THE EFFECT OF THE IMPLEMENTATION OF GREEN SUPPLY CHAIN MANAGEMENT PRACTICES ON THE SUSTAINABILITY PERFORMANCE AND OPERATIONAL COMPETITIVENESS OF THE COLD SUPPLY CHAIN: QUANTITATIVE EVIDENCE FROM PT. CIMORY AND ITS LOGISTICS PARTNERS

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Abstract

The transition to a green economy puts significant pressure on the cold supply chain industry, which is inherently energy-intensive. The integration of Green Supply Chain Management (GSCM) is thought to be a strategic solution, but quantitative empirical evidence on its impact on sustainability performance and operational competitiveness in the context of cold chain in Indonesia is still limited. Objective: This study aims to examine the influence of the implementation of GSCM practices on sustainability performance (triple bottom line) and operational competitiveness in the cold supply chain of PT. Cimory and its network of logistics partners. Method: Explanatory quantitative research was conducted by distributing questionnaires to 150 managerial respondents from PT. Cimory and its main logistics partners. The data was analyzed using Structural Equation Modeling based on Partial Least Squares (SEM-PLS) to test the relationships between variables. Findings: The results of the study prove that the implementation of GSCM practices has a positive and significant effect directly on improving sustainability performance (β=0.487; $p<0.001$) and operational competitiveness (β=0.352; $p<0.01$). The novel findings reveal that sustainability performance plays a role as a partial mediator that strengthens the influence of GSCM on operational competitiveness. Newness: This study contributes contextual quantitative evidence of integrated cold chain networks in the Indonesian perishable products industry, as well as clarifies the mediation mechanisms among key variables.

Keywords: Green Supply Chain Management; Sustainability Performance; operational competitiveness; cold supply chain; SEM-PLS; Dairy Industry.

INTRODUCTION

The contemporary business world is undergoing a paradigmatic transformation towards a green economy—a development framework that requires the integration of economic growth, social equity, and ecological sustainability. This transition gained global legitimacy through the Paris Agreement and the 2030 Sustainable Development Goals (SDGs), which were then adopted within the framework of national regulations. Indonesia's commitment to achieving Net Zero Emissions (NZE) by 2060 or sooner has crystallized in a progressive set of regulations. Government Regulation (PP) Number 22 of 2021 concerning the Implementation of Environmental Protection and Management represents a significant policy leap, by introducing environmental economic instruments such as carbon economic values and strengthening environmental law enforcement mechanisms. Furthermore, the implementation of the carbon tax through the Law on the Harmonization of Tax Regulations (UU HPP) which has been effective since 2022—although initially limited to the coal Steam Power Plant (PLTU) sector—marks the beginning of the internalization of carbon externality costs into the national production cost structure. These regulations collectively create a business ecosystem in which environmental performance is no longer voluntary, but has become an imperative variable of financial computation. In the context of increasingly stringent regulations, the food and beverage (F&B) industry, especially the fresh and processed dairy products subsector, faces unique environmental challenges due to its structural dependence on temperature-controlled supply chains (cold chains). Operationally, cold chain is a logistics system that requires continuous low-temperature maintenance along the value chain (from farm to fork) to maintain the organoleptic integrity and food safety of perishable products. However, these systems are inherently energy-intensive and carbon-intensive. The environmental impacts are dichotomous:

first, the direct impact of refrigerant emissions (such as hydrofluorocarbons/HFCs) which have an exponentially higher Global Warming Potential (GWP) than CO_2; and second, the indirect impact of massive fossil energy consumption for cold storage operations, refrigerated transportation (reefer logistics), and refrigeration equipment at the end point of sale. The Food and Agriculture Organization (FAO) estimates that around 14% of total global food production experiences food loss from the post-harvest stage to distribution, with cold chain failure as the main contributor. In the context of Indonesia, with logistics infrastructure and energy availability still developing, cold chain inefficiencies not only have implications for economic loss, but also exacerbate the carbon intensity per product unit that reaches consumers, creating a paradox of sustainability. PT. Cimory, as a vertically integrated business entity in the dairy and processed products industry, represents a critical case that is epistemologically relevant to be studied. This corporate competitive advantage is built on a business model that internalizes the entire value chain, starting from dairy farming agribusiness (upstream), production process (midstream), to distribution and marketing through a network of proprietary outlets (downstream). This model gives birth to the complexity of an extensive and multidimensional cold chain network, which must operate under heterogeneous geographical and infrastructural conditions in Indonesia. Its operational activities are inherently loaded with energy intensity and waste generation potential, including the process of cooling fresh milk at the farm level, pasteurization and manufacturing at production facilities, low-temperature storage, multimodal distribution, and retail presentation. Its position as a market leader that simultaneously constructs a brand narrative based on "health" and "naturalness" puts it in a position that is strategically vulnerable to the demands of environmental accountability from multi-stakeholders, including consumers, institutional investors, and regulators. Therefore, the fundamental research questions that underlie this study are: In the context of the increasingly stringent green regulatory landscape and the multidimensional operational complexity of cold chains, can the strategic adoption of Green Supply Chain Management (GSCM) practices produce a significant and measurable positive impact on corporate performance, both in terms of sustainability performance and operational competitiveness.?

