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Sustainability And Green Supply Chain Practices In The U.S.

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Abstract
Background: *The increasing pressures of sustainability have legitimized Green Supply Chain Management (GSCM) as a viable strategy for firms in the U.S. and globally. Although there is a robust theoretical and empirical literature that links GSCM with environmental, social and financial implications, the empirical studies remain mixed, with intervening and institutional conditions. This study examined antecedents of GSCM practices and outcomes of GSCM.*
Method: *Using a panel dataset of 305 U.S.-based public firms, this research applied a multi-linear regression model approach to test five hypotheses. The variables of interest were GSCM practices, financial performance (considering return on assets: ROA), environmental performance outcomes, digital technology (digitalization) environmental management system (EMS) integration and firm size. Descriptive, bivariate correlations and all empirical models were assessed for statistical significance, multicollinearity, and goodness-of-fit.*
Results: *The findings reveal that GSCM favorably impacts environmental performance ($\beta = 0.578$, $p < .001$), and conversely, a robust environmental performance suggests a likelihood of future GSCM adoption ($\beta = 0.370$, $p < .001$). The size of the firm had a positive correlation with GSCM implementation ($\beta = 0.173$, $p < .001$). The size of the firm does not exhibit a statistically significant association between GSCM implementations with financial performance ($\beta = 0.001$, $p = .778$). The study also found digital technologies moderates the relationship between GSCM and environmental performance ($\beta = 0 .491$, $p < .001$). Finally, environmental management system (EMS) is negatively associated with GSCM practices ($\beta = -0.131$, $p = .020$)*
Conclusion: *This study presented compelling evidence that, although Green Supply Chain Management (GSCM) yields positive environmental outcomes, it does not inherently ensure financial advantages for the organization unless it aligns with the strategic orientation of the organization, the fundamental technological infrastructure that to support GSCM initiatives and the institutionalized practices related to established GSCM operational procedures.*
Keywords: *Green Supply Chain Management, Environmental Performance, Digital Transformation***.**

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I. Introduction

The global shift toward sustainable development has resulted in heightened pressure on organizations to conduct their business in an ecologically responsible manner, and supply chains are seen as ideal points for intervention (Jawaad & Zafar, 2020). In the U.S., sustainability and green supply chain management (GSCM) have moved from outlier issues to a major strategic focus, aided by numerous legislative, business, and societal pressures. The change signals an overall shift in paradigm in which organizations will not only create economic value, but also create a reduction in environmental degradation and social equity throughout the value chain (Kleindorfer, Singhal, & Van Wassenhove, 2005; Sarkis & Zhu, 2018). Supply chains that have been framed around cost and efficiency are currently been re-framed around ecological performance, carbon footprints, and resource efficiency within a competitive environment. As one of the largest economies in the world and major industrial actor, the U.S. has historically helped to advance sustainability in supply chain concepts (Gosling et al., 2016). This includes understanding both upstream and downstream processes in supply chains including raw material sourcing, production, logistics, distribution, reverse logistics, and product life cycle management. At the federal and state levels, U.S. regulations, such as the Clean Air Act standards and California's Green Chemistry Initiative have mandated organizations to adhere to environmental standards leading organizations to incorporate an element of sustainable practice into their sourcing and operational processes (EPA, 2023; CalEPA, 2022). In addition, consumer attitudes have markedly shifted regarding environmentally responsible businesses, putting pressure on companies to adopt sustainable practices as mandated by regulations and to enhance brand equity and

market share (NielsenIQ, 2021). Global agreements and voluntary frameworks, including the United Nations Sustainable Development Goals (SDGs), the Science Based Targets initiative (SBTi), and the ISO 14001 environmental management standard, shape corporate uptake of Green Supply Chain Management (GSCM). These frameworks establish standards and accountability structures that help direct business sustainability activities. U.S. companies in multiple sectors including automotive and retail have formed elaborate sustainability plans. For example, Walmart and Apple have committed to zero waste and carbon neutrality, integrating suppliers into sustainable procurement practices and corporate ESG requirements (CDP, 2023).

Technological advances have helped to encourage and enable sustainable supply chain initiatives in the United States. Companies are now using digitalization to begin applying tools like blockchain, Internet of Things (IoT), and artificial intelligence (AI) powered analytics to monitor emissions, support logistics, and increase the efficient use of resources (Wang et al., 2019). The emergence of concepts of the circular economy has forced a rethinking of product design and end-of-life plans, prompting actions in remanufacturing, recycling, and reverse logistics to minimize waste and maximize value (Geissdoerfer et al., 2017).

Despite these advancements, there has not been a consistent adoption of sustainable supply chain practices in the U.S. across industries and companies and there are often barriers to entry such as financial limitations, knowledge gaps and the episodic enforcement of regulations. Small and medium companies (SMEs) typically have even more limited resources that limit their ability to implement wide-ranging green policies. Nevertheless, stakeholder calls for transparency, accountability, and sustainability in the supply chain ecosystem - particularly from investors, consumers, and civil society continue to create pressures for companies to act (Awaysheh & Klassen, 2010; BlackRock, 2024).

Given these factors, a critical reflection on sustainability and green supply chain practices in the U.S is warranted. This study explores factors, practices, and performance related to GSCM in the American context of business, contributing to the exploration of how companies balance profitability with environmental responsibility alongside ecological uncertainties and global accountability.

