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TOWARD GREENER SUPPLY CHAINS: ANALYSIS OF THE DETERMINING FACTORS

Abstract

The green supply chain (GSC) has become essential for companies seeking to improve their environmental performance and meet the requirements of sustainable development. This concept is particularly relevant in an era of globalization and growing environmental awareness. The study used a Probit regression method to analyze data collected from Moroccan SMEs. It aimed to examine the impact of different factors, such as economic and energy efficiency, government incentives, stakeholder pressure, managerial age, company size, and profitability, on the adoption of GSC practices. The results showed that economic and energy efficiency, as well as stakeholder pressure, are significant factors positively influencing the adoption of GSCs. When combined with stakeholder pressure, government incentives also have a positive impact. The age of the executive has a negative influence on the adoption of GSC, indicating that younger executives are more likely to adopt these practices. Company size showed no significant impact, while profitability had a positive impact with the adoption of a GSC.

Keywords green supply chain, environmental performance, sustainable development, sustainable practices

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INTRODUCTION

A green supply chain (GSC) is a multi-dimensional concept that has emerged in response to growing concerns about environmental performance as part of the proliferation and drive to promote sustainable development worldwide. Initially formulated in the 1990s and gaining popularity in the 2000s, GSC experienced significant growth after 2010. According to Khan et al. (2022), GSC has become necessary for many organizations to improve relationships between suppliers of green products and customers. This approach aims to reduce activities that harm the environment and society. Hervani et al. (2005) describe GSC as including green procurement, green manufacturing, green distribution, and reverse logistics, highlighting the importance of considering all stages of a product, from raw materials to logistics and end-users. Sarkis (2003), Chiou et al. (2011), Darnall et al. (2008), Green et al. (2012), Vachon and Klassen (2006), and Wu et al. (2011) have all contributed to developing the conceptual framework of GSC, examining its impact on environmental performance and competitive advantage, as well as its role in overall sustainability. Saha et al. (2020) define GSC as the application of sustainable development principles in business processes concerning environmental impacts. It encompasses eco-responsible design, production processes, and recycling. GSC is seen as a promising supply chain model that considers environmental influences in supply chain management, seeking to achieve full environmental progress through the adoption of product life cycle methods.

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Despite the enormous potential of GSC, many companies, particularly small and medium-sized enterprises, are finding it difficult to achieve their environmental management objectives. However, industries are beginning to link their suppliers' environmental performance to GSC, seeing it as a new approach to achieving a more nature-friendly environment. Following the supply chain revolution of the 1990s, many companies have changed their framework for environmental performance by incorporating sustainability objectives into their vision and recognizing the need to integrate environmental management practices across all organization departments (Yang et al., 2021; Maditati et al., 2018). This approach aims to reduce the impact of production processes and products on the environment, thus integrating environmental factors into supply chain management. As a result, a GSC is economically viable and environmentally responsible (Rabbi et al., 2020; Srivastava, 2007). This implies an awareness of and commitment to practices beyond mere environmental compliance, moving toward an active contribution to a sustainable future.

1. LITERATURE REVIEW AND HYPOTHESES

The integration of sustainable practices, particularly within GSCs, has become imperative in business management. This need is driven by increasing globalization and competition, prompting companies to seek competitive advantage while reducing costs and addressing environmental concerns. The concept of a sustainable or green supply chain has evolved to include additional ideas and mechanisms related to sustainability, thanks to Govindan et al. (2015), Ansari and Kant (2017), and Barbosa-Póvoa et al. (2017). This development highlights the importance of integrating socio-environmental sustainability objectives into systematically organizing essential business functions along a supply chain. The corporate focus on sustainability is driven by environmental legislation, societal standards, and growing stakeholder awareness. Terms such as 'GSC', 'low carbon supply chain', and 'social supply chain' have emerged in the literature, underlining the importance of aligning green thinking with production and distribution.

GSC management practices encompass manufacturing, purchasing, marketing, logistics and information systems focused on quality, customer response, and environmental sustainability. These practices aim to reduce air emissions, solid waste, and effluents, thereby contributing to the achievement of corporate sustainability objectives. The increasing adoption of these practices to improve companies' sustainable performance has been the subject of much-abandoned research. Tseng and Hung (2014) highlight the impact of globalization on supply chain management, emphasizing the need for extensive cooperation and a shift in perspective toward operational and sustainable goals. Systematic literature reviews by Govindan et al. (2015), Ansari and Kant (2017), Barbosa-Póvoa et al. (2017), Bastas and Liyanage (2018), and Koberg and Longoni (2019) have identified progressive evolutions of the concept of GSC, highlighting how thinking around sustainability has evolved.

From a historical perspective, Du Pisani (2006) examined the history of sustainability and its impact on supply chain management, showing how environmental concerns have influenced business practices and government legislation. This work provides an essential framework for understanding the evolution and growing importance of GSCs in today's business environment. Schaltegger and Wagner (2017) and Muhammad et al. (2021) have focused on the relationship between firms' green behaviors and their long-term performance. Their research highlighted the importance of evaluating economic, social, and environmental performance to ensure long-term viability, underlining the need to adopt sustainable practices. De et al. (2020) and Ikram et al. (2018) examined the impact of supply chain management practices on customer satisfaction and environmental sustainability. Their results showed an increasing adoption of green practices by manufacturing companies, positively affecting sustainable performance, profitability, and market share.

Govindan et al. (2015) and Gupta (2019) investigated green manufacturing practices in Pakistani manufacturing firms, demonstrating their direct link to sustainable performance and market attractiveness. Liobikienė et al. (2016) and Khoiruman and Haryanto (2017) explored the link between green purchasing practices and environmental management, highlighting the increasing importance of green criteria in purchasing decisions. Fernando and Rou Uu (2017) explored eco-design strategies in business management, highlighting how eco-design can contribute to better sustainable performance by influencing product production, packaging, and distribution. Recker (2016) and Anthony (2016) examined the role of green information systems in GSC management, highlighting their importance in facilitating sustainable business performance by providing crucial information for product life cycle analysis and environmental management. Khoiruman and Haryanto (2017) highlighted the critical link between green procurement and sustainable corporate performance. These practices strengthen companies' reputation in the market while ensuring that the products purchased respect the environment, thus contributing to long-term sustainable performance.