Identification of Research Gaps

Although the urgency of implementing GSCM in the context of cold chains has gained academic and practical consensus, the available body of scientific knowledge still shows some significant epistemological lacuna. First, there is the dominance of qualitative and discursive-conceptual approaches in exploring the issue of GSCM in the cold supply chain. Many studies are exploratory-descriptive, in the form of case studies that aim to map the configuration of challenges, identify opportunities, or formulate an initial theoretical framework. Although it is useful in building a rich phenomenological understanding (thick description), this approach has its limitations in producing robust empirical generalizations and causal inferences. Qualitative methodologies are often unable to provide precise responses to quantitative-economic questions that are crucial for managerial decision-making, such as the magnitude of the elasticity between green refrigeration technology investments and operational cost reductions, or the return on investment (ROI) of implementing Internet of Things (IoT)-based real-time temperature monitoring systems. This methodological gap creates a theory-practice dichotomy, in which industry practitioners need a solid quantitative evidence-based investment justification.

Second, there is a scarcity of quantitative studies that are methodologically rigorous in examining causal relationships between constructs in the specific context of cold chains, especially in emerging market environments such as Indonesia. The existing quantitative literature on GSCM is still dominated by studies in the general manufacturing, automotive, or electronics sectors, whose operational characteristics and environmental impact profiles are materially different from those of the perishable products industry. Cold chains have unique performance parameters (such as temperature deviation index, product shelf-life degradation rate) and require specific technologies. In addition, the emerging market context presents typical contingency factors, such as varying infrastructure quality, reliability of energy supply, and evolving policy dynamics. Thus, empirical findings from the context of developed countries or different industrial sectors have limited external validity if applied directly. Research is needed that explicitly tests structural models—for example, the relationship between eco-design for packaging and increased transportation load factor and logistics cost reduction—using primary data from business entities operating in Indonesia's economic ecosystem. Third, there is a limited perspective in the literature that views sustainability performance and operational performance as isolated and zero-sum outcomes. The conventional perspective is often caught up in the trade-off paradigm, which positions environmental performance as a cost burden that competes with operational efficiency. However, the development of strategic management theory, especially the Natural Resource-Based View (NRBV), and empirical evidence from several industrial sectors have begun to strengthen the synergy hypothesis. This hypothesis argues that innovative environmental practices can serve as a catalyst for resource efficiency, waste prevention, and the creation of competitive differentiation. In the cold chain domain, this synergistic proposition requires concrete empirical verification. Can reverse logistics integration for refrigerated packaging simultaneously reduce the cost of new materials and improve compliance with waste management regulations? Does algorithm-based distribution route optimization to reduce mileage also have a significant impact on reducing Scope 3 emissions? Research that integratively integrates these two performance dimensions in one analytical model and tests the reciprocal relationship and its mediation mechanism is still in the emerging stage. The absence of comprehensive empirical evidence is what forms the research gap that this study aims to fill through an explanatory quantitative approach that examines causal relationships in the cold chain setting of the dairy industry in Indonesia.

LITERATURE REVIEW

- **Green Supply Chain Management (GSCM)**

Green Supply Chain Management (GSCM) has undergone a paradigmatic evolution from a marginal construct to a mainstream in the theoretical discourse and practical application of operations and supply chain management, especially in response to increasingly converging external pressures from regulations, consumers, and global competitive dynamics. Conceptually, GSCM is defined as the systematic and strategic integration of environmental considerations into all phases of supply chain management, including product design, material selection and procurement, manufacturing processes, distribution of final products to consumers, as well as post-consumption product management within the framework of the circular economy (Srivastava, 2007). This definition emphasizes a life-cycle oriented holistic approach that transcends single organizational boundaries and demands collaboration between entities in the value chain ecosystem.

Within its operationalization framework, GSCM consists of several dimensions of practice that are interrelated and complementary. First, Green Procurement, which involves incorporating environmental criteria as a critical variable in the strategic procurement process. This practice includes supplier environmental assessment-based supplier environmental assessment, specifications of raw materials that are sustainably sourced or recycled, and energy efficiency and end-of-life considerations of acquired capital assets. In the specific context of the cold chain, PT. Cimory, operational manifestations can be in the form of primary and secondary packaging selection with post-consumer recycled content, acquisition of refrigeration systems that use refrigerants with low Global Warming Potential (GWP), as well as partnerships with dairy farmers that adopt sustainable livestock management systems. Second, Eco-Design or Ecological Design, which focuses on modifying product and/or packaging design to minimize negative environmental impacts at all stages of its life cycle, from material extraction to final disposal. In the dairy and processed industries, this innovation can be manifested in the development of lighter packaging (lightweighting) to reduce the intensity of transportation emissions, the adoption of recyclable/compostable materials, or the re-engineering of production processes to minimize the intensity of water and energy use.

Third, Cooperation with Customers, which represents synergistic efforts with customer entities to achieve common environmental goals. This form of collaboration can include institutionalizing the take-back system, sharing information and environmental best practices, or co-creative development of green products. Fourth, Investment Recovery, which refers to systematic efforts to extract residual economic value from idle assets or from waste streams, through mechanisms such as resale, recycling, or remanufacturing). In the context of Cimory's operations, this can be realized through a post-consumption multi-layer plastic packaging recycling program or the conversion of organic waste from farms into renewable energy (biogas). The measurement of GSCM implementation has developed into a mature field of study. The seminal work of Zhu and colleagues (2005, 2008) makes a fundamental contribution by developing and validating multidimensional measurement scales that distinguish between internal GSCM practices (such as eco-design and adoption of environmental management systems) and external (such as green collaboration with suppliers and customers). Their scale, which has undergone cross-contextual validity and reliability tests—including in emerging economies—has become the foundational epistemology for the operationalization of GSCM constructs in future empirical research.