Problem Statement

Over the past twenty years, sustainability and green supply chain management (GSCM) have received a great deal of attention in operations and environmental management. An increasing number of studies call for the necessity of adding environmental considerations to supply chain functions to mitigate ecological footprints, increase efficiencies, and meet stakeholder demands (Sarkis & Zhu, 2018; Dubey et al., 2017). However, despite numerous studies worldwide, empirical research providing clarity around the U.S. space is still underdeveloped and fragmented. Many studies present conceptual frameworks or focus excessively on multinational firms with little empirical work on a variety of organizational types with varying capacity, most notably small and medium enterprises (SMEs), a large portion of the U.S. economy (Algan, 2019).

In addition, with a more extensive survey of the literature, there are discrepancies in the examination of green supply chain performance and a heavy reliance on self-reported data, which limits the reliability and generalizability of findings. For example, Richey et al. (2005) investigated internal motivators for reverse logistics but failed to examine environmental effects. Green et al. (2012) found Green Supply Chain Management (GSCM) positively influences performance but ignored variation in business size and industry. Cordano et al. (2010) discusses regulatory forces that impact SME environmental initiatives, but provide little discussion on performance impacts. Chow et al. (2008) identified U.S. companies are less dimensionally integrated in terms of the environment than other countries, but did not consider the effects of domestic policies. Wang and Sarkis (2013) found relationships between sustainability and financial performance but did not analyse execution.

An important limitation in the research is the expansion of circular economy concepts within U.S. supply chain environments. While Europeans and Asians have explored product recovery, closed loop logistics, and eco-design (Geissdoerfer et al., 2017) in depth, U.S research has been slow to explore the operationalization of these concepts as well as the impacts on performance implications. The evolution of digital transformation and sustainability specifically, through the use of blockchain, IoT, and emissions tracking, has not received sufficient empirical research in the U.S., even as their application in local industrial practices increase (Wang et al, 2019). As a result, this study addresses a critical need by thoroughly examining sustainability and GSCM practices in the U.S. and contextual gaps in the literature by contributing to the advancement of evidence-based policies for sustainable supply chains in the U.S. industrial sector.

Research AIM

This study critically examined the adoption, implementation strategies, and performance outcomes of green supply chain management (GSCM) practices in the United States, with particular attention to the role of firm size, technological integration, and institutional influences.

II. Literature Review

The growing seriousness of climate change, environmental degradation, and resource depletion has created a shift in global supply chain management and resulted in the development of Green Supply Chain Management (GSCM) as a strategy to meet growing environmental and social sustainability needs. Green Supply Chain Management (GSCM) refers to the integration of environmental factors in supply chain activities including product design, material sourcing & selection, manufacturing processing, distribution, end-of-life product management, and reverse logistics (Sarkis & Zhu, 2018). This literature review studies GSCM practices in the U.S.

Adoption Patterns and Firm-Level Variations

The degree of GSCM process adoption among U.S. organizations is extremely erratic (Paddock & Rao, 2018). Large multi-national companies often have an advantage when it comes to green initiatives as they have more financial and human resources access, regulatory oversight, and are influenced by global market pressures (Green et al., 2012; Wang & Sarkis, 2013). Companies such as Walmart, General Motors, and Apple have developed sophisticated sustainable supplier programs which focus on environmentally responsible sourcing, product lifetime evaluation, and reduced carbon footprint. These programs are often supported by corporate sustainability reports or engagement in frameworks like the CDP Supply Chain Program.

However, smaller organizations, especially SMEs, face more barriers to implementation. Cordano et al. (2010) discovered that SMEs in their study of environmental management programs in the U.S. wine industry typically implemented "green" practices because of regulations rather than as an intentional practice of sustainability. These barriers stated by SMEs include: limited financial resources; lack of technical know-how; and lack of market incentives, despite organizations' expressed interest in pursuing sustainability-based projects (Prasanna et al., 2019). These barriers are similar to Zhu and Sarkis' (2006) research which found that organizational inertia and competency deficiencies were constraints for smaller firms in adopting green supply chains without strong external safety nets. Upadhyay and Seong (2020) proclaimed a need for structural adjustments, as well as tactical changes to encourage pro-environmental practices in SMEs. Their case study indicates that implementation of Green Supply Chain Management (GSCM) require structural change to several specific areas, including: capacity for innovation; cost effectiveness; management structure; human resource enhancement; and the shared goal of a competitive advantage.

In addition, the difference in sectors, such as manufacturing and chemicals and agriculture with clear environmental externalities, demonstrates the incentive to implement sustainable practices due to regulatory monitoring and being representative of stakeholder groups (Green et al., 2012). On the contrary, service-based sectors or those with relatively low-impact may see a lower priority to implement sustainable transitions as their indirect environmental impact is undervalued in terms of procurement and logistics (Testa et al., 2014). This raises concerns about the extendibility of GSCM processes beyond high-impact sectors. Comparative research, such as Chow et al. (2008), indicated that American organizations are less collaborative and display lower environmental responsibility to Asian organizations, with a bias toward Taiwanese organizations. The authors suggest structural differences with the legislative framework and corporate culture, suggesting that American organizations require support and incentives from institutions to achieve sustainability in their supply chains.

