Does increasing supply chain flexibility contribute to the enhancement of a firm's sustainability performance?

Abstract

The study empirically examines whether increased supply chain (SC) flexibility correlates with improvements in an SC's ability to address a firm's sustainability performance (SP). In addition, we investigate how SC visibility impacts a firm's SP by way of enhancing SC agility in the model. SC flexibility plays a vital role in SC operations to achieve sustainability. However, there is a limited understanding of the effects of SC flexibility on SP. The study explores the moderating roles of SC flexibility and environmental uncertainty in the connections between SC visibility, SC agility, and SP within the research framework. We use the Partial Least Squares Structural Equation Modelling (PLS-SEM) technique to validate both the measurement and structural models. Besides, the mediation analysis, moderation analysis and multi-group analysis are employed to test the various effects in the model. The results indicate the positive and significant relationships among SC visibility, SC agility and the organisation's SP in the model. The significant moderating effects of SC flexibility on the relationships among SC visibility, SC agility, and the organisation's SP are identified in this study. Our findings show that increasing SC flexibility could potentially pose challenges. We argue that increasing SC flexibility cannot always help an organisation's SP, furthermore, firms with high SC flexibility may perform worse than firms with low SC flexibility in terms of a firm's SP. The study provides valuable insight into sustainable SC management and contingency management post-COVID-19 pandemic, especially drawing attention to SC flexibility.

Keywords: supply chain, visibility, flexibility, agility, sustainability performance

Managerial relevance statement

When striving to bolster supply chain capabilities for the enhancement of sustainability performance, managers must adeptly navigate potential challenges and risks. The study indicates that SC visibility and SC agility play a pivotal role in contributing to sustainability performance post COVID-19. However, supply chain flexibility may not consistently yield positive impacts on sustainability performance, especially when considered in conjunction with other capabilities. The findings from our study suggest that firms endowed with high supply chain flexibility may face the outcome of performing worse in sustainability measures compared to those with lower supply chain flexibility. This insight highlights the importance of striking a balance between supply chain flexibility and a strategic commitment to sustainable

practices (or other capabilities) to optimize overall sustainability performance. While supply chain flexibility is valuable, achieving the right equilibrium is crucial to ensure that supply chain flexibility does not jeopardize long-term sustainability goals.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

1. Introduction

The global economies and supply chains (SCs) have been profoundly impacted by the devastating effects of the COVID-19 pandemic [1]. Many firms worldwide have recognised the crucial importance of building a resilient SC [2]. We have entered a post-pandemic era. The post-pandemic business environment is characterised by unprecedented complexity and uncertainty, requiring organisations to reassess and adjust their operating strategies. SC flexibility is often reorganised as an important capability to address those uncertainties and adjust strategies [3, 4]. In the dynamic business landscape of the post-epidemic era, with a growing awareness of environmental concerns, the integration of sustainability into business practices has become imperative for firms across industries [5]. As organisations strive to balance economic objectives with environmental and social responsibilities, the role of SC management emerges as a critical determinant of overall sustainability performance (SP). SC flexibility has emerged as a strategic lever for organisations to respond swiftly and effectively to changing market conditions, disruptions, and stakeholder expectations [6, 7]. While the benefits of SC flexibility in improving responsiveness and operational efficiency are well-established [8, 9], its potential impact on SP remains an intriguing and underexplored area.

According to the Contingency Theory, and the Resource-based View (RBV), managers should focus on the right capabilities to generate competitive advantage [10]; also capture the changing pace, achieve alignments and good fits, and respond to various changes to enhance the firm's performance [11, 12]. Bag and Rahman [13] argue that dynamic capabilities play a vital role in achieving sustainable development. It's important to understand the impact these capabilities have on the firms [14]. SC visibility is a crucial capability for facilitating communication and sharing information within SCs [15]. SC agility is recognised as an important capability for managing and mitigating SC disruptions and one of the most crucial SC capabilities in the post-pandemic era [16]. These SC capabilities are closely linked to disruptions, SC transparency, and resilience in the aftermath of COVID-19 [15, 17, 18].

While the significant advantages of incorporating SC flexibility are evident [8, 13], it is important to note that SC flexibility could potentially exert adverse effects on performance [19]. For instance, while SC flexibility can enhance adaptability, it may also lead to increased SC complexity [20], which may negatively impact performance [21]. In addition, flexibility may increase costs [22]. Tang and Tomlin [23] contend that the majority of advantages are realised when flexibility is maintained at lower levels. Furthermore, the pursuit of SC flexibility could introduce operational uncertainties, as organisations may need to diversify their offerings to enhance adaptability.

The objective of the study is to revisit the important concepts of SC capabilities, encompassing visibility, agility, and flexibility [14], and delve into the connections between these capabilities and the sustainability performance (SP) of firms, and empirically verify the impact of SC flexibility on these SC capabilities and SP. Past studies have indicated that the impact of SC flexibility on performance yields mixed results [19, 23]. There is a limited body of empirical research that explores the moderating effects of SC flexibility within the realm of SC management and sustainability practices. To bridge these gaps in knowledge, this research seeks to delve into the intersection of SC capabilities and sustainability outcomes by posing a fundamental question: Does increasing SC flexibility contribute to the enhancement of a firm's SP?

To tackle the research question, we develop a research conceptual framework (Figure. 1). Within this framework, SC flexibility and environmental uncertainty (EU) are treated as moderating variables. We examine the mediating effects of SC agility, as well as the moderating effects of SC flexibility and EU in the research model. The presence of the EU is widely acknowledged as a significant concern in logistics and SCs [7, 24]. SC flexibility may cause both beneficial and detrimental effects in SCs [19]. In this study, we posit that SC flexibility is important, but it does not always provide benefits in SC operations. More importantly, our results show that it has significant negative impacts on the relationships between SC visibility, SC agility and SP. The muti-group analysis results affirm that SC visibility, agility, and flexibility may mitigate EU. By evaluating the ways in which increased flexibility in the SC may influence a firm's ability to address a firm’s SP, we seek to provide insights that can inform both theory and practice.

The remainder of this paper is structured as follows: Section 2 will conduct a review of pertinent literature and present the theoretical foundation. In Section 3, we will establish a research model and outline the development of hypotheses. Section 4 will detail the research methodology and the instruments used. Following that, Section 5 will present the research

findings. Sections 6 and 7 will delve into the key discoveries, research implications, and limitations of the study.

2. Theoretical background

The RBV, triple bottom line approach and contingency theory provide a theoretical foundation for this study. Organisations must have superior resources and the right capabilities to develop sustainable competitive advantage [10, 25, 26]. Meanwhile, managers must respond to SC disruptions and fluctuating environments quickly post-COVID-19 [15]. Implementing the principle of adapting to changing circumstances from contingency theory underscores the importance of supply chain flexibility in meeting both internal and external customer demands. Nonetheless, it's essential to acknowledge that while supply chain flexibility is vital, it can also introduce complexity into operations [4]. As market conditions, societal expectations, and regulatory environments evolve, adjust SC strategy to remain effective and aligned with the organisation's mission and right capabilities. SC visibility is a key capability to facilitate agility [27], promote sustainability [28], and anticipate and mitigate disruption impacts [29]. The research model integrates SC visibility, SC agility, SC flexibility, EU, and the SP of the firm.