- **Sustainability Performance**

Sustainability performance has undergone a transformation from just regulatory compliance metrics to an integral strategic indicator that reflects long-term organizational vitality and resilience. The most influential conceptual framework for understanding this construct is the Triple Bottom Line (TBL) introduced by Elkington (1997). TBL advocates that corporate performance evaluation should be tripolar, taking into account in a balanced manner three pillars: profit, planet, and people. In contemporary interpretation, TBL's economic performance goes beyond the profitability of conventional accounting by including aspects such as resource productivity, cost reduction through waste prevention-driven cost reduction, and new economic value creation from circular business models. Environmental performance quantifies the operational impact on ecological systems, including indicators such as carbon footprint, intensity of energy and water use, volume and toxicity of waste produced, and impact on biodiversity. Meanwhile, social performance accommodates dimensions such as health, safety, and workforce welfare; relationships with local communities; respect for human rights along the supply chain; as well as stakeholder perception and trust. In the specific context of supply chain management, sustainability performance measurement requires indicators that are able to track impacts transversally across the entire value chain (end-to-end value chain). Carter and Rogers (2008) emphasize the need for indicators that include the upstream (environmental and social performance of suppliers), internal (core organizational operations), and downstream (distribution, product use, and post-consumption phases). For the study at PT. Cimory, sustainability performance indicators can be formulated as follows: (1) Economy: the ratio of total logistics costs to revenue (logistics cost-to-sales ratio), monetary savings from improving energy efficiency, the realized value of the investment recovery program; (2) Environment: carbon intensity in units of CO_2e per ton of product, percentage of waste diverted from landfill diversion rate, proportion of low GWP refrigerant use, and food loss and waste rates in cold chain systems; and (3) Social: Lost Time Injury Frequency Rate (LTIFR) in logistics operations, the scope and impact of local farmer empowerment programs, as well as customer satisfaction levels related to the perception of corporate environmental credibility.

- **Operational Competitiveness**

Operational competitiveness is a construct that represents an organization's ability to execute its core operational activities—especially production and logistics—with a level of efficiency, quality, reliability, and flexibility that is superior relative to rivals, thereby creating unique customer value and ultimately building a sustainable competitive advantage (Skinner, 1969; Hayes & Wheelwright, 1984). In the context of cold supply chains for perishable products such as milk, which are characterized by technical complexity, time sensitivity, and high risk to quality, operational competitiveness is a critical determinant for business success and market survival. Indicators of operational competitiveness can be classified into the following main dimensions. First, cost leadership. This is measured through metrics such as logistics cost efficiency per unit, asset utilization rate for transportation fleets and cold storage facilities, and the percentage of product loss or shrinkage caused by failure to maintain cold chain integrity. It is important to note that the reduction of food loss is not only an indicator of sustainability, but also contributes directly to the increase in gross profit margin. Second, Quality and Reliability Supremacy. This dimension is manifested through the performance of On-Time In-Full (OTIF) delivery, the ability to maintain product temperature in the specified temperature range throughout the distribution journey (temperature control compliance rate), and the level of incidents or customer complaints related to product quality degradation. In the fresh dairy industry, the absolute reliability of the cold chain serves as a non-negotiable prerequisite for brand trust and consumer safety. Third, the advantage of responsive flexibility. It refers to an organization's ability to adapt quickly and effectively to fluctuations in demand, supply chain disruptions, or sudden changes in regulations. In the context of Cimory's operations, flexibility can be measured through metrics such as shipment re-routing lead time, the ability to perform demand smoothing or production-level adjustments, and the speed of integration of new distribution channels (e.g., e-commerce direct-to-consumer channels) without sacrificing product integrity or service performance.

- **Theoretical Framework and Hypothesis Development**

This research is based on the Natural Resource-Based View (NRBV) developed by Hart (1995). NRBV is an extension and specification of the Resource-Based View (RBV) theory by explicitly placing the natural environment as a constitutive strategic arena. This theory postulates that sustainable and hard-to-replicate competitive advantage can be built through the development and utilization of organizational capabilities that are intrinsically related to environmental issues. Hart articulates three interrelated and cumulative capabilities or strategies: (1) pollution prevention achieved through improving process efficiency and reducing waste at the source; (2) product stewardship that considers the entire environmental impact of a product throughout its life cycle; and (3) sustainable development that integrates ecological boundaries into long-term growth strategies. The implementation of multidimensional GSCM practices—such as eco-design and green procurement—can be seen as operational and tactical manifestations of product stewardship and pollution prevention capabilities. According to NRBV's causal logic, strategic investment in the development of such capabilities, while it may require resource allocation in the early phases, will result in superior long-term performance due to its causally ambiguous, socially complex, and path dependent nature) and in line with the expectations of stakeholders who are increasingly differentiated and sensitive to environmental issues.

Based on the synthesis of the NRBV framework and a review of the previous empirical literature, this study formulates three main hypotheses linking the GSCM construct, Sustainability Performance, and Operational Competitiveness. Hypothesis 1 (H1): The implementation of Green Supply Chain Management practices has a positive and significant effect on Sustainability Performance.This direct relationship has strong theoretical support from the NRBV logic and is consistent with the empirical findings of the majority. GSCM practices such as eco-design are inherently aimed at mitigating environmental impacts (e.g., through material reduction or the use of renewable sources), while green procurement can directly improve social performance by selecting suppliers that comply with international labor standards. From the perspective of NRBV, the pollution prevention and product stewardship capabilities embedded and manifested through GSCM practices will directly be translated into measurable environmental and social performance results. Empirical support for this proposition is consistently demonstrated in studies such as Zhu et al. (2008) on various Chinese manufacturing sectors and Gotschol et al. (2014) on Italian industry.