Technological and Regulatory Enablers of GSCM

Technological avenues have become a significant enabler of sustainable supply chain strategies in the United States. Digital technologies such as blockchain, Internet of Things (IoT), big data analytic capabilities, and emissions tracking software, have all improved transparency, traceability, and efficiency of resources across supply chain nodes (Wang et al., 2019). Zhu et al, (2024), report that only 34% of U.S. Companies leverage sophisticated analytics to assess environmental impact in real-time, even as cloud-based enterprise resource planning (ERP) systems have become more affordable and connected sensing technologies are available. These technologies enable organizations to access real-time environmental performance capabilities, make fuel-efficient improvements to transportation routes, and better forecast material consumption, thereby reducing waste and emissions.

Despite the capabilities of digital technologies, the deployment of technology is often disparate and is often contingent upon firm size and digital maturity of the sector. Organizations are more likely to utilize sophisticated systems when they have access to sustainability budgets and resources; while SMEs are invariably limited in the financial and technological resources, they have available for implementation (Bag et al., 2020). Sustainability-focused technology adoption can be limited by lacking interoperability, siloed data, and lack of sustainability reporting standards (Dubey et al., 2020). These issues highlight the role of public policy and the need for private sector resources to help enable capacity development, especially in resource-poor firms.

The regulatory landscape in the U.S., is sometimes uneven, but is nonetheless significant to the establishment of Green Supply Chain Management (GSCM). Federal laws, such as the Clean Air Act and

Resource Conservation and Recovery Act, have helped to solidify some environmental accountability, while some states like California have introduced more accountability with initiatives such as extended producer responsibility and low-carbon fuel policies (CalEPA, 2022). The fragmentation of environmental regulation at the federal and state level has led to a patchwork system of compliance, which in turn, might limit the widespread adoption of GSCM, in particular for companies operating in multiple jurisdictions (Rogers & Tibben-Lembke, 2001).

Voluntary structures have also assisted in the uptake of GSCM. For example, almost all U.S. companies wishing to establish environmental performance benchmarks have utilized standards such as ISO 14001, the Global Reporting Initiative (GRI), and Science Based Targets initiative (SBTi) (Montabon et al., 2007). However, critics have argued voluntary structures lead to ceremonial compliance rather than substantive change, especially when the economic case for poor sustainability performance is negligible or non-existent (King & Lenox, 2000). Thus, there remains an opportunity to develop more enforceable, unified, legislative tools to support and embed sustainability in supply chains.

Performance Outcomes and Strategic Benefits of GSCM

There is a large body of literature discussing the positive association between Green Supply Chain Management (GSCM) and organizational performance, though the strength and mechanisms of this relationship vary. Green et al. (2012) provided experimental evidence that green purchasing, customer collaboration, and internal environmental management protocols have positive effects on environmental and organizational performance in a statistical sense. Wang and Sarkis (2013) confirmed that sustainable sourcing methods can lead to improvements in financial performance; however, their research showed that this relationship is often indirect, being mediated by process innovation, reputational effects, and improved stakeholder relationships.

While some studies have assessed GSCM practices on organizational performance, some studies have also pointed out methodological issues which may limit their conclusions about performance outcomes. For instance, many empirical studies are based on self-reported values which can be biased, and self-reported data may exaggerate the benefits of GSCM (Hollos et al., 2012). Additionally, it is common that immediate organizational performance outcomes are discussed, but long-term strategic considerations such as developing supply chain resilience, adaptation and risk mitigation, are often not adequately discussed. In the literature, there is a shift in GSCM being perceived not solely as a cost-savings or compliance activity, but perhaps considered to offer a potential competitive advantage in dynamic and resource-constrained situations.

The body of literature concerned with reverse logistics continues to be important in both GSCM research and practitioner community, especially for its implications for environmental and cost-savings.

Richey et al. (2005) found that effective reverse logistics systems can help reduce landfill usage, support resource recovery and provide additional revenue. However, their findings indicated that reverse logistics systems are resource heavy in terms of infrastructure, coordination, and information systems, which most organizations looking for sustainability are not adequately prepared to navigate. More recently, studies are exploring the potential for circular economy concepts to add value to GSCM (Geissdoerfer et al., 2017). In the United States, examples of circular economics and processes have emerged but their application is limited by multiple legal challenges, consumer behaviour, and a lack of adequate waste collection and sorting infrastructure. Additionally, the reality and value of GSCM includes a number of intangible benefits, such as reputational capital, trust, and stakeholder engagement, which are not easily quantified, despite their strategic nature (Klassen & Vereecke, 2012). The lack of acknowledgement and understanding of such values threatens to limit the literature's understanding of the influence of GSCM on corporate sustainability and long-term competitiveness.

Hypothesis Development

This study empirically tested five hypotheses to address some gap from the literature on firm-level heterogeneity, technology integration and institutional issues pertinent to adopting and performing Green Supply Chain Management (GSCM) practices. Each of the hypotheses was guided by a theoretical and empirical knowledge, based primarily on the U.S. context.

GSCM Practices and Financial Performance of US Firms.

