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The effect of supply chain flexibility, supply chain governance and green supply chain practices on supply chain performance: TQM as a moderator

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The purpose of the study is to determine how supply chain flexibility (SCF), supply chain governance (SCG), and green supply chain practices (GSCPs) affect supply chain performance (SCP). In addition to exploring whether TQM moderates the effect of SCF, SCG, GSCPs on SCP of Saudi medium-sized industrial firms. To this end, data was gathered from 312 employees in Saudi medium-sized industrial firms and analyzed using structural equation modeling (SEM) via Smart PLS 4 software. The study revealed that GSCPs and SCG have a positive, significant and direct effect on SCP, in addition to that SCF and TQM do not have a direct positive effect on SCP. The study also found that TQM modifies the relationship between GSCPs, SCF, SCG and SCP.

1. Introduction

Supply Chain Flexibility (SCF) refers to the ability of a well-designed structure to respond to disruptions and resume regular operations (Chowdhury & Quaddus, 2017; Juan et al., 2021). Al-Hakimi et al. (2022a,b), the primary focus was on the resilience of suppliers and consumers in relation to the supply chain node where the disruption occurred. Yu et al. (2022) opined that there is a need for two complementary mechanisms, namely internal coordination between functions and external information equality between partners, in light of the speed of joint interpretation of disturbances. Several supply chain governances have been introduced recently to enhance SCF (Wang et al., 2018). Gupta et al. (2021), for example, presented an AI-focused system that can enable a disruptive supply chain ecosystem to reduce expenses and enhance efficiency, depending on several factors. Previous studies on SCF have mostly addressed the elements that drive SCF from a resources and capabilities perspective. For example, communication and information exchange have been viewed as resources before (Brandon Jones et al., 2014). Brusset and Teller (2017) provide a conceptual model that suggests a link between supply chain capabilities and supply chain resilience. According to Baugh and Rowell (2023) and Al-Hakimi et al. (2021), supply chain risk management allows companies to restructure and deploy resources and skills in a way that helps them retain supply chain resilience in the face of disruptions. The ongoing operation of the entire supply chain has been impeded by global trade protectionism, local conflicts, natural disasters, and the growing interconnectedness between various supply chain stages and supply chain governance (Kamalahmadi & Parast, 2016; Faruquee et al., 2021). For instance, a large 32% increase in supply chain interruptions in 2022 was found by Resilinc Corporation, a global business that specializes in tracking supply chain disruptions. The use of information-intensive supply chain governance which includes big data, blockchain, cloud computing, and artificial intelligence has noticeably increased in tandem with the number of these unforeseen incidents. Supply chain governance has been implemented to boost the target company's resilience skills in order to prevent disruptions in the supply chain and/or recover as soon as feasible. IBM (International Business Machines Corporation) reports that in order to access

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more information, 64% of organizations have moved supply chain governance to more cloud-based businesses, and that digital transformation has accelerated by 59% (IBM, 2020). Due to these evolving processes, supply chain governance which relies on a variety of information sources and seamless information channels is essential for efficiently managing disruptions (Wong et al., 2020; Choudhary et al., 2021; El Baz & Ruel, 2021). In order to examine the determinants of supply chain governance, prior research has mostly relied on the several resources and capacities, such as supply chain risk management (Elbaz and Rowell, 2021), supply chain connection and information sharing (Brandon-Jones et al., 2014), external capabilities/integration/flexibility (Brusset & Teller, 2017), and big data analytics capabilities (Singh & Singh, 2019). After that, there was a steady rise in the quantity of research on supply chain governance using technological applications (big data, for example). Research on digital technology (DT) (Shi et al., 2022), digital transformation (He et al., 2023), and risk management are a few examples. According to some academics, GSCPs improve overall business performance (Agyabeng-Mensah et al., 2019a, b, c; Baah et al., 2020; Green et al., 2019a). The disparities described in the relationship between GSCPs and performance may stem from the absence of complementary firm practices that can be implemented to enhance GSCP effectiveness and achieve superior performance over an extended period. TQM and just-in-time (JIT) management complement each other, and implementing both at the same time may improve supply chain performance (Flynn et al., 2010). Moreover, according to Green et al. (2019a), TQM and GSCPs can help production managers achieve the "three zero manufacturing paradigms," which call for them to achieve zero defects, zero environmental waste and emissions, and zero inventory. Florida's (1996) findings also showed that lean management (GSCPs and TQM) and environmental management techniques work well together, and a number of studies (King & Lenox, 2001; Rothenberg et al., 2001) have shown that GSCPs and TQM Sustainable consumption and production have a positive relationship because they reduce waste and emissions. Researchers have not paid enough attention to the combined effect of TQM and TQM to improve the operational performance of SCPs, despite the fact that the impact of GSCPs on sustainable production and production has been well researched (Narasimhan et al., 2006). More research is necessary, according to Bastas and Liyanage (2018), who assert that there may be an undiscovered synergistic link between TQM and GSCPs to promote sustainable production and production. Green et al. (2019a), who investigated TQM as forerunners of GSCPs, only focused on the environmental aspect of performance, failing to take into account the combined benefits of SCF, GSCPs SCG and TQM on BP and OP. To achieve SCP improvement, this calls for the discovery of complimentary techniques that increase the effectiveness of GSCPs.