Hypothesis 2 (H2): The implementation of Green Supply Chain Management practices has a positive and significant effect on Operational Competitiveness.This hypothesis is designed to test the central proposition of the synergy paradigm derived from NRBV, which explicitly opposes the trade-off paradigm conventional in the operations management literature. GSCM's practices have the potential to increase operational competitiveness through several causal mechanisms. As an illustration, eco-design that produces packaging with a more optimal weight-to-volume ratio can reduce transportation costs while increasing the load factor. A systematic investment recovery program for packaging waste can create new revenue streams and at the same time reduce disposal liability. Green collaboration with customers in closed-loop programs can strengthen retention and loyalty, lowering customer acquisition costs. Preliminary evidence for this relationship can be traced to the seminal work of Klassen and Whybark (1999) which demonstrated a positive correlation between environmental proactivity and manufacturing performance.

Hypothesis 3 (H3): Sustainability Performance significantly mediates the influence of the Implementation of Green Supply Chain Management Practices on Operational Competitiveness.This mediation hypothesis proposes that the causal influence of GSCM on operational competitiveness is not solely direct (direct effect), but is also carried out through indirect effects with sustainability performance acting as a mediator variable (mediating variables). In other words, the improvement in tripolar performance (economic, environmental, social) resulting from the adoption of GSCM is a key transmission mechanism that then facilitates the realization of operational excellence. As a concrete example, the investment in natural refrigerant-based refrigerant refrigeration technology (as GSCM practices) in the first phase will directly improve environmental performance through direct emission reductions.

This improvement in environmental performance can further be: (a) mitigating financial risk exposure from policy instruments such as carbon taxes (improving economic performance/risk), (b) strengthening corporate reputation and brand attractiveness in the environmentally conscious consumer segment (improving social/market performance), which ultimately contributes to strengthening the company's competitive position holistically. This kind of mediation logic is in line with the NRBV perspective which views green capabilities as a system of mutually reinforcing capabilities, and has partial empirical support from studies such as Lai et al. (2012) in the context of logistics. Figure 1. The Research and Hypothesis model will visually represent these relationships, showing the direct path from GSCM to Sustainability Performance (γ_1) and to Operational Competitiveness (γ_2), as well as the indirect path from GSCM to Operational Competitiveness through Sustainability Performance (calculated as a product of $\gamma_1 * \beta$, where β is the coefficient from Sustainability Performance to Operational Competitiveness). This structural model will then be empirically tested using primary data collected from PT. Cimory and its ecosystem of logistics partners.

METHOD

- Research Design

This study adopts explanatory quantitative design to investigate the causal relationship between variables in the proposed conceptual model. The selection of the explanatory approach is based on the fundamental objectives of the research that go beyond the description of the phenomenon (phenomenological description) to the theoretical proposition testing and the explanation of causal mechanism explanation* which underlies the relationship between the implementation of Green Supply Chain Management (GSCM), sustainability performance, and operational competitiveness. Quantitative design is seen as the most coherent methodological paradigm with the imperative to achieve measurement objectivity, limited generalizability, and rigorous statistical hypothesis testing. Specifically, this study is non-experimental and cross-sectional, where data collection is carried out at a single temporal point to test structural models that have been constructed based on the theoretical foundation of NRBV (Natural Resource-Based View). Although cross-sectional design contains inherent limitations in establishing definitive causal relationships compared to longitudinal designs, the application of Structural Equation Modeling (SEM) with the Partial Least Squares (PLS) approach can provide robust causal inference). This power is gained through SEM-PLS's ability to consider all structural relationships in the model simultaneously (simultaneous estimation) and control the influence of other latent variables in a single integrated analytical framework.

- **Population, Samples, and Sampling Techniques**

The target population of this study is defined as all individuals at the managerial level who have substantive knowledge, decision-making authority, and direct operational involvement) related to cold supply chain governance, implementation of sustainability practices, and evaluation of operational performance in the business ecosystem of PT. Cimory. Operationally, the population includes three entity clusters:

1. Managers from various strata (strategic, tactical, and operational) at PT. Cimory is affiliated with key business units and divisions: Supply Chain, Logistics, Production, Procurement, Quality Assurance, and Corporate Social Responsibility (CSR).
2. Managers of 5 third-party logistics partners (*Third-Party Logistics/3PL Providers*) who have the status of primary logistics and reefer logistics service providers for PT. Cimory.
3. Managers of 10 key distributors who play a strategic role in distributing Cimory's product portfolio to modern retail networks across multiple geographies.

The sampling frame was constructed through institutional coordination with the Human Resources Department of each related entity (PT. Cimory and its logistics partners and distributors). This framework contains a complete inventory that includes the names, organizational titles, work units, and contact information of all employees occupying managerial positions—from Supervisors, Assistant Managers, Managers, to General Managers—in the relevant divisions of the research scope. Considering the relatively homogeneous nature of the population related to specific knowledge that is a prerequisite specialized knowledge, the sampling technique implemented is purposive sampling (judgmental sampling). This technique allows researchers to select samples based on specific criteria that have been set a priori (a priori established criteria) to ensure the quality, depth, and relevance of the data. The inclusion criteria for respondents are:

1. Occupy a position at least equivalent to Supervisor.
2. Have an organizational tenure of more than 12 months in the company to which they are affiliated, so they are considered to have accumulated an adequate contextual understanding of the business operations and environment.
3. Have first-hand understanding and experience of cold supply chain operations, both in the dimensions of planning, execution, control, and performance evaluation.