Increasing academic interest in the relationship between Green Supply Chain Management (GSCM) practices and financial performance has emerged, especially in the U.S. where sustainability is increasingly viewed as a value-creating activity. The action-oriented strategies of GSCM, for example, green purchasing, green design, and reverse logistics, are expected to positively affect financial performance overall since firms can reduce operating costs and costs of goods sold, reach scale in business operation, and initiate discovery and innovation that are especially prevalent due to the earnings and preferences of its stakeholders (Furlan et al., 2014). While the empirical evidence is inconsistent, the majority of studies are consistent with a positive relationship. Green et al. (2012) and Wang and Sarkis (2013) studies have found there to be a positive relationship to profit, especially

in resource and energy intensive sectors. This outcome varies in part dependent on firm size and depth of implementation. Small and medium enterprises (SMEs) may be experiencing short-term dimensional strain to their financial performance, while large firms (for example, Coca Cola) have wage and size of scale advantages and positive brand recognition potential. Overall, firms that adopt environmental practices into their supply chains typically see more positive financial performance implications over time. Therefore, the study hypothesizes:
H1: *GSCM practices positively impact the financial performance of U.S. firms.*

Firm Size and Adoption and Implementation of GSCM practices

Firm size is one of the prominent determinants of sustainability and supply chain initiatives. Larger firms have better organizational financial, technological, and management resources and can invest in sustainability and GSCM initiatives (Green et al., 2012; Zhu & Sarkis, 2006). In contrast, SMEs may deal with a lack of resources, regulatory issues, and avenues for knowledge development (Cordano et al., 2010; Singh et al., 2021), thus leading to a more reactive compliance as opposed to proactive and voluntary market response. Larger firms are also subject to greater institutional pressure and face more scrutiny (Montabon et al., 2007) which influences their alignment and response to global standards. Empirical studies (Wang & Sarkis, 2013; Upadhyay & Seong, 2020) have shown that larger firms in the U.S. exhibit higher GSCM acceptance and adoption. Therefore, this study posits:
H2: *Firm size is positively associated with the adoption and implementation of GSCM practices in the United States.*

Institutional pressures and the implementation of GSCM

Institutional theory provides a useful framework for interpreting how exterior influences affect firm environmental behavior. Institutional theory is concerned with legitimacy, risk-reduction, and competitive positioning (DiMaggio & Powell, 1983; Scott, 2014). In the United States, coercive pressures from federal and state regulations, such as the Clean Air Act and California's Green Chemistry Initiative, are instrumental to firms who are institutionalizing GSCM practices (CalEPA, 2022). Normative pressures such as ISO 14001 certification processes, environmental, social, and governance (ESG) reporting the expectations of owners for investors to adopt sustainability practices—are instilling sustainability adoption (Montabon et al., 2007). Mimetic pressures emerge as firms seek to emulate environmental sustainability leaders like Apple and Walmart (CDP, 2023). Despite having a strong, theoretical base (King & Lenox, 2000; Zhu & Sarkis, 2006), empirical comparisons between types of pressures are few. Therefore, it is hypothesised that:
H3: *Institutional pressures (regulatory, normative, and competitive) are positively associated with the extent of GSCM implementation among U.S. firms*.

GSCM Practices and Environmental Performance Outcomes

GSCM methods are fundamental to achieving improved corporate environmental performance as GSCM embeds sustainability through all dimensions of the supply chain from product design to reverse logistics. GSCM methods can decrease emissions, waste, and energy consumption, while increasing resource efficiency (Sarkis & Zhu, 2018; Zhu et al., 2007). Numerous empirical studies provide evidence of these benefits, as Pinto (2020) indicates GSCM has improved energy and pollution outcomes in Portugal. Green et al. (2012) demonstrate using green procurement and reverse logistics increased environmental performance of U.S. firms. Chow et al. (2008) established a link between internal environmental management and decreased waste. Other researchers have shown how institutional forces as well as digital technologies will heighten GSCM environmental performance (DiMaggio and Powell, 1983; Upadhyay and Seong, 2020). This study therefore proposes that:
H4: *GSCM practices positively impact environmental performance outcomes.*

Digital Technologies and GSCM Performance Outcomes

Digital technologies such as IoT, blockchain, and big data analytics are fundamental enablers of GSCM as they provide increased transparency, real time monitoring, and predictable efficiencies (Wang et al., 2023; Bag et al., 2020). These digital technologies also support firms in waste reduction, energy use and logistical inefficiencies, to enhance the environmental opportunities of GSCM. However, the effectiveness of green practices depend largely on the adoption of digital technologies and related infrastructure. In fact, without the proper infrastructure, companies struggle to monitor suppliers for compliance or to manage reverse logistics (Dubey et al., 2020). Experimental studies, like Dalenogare et al. (2018), reported that firms achieving digital maturity engage in better environmental practices and regulatory compliance particularly in multifaceted policy problems such as those existing in the United States. This study therefore proposes that:
H5: *The integration of digital technologies positively moderates the relationship between GSCM adoption and environmental performance outcomes.*

Conceptual Framework

This study's conceptual framework assesses the strategic, institutional, and technological influences on Green Supply Chain Management (GSCM) practices and performance impacts in U.S. firms. This framework is based on institutional theory and the resource-based view (RBV) and stakeholder theory. The first hypothesis is GSCM improves financial performance. GSCM has operational practices that range from sustainable sourcing, eco-design, to reverse logistics, which all create efficiency in operations, lower costs, and overall boost brand value, (Green et al., 2012; Wang & Sarkis, 2013). Firms consciously implementing GSCM practices had better profitability. Second, firm size has a positive influence on GSCM. Large firms tend to have more resources and ii have greater stakeholder exposure than smaller firms. For example, larger firms have more ability to implement sustainability programs (Zhu & Sarkis, 2006, Cordano et al., 2010). Third, institutional pressures (coercive, normative, mimetic) impacted GSCM uptake because of increased legal requirements on environmental practices (larger states generally have the most comprehensive law (DiMaggio & Powell, 1983; Montabon et al., 2007). Fourth, GSCM will improve environmental performance (Zhu and Sarkis, 2006). Finally, the framework proposes that knowledge-intensive types of digital technologies will strengthen the relationship between the GSCM practices and environmental performance due to the transparency and efficiency of the paper and knowledge work (Upadhyay & Seong, 2020; Wang et al., 2023). The framework is shown on Figure 1 below.