2. Literature review and hypothesis development

2.1 Green supply chain practices and supply chain performance

Supply chain practices, both internal and external, have had unfavorable environmental impacts that increase the likelihood of Earth extinction. To salvage the situation, a number of stakeholders have put pressure on companies to implement green strategies (Baah et al., 2020; Agyabeng-Mensah et al., 2020a, b, c; Walker et al., 2008). GSCPs represent the integration of environmental principles into product development and supply chain operations, with the primary goal of preventing environmental degradation. According to Linton et al. (2007), businesses must embed green practices throughout their entire supply chain to increase the effectiveness and competitiveness of their supply networks. Furthermore, according to other researchers, the adoption of GSCPs is encouraged by international environmental standards such as ISO 14001 (Rondinelli & Perry, 2000), the impact of an organization's environmental performance on its worldwide reputation (Christman & Taylor, 2002), and cost reduction. measures (De Brito, et al., 2008), and environmental policies (Hanson et al., 2004). Once again, it is recognized that enhancing supply chain performance is the main factor behind companies adopting global guidelines (Feng et al., 2018; Baah et al., 2020; Agyabeng-Mensah et al., 2019a, b, c). Srivastava (2007) found that following international standards reduces the harmful effects that business operations have on the environment without sacrificing quality. According to previous studies (Green et al., 2012; Vachon & Klassen, 2008; Yu et al., 2014; Zailani et al., 2012), GSCPs enhance operational processes in terms of cost, quality, flexibility and delivery. According to Vachon and Klassen (2008), green supply chain collaboration is associated with enhancing quality, delivery and flexibility – the four traditional aspects of supply chain performance in manufacturing. In order to enhance the operational, market and financial supply chain performance of its focus organizations and their supply chain partners, this article defines global supply chains as a set of environmental practices and activities that are integrated into companies' supply chain operations (Zhu et al, 2008; Green et al, 2012). When green products and services are produced to meet customers' environmental requirements, GSCPs improve operational and financial performance (Green et al., 2012; Zaid et al., 2018). While there is a wealth of literature (Feng et al., 2018; Zaid et al., 2018; Agyabeng-Mensah et al., 2019a, b, c; Green et al., 2012 Lai & Wong, 2012; Zilani et al., 2012) , suggest a comprehensive investigation into the relationship between GSCPs and supply chain performance, but the results are still contradictory and unclear. Furthermore, most of the research conducted from an African perspective focuses on environmental sustainability. This has inspired an investigation into the relationship between supply chain performance and GSCPs. Based on the above, the following hypothesis was formulated:

H_1: *GSCPs positively affect SCP.*

2.2 Supply chain flexibility and supply chain performance

According to Xiao et al. (2012), supply chain flexibility is the capacity of a supply chain to bounce back from outside disruptions and revert to its ideal or initial form. This encompasses the capacity to adjust to one's surroundings and bounce

back from disruptions (Al-Swidi et al., 2024; Goaill & Al-Hakimi, 2021). The issues brought about by the dispersion of conventional blockchain platforms with disparate standards and inadequate governance can be resolved by the powered supply chain system (Yan, 2023). Cui et al. (2022) propose that implementing appropriate technology can enhance the flexibility of the supply chain. The methods by which supply chain capabilities devoted to resilience and risk management might improve resilience performance during periods of disruption brought on by inevitable hazards were empirically investigated by Barahmi (2023). Analogously, numerous scholars propose that the integration of Metaverse technology with other associated technologies can augment supply chain resilience by amplifying visibility, adaptability, velocity, and enabling more efficacious proactive risk mitigation (Queiroz et al., 2023; Spieske & Birkel, 2021). The ability of the supply chain to effectively and efficiently deliver the correct product at the right time and location while minimizing logistics costs is referred to as supply chain performance (Zhang & Okoroafo 2015). A statistically significant correlation between supply chain performance and management techniques was discovered by (Sabry et al., 2021). Danishvar et al. (2020), who stress the managerial significance of an efficient supply chain strategy to enhance supply chain performance, lend support to this. Furthermore, Asimovic et al. (2022), contend that supply chain performance is heavily influenced by logistics performance, which in turn makes it crucial to organizational success. According to Yemenici (2022), a well-functioning supply chain is essential for cutting expenses, waiting times, and delivery delays while also enhancing product quality. According to Christina (2021), supply chain performance can be raised by supply chain resilience. Similarly, supply chain resilience is essential to supply chain performance, according to Cherian et al. (2023), According to Queiroz et al. (2023), the supply chain's total performance will be improved by implementing the met averse of operational activities. Trivedi and Negi (2023), note that the metaverse's application to a variety of supply chain elements will eventually boost the efficiency and profitability of the chain. Therefore, this study proposes the following research hypothesis:

