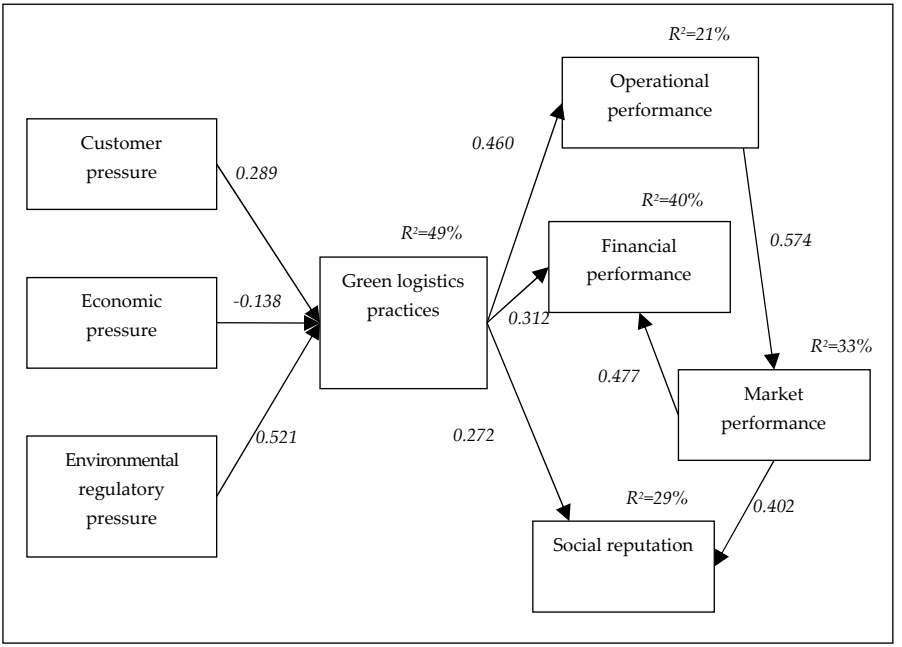


**Figure 2.** The modified research model (all paths are statistically significant)



# Appendix

## Measurement items

**Customer Pressure (CP)**
(Chu *et al.*, 2019; Huang *et al.*, 2016; Lai and Wong, 2012)
CP01. Our customers are putting pressure on our company, regarding various environmental issues (e.g., green practices, green supply chain, green transportation, etc.).
CP02. Our customers require us to be ISO 14000 certified.
CP03. Our customers carry out environmental audits of our firm.
CP04. Our customers seek green suppliers.
CP05. If the company does not meet the environmental requirements of its customers, they will terminate the contracts.

**Economic Pressure (EP)**
(Lai and Wong, 2012)
EP01. The energy (transportation) cost is constantly increasing.
EP02. Subsidies can be obtained from the government by implementing processes that concern the green management of logistics.
EP03. The use of green practices in logistics contributes to cost savings.
EP04. The use of green practices in logistics helps reducing waste in materials and transportation.
EP05. Our competitors have gained financial benefits from the green management of their logistics.

**Environmental Regulatory Pressure (ERP)**
(Baah *et al.*, 2020; Lai and Wong, 2012)
ERP01. My company has been forced in the past to adjust its operations to comply with rules of the regulatory framework.
ERP02. Environmental regulations governing our products are very strict.
ERP03. The regulatory framework restricts the use of hazardous materials and the waste of transportation resources.
ERP04. My company complies with most environmental regulations.

**Government Support (GS)**
(Lee, 2008)
GS01. Government provides financial support for developing green practices.
GS02. Government encourages companies to propose green logistics projects.
GS03. Government helps training manpower with green logistics skills.
GS04. Government sets the environmental regulations for the logistics industry.

**Green Logistics Practices (GLP)**
(Agyabeng-Mensah *et al.*, 2020; Baah *et al.*, 2020)
GLP01. My company uses sustainable (green) transport methods to reduce CO2 emissions.
GLP02. My company has a preference towards reusable and recyclable materials.
GLP03. My company uses eco-friendly packaging materials for product transportation.
GLP04. My company enhances the sharing of environmental information across our logistics network.
GLP05. My company monitors and evaluates environmental policies and practices.
GLP06. My company participates in reverse logistics initiatives.

**Operational Performance (OP)**
(Abdallah *et al.*, 2023; Huo *et al.*, 2021)
*Evaluate the performance of your company over the past three years, based on the following indicators:*
OP01. Timely delivery of products.
OP02. Optimization of inventory management.
OP03. Quality of products.

OP04. Excellent use of production (transportation) capacity.
OP05. Time required for designing new products.
OP06. Flexibility of the production (transportation) system
OP07. Timely response to customer demands

**Financial Performance (FP)**
(Agyabeng-Mensah *et al.*, 2020; Baah *et al.*, 2020)
*Evaluate the performance of your company over the past three years, based on the following indicators:*
FP01. Sales.
FP02. Profit margin.
FP03. Net profits.
FP04. Liquidity.
FP05. Return on Investments - ROI.
FP06. Return on Equity - ROE.
FP07. Accounts Payable Turnover.

**Market Performance (MP)**
(Dangelico, 2017)
*Evaluate the performance of your company over the past three years, based on the following indicators:*
MP01. Growth in market share.
MP02. Growth in sales.
MP03. Improvement in customer loyalty.
MP04. Improvement in the company's reputation and image in the market.
MP05. Better alignment between the company's offerings and consumer expectations.
MP06. Excellence in introducing new products in the market.

**Social Reputation (SR)**
(Baah *et al.*, 2020)
SR01. Engage in philanthropic / charitable practices.
SR02. Encourage development of employee skills.
SR03. Ensure employees safety and quality of life.
SR04. Improve the job satisfaction levels of employees.
SR05. Improve community in which my company operates.