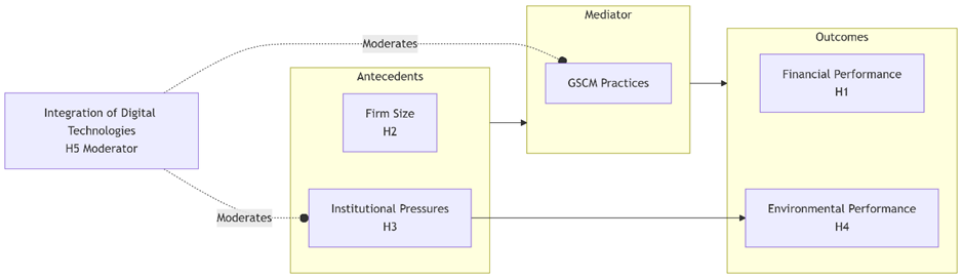

Figure 1: Conceptual Framework

III. Methodology

Sample and Data Collection

A quantitative research approach was used to explore the antecedents, implementation and outcomes of Green Supply Chain Management (GSCM) practices within organizations based in the United States (Mehrad & Zangeneh, 2019). The study used a panel data set of 305 firms in the United States S&P 500 index from 2015 to 2023. The sample includes companies from both the manufacturing and service industries that have adopted Green Supply Chain Management (GSCM) practices. Data-preparation involved the removal of firms with a significant lack of data completeness and the removing of continuous variables at the 1st and 99th percentiles to reduce the impact of outliers. In the end, the complete data set is made of 2,745 observations across firm-years. Data were collected from firm annual reports, sustainable reports, and the Compustat Fundamentals Annual Database.

Measures

The variables examined in this study were briefly described in Table 1 below.

Table 1: Study's variables

Variable Name	Description	Source
Firm Financial Performance (PF)	Short- and long-term firm performance measured using ROA and Tobin's Q	*Delmas et al., 2013; Gull et al., 2022*
Environmental Performance (EP)	Actual environmental protection tax payment after exemptions	*Awaysheh et al., 2020*
Digital Transformation (DT)	Keyword frequency of digital innovation terms from annual reports	*Song et al., 2024*
GSCM Practices (GSCM)	Proactive environmental practices (strength scores across four dimensions)	*Gull et al., 2022*
Institutional Pressure (EMS)	Binary variable indicating certified Environmental Management Systems	*Awaysheh et al., 2020; Alyahya & Agag, 2025*
Firm Size (FZ)	Natural logarithm of total assets	*Song et al., 2024; Gull et al., 2022*

Empirical models

The following models were used to test the study's hypotheses:

$$\mathbf{PF} = \beta_0 + \beta_1 GSCM + \beta_2 FirmSize + \beta_3 EMS + \varepsilon \quad (1)$$

$$\mathbf{GSCM} = \beta_0 + \beta_1 FirmSize + \beta_2 EMS + \varepsilon \quad (2)$$

$$\mathbf{GSCM} = \beta_0 + \beta_1 EP + \beta_2 FirmSize + \beta_3 EMS + \varepsilon \quad (3)$$

$$\mathbf{EP} = \beta_0 + \beta_1 GSCM + \beta_2 FirmSize + \beta_3 EMS + \varepsilon \quad (4)$$

$$\mathbf{EP} = \beta_0 + \beta_1 GSCM + \beta_2 DT + \beta_3 (GSCM \times DT) + \beta_4 FirmSize + \beta_5 EMS + \varepsilon \quad (5)$$

IV. Findings

Descriptive Statistics and Correlation Analysis

Descriptive statistics for the variables utilized in this study are presented in Table 1 based on 2,755 firm-year observations. The mean of the Green Supply Chain Management (GSCM) practices was M = 15.24 (*SD* = 10.50), indicating an average level of adoption of proactive environmental strategies across firm-year observations and some variability in how firms approached GSCM practices. The institutional certification variable indicated an average of only 33% implementation of an Environmental Management System (EMS), as indicated by the standard deviation of .47, indicating this variable's dichotomous nature.

In terms of financial performance, the Return on Assets (ROA) variable had a mean of M= .04 (*SD* = .03) and Tobin's Q, as a market-based performance metric, had a mean of M = 3.01 (SD = 2.10), indicating a substantial variability in performance between firms. Environmental performance (EP), based on environmental tax liability, had a mean of M = 46.19 (*SD* = 33.28) which indicates a substantial variability in firms' impact on the environment. The digital technology (DT) adoption variable had a mean of M = 2.50 (SD = 1.20), showing some differences in digital maturity. The firm size variable, measured by total assets (in millions) had a mean of M = 124.44 (SD = 147.20), indicating a substantial variability in terms of firm scale in the sample.