De Brito and Dekker (2004) studied the benefits of reverse logistics programs for organizations. Results showed that these programs provide direct monetary benefits by reducing raw material use and disposal costs, highlighting the link between reverse logistics practices and sustainable environmental performance. Sharif et al. (2020) examined the impact of reverse logistics systems on organizational structure and relationships within companies. Their results indicated that organizations focused on reverse logistics systems reorganize their structures, promoting knowledge sharing and decision-making, contributing to more efficient and green supply chain management. Shao (2013) and Soni and Kodali (2012) highlight the importance of supply chain agility in improving companies' energy efficiency and sustainable environmental performance. Their research highlights the need to collaborate with suppliers and customers to restructure functions and align with sustainability goals. Muduli et al. (2020) look at the behavioral aspects of organizations in the context of GSC. Their study identifies the key behavioral factors that influence the effective implementation of these practices. They emphasize the importance of these behavioral aspects in improving energy efficiency and highlight the crucial role of environmental management in the effectiveness of GSCs.

Kitsis and Chen (2021) converged toward a common conclusion: environmental initiatives positively impact company performance. Kitsis and Chen (2021) highlight the importance of management commitment to the environment in implementing effective green practices. Similarly, Vachon and Klassen (2008) establish a correlation between environmental practices and improved corporate performance, highlighting the importance of adopting environmental measures. Lintukangas et al. (2016) highlight the essential role of environmental initiatives in responding to stakeholder pressure while preserving corporate reputation. Meanwhile, Habib et al. (2021) and David and Muthini (2019) focused on the impact of institutional pressure on the adoption of GSC practices. These studies highlight that institutional pressures strengthen the relationship between green manufacturing and sustainable performance while positively influencing supply chain relationship management and sustainable supply chain design. Regarding the role of government, Govindan et al. (2015), Mhelembe and Mafini (2019), and Pakdeechoho and Sukhotu (2018) examine the role of government rules, regulations and incentives in the mandatory adoption of flexible GSC management practices by companies. These studies conclude that government interventions, such as mandatory regulations and financial incentives for the training and development of GSC management initiatives, play a crucial role in promoting these practices.

In order to study the problem of the study, nine research hypotheses are to be considered: the first six are the main research hypotheses (*H1* to *H6*), and other hypotheses relate to the control variables (*H7* to *H9*). The research hypotheses are therefore given below:

H1: *Greater economic efficiency within a company is positively associated with the adoption of GSC practices.*

H2: *Better energy efficiency in a company is positively associated with the adoption of GSC practices.*

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H3: Economic efficiency coupled with energy efficiency has a positive impact on the adoption of GSC practices.

H4: Stakeholder pressure is positively associated with the adoption of GSC practices.

H5: Government incentives are positively associated with the adoption of GSC practices by companies.

H6: Government incentives coupled with pressure from stakeholders have a positive impact on the adoption of GSC practices.

H7: Director age has an impact on the adoption of GSC practices.

H8: Company size influences its adoption of GSC practices.

H9: Company profitability is positively associated with its adoption of GSC practices.

2. METHODOLOGY

The study focuses on 222 Moroccan SMEs from various sectors, chosen from 500 companies that were approached, with a response rate of 44.4% (222 out of 500). Non-respondents either refused to participate or provided incomplete or unusable data. Probit regression was used to study the adoption of GSC practices. In the face of the collinearity observed in a basic model, two alternative models are proposed, in which variables with interactions are examined separately to better understand their individual and combined influence on the adoption of GSCs.

2.1. The basic model (collinearity problems)

The research model aims to analyze the impact of different factors on the adoption of green supply chain adoption (GSCA) practices in companies. This adoption is coded in a binary way: a score of 1 indicates that the company agrees to adopt these practices, while a score of 0 indicates the opposite. The main objective of the model is to examine the probability of a company adopting GSC practices.

Economic efficiency (EEF) is measured by the inverse of the ratio of operating costs to value generated. Energy efficiency (ENE) is based on energy consumption in relation to quantities transported per kilometer. Government incentives (GIN) are a binary variable that indicates whether the company is willing to adopt GSC practices in the presence of government incentives. Stakeholder pressure (STP) is a binary variable reflecting pressure from customers, suppliers, shareholders, or environmental groups. The age of the director (DAG) is the age of the company's director, which can influence his or her propensity to adopt innovations and sustainable practices. Company size (CSZ) is determined by the number of employees. Company profitability (CPF) is measured by net margin. The basic model for the study is given as:

$$\begin{aligned} GSCA = {} & \beta_0 + \beta_1 \cdot EEF + \beta_2 \cdot ENE + \\ & \beta_3 \cdot EEF \cdot ENE + \beta_4 \cdot GIN + \beta_5 \cdot STP + \\ & + \beta_6 \cdot GIN \cdot STP + \\ & + \overbrace{\beta_7 \cdot DAG + \beta_8 \cdot CSZ + \beta_9 \cdot CPF}^{\text{Control variables}} + \mu. \end{aligned} \quad (1)$$

Table 1 summarizes the hypotheses, the associated variables, and the direction of correlation for each hypothesis in the study on adopting GSC.