2.1. SC visibility

The role of SC visibility is growing in significance within the field of SC management [27, 30, 31]. It enables firms to better manage SC risk and uncertainty [1, 27]. A lack of SC visibility could hinder the ability to adapt to changes and effectively address disruptions in SCs [32]. It has been closely associated with trust, traceability, SC relationships, transparency, SC integrity, and SC performance. SC visibility is characterised by cooperation, exchange of information, and establishment of trust among partners. This capability holds the promise of eliminating obstacles and enhancing the efficiency of various processes within an international SC network, including collaborative planning, customer integration, responding to demand, and managing inventory levels. [33]. The SC is a complex system, that contains various processes, entities, and stakeholders [34, 35]. Efficient and effective SC management must involve and access end-to-end SC processes [35, 36]. SC visibility can enable efficient and effective SC management. For instance, SC visibility may improve SC transparency [18], and SC responsiveness [37], and enable companies to better collaborate and cooperate in a SC to achieve sustainable competitive advantage [38]. SC visibility may contain supply visibility and demand visibility, which are crucial factors contributing to a firm's innovation performance

[39]. By leveraging advanced technological solutions, organisations can achieve greater SC visibility and insight into the entire SC process [40].

The concept of visibility has often been used interchangeably with the practice of information sharing [35, 38]. It is closely associated with SC transparency and sustainability, enhancing the transparency of their SC operations is a way for companies to demonstrate their dedication to sustainability to stakeholders [18]. Having visibility into its supply chain is key for a company to be able to become transparent [28]. In previous studies, SC visibility was defined as a potential outcome of information sharing across the SC, it may lead to a more effective SC [38, 41]. Information sharing in a firm and between firms supports SC integration and improves firm performance [36]. Information sharing facilitates SC collaboration and cooperation [41]. In addition, achieving SC visibility necessitates the presence of high-quality information within the SC [37]. It includes collecting, storing and disseminating information across SCs [42]. Information exchange within the SC can be characterised by two primary attributes: connectivity and willingness [41, 43]. Firms need to gather useful information from the downstream SC (demand visibility) and upstream SC (supply visibility) [18, 37]. Both visibility of demand and supply are required to manage the dynamic operation [42, 44]. Swink, Sant'Ana Gallo, Defee and Silva [27] summarise types of SC visibility including demand visibility, supply visibility, process visibility, product visibility, and risk visibility. Technology plays a crucial role in enhancing SC visibility [40, 45-47]. Additionally, SC visibility enables the disclosure of information across all tiers to enhance SP [18]. This includes providing environmental data, such as carbon emissions, pollution, and energy usage, which aids firms in monitoring and managing their SP within SCs. SC visibility and SP are interconnected aspects that organizations are increasingly considering to create more responsible and efficient SC practices [48]. In this study, SC visibility is defined as a company's ability to efficiently process and distribute valuable SC information, both within the organisation and among SC stakeholders. This approach is intended to bolster customer value and foster sustainable competitive advantages.

2.2. SC agility

SC agility represents a strategic competitive prowess, empowering enterprises to deliver tailored and exceptional quality products with efficiency and within stipulated timeframes [49]. Swafford, Ghosh and Murthy [50] posit that SC agility encompasses the capability of a SC to swiftly adapt to changes in the environment. Additionally, it entails cooperation with suppliers to rapidly address alterations [5, 33]. Agility provides support to firms within SCs for making

timely decisions and attaining sustained effectiveness. In highly uncertain environments, it is strongly advised that firms adopt the agility capability [51]. SC agility can be perceived as an outwardly oriented capability, whereas SC flexibility is an inwardly focused competency. SC agility encompasses collaborative planning, demand responsiveness, and responsiveness [5, 33, 51]. Those agile practices often involve optimising resource utilisation. By efficiently using resources, organisations can minimize waste and reduce their environmental impact.

Modern SCs perpetually encounter a multitude of risks and fluctuations, including factors such as emerging markets, policy reforms, innovation trends, the repercussions of new technologies, natural disasters, events like the Russian invasion of Ukraine, the US-China trade conflict, the COVID-19 pandemic, and Brexit. By fostering SC agility, firms can strategically tackle challenges in their decision-making processes, leading to enhanced responsiveness in the face of both intra- and inter-organisational changes [14, 52]. Sustainability is closely linked to the ability to respond and adapt to changing environmental, social, and economic conditions. SC agility allows firms to quickly adjust their strategies, processes, and product offerings in response to evolving sustainability challenges and opportunities [53]. Furthermore, SCs that embrace agility are more prone to promoting sustainability [5]. This can lead to the development of sustainable products and services that meet market demands for environmentally friendly alternatives. This paper defines SC agility as the organisation's ability to promptly adapt and respond to various internal and external dynamics, encompassing factors such as customer requirements, market fluctuations, internal processes, and unexpected disruptions. Balancing SC agility with SP requires organizations to find synergies between responsiveness and responsible practices. It involves making sustainable choices without compromising the ability to quickly adapt to market changes which results in high firm performance [54].

2.3. Firm’s SP

Performance can be measured from different perspectives and metrics [55]. Conventionally, a firm’s performance measures focus on financial metrics, profitability and growth [3]. The indicators often include profit, return on sales, or operational costs, which assess organisational performance. More and more companies need to consider sustainability and corporate social responsibility in their overall performance evaluation post-COVID-19 pandemic [5]. Bassioni, Price and Hassan [56] suggest that stakeholder focus– customer and other stakeholders should be considered in performance measurement. SP encompasses conventional financial metrics, as well as metrics related to social and environmental

performance. The evaluation of the firm's performance is conducted through SP, which is a comprehensive assessment grounded in the triple bottom line framework [57] and stakeholder theory [58]. In this study, the firm's SP denotes the comprehensive evaluation of sustainability [59]. In line with the triple bottom line concept, SP encompasses corporate economic, social and environmental performance [60]. This assessment also takes into account various stakeholders' interests, aligning with the principles of stakeholder theory [59, 61]. From the perspective of stakeholder theory, stakeholders include both internal and external stakeholders in an organisation, such as customers, shareholders, investors, competitors, staff, community, and government [56, 59], the performance indicators we used to measure different stakeholders' interests, such as customer satisfaction, profitability, market competition, employee job satisfaction, social and environmental responsibility, they represent an overall firm's SP.

2.4. SC flexibility

SC flexibility has been extensively studied in the field of manufacturing [3, 9]. However, SC flexibility is a complex and multi-dimensional concept [62, 63]. For example, various dimensions of SC flexibilities encompass product flexibility, volume flexibility, launch flexibility, access flexibility, delivery flexibility, and target market flexibility, Vickery, Calantone and Dröge [64] argue that SC flexibility should encompass the flexibilities that directly impact the customers, internal and external stakeholders (e.g. manufacturing, sales, SC partners, suppliers, etc.). Martínez Sánchez and Pérez Pérez [20] posit that SC flexibility includes two main aspects: process flexibility and logistics flexibility. Liao, Hong and Rao [9] delve deeper into supply flexibility examining two key components: supplier flexibility and supply network flexibility.

SC flexibility refers to the extent to which a firm efficiently meets its customers' demands by adeptly managing the capabilities of multiple organisations within the SC [65]. It represents the SC's capacity to accommodate alterations in product offerings. Collaborative endeavours across functions and organizations are committed to enhancing SC flexibility in response to swiftly evolving market dynamics [9]. Sharma, Luthra, Joshi, Kumar and Jain [63] define SC flexibility as the ability to adapt logistics capacity to fulfil customer demand and indicate that a positive moderating effect of SC flexibility on the green logistics practices and Circular Economy practices relationship. Cui, Wu and Dai [66] offer flexible decisions for supplier selection, this may improve the overall SC sustainability. SC flexibility was shown to have a positive effect on firm performance [20, 67] and SC agility [33]. From a strategic standpoint,

SC flexibility can empower a company to provide adaptability in both product offerings and collaborative problem-solving approaches [65], enhance circular economy target performance [13], and adjust and respond rapidly to changes in demand and supply [3, 9]. SC flexibility also has been recognised as a crucial dynamic capability in the context of the circular economy, it provides firms with the capability to reconfigure assets and influence SP [13]. However, the question of whether flexibility is advantageous from an overall (supply chain) standpoint does not have a straightforward or unconditional answer [3]. This study views SC flexibility as a moderator to enhance the understanding of its effects within this research model. We adopted and developed the measurement items from previous studies [4, 65].