H_2: *SCF positively affects SCP.*

2.3 Supply chain governance and supply chain performance

The behavior of supply chain partners is coordinated and controlled by management through formal and informal actions (Keller al., 2021; Bonatto et al., 2022). According to this study, SCG serves as a coordination and maintenance framework when dealing with supply chain risks and supply chain performance (Keller et al., 2021). In fact, SCG can reduce the opportunity for opportunism resulting from cooperation and help organize and implement supply chain activities towards common goals of supply chain performance (Lumineau, 2017; Cao & Lumineau, 2015; Duong and Chong, 2020; Bonatto et al, 2022). Moreover, relational and contractual governance are also part of SCG (Cao and Lumineau, 2015; Keller et al., 2021; Bonatto et al., 2022). While SCG promotes a collaborative environment to persuade partners to adopt certain behaviors and reduce opportunism, relational governance focuses on applying shared values, social and cooperative norms, trust, and mutual goals (Huang et al., 2014). Conversely, contractual supply chain governance assigns duties to each contract participant and monitors supply chain performance of those duties through written contracts (Huang et al., 2014). Informal information exchange and formal information integration are two information processing methods used by Huang et al. (2021) proposed. In order to reduce information distortions and produce more solutions, supply chain participants may share more information with each other, a practice known as informal information sharing. Formal information integration is the process of working with supply chain partners based on clear procedures and structured standards to enable rapid decision-making and responses. It also includes sharing structured and standardized data. Moreover, from an information processing point of view, Tinhaeli and Salvador (2014) proposed formal and informal communication channels. In light of this, supply chain governance in this study is viewed as an informal communication channel that attempts to bridge coordination gaps and enhance the willingness of supply chain performers in companies to exchange information by enhancing social identity and trust in order to influence the actions of chain partners (Wang & Wei, 2007; Keller et al., 2021). By clarifying the content of information sharing, procedures, responsibilities and contingencies, as well as rewarding or punishing partner behavior for achieving stated goals, contractual supply chain governance, as a formal information channel, emphasizes formal contracts and rules between firms (Lumineau, 2014 ; Zhang et al., 2020) Therefore, in order to compensate for supply chain interruptions and improve SCR, SCG can facilitate information exchange and reduce information distortions. Based on the above, the following hypothesis was formulated:

H_3: *SCG positively affects SCP.*

2.4 Moderating role of TQM

By offering products that are in line with what customers want and need, total quality management seeks to improve the organization's performance and quality (Goetsch & Davis, 2014; Turan & Bozaykut-Bük, 2016). The many quality-related tasks and procedures need to be integrated in order to meet TQM's goals (Chen et al., 2022). The design, development, improvement, assurance, monitoring, and maintenance of all quality applications are all included in TQM's focus on managing quality standards and guidelines (Dale, 2015, Toni et al., 2021). According to José, (2005) and Ahmed et al., (2018), TQM strives to accomplish the right thing correctly the first time and every time. The company can reduce the time required to fix mistakes, alter faulty products, and enhance services by implementing the concepts of complete quality management (Khalaf & Salem, 2018). The company may decide to establish its own quality requirements based on a set of globally accepted standards, like those established by the International Organization for Standardization (Vanagas & Žirgutienė, 2015; Alauddin & Yamada, 2022) .The following is a summary of the fundamentals of Total Quality Management (TQM): supplier

relationship management, strategic planning, continuous improvement, employee engagement, continuous communication, training, customer focus, decision-making, methodology, and tools (Hashmi, 2007; Shankhdhar et al., 2022). The provision of a work environment that guarantees the success of quality implementation is a critical function of top management assistance in accomplishing Total Quality Management (TQM) objectives (Ababneh, 2021). Performance of the Supply Chain Enhancing supply chain performance means making the product available, reacting fast to customer needs, offering the necessary variety, making use of production capacity, and delivering the necessary products on schedule in order to effectively and efficiently meet the needs of the end customer (Gunasekaran et al., 2004). Assessing the overall operating level of the company's units, evaluating the performance of each unit, and figuring out where each unit fits into the supply chain are all necessary steps in measuring supply chain performance (Hervani et al., 2005; Abdirad & Krishnan, 2022). An efficient method for gauging supply chain performance has been devised by (Wagner & Bode, 2008). and encompasses a wide range of measures at the operational, tactical, and strategic levels. Metrics at the strategic level concentrate on how well an organization's management follows organizational supply chain management goals, gets senior management's support, and notifies the majority of employees of decisions about new or modified policies. Everything pertaining to the distribution of resources and evaluation of performance in accordance with preset goals and standards is covered by tactical level metrics. Operational metrics, on the other hand, are associated with all aspects of the organization's daily operations (Wagner & Bode, 2008). The planning and execution procedures need to be connected to the supply chain performance goals. The daily work routine needs to include the steps necessary to meet the supply chain performance targets (Cai et al., 2009). Therefore, supply chain planning, supplier selection, and supplier integration serve as markers for the chain's performance in managing costs and assets as well as its dependability, responsiveness, and flexibility (Cagnazzo et al., 2010). Hence, we assume that:

H_4: *TQM positively affects SCP.*
H_5: *TQM moderates the relationship between SCF and SCP.*
H_6: *TQM moderates the relationship between SCG and SCP.*
H_7: *TQM moderates the relationship between GSCPs and SCP.*

Fig. 1 shows the relationships in the proposed model.