Table 1. Hypotheses and the variables that represent them

Hypothesis	Variable(s)	Correlation direction
H1: Economic efficiency	EEF	Positive
H2: Energy efficiency	ENE	Positive
H3: Economic and energy efficiency interaction	EEF · ENE	Positive
H4: Government incentives	GIN	Positive
H5: Stakeholder pressure	STP	Positive
H6: Interaction of government incentives and stakeholder pressure	GIN · STP	Positive
H7: Age of director	DAG	Positive/Negative
H8: Company size	CSZ	Positive/Negative
H9: Company profitability	CPF	Positive

The model also includes interactions between certain variables, such as EEF · ENE and GIN · STP, to highlight that the impact of specific factors can be modified or reinforced by the presence of other variables. Control variables such as DAG, CSZ, and CPF are included to ensure that the analysis

Table 2. Descriptive statistics

Variable	GSCA	EEF	ENE	EEF · ENE	GIN	STP	GIN · STP	DAG	CSZ	CPF
Mean	0.639	0.158	1.9244	0.305	0.585	0.5260	0.309	47.955	138.97	0.0900
Median	1.000	0.160	1.945	0.30998	1.000	0.534	0.3194	47.252	137.145	0.090
Maximum	1.000	0.219	3.634	0.6004	1.0000	1.1520	1.1520	76.817	240.368	0.1217
Minimum	0.000	0.088	0.675	0.0844	0.000	–0.044	–0.0444	26.800	32.285	0.0573
Std. Dev.	0.4811	0.023	0.481	0.0877	0.4937	0.1993	0.3049	9.6475	33.528	0.0115
Skewness	–0.581	–0.299	–0.065	0.0861	–0.3474	–0.2194	0.3168	0.3032	–0.0070	–0.0876
Kurtosis	1.338	3.030	3.279	3.070	1.120	3.322	1.724	2.952	3.262	3.164
Jarque-Bera	38.05	3.319	0.880	0.3211	37.134	2.7454	18.771	3.4239	0.6391	0.5349
Probability	0.000	0.190	0.643	0.8516	0.0000	0.2534	0.000	0.1805	0.7264	0.7653
Sum	142.00	35.289	427.22	67.908	130.000	116.785	68.794	10646.14	30852.97	19.98158
Sum Sq. Dev.	51.171	0.1200	51.133	1.7014	53.873	8.780	20.54	20569.7	248444.7	0.029
Observations	222	222	222	222	222	222	222	222	222	222

Note: EEF = Economic efficiency; ENE = Energy efficiency; EEF · ENE = Economic and energy efficiency interaction; GIN = Government incentives; STP = Stakeholder pressure; GIN · STP = Interaction of government incentives and stakeholder pressure; DAG = Age of director; CSZ = Company size; CPF = Company profitability.

takes into account different organizational and financial aspects that may influence the adoption of GSC practices.

Analysis of the descriptive statistics for the sample (Table 2) reveals some interesting trends, particularly in the distribution of binary variables such as GSCA and GIN. The high mean of GSCA (0.639) indicates that most companies in the sample agree to adopt GSC practices. Similarly, the mean of GIN (0.585) suggests that most companies benefit from government incentives. These distributions may influence the Probit model results, as an uneven distribution of binary values (many 1s and few 0s, or vice versa) may bias the estimates. On the other hand, the standard deviation of GSCA (0.481) and GIN (0.493) shows a moderate variation among companies, which is relevant for the interpretation of the effects in the model. In addition, continuous variables such as EEF, ENE, and CPF, show relatively low standard deviations, indicating less variability in these measures within the sample.

The analysis of the Ramsey RESET test in Table 3 is used to check the adequate specification of the model. This test assesses whether the omitted variables, in this case, the squares of the fitted values, are significant in the model. According to the results, the t-statistic and the F-statistic both have a probability value of 0.185, and the likelihood ratio has a probability value of 0.156. These values suggest that the omitted variables are not statistically significant in the model at a conventional confidence level (such as 0.05 or 0.01).

The relatively high probability value indicates no strong evidence of omitted variables significantly affecting the model results. This can be interpreted as an indication that the model is correctly specified and that there is no clear evidence of significant non-linearity or other forms of misspecification.

Concerning the F-test summary, the SSR (sum of squares of residuals) tested has a value of 1.040, while the restricted SSR is 0.188 and the unrestricted SSR is 0.184. These values indicate that the addition of the omitted variables has not significantly improved the model's fit, reinforcing the conclusion that the current model is adequate without these additional variables.

Table 3. Ramsey RESET test

Omitted Variables: Squares of fitted values		
Test	**df**	**Probability**
t-statistic	211	0.185
F-statistic	(1, 211)	0.185
Likelihood ratio	1	0.156
F-test summary		
Test	df	Mean Squares
Test SSR	1	1.040
Restricted SSR	212	0.188
Unrestricted SSR	211	0.184

Analysis of the correlation matrix (Table 4) reveals that the interaction variables in the model have a high correlation between EEF · ENE and its initial variables (EEF and ENE) with correlation coefficients of 0.484 and 0.864, respectively, indicating a strong relationship. Similarly, the correlation between GIN · STP and GIN is very

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Table 4. Correlation matrix

Correlation Probability	GSCA	EEF	ENE	EEF · ENE	GIN	STP	GIN · STP	DAG	CSZ	CPF
GSCA	1.000	–	–	–	–	–	–	–	–	–
	–									
EEF	0.358	1.000	–	–	–	–	–	–	–	–
	0.000	–								
ENE	0.181	–0.002	1.000	–	–	–	–	–	–	–
	0.007	0.979	–							
EEF · ENE	0.319	0.484	0.864	1.000	–	–	–	–	–	–
	0.000	0.000	0.000	–						
GIN	–0.060	0.015	–0.001	0.003	1.000	–	–	–	–	–
	0.373	0.820	0.984	0.962	–					
STP	0.024	0.001	–0.109	–0.106	0.019	1.000	–	–	–	–
	0.724	0.987	0.105	0.115	0.782	–				
GIN · STP	0.038	0.031	–0.043	–0.033	0.857	0.422	1.000	–	–	–
	0.573	0.643	0.520	0.620	0.000	0.000	–			
DAG	–0.202	0.001	–0.034	–0.023	0.107	0.014	0.067	1.000	–	–
	0.003	0.988	0.616	0.732	0.114	0.836	0.321	–		
CSZ	0.047	0.054	–0.131	–0.098	–0.106	0.085	–0.044	0.029	1.000	–
	0.484	0.424	0.051	0.147	0.116	0.206	0.518	0.666	–	
CPF	0.104	–0.023	–0.032	–0.030	–0.042	–0.062	–0.020	–0.002	0.080	1.000
	0.123	0.731	0.631	0.657	0.537	0.358	0.768	0.974	0.236	–