2.5. Environmental uncertainty

The notion of the EU has been a subject of extensive discourse within academic literature for a significant period [68, 69]. In this study, EU refers to the uncertainty aroused by the external environment [70, 71]. For example, The COVID-19 pandemic represents a form of EU within the SC [1], and it has drawn a lot of attention to the EU in global SCs [72]. The measurement items of the EU were adapted from previous research [73, 74]. The EU may include infrastructure capability shortage, extreme weather, natural disasters/ industrial action, and regulation/government [74]. Apart from the COVID-19 pandemic, the post-COVID-19 pandemic world environment will become more volatile and influenced by many other unpredictable events, such as China–United States trade war, Brexit, the Russian invasion of Ukraine, etc. and many more unknown unknowns in the future. EU is viewed as a moderator in the study. The contingency effects of the EU are examined to better understand the underlying mechanics and associations among constructs in the study.

3. Hypothesis development

3.1. SC visibility and SP

SC visibility is the main driving force for achieving sustainable performance [28, 42]. SC visibility allows firms to gain insight into the practices of their suppliers and other partners in the SC [28]. This transparency promotes accountability, encouraging sustainable practices among all participants [40]. SC visibility is a firm's key ability, which allows firms to access important and useful information, downstream and upstream SCs, inside and outside the firm, for managing and controlling SC operations and performance [27, 42, 75]. Information sharing and end-to-end SC visibility enable organisations to stay alert and responsive to both

opportunities and challenges within the SC and the broader business environment [37]. Enhancing SC visibility has the potential to reduce waste, thereby making a positive impact on environmental sustainability [76]. Information sharing within a firm and between firms can improve a firm's SC performance [36]. Furthermore, SC visibility positively influences sustainability by providing the information and insights necessary to enhance environmental, social, and economic performance within the SC network [27, 28]. For example: with increased visibility, organisations can more effectively monitor and enforce ethical sourcing practices. This includes ensuring fair labour conditions, ethical treatment of workers, and adherence to social responsibility standards throughout the SC. In addition, SC visibility enables firms to track and assess the environmental impact of their SC activities. SC visibility helps in identifying potential risks and disruptions in the SC, whether related to social issues, environmental concerns, or other sustainability challenges [27]. Moreover, Thus, we suggest that higher levels of SC visibility may lead to a better overall firm's SP. The following hypothesis is posited;

H1: SC visibility is positively related to the firm's SP.

3.2. SC visibility and SC agility

The post-COVID-19 era has heightened the significance of exploring the connection between SC visibility and SC agility. Firms need to improve SC agility to respond to unpredictable changes and risks post-COVID-19 [16]. SC visibility is about information sharing [41]. SC visibility ensures that relevant and real-time data is accessible across the entire SC network. Comprehensive end-to-end SC visibility enables firms to gain a deeper understanding of customer demand, supplier needs, as well as the internal and external dynamics of the SC [37, 38]. This enhanced awareness empowers them to more effectively adapt to changes. Moreover, the practice of exchanging information showcases a positive influence on the enhancement of SC agility [41]. For example: with SC visibility, organizations can proactively identify potential disruptions or bottlenecks in the SC. This enables agile planning and the ability to quickly adjust strategies, allocate resources, and implement contingency plans to address unforeseen challenges. Williams, Roh, Tokar and Swink [37] suggest that SC visibility is necessary to improve the responsiveness of a global SC. All of this indicates that elevated levels of SC visibility could lead to an enhancement in SC agility. Thus, we proposed the following hypothesis;

H2: SC visibility is positively related to SC agility.

3.3. SC agility and SP

According to the triple bottom line approach [57] and stakeholder theory [58], a firm's SP reflects how well the company react to the internal and external stakeholders' requirements and the changes in the surrounding environment. In attaining sustainable performance in the post-COVID-19 era, the pivotal role of SC agility lies in its capability to swiftly adapt and respond to changes [7, 77] as well as to potential and actual SC disruptions [33] and increase SC resilience [78]. Geyi, Yusuf, Menhat, Abubakar and Ogbuke [60] posit that a correlation exists between agile practices and SP, with agile practices exerting a positive impact on both SP and operational performance objectives. For instance, SC agility may influence SP by empowering organisations to adeptly and efficiently adapt to environmental, social, and economic changes – essential components of sustainable practices. Nath and Agrawal [79] indicate that agility practices serve as notable precursors to the development of a social sustainability orientation and contribute to the performance of social sustainability. Moreover, Kazancoglu, Ozbiltekin-Pala, Kumar Mangla, Kazancoglu and Jabeen [80] stress that SC agility plays a crucial role in effectively managing SC disruptions amid the challenges posed by COVID-19. It serves to ensure that SCs remain resilient and sustainable in the face of such uncertainties. SC agility can improve SC relationships and positively impact sustainability [5]. For example: SC agility allows organizations to quickly adapt to environmental changes, social issues and risks, whether they are related to climate conditions, regulatory shifts, or other social or economic factors. This adaptability supports sustainable practices by enabling organizations to align with evolving environmental requirements. Hence, these suggest that higher levels of SC visibility may enhance the firm's SP. We proposed the following hypothesis;

H3: SC agility is positively related to the firm's SP.

3.4. The mediation effect

In this study, SC agility acts as an intermediary factor that influences the relationship between SC visibility and SP. SC agility has become a mainstream topic for academic research [81], previous studies have examined SC visibility and SC agility [81, 82], and SC agility and SP [60] respectively. However, the examination of the mediating influence of SC agility has received limited attention. SC visibility and SC agility have been widely considered critical capabilities to address the sustainability issues in SCs post-COVID-19 [5]. SC agility mediates the relationship between SC visibility and SP by acting as an intermediary that transforms enhanced visibility into tangible sustainability outcomes. SC agility involves the ability to

quickly respond to changes, disruptions, and opportunities [5, 33]. When organisations have enhanced SC visibility, they can make informed decisions regarding sustainable practices. Agility then enables them to rapidly implement changes in response to the insights gained from visibility. The combination of SC visibility and SC agility enables organizations to not only identify sustainability-related opportunities and challenges but also to swiftly and effectively respond to them, ultimately leading to improved overall SP. Leveraging SC agility can assist companies in optimising their sustainable competitive advantage [26, 60]. Thus, we proposed the following hypothesis;

H4. SC agility mediates the relationship between SC visibility and SP.

3.5. The moderation effect

Drawing on the RBV and contingency theory, we hypothesise that SC flexibility moderates the influence of SC visibility on SC agility. SC flexibility is achieved if the key processes can adjust quickly in a SC [3, 50, 64]. SC flexibility issues are quite broad [3, 4]. In this study, according to the contingency theory, we propose that there is a possibility of adverse consequences when considering the interplay between SC flexibility, SC visibility, SC agility, and SP. In this context, we suggest that the impact of SC flexibility on the relationships among these factors might not always be positive. For example, SC flexibility adds more complexity and uncertainties to SCs [74, 83] and promotes changes to meet customer needs [4]. Complexity and uncertainty are a threat to the SCs, they cause problems in SCs [21, 84].