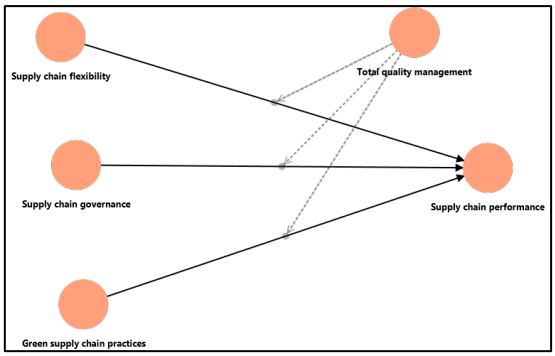

Fig. 1. Research model

3. Methodology

3.1 Design

The study employed a quantitative paradigm approach with a positive methodology. The goal of the study was to determine how SCP is directly impacted by GSCPs, SCF, SCG, and TQM. Using correlation methodology, it is also possible to ascertain the impact of GSCPs, SCF, and SCG on SCP in medium-sized industrial businesses in the Kingdom of Saudi Arabia.

3.2 Sample

The study employed stratified random sampling and systematic sampling with a sample size of forty medium-sized industrial businesses serving as the unit of analysis. Out of the 400 responders that were targeted, 344 questionnaire forms were found; 56 of them had missing pages. 32 of the 344 questionnaire forms were deemed unsuitable for processing, while 312 of the questionnaires were allowed for study. Convenience sampling, a non-probability sampling technique, was used to gather data. Samples were chosen effectively and economically by utilizing the Saudi Arabia Chamber of Industry and Commerce's database of industrial enterprises. Structural equation modeling was done in conjunction with Smart PLS 4 software (SEM). A reliability coefficient of 0.87 was used to assess the tool's dependability. By assessing the study variables using widely accepted concepts and consulting subject matter experts on the research phenomenon, the content validity of the findings was confirmed. Smart PLS 4 analysis tools were used to characterize the study's outcomes.

3.3 Data collection tool

Using specially designed questionnaires, data was gathered from middle and senior management of particular medium-sized businesses in Saudi Arabia. Three independent variables, a dependent variable, a modified variable, and five questions divided

among each variable made up the total of five variables. A five-point Likert scale was used in the questionnaire's design, and responses could range from “strongly disagree” (1) to “strongly agree” (5). The purpose of the questions was to find out how the SCP of medium-sized industrial businesses in the Kingdom of Saudi Arabia was affected by GSCPs, SCF, SCG, and TQM. The data collection process took place between February 2024 and May 10, 2024, and was made possible by a Google form created especially for industrial institution personnel and supply chain partners. Employees and stakeholders in medium-sized supply chains received the questionnaire through email and social media.

Overall, 5 items were adopted for the “GSCPs” variable from (Feng et al., 2018), 5 items were adopted for the “SCF” variable from (Queiroz et al., 2023), 5 items were adopted for the “SCG” variable from (Lu et al., 2024), while 5 items were adopted for the modified variable “TQM” from (Shankhdhar et al., 2022). For the dependent variable “SCP”, 5 items were approved (Bastas & Liyanage, 2018). Appendix 1 shows the items used to measure the constructs of the study.

4. Results

Using SmartPLS 4.0, partial least squares-structural equation modeling (PLS-SEM) was used to analyze the data. A two-step procedure was used to analyze the data (Hair et al., 2017). Data analysis was conducted using the partial least squares (PLS) method with SmartPLS version 2.0 3 M, following the recommendation by Ringle et al. (2005). PLS-SEM is widely utilized in management research due to its numerous advantageous characteristics (Al-Kahtani & Al-Mekhlafi, 2024; Al-Kahtani et al., 2024; Al-Swidi et al., 2023; Goaill et al., 2023). Evaluating the measurement model comes first, and testing the structural model comes second.

4.1 Measurement model analysis

In accordance with Hair et al. (2017)'s advice, the measurement model was assessed for validity, including convergent and discriminant validity, and reliability. Fig. 2 shows the measurement model. For reliability, it was assessed using composite reliability (CR), where the values should be greater than 0.07, and Cronbach's alpha (CA), which was also greater than 0.07. Cronbach's alpha (CA) values ranged from 0.879 to 0.916, exceeding the acceptable threshold of 0.7 (Nunnally & Bernstein, 1994). Similarly, according to Hair et al. (2010), composite dependability (CR) values are higher than the permissible limit of 0.7. According to Hair et al. (2017), convergent validity is evaluated by extracting the mean variance and utilizing loadings. Factor loadings for every item were greater than the suggested threshold of 0.773 and 0.900. Values of AVE surpass the permissible threshold of 0.5. These findings show that the measurement model's validity and reliability are good.