Note: EEF = Economic efficiency; ENE = Energy efficiency; EEF · ENE = Economic and energy efficiency interaction; GIN = Government incentives; STP = Stakeholder pressure; GIN · STP = Interaction of government incentives and stakeholder pressure; DAG = Age of director; CSZ = Company size; CPF = Company profitability.

high (0.857), suggesting a strong association. This high correlation between the interaction variables and their initial variables is expected and logical. In statistical models, an interaction variable is the product of its original variables. Consequently, it is natural for a strong correlation to exist, as these interaction variables are not independent of their constituent variables. For example, an increase in EEF or ENE would probably result in an increase in EEF · ENE, which explains the high correlation observed. However, this high correlation can pose a problem of multicollinearity, where the interacting variables are so correlated with the original variables that it becomes difficult to isolate the unique effect of each variable on the dependent variable. Multicollinearity can make the model's coefficients unstable and their interpretation less reliable.

2.2. Alternative models

A more advanced test of collinearity, such as the Variance Inflation Factor (VIF) in Table 5, is warranted in the analysis because of concerns raised by the high correlation between some of the variables, particularly the interaction variables. Analysis of the VIFs in the base model reveals significant multicollinearity concerns, particularly for the interaction variables EEF · ENE and GIN · STP, as well as for EEF and ENE. The high VIFs for these variables indicate a strong correlation between them, which is consistent with the observations of the correlation matrix. This high collinearity may affect the accuracy and interpretation of the coefficients of these variables in the model. In contrast, variables such as DAG, CSZ, and CPF show relatively low VIFs, suggesting less problematic collinearity for these variables.

To overcome collinearity, this study proposes two alternative models. The first model excludes the interaction variables (EEF · ENE and GIN · STP) to focus on the direct effects of economic efficiency, energy efficiency, government incentives, and stakeholder pressure. This approach aims to clarify the interpretation of the individual effects of each variable by reducing multicollinearity. The second model, on the other hand, eliminates the original variables and focuses solely on their interactions, emphasizing the importance of these interactions in the adoption of GSC. Each model offers a different perspective: the first simplifies

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Table 5. Variance inflation factors for the base model

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.719819	846.8423	NA
EEF	22.78490	691.8568	14.49763
ENE	0.160150	741.1714	43.39659
EEF · ENE	6.311859	751.7467	56.91138
GIN	0.030000	20.66763	8.564962
STP	0.058901	21.91726	2.740770
GIN · STP	0.094937	21.06240	10.33685
DAG	9.40E-06	26.46355	1.024921
CSZ	8.00E-07	19.23495	1.053460
CPF	6.612588	64.06142	1.037650

Note: EEF = Economic efficiency; ENE = Energy efficiency; EEF · ENE = Economic and energy efficiency interaction; GIN = Government incentives; STP = Stakeholder pressure; GIN · STP = Interaction of government incentives and stakeholder pressure; DAG = Age of director; CSZ = Company size; CPF = Company profitability.

the analysis by focusing on direct effects, while the second explores the dynamics of interactions. The two models are given as follows:

Alternative model 1:

$$GSCA = \beta_0 + \beta_1 \cdot EEF + \beta_2 \cdot ENE + \\ + \beta_3 \cdot GIN + \beta_4 \cdot STP + \\ + \overbrace{\beta_5 \cdot DAG + \beta_6 \cdot CSZ + \beta_7 \cdot CPF}^{Control\ variables} + \mu. \quad (2)$$

Alternative model 2:

$$GSCA = \beta_0 + \beta_1 \cdot EEF \cdot ENE + \\ + \beta_2 \cdot GIN \cdot STP + \\ + \overbrace{\beta_3 \cdot DAG + \beta_4 \cdot CSZ + \beta_5 \cdot CPF}^{Control\ variables} + \mu. \quad (3)$$

3. RESULTS AND DISCUSSION

The results of the Ramsey RESET tests for the two alternative models given in Table 6 of the study suggest that each model is correctly specified with no significant omitted variables. In Alternative Model 1, which excludes interaction variables, the high probabilities for the t-statistic, F-statistic, and likelihood ratio indicate the absence of significantly omitted variables. Similarly, Alternative Model 2, which focuses on the interaction variables by excluding the original variables, shows slightly lower probabilities but still above the critical thresholds, suggesting good specification. The minimal differences between the restricted and unrestricted SSRs tested in the two models reinforce this conclusion. These analyses indicate that both models are appropriate for studying the adoption of GSCs without significant concerns about misspecification.