Supply chain flexibility may adversely affect the relationship between supply chain visibility and sustainability by potentially increasing the complexity of the supply chain network [4]. As organisations strive to adapt quickly to changing market conditions, they may resort to multiple suppliers or alternative transportation routes, which can make it more challenging to track and monitor sustainability metrics across the entire supply chain. This lack of visibility can hinder efforts to ensure ethical sourcing, reduce carbon emissions, or minimise waste, thus compromising sustainability goals [27]. Additionally, a lack of visibility may make it difficult to identify areas for improvement or areas of non-compliance with sustainability standards, further exacerbating the issue. The complexity may impede efforts to ensure that the entire SC adheres to sustainable practices. Therefore, the following hypothesis is proposed.

H5a. SC flexibility negatively moderates the direct relationship between SC visibility and SP.

Supply chain flexibility may potentially hinder the relationship between supply chain visibility and agility by introducing additional layers of complexity [4]. For example, increased flexibility might lead to a proliferation of suppliers, locations, and processes, making it challenging to maintain comprehensive visibility across the entire supply chain. This lack of visibility can impede the timely identification of bottlenecks or disruptions, thus hindering agility in responding to changing market demands or unforeseen events [29]. From a customer perspective, customers expect a level of consistency and too much flexibility can confuse and alienate them. For example, if a brand is constantly changing its messaging or offerings, it may lose customer trust and loyalty. Contingency theory asserts that the effectiveness of certain strategies or practices depends on the specific circumstances or contingencies in which they are applied. For instance, when everyone is used to a fixed delivery time, a flexible delivery time may cause adverse or unfavourable consequences somewhere in the system, because everyone has different requirements. Therefore, the following hypothesis is proposed.

H5b. SC flexibility negatively moderates the direct relationship between SC visibility and SC agility.

Supply chain flexibility may have a detrimental impact on the relationship between supply chain agility and sustainability. Flexibility may lead to more frequent changes in production schedules, order quantities, or product designs, which can result in inefficient resource utilization and increased waste. Rapid changes in demand or production plans may lead to overproduction, excess inventory, or obsolete stock, all of which can have negative sustainability implications [4]. Besides, people don't like changes [85], and high flexibility may create confusion among stakeholders regarding the organisation's commitment to sustainability. Many businesses still follow daily routing operations [86]; frequent changes may cause additional problems. Furthermore, Tang and Tomlin [23] argue that high levels of flexibility cannot help companies generate most of the benefits. Too much flexibility might lead to a lack of focus on core objectives such as sustainability. It can result in scattered efforts and a failure to achieve significant progress in any particular direction. Therefore, the following hypothesis is proposed.

H5c. SC flexibility negatively moderates the direct relationship between SC agility and SP.

The EU is viewed as a contextual factor that may not affect the effectiveness of the SC visibility and SC agility in this model. The uncertainty is due to a lack of information [87], SC visibility enables companies to access high-quality demand and supply information [38].

In addition, SC agility equips companies to quickly adapt and respond to unpredictable changes and risks [33], and Brusset [81] stresses that agile strategies play a key role in survival in turbulent and volatile markets. This suggests that both SC visibility and SC agility can mitigate the impacts of the EU. Having said that, we conduct a multi-group analysis to examine the contingency effects of the EU. Thus, the moderating effects of the EU are not proposed in the study.

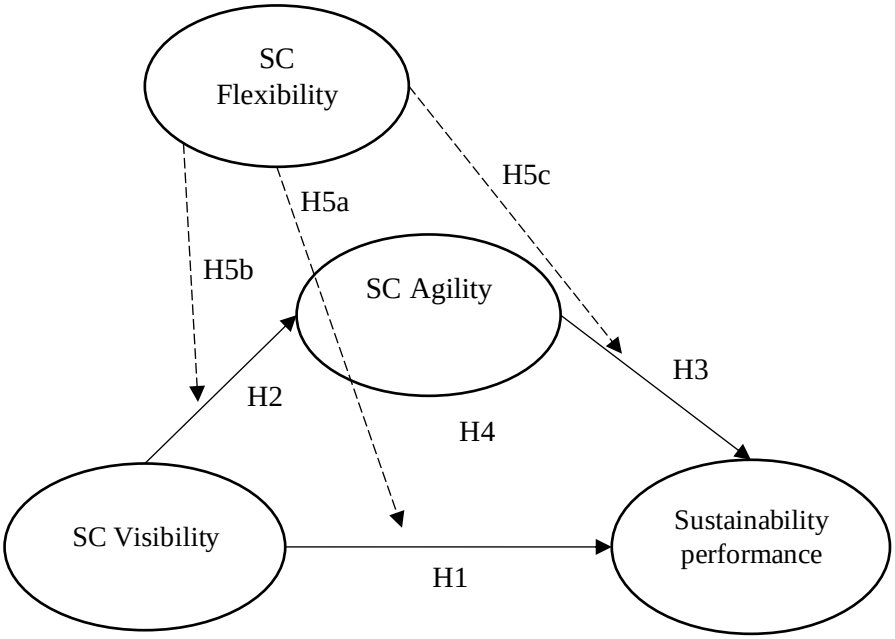


Figure 1. Conceptual framework

4. Methods

The PLS-SEM approach was employed to estimate the research models. The PLS-SEM technique offers many unique advantages [88, 89]. For example: PLS-SEM is robust in handling non-normally distributed data; it is considered more appropriate for smaller sample sizes compared to CB-SEM methods; It has the capability to manage multicollinearity and higher-order constructs through both reflective and formative measurements, a flexibility not available in CB-SEM which is confined to reflective measurement. Moreover, PLS-SEM is adept at handling formative measurement overall, as well as addressing mediation and moderation effects through product indicators or interaction terms, while CB-SEM necessitates more intricate procedures [89, 90].

4.1 Instruments

A research survey was carefully developed to obtain data and validate research models in the study. The questionnaire is a major instrument in the study. A cover letter containing

project details and explaining the purpose of our questions, our survey anonymously encourages people to take part. The scales and items were mainly drawn from the literature. We used a 7-point Likert-type scale to assess the constructs. Because a 7-point scale offers more advantages compared to other scales [91]. To ensure content validity [92] and improve the survey research design [93], measurement items were carefully reviewed and developed by academics and managers in the UAE. We asked the five SC managers and six academics to help us refine the survey questions and statements. Some questions were changed and modified to better fit Arabian businesses based on their feedback.

The questionnaire contains several sections to measure the latent variables including SC capabilities, firm performance, and EU. Table 1 presents descriptive statistics of the measures of the study. To assess the construct of SC capabilities including visibility, agility and flexibility, we requested participants to assess the statements in relation to their SC capabilities, using a scale from 1 (Strongly Disagree) to 7 (Strongly Agree).

To measure the construct of SP, the participants were advised to compare to their major competitors in the markets and indicated their firm's performance from 1=Strongly disagree to 7=Strongly agree. We applied a separate way to investigate the EU, as we don't know what will happen in the future, and uncertainty is different from risk, uncertainty cannot be measured directly [94]. The participants were required to assess the severity of uncertainty variables in their companies recently. The scales include 1=No problem, 2= Cosmetic problems, 3= Minor problems, 4= Moderate problems, 5= Significant problems, 6= Severe problems, 7= Critical problems. The scale instruction was provided in the survey.