Table 1
Convergent validity

Variable	Code	Factor loading		Cronbach’s alpha	CR	AVE
GSCPs	GSCPs1	0.832				
	GSCPs2	0.845				
	GSCPs3	0.820				
	GSCPs4	0.839				
	GSCPs5	0.853	76.468	0.894	0.895	0.702
SCF	SCF1	0.779				
	SCF2	0.773				
	SCF3	0.876				
	SCF4	0.887				
	SCF5	0.830	77.293	0.887	0.891	0.690
SCG	SCG1	0.792				
	SCG2	0.841				
	SCG3	0.800				
	SCG4	0.842				
	SCG5	0.826	75.475	0.879	0.883	0.673
SCP	SCP1	0.821				
	SCP2	0.848				
	SCP3	0.867				
	SCP4	0.887				
	SCP5	0.843	78.650	0.907	0.907	0.728
TQM	TQM1	0.835				
	TQM2	0.849				
	TQM3	0.870				
	TQM4	0.900				
	TQM5	0.872	76.856	0.916	0.917	0.750

Furthermore, the discrminant validity was evaluated using the Heterotrait-Monotrait ratio (HTMT). Henseler et al. (2015) state that in order to evaluate discriminant validity, the acceptable threshold HTMT for all values in the matrix must be less than 0.90. Consequently, Table 2 presents the findings of the HTMT Criterion, demonstrating the research model's validity (Henseler et al., 2015).

Table 2
Discriminant validity-HTMT criterion

Variable	GSCPs	SCF	SCG	SCP	TQM
GSCPs					
SCF	0.948				
SCG	0.961	0.914			
SCP	0.958	0.917	0.917		
TQM	0.967	0.945	0.943	0.957	

The discriminant validity of the model was assessed by applying the criteria established by Fornell and Larcker (1981). The requirements state that each construct's square root of the AVE must be greater than the correlation coefficients among the components. The square roots of the AVE values which are bolded for each construct are represented by the diagonal values in Table 3. Discriminant validity was satisfied when each construct's square root of the average variance extracted (AVE) was greater than its correlation with the other constructs (Fornell & Larcker, 1981).

Table 3
Discriminant validity-Fornell and Larcker criterion

Variable	GSCPs	SCF	SCG	SCP	TQM
GSCPs	0.838				
SCF	0.843	0.830			
SCG	0.855	0.809	0.821		
SCP	0.863	0.823	0.823	0.853	
TQM	0.875	0.852	0.849	0.873	0.866

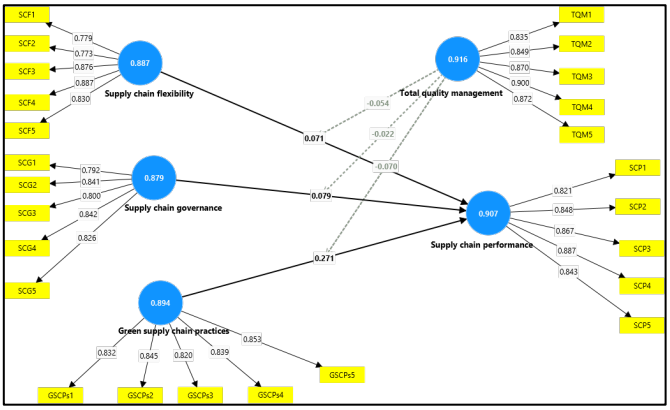

Fig. 2. Measurement model

Using a set of indicators from SmartPLS 4, we assessed model fit inside the PLS-SEM framework. A crucial metric that represents the covariance between the observed correlations and the correlation matrix that is implicit in the model is the standardized root mean square residual, or SRMR (Hair et al. 2016). Considering that values less than 0.08 typically imply an acceptable fit, the saturated model's SRMR value of 0.059 represents a remarkable fit (Hu & Bentler, 1998). The saturated model's SRMR value, which is 0.113, is much larger than the estimated model's, suggesting a large good match. According to Bentler and Bonett's (1980) ideal criterion of 0.90, the normed fit index (NFI) assesses model fit by examining Chi-square values in relation to the null or standard model (Lohmoller, 1989). The estimated model showed greater values of 1.080 for d_G and 2.105 for d_ULS, further supporting the Saturated model's superior relative fit. The Saturated model reported d_G and d_ULS values of 0.916 and 1.113, respectively. This view is supported by the Chi-square values, which show that the Saturated model has a value of 1777.455 while the Estimated model has a value of 1842.681.This suggests that the PLS-SEM model's goodness-of-fit magnitude was appropriate for proving the global PLS model's overall validity. Table 4 provides a summary of the findings.