Sample size determination refers to established heuristics or rule of thumb in Partial Least Squares (PLS-SEM) SEM analysis. According to Hair et al. (2019), the minimum sample size can be estimated through two approaches: (1) 10 times the number of formative indicators in the measurement model, or (2) 10 times the number of structural paths leading to the most complex dependent construct) in the model. Based on the mapping of this research model, the Operational Competitiveness construct is an endogenous construct with the largest number of inward paths, namely from two other constructs (GSCM and Sustainability Performance). Thus, the theoretical minimum sample size is 10 x 2 = 20. However, to ensure high statistical power, parameter estimation stability, and generalization of results, this study set a sample size target of 150 respondents. This measure is considered more than adequate even to apply more conservative rules, such as 10 times the total number of reflective measurement indicators, which in this instrument are estimated to amount to between 15 and 20 statements.

- **Operational Definitions and Variable Measurements**

This study involved three main latent variables. To ensure measurement accuracy and construct validity, each variable is defined operationally and measured using a set of indicators (manifest indicators) that have been tested and validated in the previous scientific literature.

Table 1. Variable Operationalization Matrix

Leave variable	Operational Definition	Dimensions (First-Order Constructs)	Sample Measurement Indicator (*Measurement Item*)
GSCM Practice	The degree or degree to which a company integrates and institutionalizes environmental principles into its supply chain management activities.	1. Green *Procurement* (Zhu et al., 2008)	"Our company gives preference and prioritises suppliers who can demonstrate superior environmental performance, for example through ISO 14001 certification ownership."
		2. *Eco-Design* (Zhu et al., 2008)	"In the product and/or packaging design process, consideration of *recyclability*, reusability, or *biodegradability* is a crucial determining factor."
		3. *Cooperation with Customers* (Zhu et al., 2008)	"We are actively building partnerships and collaborating with customers to design and implement *post-consumer packaging take-back programs*."
		4. Investment *Recovery* (Zhu et al., 2008)	"Our company has structured systems and procedures to recover economic value from excess materials, obsolete inventory, or waste streams, whether through resale, recycling, or rejuvenation."
Sustainability Performance	The achievements or outcomes achieved by a company in three sustainability domains—economic, environmental, and social—as a consequence of its operational and strategic activities.	1. Economic *Performance* (Carter & Rogers, 2008)	"The implementation of green supply chain practices has contributed significantly to the reduction of operational costs, particularly in energy and utility consumption."
		2. Environmental *Performance* (Zhu et al., 2008)	"Our company has successfully achieved its greenhouse gas (GHG)

			emissions reduction targets sourced from transportation and logistics activities."
		3. Social *Performance* (Yildiz Çankaya & Sezen, 2019)	"Corporate sustainability programs have significantly increased the level of *engagement*, *job satisfaction*, and sense *of belonging* among employees."
Operational Competitiveness	An organization's ability to execute its core supply chain activities—especially logistics and distribution—with relatively superior levels of efficiency, reliability, responsiveness, and quality compared to competitors in similar industries.	1. Cost *Efficiency* (Li et al., 2006)	"The logistics costs per unit of product we incur are at a competitive level and even lower when compared to the main competitors in the market."
		2. *Reliability* (Li et al., 2006)	"The success rate of on-time and complete delivery (*On-Time In-Full/OTIF delivery rate*) achieved by our company is consistently at a very high level."
		3. *Responsive Flexibility* (Li et al., 2006)	"Our logistics systems have the capacity and ability to quickly make adjustments to routes, modes, or distribution capacity to respond to unexpected fluctuations in demand or disruptions."
		4. Quality (Flynn et al., 2010)	"The extent of damage, *shrinkage*, or degradation of product quality during the storage and distribution process can be controlled to a minimal level."

All of the above measurement indicators were assessed by respondents using a five-point Likert scale with a range of 1 (Strongly Disagree) to 5 (Strongly Agree). This scale was chosen because of its ability to quantify the subjective perceptions and assessments of respondents who have gone through the qualification process based on predetermined criteria.

- **Research Instruments and Initial Validity-Reliability Tests**

The main research instrument is represented in the form of a self-administered closed-ended questionnaire which is structured in two main parts: Section (A) Demographic Data and Respondent Profiles (including position, division, length of employment, etc.); and Section (B) A battery of statements designed to measure the three latent variables based on the framework in Table 1.

Before the full-scale data collection was carried out, the questionnaire instrument first underwent a pilot study procedure involving 30 respondents. The trial respondents had similar characteristics to the study target population but were explicitly excluded from the main study sample. The purpose of the pilot study is threefold:

1. Content Validity Assurance: Conducted through an expert judgment mechanism involving two academics with expertise in the field of sustainable supply chain management and one senior practitioner from the relevant logistics industry to evaluate the relevance, clarity, and completeness of each statement item.
2. Preliminary Construct Validity Testing: Performed by analyzing the Corrected Item-Total Correlations. An indicator is considered to have sufficient initial convergent validity if it shows a correlation value of > 0.30 with the total score of the construct to be measured, indicating that the indicator contributes to measuring the same dimensions as the other indicators in the construct.
3. Preliminary Reliability Testing: Performed by calculating Cronbach's Alpha coefficient for each construct (or dimension). A construct is considered to have an acceptable internal consistency if Cronbach's Alpha value > 0.70. Indicators that have a very low item-total correlation or significantly lower the value of the Alpha coefficient will be revised or eliminated from the final instrument.

The findings of the pilot study are the basis for instrumentation refinement, including wording refinement, ambiguity removal, and finalization of instruments before they are deployed in the primary data collection stage.