Table 1. Descriptive statistics of the measurement items (n=206)

Constructs	Items	Mean	S.D.	Ref.
SC visibility (SCV)	1. Our company possesses the capability to gather, store, and distribute information horizontally within the SC network, thereby enhancing value for our customers.	5.18	1.47	Kim and Chai [41]
	2. Our company possesses the ability to predict market demand.	5.28	1.38	
	3. Our company has the competence to maintain consistent and frequent communication among members of the SC.	5.40	1.44	
	4. Our company can exchange information with both our suppliers and customers.	5.17	1.47	

SC agility (SCA)	1. Our company can effectively engage in collaborative planning with suppliers across purchasing, production, and logistics functions.	5.29	1.41	Braunscheidel and Suresh [33], Swafford, Ghosh and Murthy [50], Wang, Jie and Frederico [95]
	2. Our company can promptly address requests from both suppliers and customers.	5.42	1.38	
	3. Our company can adapt its production or service capacity and capability effectively.	5.37	1.30	
	4. In the event of an unforeseen situation, our company and the supplier are proficient in resolving issues effectively.	5.42	1.26	
	5. When confronted with unexpected situations, our company is skilled at reconfiguring operational processes to accommodate the changes.	5.39	1.31	
	6. In cases of disagreement during the transaction process, our company and the supplier are inclined to reassess the situation with the aim of finding a mutually satisfactory resolution.	5.33	1.32	
Sustainability performance (SP)	1. Customer satisfaction	5.58	1.28	Bassioni, Price and Hassan [56], Wang and Easa [59]
	2. Profitability	5.25	1.40	
	3. Employee job satisfaction	4.77	1.58	
	4. Market share	4.89	1.48	
	5. Reputation in the industry	5.70	1.45	
	6. Socially responsible business	5.41	1.43	
	7. Environmentally friendly business	5.27	1.56	
SC flexibility (SCF)	1. Our company has the ability to create new products and/or services, as well as make improvements to existing ones.	5.33	1.44	Manders, Caniëls and Ghijsen [4]
	2. Our company and the supplier adeptly addressed intricate issues that were unforeseen by either party.	5.20	1.40	
	3. Our company can align, adapt, and fine-tune the flow of goods, encompassing both inbound and outbound activities.	5.45	1.28	
Environmental uncertainty (EU)	1. Road congestion/infrastructure capability shortage	3.33	1.94	Wang [24], Wang, Jie and Abareshi [96]
	2. Natural disasters/ industrial action	3.43	2.23	
	3. Extreme weather	3.52	1.86	
	4. Regulation / Government	3.62	1.90	

4.2 Sample

The research took place amidst the COVID-19 pandemic. Moreover, considering the specific research inquiries and the scarcity of secondary supply chain data sources in the UAE,

we conducted an online survey to collect primary data from organizations within the country. The sample companies were sourced from businesses in the UAE, identified through online platforms such as Yellow Pages UAE and LinkedIn. Random sampling was utilised to choose sample companies representing various significant industries in the UAE, including but not limited to oil & gas, construction, trading, tourism, and hospitality. Random sampling is frequently employed in quantitative research endeavours where researchers seek to derive conclusions about a population by analysing data obtained from a representative sample [97]. This study does not focus on a particular industry or sector. Instead, we aim to assess this organisational phenomenon across various industries in the UAE. This approach is intended to comprehensively capture and enhance our understanding of the phenomenon. To minimise the single respondent bias [93], the questionnaire questions are carefully designed to ask about the SC of UAE companies, we invited practitioners who are currently engaged in SC-related work in the UAE's companies to answer the questionnaire. We believe they have better knowledge to answer our questions.

The data collection involved employing an online survey. Respondents were required to answer all questions before submitting the survey. Incomplete and invalid survey responses were subsequently eliminated from the dataset. During the period of July to September 2021, we received a total of 206 valid surveys, representing an approximate response rate of 25% for the research. The sample size was determined by considering our research method to ensure the reliability and validity of the data analysis. There exist various "rules of thumb" or guidelines for determining sample sizes in structural equation modelling (SEM) models, including the minimum sample size rule 200, and the "10:1 rule" - the minimum number of cases per parameter in the model [98]. Our sample size is appropriate for this study. To check the reliability of a sample, we used several common techniques, including the Pearson correlation coefficient (r) for Test-Retest and Cronbach's alpha for internal consistency reliability. The results indicate a high degree of reliability in the study.

Table 2 shows the demographic information of the samples. The UAE government industrial and company classification standard was employed in the research to classify the characteristics of the responding organisations, oil & gas industries are major contributors to the UAE's economy. Tourism become one of the main non-oil sources of revenue in the UAE. Construction and manufacturing industries are expanding rapidly in the UAE. Our research samples include all types of company sizes (small to large) and major industries across the UAE's seven emirates. The results indicate that 67.5% of the respondents were managers, and

74.7% of the respondents have more than 2 years of work experience in their current organisation. This represents high-quality data in this study.

Table 2. Demographics information (n=206)

Characteristics	Percentage	Characteristics	Percentage
Industry		*Position*	
Oil & Gas	13.6	Senior Management /CEO/Director	23.3
Construction	6.8	Manager/supervisor	44.2
Manufacturing	8.7	Staff	28.6
Trading	10.7	Others	3.9
Hospitality and Tourism	6.3	*Working years in the current organisation*	
Education	6.3	Less than 2 years	25.2
Pharmaceuticals and Healthcare	4.9	2-5 years	26.2
Warehousing and Transportation	6.8	More than 5 years	48.5
Insurance and Finance	6.3	*Size* of *Company* (Revenues, Currency United Arab Emirates Dirhams)	
Public Sector	1.0		
Other services	28.6	< 3 million	19.4
		3 million - 50 million	27.2
Location		50 million - 250 million	22.8
Dubai	51.9	> 250 million	30.6
Abu Dhabi	21.4		
Sharjah	2.9		
Other emirates	23.8		

4.3. Common method bias

Our study is meticulously designed to mitigate biases associated with a single respondent [99], survey research designs often suffer from common method bias, and they are sometimes unavoidable [93]. Common method bias is tested in this study. We conducted the Harman single-factor test [99], and We conducted an un-rotated factor analysis of all eigenvalues using

SPSS software. The findings indicated that the first factor accounted for a value of less than 35%, which falls well below the 50% threshold.

4.4. Non-response analyses

Potential non-response bias was assessed by comparing responses between early and late respondents, with the latter group being treated as a proxy for non-respondents [100]. Specifically, we compared the responses gathered from the initially returned questionnaires with those from the finally returned questionnaires. The comparison (based on t-test or $\chi 2$ test) did not detect any significant difference at $p < 0.05$, thus suggesting no serious threat of nonresponse bias.

5. Results

For data analysis, we used the SmartPLS software and adhered to the steps outlined by Hair, Risher, Sarstedt and Ringle [101] and Dash and Paul [89] to conduct our data analysis. The analysis was carried out using an iterative algorithm for estimating both the latent variable scores and the path coefficients, quantifying the direction and strength of the relationships within the model. The research model consists of five constructs. Confirmatory factor analysis was conducted to validate the measurement models. The coefficients of the structural model, representing the relationships between the constructs, are obtained by estimating a series of regression equations.

5.1. Measurement reliability and validity

We evaluated the measurement scales in terms of factor loadings, internal consistency, convergent validity, and discriminant validity.