Table 6. Ramsey RESET tests for the two alternative models

Omitted Variables: Squares of fitted values				
Test	The alternative model 1		The alternative model 2	
	Df	Probability	df	Probability
t-statistic	213	0.273	215	0.138
F-statistic	(1, 213)	0.277	(1, 215)	0.138
Likelihood ratio	1	0.226	1	0.131
F-test summary				
Test	The alternative model 1		The alternative model 2	
	df	Mean Squares	df	Mean Squares
Test SSR	1	1.664	1	3.186
Restricted SSR	214	0.187	216	0.199
Unrestricted SSR	213	0.180	215	0.185

The VIF factors in Table 7 for alternative models show a significant improvement in the management of collinearity. In Alternative Model 1, the centered VIFs are close to 1 for most variables without the interaction variables, indicating a significant reduction in multicollinearity. Similarly, Alternative Model 2, which focuses on the interaction variables by eliminating the original variables, also shows low-centered VIFs for these interaction variables. These results suggest that both alternative models have effec-

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Table 7. Variance inflation factors for the two alternative models

Variable	Alternative model 1			Alternative model 2		
	Coefficient Variance	Uncentered VIF	Centered VIF	Coefficient Variance	Uncentered VIF	Centered VIF
C	**0.153298**	**181.2173**	**NA**	**0.105293**	**117.1274**	**NA**
EEF	1.570608	47.92045	1.004157	–	–	–
ENE	0.003781	17.58312	1.029515	–	–	–
EEF · ENE	–	–	–	0.118693	13.36662	1.011927
GIN	0.003577	2.475925	1.026059	–	–	–
STP	0.021885	8.182497	1.023227	–	–	–
GIN · STP	–	–	–	0.009793	2.054402	1.008245
DAG	9.26E–06	26.18272	1.014044	9.76E–06	25.97155	1.005866
CSZ	7.91E–07	19.10272	1.046218	8.18E–07	18.60138	1.018761
CPF	6.430453	62.59656	1.013922	6.788493	62.18422	1.007243

Note: EEF = Economic efficiency; ENE = Energy efficiency; EEF · ENE = Economic and energy efficiency interaction; GIN = Government incentives; STP = Stakeholder pressure; GIN · STP = Interaction of government incentives and stakeholder pressure; DAG = Age of director; CSZ = Company size; CPF = Company profitability.

tively mitigated collinearity problems, thereby strengthening the reliability of model estimates for the analysis of GSCs adoption.

The Breusch-Pagan-Godfrey tests (Table 8) applied to the alternative models show the absence of significant heteroscedasticity in both cases. In Alternative Model 1, the probabilities for the F-statistic and the Obs · R-squared test exceed the usual thresholds, indicating constant error variance. Similarly, Alternative Model 2 also displays high probabilities for these tests, suggesting stability in error variance even when focusing on interaction variables. These results indicate that heteroscedasticity is not an issue in these models, which is crucial for the reliability of estimates and hypothesis testing in the study of the adoption of GSC practices.

In the context of Probit models, the distribution of residuals does not necessarily have to follow a normal distribution since the normality assumption concerns the latent variable and not the residuals themselves. The probabilities of the Jarque-Bera test (Figure 1) are 0.560 for Model 1 and 0.402 for Model 2, suggesting that the assumption of normality of the residuals should not be rejected for either model. The model statistics show residuals with skewness and kurtosis close to the values expected for a normal distribution, and the Jarque-Bera tests do not indicate any significant deviation from normality. Although the normality of the residuals is not required, these results suggest no underlying problems with the data or the specification of the models, thus contributing to the robustness of the Probit estimates obtained.

Table 9 shows the results of the Probit regressions for the alternative models. In Alternative Model 1, economic efficiency (EEF) and energy efficiency (ENE) are significant factors with positive coefficients. This observation confirms *H1* and *H2*, indicating that more economically and energy-efficient companies are more inclined to adopt GSC practices. Stakeholder pressure (STP) also has a positive and significant impact, supporting *H5*, suggesting that companies are influenced by external expectations and pressures to adopt more sustainable practices. On the other hand, government incentives (GIN) do not significantly affect the adoption of GSC, not supporting *H4*. This could indicate that in the context of the sample studied, government policies alone are not sufficient to motivate companies to adopt such practices without the presence of other influential factors.

Table 8. Heteroscedasticity test (Breusch-Pagan-Godfrey)

Test	Alternative model 1		Alternative model 2	
F-statistic	Prob. F(7,214)	0.1091	Prob. F(5,216)	0.4090
Obs · R-squared	Prob. Chi-Square(7)	0.1001	Prob. Chi-Square(5)	0.4201
Scaled explained SS	Prob. Chi-Square(7)	0.4068	Prob. Chi-Square(5)	0.3043