Table 4
Model fit

	Saturated model	Estimated model
SRMR	0.059	0.080
d_ULS	1.113	2.105
d_G	0.916	1.080
Chi-square	1777.455	1842.681
NFI	0.782	0.774

4.2 Structural model analysis

In this stage, model fit was investigated. R2 values were used to evaluate the model fit of the structural model (Fig. 3) before testing the hypotheses, as shown in Table 6.

In order to verify the features of the measurement model, Hair et al. (2018) used the structural model to assess the proposed correlations between constructs. R2 values of 0.836 were used to assess how well the structural model fit the data. the portion of the dependent variable's endogenous volatility that the R^2 value accounts for. Furthermore, the predictive power of the model was assessed using Stone-Geisser's (Q2). The endogenous constructs' Q^2 values, according to Peng & Lai (2012), are SCP (0.950), which denotes sufficient prediction and is greater than zero (see Table 5).

Table 5
R^2 and Q^2

Variable	R^2	Q^2
SCP	0.836	0.950

Table 5
Hypothesis testing

H	Effects	beta	S.d	T	P values	
H1	GSCPs → SCP	0.271	0.058	4.635	0.000	Supported
H2	SCF → SCP	0.071	0.054	1.318	0.188	Not Supported
H3	SCG → SCP	0.079	0.048	1.655	0.098	Not Supported
H4	TQM → SCP	0.245	0.062	3.975	0.000	Supported
H5	TQM × SCF → SCP	-0.054	0.060	0.907	0.364	Not Supported
H6	TQM × SCG → SCP	-0.022	0.050	0.451	0.652	Not Supported
H7	GSCP × GSCPs → SCP	-0.070	0.062	1.136	0.256	Not Supported

5. Discussion

The first hypothesis is that "GSCPs positively affect SCP." The study proved that GSCPs positively affect SCP. The study proved that the relationship between GSCPs and SCP is positive, where (beta value = 0.271; T = 4.635; P < 0.05), that is, GSCPs have a positive and significant effect on SCP, and as a result, the first hypothesis was accepted and is supported.

According to the first hypothesis, the current study's findings concurred with those of previous research (Feng et al., 2018; Baah et al., 2020; Agyabeng-Mensah et al., 2019a, b, c). According to Srivastava (2007), every one of them supported the significance of GSCPs in SCP. Another gift is that corporations are adopting global rules primarily to improve supply chain efficiency; adhering to international standards minimizes the negative environmental effects of corporate operations without compromising quality. Prior research (Green et al., 2012; Vachon & Klassen, 2008; Yu et al., 2014; Zailaniet al., 2012) indicates that GSCPs improve operational processes with regard to quality, cost, delivery, and flexibility. According to Vachon and Klassen (2008), improving quality, delivery, and flexibility in the four traditional dimensions of supply chain performance in the manufacturing industry is linked to green supply chain collaboration. In this regard, the results of the current study are in line with those of earlier research. According to Abdullah and Al-Ghuwayn's (2019) research, GSCPs have a marginally favorable impact on SCP. This finding runs counter to the current study's findings, which showed that GSCPs significantly improve SCP while finding a negative association between GSCPs and SCP in Jordanian manufacturing firms. The present study's findings also corroborated findings from research conducted in China ((Lai & Wong, 2012; Yu et al., 2017), Thailand (Laosirihongthong et al., 2013), Korea (Lai et al., 2012), Japan (Jabour et al., 2017), and the United States. According to American research (Green et al., 2019), GSCPs significantly and favorably impact SCP.

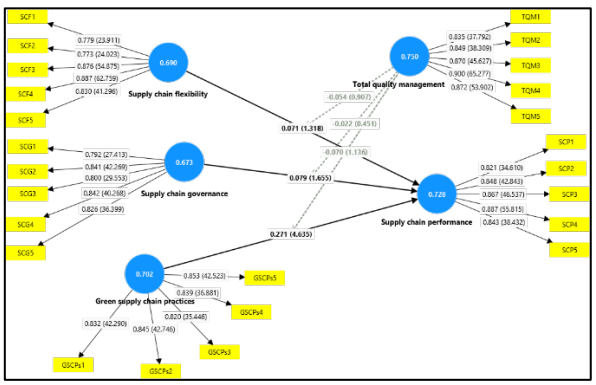

Fig. 3. Structural model

The second hypothesis is that “SCF positively affects SCP.” The study proved that SCF does not positively affect SCP. The study proved that the relationship between SCF and SCP is a positive relationship, where (beta value = 0.071; T = 1.318; P > 0.05), i.e. That SCF does not have a positive and significant effect on SCP, and as a result, the second hypothesis was rejected, which is an unacceptable and unsupported hypothesis. The current study's findings regarding the second hypothesis were in line with those of (Xiao et al., 2012; Cui et al., 2022; Barhmi, 2023) research, all of which established that (SCF) influences (SCP) and that there is a positive relationship between the two. Our findings support the hypothesis that supply chain operations, as discussed in the works of Zhang & Okoroafo (2015) and Sabry et al. (2021), significantly improved operational efficiency and effectiveness. This is because the results of the current study related to the second hypothesis agreed in the context of supply chain performance. The present study's findings concurred with those of Tukamuhabwa et al. (2015) and Mukhsin et al. (2022). As stated by Luo et al. (2020), who all emphasize the significance of SCF in SCP Flexibility in the supply chain is essential for ensuring that the business can react swiftly to shifts in supply and demand. In SCF, the firm's SCP and the supply chain both benefit (Mukhsin et al., 2022). SCF is necessary for businesses to be able to adjust to the demands of their customers and shifting market conditions, particularly in times of uncertainty, (Luo et al., 2020).