The internal consistency of the scale items was assessed by Cronbach's α test was conducted to assess. The Cronbach's α, factor loadings, and composite reliability greater than the 0.7 thresholds are acceptable [102]. Construct validity is evaluated by establishing both convergent and discriminant validity in reflectively measured constructs. Convergent validity is established when the Average Variance Extracted (AVE) is greater than a threshold of 0.50 [88]. Table 3 presents the items' loadings, Cronbach's alpha, and Composite Reliability for each construct. We employed several criteria to assess the discriminant validity [88]. Firstly, measurement items should exhibit strong loadings on the construct they are designed to measure. All items demonstrated significant loadings on their respective constructs (>0.70) in Table 3. Secondly, The Fornell-Larcker criterion stands out as a widely utilized method for assessing the discriminant validity of measurement models. The square root of the AVE should be greater than the inter-construct correlations [102]. The square root of the AVE of each construct was larger than the 0.7 threshold and was also larger than the inter-construct

correlations. Moreover, the heterotrait–monotrait ratios (HTMT) were computed for pairwise correlations between the constructs, as shown in the lower part of Table 4. With all HTMT values below 0.85, this analysis further demonstrates the discriminant validity of the measures [103]. Overall, all constructs demonstrated favourable levels of construct validity.

Table 3. Results of construct reliability and validity

Latent variable	Items	St. factor loading	Cronbach's α	AVE	Composite reliability
SCV	SCV1	0.75	0.83	0.67	0.89
	SCV2	0.86			
	SCV3	0.89			
	SCV4	0.77			
SCA	SCA1	0.81	0.91	0.70	0.93
	SCA2	0.85			
	SCA3	0.85			
	SCA4	0.81			
	SCA5	0.87			
	SCA6	0.82			
SP	SP1	0.79	0.89	0.67	0.89
	SP2	0.77			
	SP3	0.78			
	SP4	0.72			
	SP5	0.82			
	SP6	0.81			
	SP7	0.75			
SCF	SCF1	0.85	0.78	0.70	0.87
	SCF2	0.81			
	SCF3	0.85			
EU	EU1	0.79	0.80	0.62	0.87
	EU2	0.90			
	EU3	0.78			
	EU4	0.70			

Table 4. Discriminant validity

	SCA	SCF	SCV	SP	EU
Fornell-Larcker Criterion					
SCA	**0.84**				
SCF	0.81	**0.83**			
SCV	0.76	0.64	**0.82**		
SP	0.72	0.65	0.64	**0.78**	
EU	0.13	0.11	0.13	0.03	**0.79**
HTMT					
SCA	-				
SCF	0.83				

SCV	0.81	0.79			
SP	0.79	0.77	0.74		
EU	0.14	0.14	0.16	0.14	-

Note: Items on the diagonal (highlighted in bold) represent the square root of AVE (Average Variance Extracted) scores.

5.2. Structural model and hypothesis testing

Hypothesis testing was carried out within the structural model [88]. Before evaluating the structural relationships, it is essential to examine collinearity to ensure it does not introduce bias to the regression results. We tested the collinearity issues by calculating the variance inflation factor (VIF). Values of VIF exceeding 5 suggest potential collinearity issues [101]. Our results indicate that the VIF values are below 3. Collinearity is not an issue in this study.

Model fit indices in PLS offer limited options compared to CB [89]. To evaluate the model's quality, the study utilising PLS-SEM depends on alternative measures that assess the model's predictive capabilities [101]. The overall model fit with an R^2 value 0.58 of for the variance of agility and an R^2 value 0.57 of for the variance of SP. f^2 is a common measure of effect size. Cohen [104] suggested that f^2 effect sizes of 0.02, 0.15, and 0.35 are termed small, medium, and large, respectively. Our results show that SCV→SCA (f^2 = 0.352, effect size: large), SCA→SP (f^2 = 0.275, effect size: medium), and SCV→ SP (f^2 = 0.05, effect size: small). Aguinis, Beaty, Boik and Pierce [105] showed that the overall mean observed effect size in tests of moderation is only 0.009. Thus, a realistic standard for effect sizes in moderation tests should be 0.005, 0.01, and 0.025 for small, medium, and large, respectively. Our results show that H5a (f^2 = 0.022, effect size: medium), H5b (f^2 = 0.035, effect size: large), and H5c (f^2 = 0.037, effect size: large). The Normed Fit Index (NFI) is a measure used in PLS-SEM to assess the goodness of fit of a model. It provides information about how well the proposed model fits the observed data, with values typically ranging from 0 to 1. A higher NFI value indicates a better fit and a common rule of thumb is that an NFI value above 0.90 suggests an acceptable fit. In addition, Standardized Root Mean Square Residual (SRMR) was used to measure the overall model fit in this study. A value below 0.10 or specifically at 0.08 is considered indicative of a good fit [89, 101], PLS-SEM has reported NFI at 0.93 and SRMR at 0.06. The results indicate a good model fit in the study.

Figure 2 summarises our research results of the structural model. We tested the path coefficients and their statistical significance. The structural model was established through bootstrapping using the PLS technique [90]. We conducted bootstrapping with 5000 resamples to obtain standard error estimates for testing the statistical significance of the path coefficients [88]. The results revealed a significant relationship between SC visibility and the firm's SP,

with a path coefficient of 0.22 at p=0.002. Thus, Hypothesis 1 is supported, SC visibility positively affects a firm's SP. Our results support Hypothesis 2, a statistically significant relationship between SC visibility and SC agility, with a path coefficient of 0.76 at p<0.001. Thus, SC visibility positively affects SC agility. The study provided empirical support for Hypothesis 3, there is a significant and positive relationship between SC agility and a firm's SP, with a path coefficient of 0.55 at p<0.001. Thus, SC agility has a positive impact on a firm's SP.