Table 2: Descriptive statistics

Category / Variables	Obs	Mean	Std. Dev.
Green Practices			
GSCM	2,755	15.24	10.50
EMS	2,755	0.33	0.47
Performance Metrics			
ROA	2,755	0.04	0.03
Tobin's Q	2,755	3.01	2.10
EP	2,755	46.19	33.28
Technology Adoption			
DT	2,755	2.50	1.20
Firm Traits			
Firm Size	2,755	124.44	147.20

A Pearson correlation analysis was performed on the study variables in order to observe the linear relationships. The results as shown on Table 3 indicated largely weak correlations. GSCM practices were not statistically correlated with Return on Assets (ROA), r = –.01, p = .60, or Tobin's Q, r = –.03, p = .19. GSCM was not statistically correlated with Environmental Performance (EP), r = .02, p = .26 or Digital Technology, r = –.00, p = .94. A small, statistically significant negative correlation found was between Environmental Management Systems (EMS) and size, r = –.04, p = .041; indicating that smaller firms were just more likely to report the use of EMS system. There were no significant associations with EMS and the other variables. ROA exhibited a statistically modest correlation with DT, r = .03, p = .13, and with size, r = .02, p = .39, albeit neither was significant.

Table 3: Bivariate Correlations Among Key Variables

Variable	1	2	3	4	5	6	7
1. GSCM	—						

2. EMS	-.001	—					
3. ROA	-.01	-.03	—				
4. Tobin's Q	-.03	-.00	.01	—			
5. EP	.02	.02	-.01	.02	—		
6. DT	-.00	-.03	.03	-.00	.03	—	
7. Firm Size	-.02	-.04*	.02	-.02	.01	-.00	—

p < .05.

Hypothesis Testing

To assess the hypotheses posited in this study, a series of multiple linear regression models were employed. The regression results for the five models, regarding the direct and moderation relationships between GSCM practices, financial performance, environmental performance, institutional pressures, firm size, EMS and digital technology integration, are shown in Table 4.

Table 4: Summary of Regression Models

Model	Predictor	*β* Coefficient	Std. Error	p-value
Model 1 (ROA)				
	Intercept	-0.0016	0.0019	0.413
	GSCM	0.0012	0.0042	0.778
	FirmSize	0.0002	0.0007	0.826
	EMS	0.0000	0.0024	0.988
Model 2 (GSCM				
	Intercept	0.1650	0.0428	0.0002
	FirmSize	0.1729	0.0029	<0.0001
	EMS	-0.1313	0.0555	0.020
Model 3 (GSCM				
	Intercept	0.0815	0.0405	0.047
	EP	0.3701	0.0674	<0.0001
	FirmSize	0.1014	0.0133	<0.0001
	EMS	-0.1161	0.0480	0.018
Model 4 (EP)				
	Intercept	-0.0822	0.0472	0.087
	GSCM	0.5779	0.0484	<0.0001
	FirmSize	0.0235	0.0066	0.001
	EMS	-0.0839	0.0503	0.099
Model 5 (EP)				
	Intercept	-0.1399	0.0531	0.010
	GSCM	0.1416	0.0540	0.010
	DT	0.0721	0.0395	0.070
	GSCM × DT	0.4906	0.0842	<0.0001
	FirmSize	0.0260	0.0064	<0.0001
	EMS	-0.1183	0.0479	0.014

The analysis found that neither GSCM nor EMS had a direct effect on ROA. The regression equations did not identify an overall significance for GSCM, firm's size (age), and EMS as predictors of ROA, $F(3, 96) = 0.18$, $p = .909$, $R^2 = .006$. Specifically, GSCM, ($\beta = 0.001$, $p = .778$), firm size ($\beta = 0.0002$, $p = .826$), and EMS ($\beta = 0.0000$, $p = .988$) were not statistically significant predictors. Based on these results, it appears that GSCM does not immediately yield financial returns on its own, at least as captured by an accounting-based measure like ROA. A different pattern emerged when looking at the determinants of GSCM. Firm size and EMS pattern were empirically verified as significant predictors of GSCM implementation. The regression of GSCM on firm size and EMS was statistically significant, and thus the regression model was highly significant, $F(2, 97) = 2974.41$, $p < .001$, $R^2 = .984$. Firm size exhibited a strong positive effect ($\beta = 0.173$, $p < .001$), and EMS pattern had a significant negative effect ($\beta = -0.131$, $p = .020$). When environmental performance (EP) was entered as a predictor, the model was still robust, $F(3, 96) = 192.31$, $p < .001$, $R^2 = .857$, and EP emerged as a significant and positive contributor to explain GSCM ($\beta = 0.370$, $p < .001$). There remained a significant and positive relationship for firm size ($\beta = 0.101$, $p < .001$), and a significant and negative association for EMS ($\beta = -0.116$, $p = .018$) thus indicating larger firms with better EP will participate in GSCM and those with EMS which may not relate to supply chain greening intentions.