The third hypothesis is that “SCG positively affects SCP.” The study proved that SCG does not positively affect SCP. The study proved that the relationship between SCG and SCP is a positive relationship, where (beta value = 0.079; T = 1.655; P > 0.05), i.e. That SCG does not have a positive and significant effect on SCP, and as a result, the third hypothesis was rejected, which is an unacceptable and unsupported hypothesis. For the third hypothesis, the current study's findings were inconsistent with other research (Keller et al., 2021). The present study's findings suggested that the SCG had no beneficial effects on the SCP, while earlier research suggested that the SCG serves as a framework for coordination and upkeep when it comes to supply chain performance and hazards. Regarding the third hypothesis, the current study's findings were inconsistent with those of previous research (Lumineau, 2014; Cao and Lumineau, 2015; Duong and Chong, 2020; Bonatto et al, 2022). All of them suggested that supply chain performance is positively impacted by SCG; nevertheless, the results of the current study showed the contrary.

The fourth hypothesis is that “TQM positively affects SCP.” The study proved that TQM positively affects SCP. The study proved that the relationship between TQM and SCP is positive, where (beta value = 0.245; T = 3.975; P < 0.05), that is, TQM has a positive and significant effect on SCP. As a result, the fourth hypothesis was accepted, which is acceptable and supported.

The current study's findings concurred with those of another study (Gunasekaran et al., 2004). Hervani et al., 2005; Abdirad and Krishnan, 2022). All of which demonstrated the significance of overall quality management and its beneficial effects on SCP. Wagner and Bode (2008) developed an efficient technique for assessing supply chain performance. Improving supply chain efficiency entails having the product available and reacting fast to consumer demands. Meeting customer needs effectively and efficiently means offering the required diversity, making use of manufacturing capacity, and delivering the required products on time. last client.

The fifth hypothesis is that “SCF positively affects SCP when using a modified variable TQM.” The study proved that SCF does not have a positive effect on SCP when using a modified variable TQM. The study proved that the relationship between SCF and SCP when using a modified variable TQM is a negative relationship, where (the value Beta = -0.054; T = 0.907; P > 0.05), and SCF does not have a positive and significant effect on SCP when using the modified variable TQM. As a result, the fifth hypothesis was rejected, which is an unacceptable and unsupported hypothesis.

The sixth hypothesis is that “SCG positively affects SCP when using a modified variable TQM.” The study proved that SCG has no positive effect on SCP when using a modified variable TQM. The study proved that the relationship between SCG and SCP when using a modified variable TQM is a negative relationship, where (Beta value = -0.022; T = 0.451; P > 0.05), meaning that SCG does not have a positive and significant effect on SCP when using TQM as a modified variable. As a result, the sixth hypothesis was rejected, which is an unacceptable and unsupported hypothesis.

The seventh hypothesis is that “GSCPs positively affect SCP when using a modified variable TQM.” The study proved that GSCPs do not have a positive effect on SCP when using a modified variable TQM. The study proved that the relationship between GSCPs and SCP when using a modified variable TQM is a negative relationship, where (Beta value = -0.070; T = 1.136; P > 0.05), meaning that GSCPs do not have a positive and significant effect on SCP when using TQM as a modified variable. As a result, the seventh hypothesis was rejected, which is an unacceptable and unsupported hypothesis.

6. Conclusion

Finding out how SCF, SCG, GSCPs, and TQM directly impact SCP is the aim of the research. Realizing the minimal effect of TQM on the connections between SCF, SCG, SCP, and GSCPs in medium-sized Saudi industrial firms is another thing. The samples were chosen using a database of industrial businesses in Saudi Arabia. The study included statistical modeling, and the hypotheses were assessed using Smart PLS 4 software and structural equation modeling (SEM). The study came to the conclusion that while SCF and TQM do not directly benefit SCP, GSCPs and SCG do have a favorable, significant, and direct impact on SCP. Additionally, the study discovered that TQM modifies the connection between SCF, SCG, SCP, and GSCPs.