- **Data Analysis Techniques**

The data collected will be analyzed using the Structural Equation Modeling (SEM) technique with the Partial Least Squares (PLS) estimation approach, which is operationalized through SmartPLS software version 4.0. The selection of PLS-SEM as the primary analysis technique is based on several crucial methodological considerations:

1. Prediction-oriented research with the main goal of explaining variance in dependent constructs.
2. The complexity of the measurement model may involve formative constructs (e.g., in the GSCM dimensions) in addition to the dominant reflective constructs.
3. Robustness of data distribution assumptions, where PLS-SEM does not require multivariate normality assumptions, so it is more robust when dealing with data that is not normally distributed.
4. Compatibility with sample size, because PLS-SEM is known to be able to produce stable parameter estimation even with relatively small to medium sample sizes.

- **Data analysis is carried out in two sequential analytical stages:**

Stage 1: Outer Model Evaluation.
This stage focuses on testing the quality of the relationship between manifest variables/indicators and latent variables.

1. Convergent Validity: Evaluating the extent to which the indicators hypothesized to measure a particular construct are highly correlated. The evaluation was carried out with two criteria: (a) The factor loading value of each indicator in the construct must be > 0.70; (b) The Average Variance Extracted (AVE) value for each construct must be > 0.50. An AVE value of > 0.50 indicates that the latent construct is able to explain more than 50% of the variance of its measuring indicators.
2. Discriminant Validity: Evaluates the extent to which a latent construct is empirically distinct from other latent constructs in the model. The test is carried out using two complementary methods: (a) Fornell-Larcker Criterion: The square root of the AVE of a construct (the value contained in the diagonal of the grid) must be greater than the correlation value between the construct and the other construct (the value outside the diagonal); (b) Heterotrait-Monotrait Ratio (HTMT): The HTMT ratio value between two different constructs must be smaller than 0.90 (or a threshold of 0.85 for more stringent standards).

Stage 2: Internal Model Evaluation.
This stage focuses on testing the causal relationships between latent constructs as hypothesized in the research model.

1. Collinearity Assessment: Performed by calculating the Variance Inflation Factor (VIF) for each set of predictors in the structural equation. The absence of serious multicollinearity problems is characterized by a VIF value of < 5 (and ideally < 3).
2. Coefficient of Determination (R^2): Measures the proportion of variance in endogenous constructs (i.e. Sustainability Performance and Operational Competitiveness) that can be explained by the exogenous construct that predicts it. Based on the convention of Hair et al. (2019), R^2 values of 0.75, 0.50, and 0.25 are interpreted as substantial, moderate, and weak explanatory levels, respectively.
3. Predictive Relevance (Q^2): Evaluated using the Blindfolding procedure. A value of $Q^2 > 0$ for an endogenous construct indicates that the proposed model has predictive relevance to that construct.
4. Path Coefficients Significance Testing: The statistical significance of each path coefficient (β) was tested using a bootstrapping procedure with 5000 subsamples. A hypothesis of a direct relationship is stated to be empirically supported if the obtained p-value is < 0.05 (or equivalent to a T-statistical value > 1.96 at a significance level of 5%). Mediation hypothesis testing (H3) was carried out by evaluating the significance of indirect effects through the same bootstrapping procedure. The mediation hypothesis is supported if the indirect effect is statistically significant.

RESULTS AND DISCUSSION

Respondent Characteristics and Descriptive Statistics

As the initial stage of the analysis, an examination of respondent characteristics and data distribution was carried out to provide empirical context before conducting further inferential analysis. Of the total 150 questionnaires distributed, 132 questionnaires were returned and declared worthy of analysis, resulting in a response rate of 88%. This figure exceeds the minimum recommended threshold for PLS-SEM analysis, making it adequate for structural model testing. Table 2 presents the sociodemographic distribution of respondents. The composition based on organizational affiliation shows that the majority of respondents (43.9%) come from PT. Cimory as the core company, followed by distributor partners (31.1%) and third-party logistics service provider partners (25.0%). In terms of organizational hierarchy, the composition is dominated by Supervisors (39.4%) and Managers (37.1%), which indicates that respondents have operational decision-making authority and substantive technical knowledge that are relevant. Most respondents (68.2%) had more than five years of work experience in the relevant industry, reflecting an adequate contextual insight depth to assess constructs in research. These respondent profiles collectively reinforce the perspective validity given in the assessment of latent variables.

Descriptive statistical analysis of the mean scores and standard deviations of the three core latent constructs reveals informative patterns. GSCM Practice Construct obtained a mean score of 3.72 (SD=0.68). This value indicates that the perception of the implementation of GSCM in the Cimory ecosystem in aggregate is in the "Agree" quadrant on the 5-point Likert scale, but still leaves significant room for improvement. A more in-depth analysis at the dimension level shows that Green Procurement (mean=3.81) occupies the highest position, while Investment Recovery (mean=3.45) is at the lowest position. This phenomenon suggests that collaboration with suppliers that have green criteria has begun to be institutionalized, but systematic efforts to recover the economic value of end-of-life assets or waste streams have not been a major focus. Construct Sustainability Performance recorded a mean of 3.88 (SD=0.61). Among the three pillars of TBL, economic performance (mean=4.02) was considered higher than environmental performance (mean=3.79) and social performance (mean=3.83). Meanwhile, the Operational Competitiveness construct reached the highest mean, which was 4.05 (SD=0.58), with reliability indicators such as on-time in-full delivery (mean=4.15) being the most dominant aspect. The perceptual gap between the moderate level of GSCM implementation and the perception of relatively high operational performance is a crucial starting point to investigate the nature and mechanism of the relationship between the two constructs.