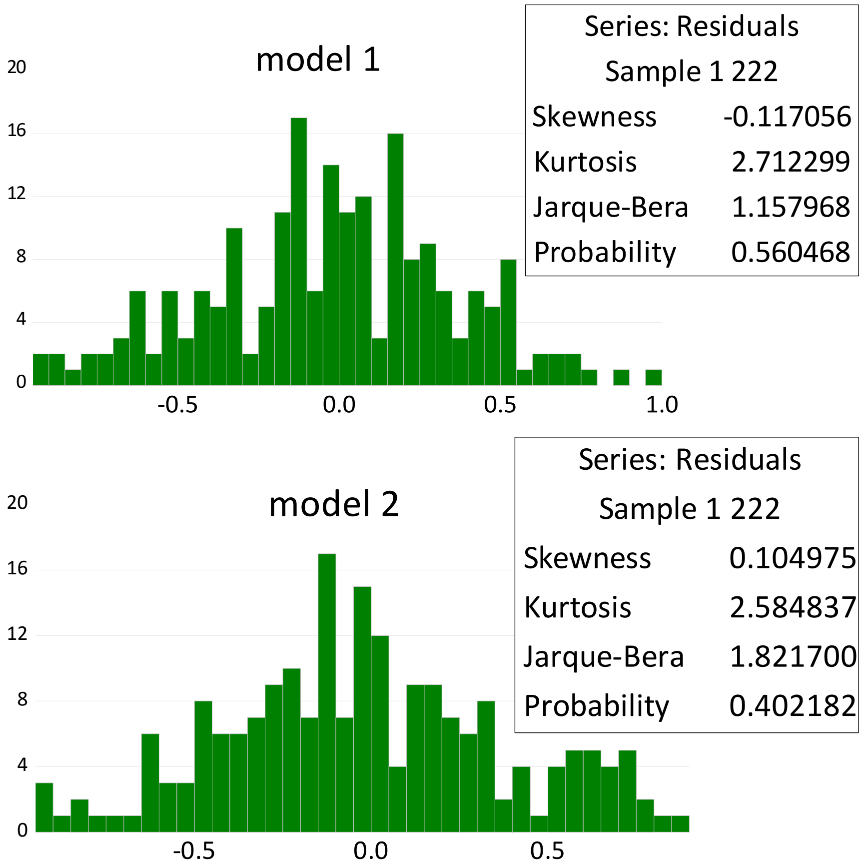

Figure 1. Residual normality tests for the two models

Alternative Model 2 focuses on the impact of interactions between variables. The combination of economic and energy efficiency (EEF · ENE) shows a positive and significant effect, confirming *H3*. This observation suggests that companies are more likely to adopt green supply chains when they achieve synergy between cost savings and energy efficiency. Similarly, the interaction of government incentives with stakeholder pressure (GIN · STP) also shows a significant positive effect, validating *H6*. This indicates that government incentives can be more effective when combined with stakeholder pressure.

Director age (DAG) is negatively correlated in both models, suggesting that older executives may

Table 9. Probit regression results

Variable	Alternative model 1				Alternative model 2			
	Coefficient	Std. Error	z–Statistic	Prob.	Coefficient	Std. Error	z–Statistic	Prob.
C	–2.3663*	1.244968	–1.900694	0.0573	0.5804	0.955124	0.60767	0.5434
EEF	22.6958***	4.381393	5.180044	0.0000	–	–	–	–
ENE	0.5463***	0.200651	2.722832	0.0065	–	–	–	–
EEF · ENE	–	–	–	–	5.0517***	1.079598	4.67927	0.0000
GIN	–0.1297	0.191942	–0.676108	0.4990	–	–	–	–
STP	0.9275**	0.467109	1.985674	0.0483	–	–	–	–
GIN · STP	–	–	–	–	0.8796***	0.298942	2.94261	0.0036
DAG	–0.0301***	0.01002	–3.008589	0.0026	–0.028***	0.009731	–2.97855	0.0029
CSZ	0.0026	0.00285	0.926983	0.3539	0.0042	0.002761	1.55540	0.1199
CPF	23.3960**	10.66544	2.193627	0.0293	16.2177**	7.515118	2.15801	0.0320

Note: *** Significant at 1%; ** significant at 5%; * significant at 10%. EEF = Economic efficiency; ENE = Energy efficiency; EEF · ENE = Economic and energy efficiency interaction; GIN = Government incentives; STP = Stakeholder pressure; GIN · STP = Interaction of government incentives and stakeholder pressure; DAG = Age of director; CSZ = Company size; CPF = Company profitability.

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be less likely to adopt GSC practices, a finding that challenges *H7*. This result could reflect generational differences in attitudes toward sustainable practices. Firm size (CSZ) was not significant in either model, which does not allow definitive conclusions to be drawn regarding its impact on the adoption of GSC (*H8*). Finally, company profitability (CPF) shows a positive and significant relationship in both models, supporting *H9*. This implies that more profitable companies may be better positioned financially to invest in sustainable initiatives. Thus, the results highlight the importance of economic and energy efficiency, stakeholder pressure, and the combination of these factors with government incentives for adopting green supply chains. The results also highlight the potential role of managerial characteristics and the company's financial situation in these decisions.

Economic and energy efficiency are key indicators for adopting GSC practices, aligned with the findings of Govindan et al. (2015) and Ansari and Kant (2017). These results suggest that managers of economically and energy-efficient firms recognize the benefits associated with the adoption of GSCs, particularly in terms of reduced energy costs and improved economic efficiency. Thus, adopting these practices is not perceived as a constraint but rather as a strategic advantage for the company.

On the other hand, government incentives alone do not seem to significantly impact the adoption of sustainable practices, contrary to the suggestions of De et al. (2020). However, when combined with stakeholder pressure, their effectiveness is notable, corroborating the ideas of Schaltegger and Wagner (2017). In addition, the study reveals a trend where younger leaders are more willing to adopt sustainable supply chain practices. This finding may indicate generational differences in the perception of sustainability and highlights the importance of educating and raising awareness of these issues among leaders of all ages.

Concerning company size, no significant impact was observed on the adoption of green practices. On the other hand, a positive correlation between profitability and adopting such practices was established, confirming the findings of Khoiruman and Haryanto (2017). This indicates an awareness among managers that such practices not only enhance the company's reputation but also ensure that the products acquired are environmentally friendly, contributing to long-term sustainable performance. It also suggests that financial resources are crucial to a company's ability to adopt sustainable practices such as GSCs.

CONCLUSION

The paper examines the influence of various factors, such as economic and energy efficiency, government incentives, stakeholder pressure, manager age, company size, and profitability, on adopting GSC practices. This study offers a perspective on the adoption of GSC in Moroccan SMEs. It highlights the determining factors and dynamics influencing this adoption. The multidimensional analysis highlights the significance of companies' economic and energy efficiency in adopting GSC practices. It reveals that companies that achieve economic and energy efficiency synergy are more likely to integrate sustainable practices into their operations. Significantly, the study challenges the widely held belief that government incentives alone are sufficient to encourage the adoption of sustainable practices. On the contrary, these incentives are much more effective when combined with stakeholder pressure. This finding underlines the importance of a collaborative approach involving government policies and stakeholder engagement to achieve a greener supply chain.