5.2.1. Mediation analysis

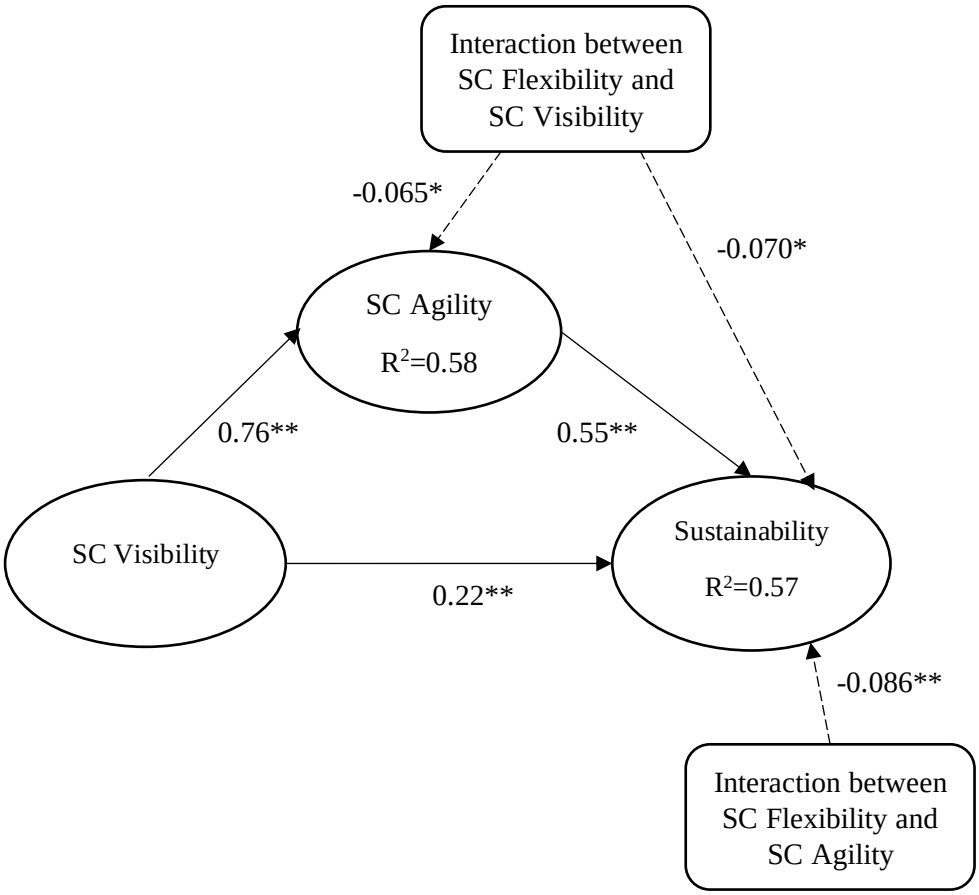
We have employed various techniques to perform mediation analysis. The Baron and Kenny approach is a widely used method for assessing mediation in research [106]. It involves a series of regression analyses to examine the indirect effect of an independent variable (SCV) on a dependent variable (SP) through a proposed mediator (SCA). Assess mediation by testing the significance of three regression equations: the effect of the independent variable on the mediator, the effect of the mediator on the dependent variable controlling for the independent variable, and the total effect of the independent variable on the dependent variable. Upon introducing the mediator, SC agility, into the model, the direct association between SC visibility and the firm's SP remained statistically significant. Additionally, we conducted 5,000 resamples with replacements to empirically model the sampling distribution of the indirect effects [107]. This Bootstrapping approach allowed us to ascertain the significance of the individual mediation paths by estimating the indirect effect within the sampled population, thereby generating a 95% confidence interval. The specific indirect effect SCV→ SCA→ SP was significant. The empirical results show that SC agility mediates the relationship between SC visibility and SP (t= 6.10, p<0.001) [106]. These results indicate strong evidence of complementary mediation [108]. Thus, Hypothesis 4 is supported.

5.2.2. Moderation analysis

We have used several common moderation testing methods in the study. Interaction Effects Analysis: This method involves including an interaction term in a regression model to assess whether the effect of the predictor variable on the outcome variable varies across different levels of the moderator. When the path coefficient from the interaction term to the dependent variable displays the anticipated direction and achieves statistical significance, it suggests that the relationship between the predictor and outcome variables is moderated by the moderator variable [106]. The bootstrapping technique also is used to provide more robust estimates of moderation effects [98]. Further, a Simple slope analysis was performed to interpret significant interaction effects. It involves examining the slope of the regression line

for the predictor variable at different levels of the moderator. This helps understand how the relationship between the predictor and outcome variables changes across different levels of the moderator.

Figure 2 - 5 indicate the results of the moderating effect of SC flexibility in this model. The three interaction terms are formed by computing and using SmartPLS software. The assumed direction of the interaction terms in our research model is a negative path coefficient, as SC flexibility negatively moderates the relationships between SC visibility and SP (H5a), between SC visibility and SC agility (H5b), and between SC agility and SP (H5c). Table 5 indicates results of hypotheses testing.



*p<0.05 **P<0.01

Figure 2. Structural model results

Table 5. Results of hypotheses testing

Hypotheses	Path Coefficient	St. Dev	t-Value	P-Value	Notes
H1: SCV→ SP	0.224	0.071	3.17	0.002	Supported
H2: SCV→SCA	0.762	0.045	16.99	0.000	Supported
H3: SCA→SP	0.549	0.078	7.05	0.000	Supported
H4: SCV→SCA→SP	0.418	0.069	6.10	0.000	Supported

H5a: SCV* SCF→SP	-0.076	0.029	2.40	0.017	Supported
H5b: SCV* SCF→SCA	-0.065	0.025	2.47	0.014	Supported
H5c: SCA*SCF→SP	-0.086	0.029	2.68	0.008	Supported