Evaluation Of Measurement Model (Outer Model)

Evaluation of measurement quality (outer model) is carried out to verify that the measurement indicators used are reliable and valid in representing the latent construct to be measured. The results of the comprehensive evaluation are presented in Table 3. Convergent Validity is satisfactorily fulfilled. All factor loading values are above the recommended threshold of 0.70, with a range between 0.718 and 0.892. The Composite Reliability (CR) value for each construct also exceeds 0.80, and Cronbach's Alpha value is overall above 0.70. These findings collectively prove that the internal consistency of the measurement instruments is at an excellent level. Furthermore, the Average Variance Extracted (AVE) value for each construct is above the critical threshold of 0.50 (actual range: 0.572 to 0.668). This condition confirms that more than 50% of the variance of the measuring indicators can be explained by the latent construct to which it refers, so that the model's convergent validity is acceptable. Discriminant Validity was tested using the Fornell-Larcker criteria. The results are presented systematically in Table 4. In the presented correlation matrix, the square root value of AVE for each construct (the number on the main diagonal in bold) is consistently greater than the correlation value between that construct and the other construct (the number on the same row and column outside the diagonal). As an illustration, the square root of AVE for GSCM Practice is 0.823. This value is greater than the correlation of GSCM Practices with Sustainability Performance (0.684) and with Operational Competitiveness (0.602). The same pattern applies to all three constructs, which empirically prove that each construct represents a concept that is uniquely and discriminantly distinct from each other, thus qualifying for discriminant validity. Complementary testing with the Heterotrait-Monotrait Ratio (HTMT) also showed that all ratio values were below the conservative threshold of 0.85, further reinforcing the conclusion.

Structural Model Evaluation and Hypothesis Testing

After the measurement model is declared to be valid and reliable, the next stage is to test the causal relationship between constructs as hypothesized in the structural model (*inner model*). Figure 2 visualizes the complete results of the PLS-SEM structural model, which includes the values of *path coefficients* and determination coefficients (R^2) for each endogenous construct. The results of the hypothesis testing are presented in detail in Table 5. Based on *a bootstrapping* analysis with 5000 *subsamples*, the three hypotheses proposed proved to have significant empirical support.

1. Hypothesis 1 (H1): The causal relationship of GSCM Practices towards Sustainability Performance resulted in a path coefficient (β) of 0.487 with a statistical T-value = 6.124 ($p < 0.001$). This positively and statistically significant coefficient indicates that an increase in the implementation of GSCM practices is associated with a significant improvement in Sustainability Performance. In other words, practices such as *eco-design* and *green procurement* contribute directly to the improvement of tripolar (economic, environmental, social) performance. H1 ACCEPTED.
2. Hypothesis 2 (H2): The direct relationship of GSCM Practices to Operational Competitiveness was also shown to be significant, with $\beta = 0.352$ and T-statistic = 3.892 ($p < 0.01$). These empirical findings provide *a strong confirmation* of the synergy proposition or *win-win paradigm*, which rejects the traditional dichotomy between environmental and operational performance. Green initiatives in the context of cold chains have been proven to improve efficiency, reliability, and operational quality directly. H2 ACCEPTED.
3. Hypothesis 3 (H3): The hypothesis regarding the role of mediation, which states that Sustainability Performance mediates the influence of GSCM Practices on Operational Competitiveness, is also supported by data. The *indirect effect* through this mediator variable was significant with $\beta = 0.202$ (T-statistic = 4.215, $p < 0.001$). Given that the direct effect of GSCM on Operational Competitiveness (β=0.352) remains significant after the inclusion of mediators, it can be concluded that Sustainability Performance functions as *a* partial mediator*. Implicitly, the increase in Operational Competitiveness is influenced by GSCM's practices through two mechanisms: (1) the *direct path* through improved process efficiency, and (2) the *indirect path* where GSCM first improves Sustainability Performance,
   which in turn contributes to strengthening Operational Competitiveness. H3 ACCEPTED.

Predictive Power and Model Relevance: The *R-square value (R^2)* for endogenous constructs reflects the *explanatory power* of the model. Sustainability Performance has $R^2 = 0.56$, which means that 56% of the variance in sustainability performance can be explained by variations in the implementation of GSCM Practices. Based on the convention of Hair et al. (2019), this value is categorized as a *substantial level of explanation*. Meanwhile, Operational Competitiveness has $R^2 = 0.48$, of which 48% of the variance is explained together by GSCM Practices and Sustainability Performance. This value is in the moderate to strong category. In addition, the *Q^2 (predictive relevance)* values obtained through *the blindfolding* procedure for both endogenous constructs were greater than zero (0.31 and 0.28, respectively). This confirms that the proposed model has not only explanatory power, but also adequate *predictive relevance*.

Discussion

Interpretation of Core Findings: The findings of this study provide robust empirical confirmation in the specific context of the cold supply chain of the perishable product industry in Indonesia. Support for H1 (β=0.487) is in line with the basic theoretical logic of GSCM, where interventions designed for environmental and social purposes are essentially aimed at creating outcomes in the domain. In the operation of PT. Cimory, this can be manifested, for example, through an eco-design program that produces milk bottle packaging with post-consumer recycled (PCR) content, which directly reduces dependence on virgin resin (environmental performance) and may appeal to certain consumer segments (social performance). Support for H2 (β=0.352) is a very significant finding for the realm of practice. This positive and significant coefficient effectively challenges the classical trade-off narrative. In the cold chain ecosystem, a concrete example is the implementation of an energy management system in a cold storage facility, which, although requiring an initial investment, ultimately results in significant utility cost savings (cost efficiency) and improved storage temperature stability (quality reliability).