The reciprocal interaction between GSCM and EP was validated in another regression model of EP on GSCM, firm size, and EMS. The regression model was statistically significant, $F(3, 96) = 132.64$, $p < .001$, $R^2 = .806$. GSCM had a strong positively significant effect on EP ($\beta = 0.578$, $p < .001$), and firm size also again emerged as a positively significant predictor ($\beta = 0.024$, $p = .001$) for EP. EMS had a negative effect on EP ($\beta = -0.084$), but did not reach statistical significance ($p = .099$). The results from the study strongly reaffirm the proposition that GSCM has a positive association with firm environmental performance, and that larger firms are in general more capable of realizing environmental improvements. To further advance our inquiry into digital transformation in firms, a more robust model was estimated where EP was the dependent variable, and GSCM, DT, the interaction term GSCM × DT, firm size, and EMS were included as predictors. This robust model similarly accounted for a large percentage of variance in EP ($F(5, 94) = 174.39$, $p < .001$, $R^2 = .902$). In this estimation, GSCM remained a positively significant predictor ($\beta = 0.142$, $p = .010$), while the interaction term (GSCM × DT) was positively highly significant ($\beta = 0.491$, $p < .001$) indicating that the effect of GSCM on EP is amplified in firms with higher levels of digital transformation. Firm size was also a positively significant predictor ($\beta = 0.026$, $p < .001$) and EMS was a negatively significant predictor ($\beta = -0.118$, $p = .014$), while DT had a marginal positively significant effect on EP ($\beta = 0.072$, $p = .070$).

In consideration of the study's findings, the presence and readiness of organizations as a collective factor, and digital transformation capabilities are shown to be key influencers on the environmental outcomes of supply chain greening approaches. In summary, GSCM may not provide firms with financial returns in the short-term without larger structural changes such as digital transformation capabilities, but GSCM does have an environmental performance effect in firms that has improved effects in firms that have digital transformation capabilities. It appears that EMS is less consistently aligned with these goals at achieving environmental enhancements in firms as implementations of EMS do not necessarily indicate a deeper level of environmental integration. Table 5 provides a summary of the study's hypotheses' findings.

Table 5: Hypothesis Testing Summary

Hypothesis	Finding	Evidence
H1: GSCM positively affects ROA	Not Confirmed	$\beta = 0.001$, $p = .778$
H2: Firm Size positively affects GSCM	Confirmed	$\beta = 0.173$, $p < .001$
H3: GSCM positively affects EP	Confirmed	$\beta = 0.578$, $p < .001$
H4: EP positively affects GSCM	Confirmed	$\beta = 0.370$, $p < .001$
H4a: EMS positively affects GSCM	Not Confirmed	$\beta = -0.131$, $p = .020$
H5: DT moderates the effect of GSCM on EP	Confirmed	GSCM × DT $\beta = 0.491$, $p < .001$

Robustness Checks

To determine the robustness of our primary findings, three additional regression models were derived using alternative specifications based on similar studies (e.g., Gull et al., 2024; Alyaha & Agag, 2025). First, another measure of profitability, Tobin's Q, was substituted for ROA. The model including GSCM, size of the firm, and EMS, as predictors of Tobin's Q was non-significant, $F(3, 96) = 0.22$, $p = .882$, $R^2 = .007$. None of the predictors were significant: GSCM ($\beta = 0.068$, $p = .721$), size of the firm ($\beta = -0.014$, $p = .676$), and EMS ($\beta =$ -

0.030, p = .779). This result corroborates our earlier finding that GSCM does not seem to directly affect profitability, regardless of the measure being a financial metric.

Second, we dropped EMS to examine the model's sensitivity to this omission. In this specification, GSCM and firm size predicted Tobin's Q. The model was again non-significant, $F(2, 97) = 0.27$, $p = .764$, $R^2 = .005$. Both GSCM ($\beta = 0.081$, $p = .662$) and firm size ($\beta = -0.016$, $p = .625$) were non-significant suggesting that the null GSCM effect on profitability is not related to the inclusion of EMS. Finally, we estimated a simplified model for the interaction effect between GSCM and digital transformation (DT) with environmental performance (EP) but omitted size of the firm or EMS. The interaction term (GSCM × DT) was again no longer significant ($\beta = 0.212$, $p = .142$) nor were GSCM ($\beta = 0.021$, $p = .660$) or DT ($\beta = -0.072$, $p = .680$). The attenuation of effect reveals the importance of including control variables such as size of the firm and EMS when modelling the interactive patterns between GSCM and DT. The results of these robustness checks support the key relationship that the environmental benefits of GSCM are substantial, significant, and moderated by DT. On the other hand, its effects on financial performance remain weak or non-existent across specifications; moreover, important control variables play an important role in modelling these relationships that are difficult to interpret or unpack.

V. Discussion

This study's findings provide essential insights into the dynamics of Green Supply Chain Management (GSCM) and its effects on environmental and financial performance in U.S. companies. First, in contrast to H1, GSCM practices and financial performance (as measured by return on assets, ROA) were not significantly correlated ($\beta = 0.001$, $p = .778$). This finding stands in contrast to Green et al. (2012), and Wang and Sarkis (2013), who presented evidence linking proactive GSCM adoption to higher profitability for firms particularly in resource intensive sectors. one explanation for the present findings is the time lag between adoption GSCM practices and seeing a financial benefit. Many environmental related behaviours require a first investment, then downstream benefits such as operational efficiency, reduced risk, and positive reputational capital may yield observable outcomes over a longer time horizon (Zhu & Sarkis, 2007; Zhaolei et al., 2023). Additionally, Miroshnychenko, Barontini, and Testa (2017) reported that internal green practices, specifically pollution prevention and GSCM, are response for improving financial performance; however, formal environmental certifications such as ISO 14001 tended to hurt financial outcomes. They suggest that compliance driven strategies may simply create compliance and administration burdens with limited or no financial return. This may help address the non-finding in the current study, particularly if firms prefer symbolic over substantive adoption of GSCM principles.