Another interesting finding is the role of the age of the leader. The study indicates that younger leaders are more likely to adopt GSC practices, highlighting generational differences in attitudes toward sustainability. This suggests a growing need to educate and train leaders of all ages on the importance and benefits of sustainable practices. In terms of company size, the study found no significant correlation with adopting green practices, indicating that other factors, such as organizational culture and management capabilities, may be more influential. However, the positive correlation between profitability and the adoption of green practices indicates that financially stable companies are more willing to implement sustainable initiatives, highlighting the role of financial resources in facilitating the transition to greener supply chains.

AUTHOR CONTRIBUTIONS

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REFERENCES

1. Ansari, Z. N., & Kant, R. (2017). A state-of-art literature review reflecting 15 years of focus on sustainable supply chain management. *Journal of Cleaner Production, 142,* 2524-2543. https://doi.org/10.1016/j.jclepro.2016.11.023
2. Anthony, B. J. (2016). Green information systems integration in information technology based organizations: An academic literature review. *Journal of Soft Computing and Decision Support Systems, 3*(6), 45-66. Retrieved from https://www.jscdss.com/index.php/files/article/view/117
3. Barbosa-Póvoa, A. P., da Silva, C., & Carvalho, A. (2017). Opportunities and challenges in sustainable supply chain: An operations research perspective. *European Journal of Operational Research, 268*(2), 399-431. https://doi.org/10.1016/j.ejor.2017.10.036
4. Bastas, A., & Liyanage, K. (2018). Sustainable supply chain quality management: A systematic review. *Journal of Cleaner Production, 181,* 726-744. https://doi.org/10.1016/j.jclepro.2018.01.110
5. Chiou, T. Y., Chan, H. K., Lettice, F., & Chung, S. H. (2011). The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan. *Transportation Research Part E: Logistics and Transportation Review, 47*(6), 822-836. https://doi.org/10.1016/j.tre.2011.05.016
6. Darnall, N., Jolley, G. J., & Handfield, R. (2008). Environmental management systems and green supply chain management: Complements for sustainability? *Business Strategy and the Environment, 17*(1), 30-45. https://doi.org/10.1002/bse.557
7. David, R. A., & Muthini, J. N. (2019). Influence of green supply chain management practices on procurement performance of private health institutions in Kenya: A case of Aga Khan Hospital Kisumu. *The Strategic Journal of Business & Change Management, 6*(2), 1378-1396. https://doi.org/10.61426/sjbcm.v6i2.1190
8. De Brito, M. P., & Dekker, R. (2004). A framework for reverse logistics. In R. Dekker, M. Fleischmann, K. Inderfurth, & L. N. Van Wassenhove (Eds.), *Reverse logistics: Quantitative models for closed-loop supply chains* (pp. 3-27). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-24803-3_1
9. De, D., Chowdhury, S., Dey, P. K., & Ghosh, S. K. (2020). Impact of lean and sustainability oriented innovation on sustainability performance of small and medium sized enterprises: A data envelopment analysis-based framework. *International Journal of Production Economics, 219,* 416-430. https://doi.org/10.1016/j.ijpe.2018.07.003
10. Du Pisani, J. A. (2006). Sustainable development – Historical roots of the concept. *Environmental Sciences, 3*(2), 83-96. https://doi.org/10.1080/15693430600688831
11. Fernando, Y., & Rou Uu, N. C. (2017). An empirical analysis of eco-design of electronic products on operational performance: Does environmental performance play role as a mediator? *International Journal of Business Innovation and Research, 14*(2), 188-205. http://dx.doi.org/10.1504/IJBIR.2017.10007033
12. Govindan, K., Diabat, A., & Shankar, K. M. (2015). Analyzing

the drivers of green manufacturing with fuzzy approach. *Journal of Cleaner Production, 96,* 182-193. https://doi.org/10.1016/j.jclepro.2014.02.054

13. Green, K. W., Zelbst, P. J., Bhadauria, V. S., & Meacham, J. (2012). Do environmental collaboration and monitoring enhance organizational performance? *Industrial Management & Data Systems, 112*(2), 186-205. https://doi.org/10.1108/02635571211204254

14. Gupta, K. (2019). *Innovations in manufacturing for sustainability*. Springer International Publishing. https://doi.org/10.1007/978-3-030-03276-0

15. Habib, M. A., Bao, Y., Nabi, N., Dulal, M., Asha, A. A., & Islam, M. (2021). Impact of strategic orientations on the implementation of green supply chain management practices and sustainable firm performance. *Sustainability, 13*(1), 340. https://doi.org/10.3390/su13010340

16. Hervani, A. A., Helms, M. M., & Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking: An International Journal, 12*(4), 330-353. https://doi.org/10.1108/14635770510609015

17. Ikram, A., Su, Q., Fiaz, M., & Rehman, R. U. (2018). Cluster strategy and supply chain management: The road to competitiveness for emerging economies. *Benchmarking: An International Journal, 25*(5), 1302-1318. https://doi.org/10.1108/BIJ-06-2015-0059

18. Khan, M. T., Idrees, M. D., Rauf, M., Sami, A., Ansari, A., & Jamil, A. (2022). Green supply chain management practices' impact on operational performance with the mediation of technological innovation. *Sustainability, 14*(6), 3362. https://doi.org/10.3390/su14063362

19. Khoiruman, M., & Haryanto, A. T. (2017). Green purchasing behavior analysis of government policy about paid plastic bags. *Indonesian Journal of Sustainability Accounting and Management, 1*(1), 31-39.