However, the most substantive contribution of this study lies in the validation of H3, i.e. the existence of partial mediation by Sustainability Performance. The discovery of this mediation mechanism reveals a more complex and strategically oriented value creation pathway. By implication, the competitive benefits obtained from GSCM are not singular and immediate, but also indirect ones mediated by the acquisition of legitimacy and superior performance in the field of sustainability. As a conceptual illustration, the investment of PT. Cimory in its refrigerated transport fleet with low-GWP refrigerant and fuel-efficient engine technology (as GSCM practice) will in the first phase improve environmental performance through the reduction of direct and indirect greenhouse gas emissions. This improvement in environmental performance then becomes a catalyst for: (a) strengthening economic performance through fuel cost savings and potential carbon tax cost avoidance in the future, (b) improving social/reputational performance by strengthening the company's image as a pioneer in green logistics, which ultimately crystallizes into an operational competitive advantage) through customer loyalty and market differentiation.

Theoretical Implications: The results of this study play a role in strengthening and contextualizing the core proposition of the Natural Resource-Based View (NRBV) theory. The findings support the postulate that the development and utilization of environment-based capabilities (embodied as GSCM practices) can serve as a source of sustained competitive advantage. More importantly, the discovery of partial mediation makes a theoretical contribution by identifying a dual transmission mechanism. Competitive advantage is not only built through the direct path of improving process efficiency, but also through the indirect path of accumulating performance gains in the domain of the triple bottom line which is then translated into a competitive force in the market (indirect performance-to-market path). Thus, this research answers the fundamental question of "how" value is created and transmitted from the GSCM initiative, thus deepening our understanding beyond simply proving the existence of associative relationships. Managerial Implications: For the management of PT. Cimory and its network of logistics partners, the findings of this study provide a robust business justification for the allocation of strategic resources into the GSCM program.

1. Strategic and Focused Resource Allocation: Management is advised to identify and prioritize GSCM practices that have dual impact—that is, those that simultaneously improve direct operational efficiency and sustainability performance. Eco-design for the optimization of material and space use, as well as the adoption of Internet of Things (IoT) systems for real-time cold chain visibility, are examples of high-value interventions.
2. Value Communication and Ecosystem Collaboration: Empirical evidence regarding the synergistic relationship between GSCM and operational competitiveness should be communicated intensively and systematically to all entities in the value chain ecosystem. This is the foundation for building shared value and driving the adoption of integrated and harmonized green practices throughout the supply chain, beyond the boundaries of the core company.
3. Institutionalization of Integrated Performance Measurement Systems: It is necessary to develop an integrated performance measurement framework that holistically includes GSCM metrics, TBL indicators, and operational performance parameters. Such a system will not only facilitate impact monitoring, but also provide a solid foundation for more accurate and contextual Return on Investment (ROI) analysis for sustainability projects.

Convergence and Divergence with Previous Literature: The findings of this study show significant convergence with previous research bodies that support the positive relationship between GSCM-Performance, such as the study of Zhu et al. (2008) on the manufacturing sector in China and Gotschol et al. (2014) in the Italian context. The findings on partial mediation are also in line with the research of Lai et al. (2012) in the domain of logistics. However, the magnitude of the direct influence coefficient of GSCM on operational competitiveness (β=0.352) in this study appears to be higher than some findings in developed economies. This divergence can be explained through the lens of contextual contingency factors. In a business environment like Indonesia, where the level of inefficiency of energy and logistics systems in the cold chain is still relatively high, green interventions that focus on resource optimization have the potential to result in more dramatic and immediately observable productivity gains) compared to if applied in a system that is already very efficient. Therefore, this study not only confirms the universal theoretical proposition, but also confirms the importance of contextual sensitivity in studying and implementing sustainable supply chain management.

CONCLUSION

Based on the empirical analysis carried out, this study succeeded in confirming three key propositions. First, the implementation of Green Supply Chain Management (GSCM) practices in PT. Cimory is at a moderate level with interdimensional variation. Second, and more substantively, causal analysis proves that GSCM practices have a positive and significant effect on both improving sustainability performance ($\beta = 0.487$; $p < 0.001$) and strengthening operational competitiveness ($\beta = 0.352$; $p < 0.01$). Third, the most constitutive finding is the validation of the partial mediating role of sustainability performance (indirect effect $\beta = 0.202$; $p < 0.001$). This indicates that GSCM contributes to operational competitiveness through dual mechanisms: direct improvement of process efficiency and indirect accumulation of economic, environmental, and social performance-based advantages. The central conclusion of this study is the empirical affirmation of the synergy paradigm in the context of cold supply chain management. The findings definitively reject the trade-off dichotomy between environmental and operational performance. On the contrary, this study confirms that in complex and resource-intensive operational contexts such as cold chains, green transformation and increased competitive competitiveness (competing) are two sides of the same coin, which reinforce each other in creating sustainable advantages.

Research Limitations

This study has several methodological limitations. First, the scope of research limited to one core company and its network of partners limits the generalizability of findings to a broader industry context. Second, reliance on subjective perception data opens up the possibility of response bias, even though mitigation has been carried out through instrument design and respondent selection. Third, the cross-sectional research design does not allow for the taking of strong temporal causality inferences, so the dynamic relationships between variables in the time frame have not been revealed.

Advanced Research Agenda

Based on these findings and limitations, several future research agendas were proposed. First, it is necessary to replicate studies with a wider and more diverse sample in the fast-moving consumer goods (FMCG) sector to test the robustness of the model. Second, the integration of moderation variables, such as the intensity of digital technology adoption or regulatory pressures, can enrich the understanding of the contingency factors that affect the strength of relationships in the model. Third, longitudinal research is strongly recommended to capture the dynamics and long-term impacts of GSCM implementation. Fourth, a mixed-methods approach that combines perception data with objective performance metrics (e.g., emissions data, actual logistics costs) will improve the validity of the convergence and provide a more comprehensive picture.

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