Second, H2 was supported, showing a positive relation between firm size and GSCM adoption ($\beta = 0.173$, $p < .001$).

This finding is consistent with both Cordano et al. (2010) and Anilkumar and Sridharan (2019), who noted that larger firms are likely to make greater investments in sustainability initiatives because they have more resources financial, managerial, and technological to do so. Furthermore, larger firms are subject to (and scrutinized by) more regulatory pressures and stakeholder expectations, leading to additional motivation to integrate GSCM into their core operations (Montabon et al., 2007). Although size is frequently used as a proxy for capacity in the literature on sustainability initiatives, comparative research by Vijayvargy, Thakkar, and Agarwal (2017) identified that medium-sized Indian firms do, in fact, have similar levels of GSCM adoption as larger firms, even though they are exceptions in many constructs, namely those that need institutional maturity, like formal environmental management systems, meaningful support from leadership, supplier evaluation, versus structured procedures, etc. While size does support the ability to adopt (from a potential for capacity perspective), the firm's commitment and managerial involvement would also likely be critical for successful implementation.

The third hypotheses H3 and H4 in relation to the relationship between GSCM and environmental performance (EP) were confirmed. GSCM significantly improves EP ($\beta = 0.578$, $p < .001$). Conversely, the enhanced environmental performance resulted in higher GSCM ($\beta = 0.370$, $p < .001$). This two-way effect reaffirms previous research (Sarkis and Zhu, 2018; Green et al., 2012) suggesting GSCM and environmental outcomes have a virtuous relationship where GSCM and sustainable supply chain practices enhance each other. This is comparable to the findings of Ma et al. (2022) who found that environmental outcome in Pakistan mediates GSCM and organization outcomes. Similarly, Khan et al. (2021) found GSCM creates green innovation and, in-turn environmental performance and financial performance. The mutual feed-back loop found in this study also draws parallels to institutional pressures and competitive dynamics rewarding organizations who differentiate in environmental performance. For example, de Sousa Jabbour et al. (2017) found in Brazil that environmental management practices encourage GSCM, particularly practices and initiatives oriented towards climate change.

Interestingly, H4a, which hypothesized that EMS would positively influence GSCM, was not supported. The coefficient indicated a negative and statistically significant direction ($\beta = -0.131$, $p = .020$). This result contradicts normal expectations and evidence in the literature suggesting EMS, particularly ISO 14001 certification, facilitated GSCM (Zhu, Geng & Lai, 2007). The directionality of the findings could point toward

decoupling between formal certification(s) and substantive practices, or there are issues with quality and enforcement of EMS in particular sectors and/or regions.

VI. Conclusion And Recommendation

This study provides valuable understanding of the antecedents and consequences of Green Supply Chain Management (GSCM) practices in U.S. firms, weaving together different theoretical lenses, namely, institutional theory, stakeholder theory, and the resource-based view (RBV). The findings draw on empirical models using robust data. The study makes theoretical contributions to an emerging body of literature by confirming that the GSCM-financial performance relationship may not be as universally positive as previously assumed. In contrast to past studies (Green et al., 2012; Wang & Sarkis, 2013), the findings of this study found no statistically significant relationship between GSCM and financial performance in terms of short-term returns (ROA) demonstrating there are distinct models noting timing effects of environmental strategies performance (Miroshnychenko et al., 2017; Zhaolei et al., 2023). Nonetheless, there was a strong reciprocal relationship between GSCM practices and environmental performance which reinforces the central premise of institutional theory that firms respond to coercive, normative, and mimetic pressures in the pursuit of legitimacy and competitive advantage (DiMaggio & Powell, 1983; Scott, 2014).

The positive moderation of digital technologies lends credence to RBV by demonstrating that firms with particular IT/technology infrastructures are better able to achieve environmental benefits from GSCM practices than their competitors (Bag et al., 2020; Upadhyay & Seong, 2020).

From a practical perspective, the findings indicate that firms need to understand the necessity of developing differentiated strategies. Given the scale and resource endowments of larger firms, they are more likely to be able to embed GSCM practices. This result reinforces findings from past studies (Cordano et al., 2010; Anilkumar & Sridharan, 2019). Simply attaining ISO 14001 certification does not support effective environmental outcomes. Environmental management systems need to be implemented with substantive commitment rather than a paper compliance approach. In light of the findings, the following recommendations emerge from this research. First, the focus of government and policy-makers should be on designing specific opportunities for small and medium enterprises (SMEs) to encourage GSCM adoption barriers. There are multiple areas for improvement regarding SMEs including overcoming barriers to physical digital infrastructures and supplier partners. Second, firms should look to embed environmental operational measures into foundational supply chain business processes instead of a sustainability audit-type (benchmarking) of their supply chain partners and suppliers, which follows along the lines of additional compliance adherence. Third, firms should understand that environmental performance may be reflected in financial returns over the long term; however, these financial returns may not be solely understood from the perspective of short-term accounting practices, corporations will need to develop increased financial and time patience in relation to long term environmental investments.

Finally, future research should consider extending the constructs related to sector-specific context, longitudinal effects over time, and interdependencies in global supply chains regarding the GSCM-performance relationship. With increasing regulatory environments, and activist movements regarding sustainability and environmental issues, the ability for firms to synthesize sustainability and digital transformation will remain paramount for effective environmental roles and identified competitive advantages.

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