20. Kitsis, A. M., & Chen, I. J. (2021). Do stakeholder pressures influence green supply chain practices? Exploring the mediating role of top management commitment. *Journal of Cleaner Production, 316,* 128258. https://doi.org/10.1016/j.jclepro.2021.128258

21. Koberg, E., & Longoni, A. (2019). A systematic review of sustainable supply chain management in global supply chains. *Journal of Cleaner Production, 207,* 1084-1098. https://doi.org/10.1016/j.jclepro.2018.10.033

22. Lintukangas, K., Kähkönen, A. K., & Ritala, P. (2016). Supply risks as drivers of green supply management adoption. *Journal of Cleaner Production, 112,* 1901-1909. https://doi.org/10.1016/j.jclepro.2014.10.089

23. Liobikienė, G., Mandravickaitė, J., & Bernatonienė, J. (2016). Theory of planned behavior approach to understand the green purchasing behavior in the EU: A cross-cultural study. *Ecological Economics, 125,* 38-46. https://doi.org/10.1016/j.ecolecon.2016.02.008

24. Maditati, D. R., Munim, Z. H., Schramm, H. J., & Kummer, S. (2018). A review of green supply chain management: From bibliometric analysis to a conceptual framework and future research directions. *Resources, Conservation and Recycling, 139,* 150-162. https://doi.org/10.1016/j.resconrec.2018.08.004

25. Mhelembe, K., & Mafini, C. (2019). Modelling the link between supply chain risk, flexibility and performance in the public sector. *South African Journal of Economic and Management Sciences, 22*(1), a2368. http://dx.doi.org/10.4102/sajems.v22i1.2368

26. Muduli, K. K., Luthra, S., Kumar Mangla, S., Jabbour, C. J. C., Aich, S., & de Guimaraes, J. C. F. (2020). Environmental management and the "soft side" of organisations: Discovering the most relevant behavioural factors in green supply chains. *Business Strategy and the Environment, 29*(4), 1647-1665. https://doi.org/10.1002/bse.2459

27. Muhammad, F., Ikram, A., Jafri, S. K., & Naveed, K. (2021). Product innovations through ambidextrous organizational culture with mediating effect of contextual ambidexterity: An empirical study of it and telecom firms. *Journal of Open Innovation: Technology, Market, and Complexity, 7*(1), 9. https://doi.org/10.3390/joitmc7010009

28. Pakdeechoho, N., & Sukhotu, V. (2018). Sustainable supply chain collaboration: Incentives in emerging economies. *Journal of Manufacturing Technology Management, 29*(2), 273-294. https://doi.org/10.1108/JMTM-05-2017-0081

29. Rabbi, M., Ali, S. M., Kabir, G., Mahtab, Z., & Paul, S. K. (2020). Green supply chain performance prediction using a Bayesian belief network. *Sustainability, 12*(3), 1101. https://doi.org/10.3390/su12031101

30. Recker, J. (2016). Toward a design theory for green information systems. *The 2016 49th Hawaii International Conference on System Sciences (HICSS)* (pp. 4474-4483). Koloa, HI: IEEE. https://doi.org/10.1109/HICSS.2016.556

31. Sahar, D. P., Afifudin, M. T., & Indah, A. B. R. (2020). Review of green supply chain management in manufacturing: A case study. *IOP Conference Series: Earth and Environmental Science,* 575, 012239. https://doi.org/10.1088/1755-1315/575/1/012239

32. Sarkis, J. (2003). A strategic decision framework for green supply chain management. *Journal of Cleaner Production, 11*(4), 397-409. https://doi.org/10.1016/S0959-6526(02)00062-8

33. Schaltegger, S., & Wagner, M. (2017). Managing and measuring the business case for sustainability: Capturing the relationship between sustainability performance, business competitiveness and economic performance. In S. Schaltegger & M. Wagner (Eds.), *Managing the business case for sustainability* (pp. 1-27). Routledge. Retrieved from https://www.taylorfrancis.com/chapters/edit/10.4324/9781351280525-1/managing-measuring-business-

case-sustainability-stefan-schaltegger-marcus-wagner

34. Shao, X.-F. (2013). Supply chain characteristics and disruption mitigation capability: An empirical investigation in China. *International Journal of Logistics Research and Applications, 16*(4), 277-295. https://doi.org/10.1080/13675567.2013.815695

35. Sharif, A., Baris-Tuzemen, O., Uzuner, G., Ozturk, I., & Sinha, A. (2020). Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: Evidence from Quantile ARDL approach. *Sustainable Cities and Society, 57,* 102138. https://doi.org/10.1016/j.scs.2020.102138

36. Soni, G., & Kodali, R. (2012). Evaluating reliability and validity of lean, agile and leagile supply chain constructs in Indian manufacturing industry. *Production Planning & Control, 23*(10-11), 864-884. https://doi.org/10.1080/09537287.2011.642207

37. Srivastava, S. K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews, 9*(1), 53-80. https://doi.org/10.1111/j.1468-2370.2007.00202.x

38. Tseng, S. C., & Hung, S. W. (2014). A strategic decision-making model considering the social costs of carbon dioxide emissions for sustainable supply chain management. *Journal of Environmental Management, 133,* 315-322. https://doi.org/10.1016/j.jenvman.2013.11.023

39. Vachon, S., & Klassen, R. D. (2006). Extending green practices across the supply chain: The impact of upstream and downstream integration. *International Journal of Operations & Production Management, 26*(7), 795-821. https://doi.org/10.1108/01443570610672248

40. Vachon, S., & Klassen, R. D. (2008). Environmental management and manufacturing performance: The role of collaboration in the supply chain. *International Journal of Production Economics, 111*(2), 299-315. https://doi.org/10.1016/j.ijpe.2006.11.030

41. Wu, K. J., Tseng, M. L., & Vy, T. (2011). Evaluation the drivers of green supply chain management practices in uncertainty. *Procedia – Social and Behavioral Sciences, 25,* 384-397. https://doi.org/10.1016/j.sbspro.2012.02.049

42. Yang, Q., Geng, R., Jiang, Y., & Feng, T. (2021). Governance mechanisms and green customer integration in China: The joint effect of power and environmental uncertainty. *Transportation Research Part E: Logistics and Transportation Review, 149,* 102307. https://doi.org/10.1016/j.tre.2021.102307

http://dx.doi.org/10.21511/ee.14(2).2023.09