6.1 Theoretical implications

By establishing synergies between SCP and SCF, SCG, TQM, and GSCPs, this research adds to the body of information already available in these areas. Additionally, the study balances the literature by proposing a complicated model that incorporates GSCPs, SCF, SCG, TQM, and SCP from the viewpoint of a powerful economy like Saudi Arabia. Furthermore, this study made a significant contribution by investigating the moderating effects of TQM between GSCPs, SCF, SCG, and SCP. Previous research in the field did not take GSCPs into account as an antecedent of TQM and SCP. Furthermore, as Inman and Green (2018) suggested further research, analyzing the connections between GSCPs, SCF, SCG, TQM, and SCP is also an important contribution to knowledge in supply chain and production. Since no prior research has examined them together in Saudi industrial companies or in any other companies in the Kingdom of Saudi Arabia, this study's examination of the synergy between GSCPs, SCF, SCG, TQM, and SCP is a significant contribution to the literature. This sets the current study apart from other studies prior.

6.2 Practical implications

The findings of this paper offer managers a positive foundation for adopting SCF, SCG, GSCPs, and TQM in order to encourage green strategy (Green et al., 2019) as GSCPs to achieve higher TQM and SCP. This paper has consequences for practitioners of SCF, SCG, TQM, and GSCPs. It is commonly known that GSCPs and TQM and SCP have a good and substantial relationship since they work together to lower costs and boost market share, sales, and profitability. Businesses are encouraged to use TQM, SCF, SCG, GSCPs, lower batch sizes, shorten setup times, get rid of all waste, cut production costs, and guarantee better product delivery, all of which will increase supply chain performance and profitability. Additionally, the study suggests that managers implement Just-in-Time (JMTM) initiatives like customer focus, which results in the creation of products and services that raise customer satisfaction through better quality and lower costs of products and services, increasing market share and sales, which impacts profitability and return on assets. In order to improve a company's ability to reduce the environmental effects of its products and activities, the study also encourages managers to simultaneously implement GSCPs, SCF, SCG, and TQM. This will help the company reduce waste, improve product quality, lower commodity prices, and guarantee faster product delivery. to enhance SCP. This implies that businesses can improve both SCP at the same time by implementing GSCPs along with SCF, SCG, and TQM. In order to maximize the advantages of global quality standards, the findings recommend businesses to match them with TQM (Inman and Green, 2018; Larson & Greenwood 2004).

6.3 Limitations

It is acknowledged that the limitations of this study pave the way for future research opportunities. Firstly, this paper utilized a quantitative approach for analysis and investigation; future studies could adopt qualitative or mixed methods for a more in-depth exploration of related issues. Secondly, data was collected from employees in Saudi medium-sized industrial firms. Expanding the data collection to include multiple countries could enhance the study's scope and generalizability. Lastly, this study was conducted in Saudi Arabia, a developing country, therefore, it is difficult to generalize the results for developed or even less developed countries.

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Appendix 1:

Questionnaire and references

	Green supply chain practices	**References**
GSCPs1	Our company designs products aimed at reducing the environmental impact of the product.	Feng et al., 2018
GSCPs2	Our company adopts green purchasing with suppliers to produce sustainable green products.	
GSCPs3	Our company relies on credit and investment in green supply chains.	
GSCPs4	Our company leaves proactive engagements as the foundation of the entire green supply chain management transformation process	
GSCPs5	Our company engages in a process of cooperation with its customers with the aim of meeting customers' environmental requirements.	
	Flexibility of supply chains	**References**
SCF1	Our company provides flexibility of supply to meet changes in customer needs.	Queiroz,et,al., 2023
SCF2	Our company handles complex orders that meet different specifications to meet customers' needs.	
SCF3	Our company achieves a balance between production capacity on the one hand and supply chain energy on the other.	
SCF4	Our company moves production units into the supply chain in response to environmental changes.	
SCF5	Our company adapts and organizes different methods of building information systems to the company's purposes.	
	Supply chain governance	**References**
SCG1	Our company uses governance to coordinate and monitor the behavior of supply chain partners.	Lu et al., 2024
SCG2	Our company plans and implements supply chain operations towards common goals.	
SCG3	Our company uses contractual governance for monitoring purposes and providing responsibilities.	
SCG4	Our company uses relational governance to increase information sharing on the behaviors of supply chain partners. Our company facilitates information exchange to address and enhance supply chain disruptions.	
SCG5	Our company facilitates information exchange to address and enhance supply chain disruptions.	
	Total Quality Management	**References**
TQM1	Our company is interested in continuous improvement of its products.	Shankhdhar et al., 2022
TQM2	Our company reduces production and supply chain costs.	
TQM3	Our company seeks to increase customer satisfaction.	
TQM4	Our company provides high quality products.	
TQM5	Our company meets customers' needs at the right time and place.	
	Supply chain performance	**References**
SCP1	Our company emphasizes the ability of the supply chain to provide the right product effectively and efficiently.	Bastas,and Liyanage , 2018
SCP2	Our company reduces supply chain logistics costs.	
SCP3	Our company develops efficient supply chain to increase supply chain performance.	
SCP4	Our company is interested in performing logistics services to perform the supply chain.	
SCP5	Our company reduces costs and improves product quality through efficient supply chain performance.