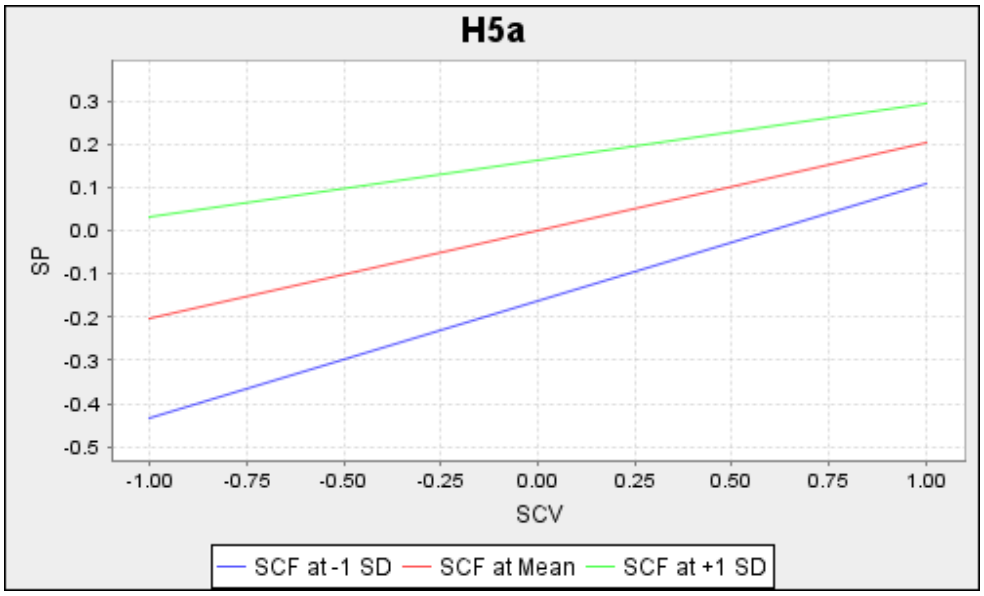


Figure 3. The moderating effect of SC flexibility - H5a

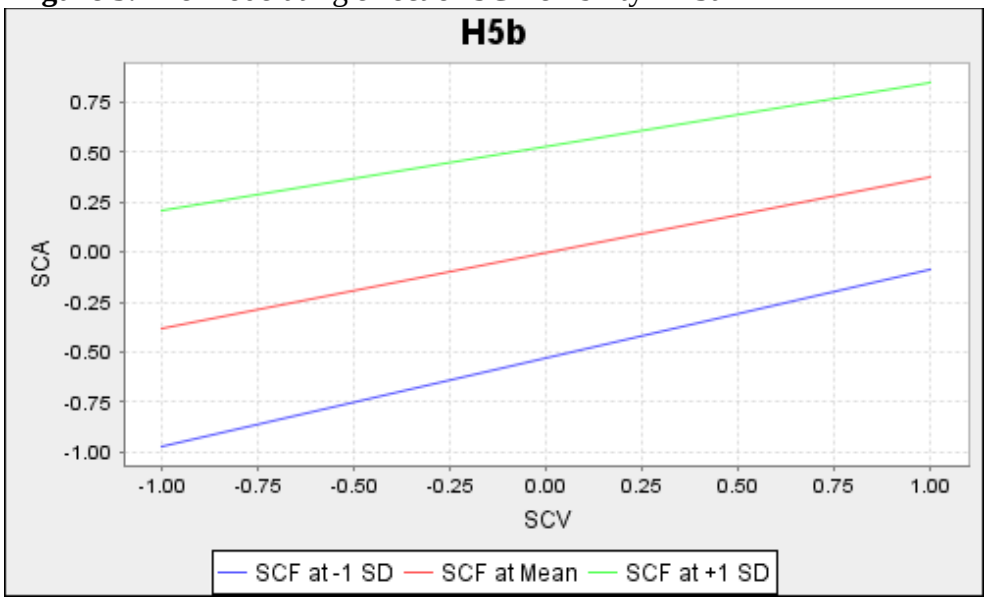


Figure 4. The moderating effect of SC flexibility - H5b

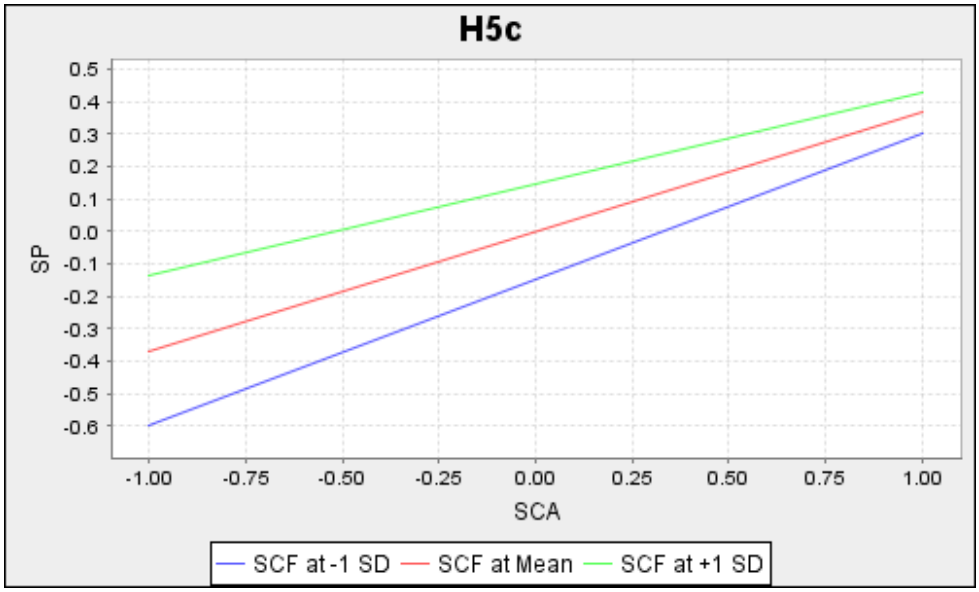


Figure 5. The moderating effect of SC flexibility - H5c

SC flexibility loads significantly positively on SC visibility and SC agility, but insignificantly on SP. As SC flexibility is a moderator in the model, the results of the direct path coefficient from SC flexibility to other constructs are not relevant for hypothesis testing, thus, we did not report the results.

Multigroup analysis is performed to examine the contingency effects of the EU, first, we conducted a cluster analysis to divide the sample into groups. In this study, the EU contains four measurement items. We saved the standardized value of measurement items as new variables. Two clusters were formed by using K-means clustering. The clusters were validated by applying an analysis of variance (ANOVA). There are significant differences between the mean values of EU measurement items ($p<0.001$) across the derived clusters. Group 1 (n=99) represents low EU, and Group 2 (n=107) represents high EU. Next, we conducted a multi-group analysis (MGA) based on the validated research models. A bootstrapping procedure with 2,000 subsamples to test the strength of the hypothesized relationships among the constructs. The contingency effects of the EU are insignificant in the research model. The MGA results are reasonable as we expected, path coefficients remain significant in both two groups, and we did not identify any significant differences in path coefficients between the two groups. The findings align with previous research, the empirical evidence supports that SC visibility, SC agility and SC flexibility can mitigate the contingency effects of the EU.

5.3. Robustness checks

Addressing endogeneity is a critical concern when employing regession-baed techniques such as PLS-SEM [109]. In PLS-SEM, endogeneity occurs when a predictor construct is correlated with the error term of the dependent construct it relates to, indicating that the predictor construct not only explains the dependent construct but also its error item [110]. Gaussian Copula test is performed to check endogeneity in this study. The results from the Gaussian Copula analysis suggest that there are no endogeneity issues, as indicated by both the path coefficients and F Square values. To ensure the validity of our findings, we also incorporated control variables: company size and industry types. Company size was assessed using the metric of company revenues. The industry types encompassed both service and non-service sectors. The two control variable were found to have no significant impact on the endogenous variables in this study.

To make sure that the aggregate data level analysis is not substantially biased due to two or more unidentified, distinct groups within the data set, it is crucial to check for unobserved heterogeneity [111]. In this study, We used the four-step Finite Mixture Partial Least Squares (FIMIX-PLS) method with SmartPLS [111]. FIMIX-PLS is an extension of the PLS-SEM that allows for the analysis of latent variable models in the presence of unobserved heterogeneity. By analysing segment-specific parameter estimates, FIMIX-PLS facilitates the interpretation of heterogeneity in the relationships between variables across different segments. We use the algorithm settings for the stop criterion ($1 \cdot 10^{-10}$ = 1.0E-10), the maximum number of iterations (5,000) and the number of repetitions (10) [112]. To determine the maximum number of segments to extract, we first computed the minimum sample size -70 required to estimate each segment. The greatest integer from dividing the sample size (i.e., 206) by the minimum sample size (i.e., 70) yields a theoretical upper bound of 2. The segmentation solution is better the lower the value of a certain information criterion [111]. The findings of the FIMIX-PLS to examine the unobserved heterogeneity are displayed in Table 6. Considering the 2-segment solution, the normed entropy statistic (EN) is under the threshold of 0.5, suggesting that the segments are not well separated [112]. Therefore, it is reasonable to conclude that there is no evidence of unobserved heterogeneity in the FIMIX-PLS analysis. We also assessed the predictive performance of the FIMIX-PLS model by utilising the appropriate metric, predictive relevance (Q^2). Our findings indicate that the Q-square values range between 0.30 and 0.51, representing medium to large predictive relevance across all cases. The model successfully captured the underlying structure of the data without the need to account for latent segments. This suggests that the relationships between variables are consistent across the entire sample, providing confidence in the generalisability of the results. The absence of unobserved

heterogeneity simplifies the interpretation of the FIMIX-PLS model and underscores the robustness of the findings.

Table 6 FIMIX-PLS Analysis

	Number of Segments	
Criteria	1	2
AIC (Akaike's Information Criterion)	1424.655	**1400.927**
AIC3 (Modified AIC with factor 3)	1435.655	**1423.927**
AIC4 (Modified AIC with factor 4)	**1446.655**	1446.927
BIC (Bayesian Information Criteria)	**1461.261**	1477.468
CAIC (Consistent AIC)	**1472.261**	1500.468
HQ (Hannan Quinn Criterion)	1439.46	**1431.882**
MDL5 (Minimum Description Length with Factor 5)	**1695.688**	1967.632
LnL (LogLikelihood)	**-701.327**	-677.463
EN (Entropy Statistic (Normed))		0.317
NFI (Non-Fuzzy Index)		0.36
NEC (Normalized Entropy Criterion)		14

6. Discussion and implications

The purpose of the paper is to revisit the relationships among SC visibility, SC agility, SC flexibility, and a firm's SP and explore the mediating effect of SC agility and the contingency effects of SC flexibility and EU in a research model. The results of the SC visibility, SC agility and firm's SP (H1-H3) are largely consistent with prior studies [13, 81]. The capabilities of a firm positively contribute to its SP. The study additionally confirms the existence of a partial mediation effect, with SC agility serving as the mediating variable (H4).

Unlike most prior studies that demonstrate that SC flexibility has a positive impact on SC practices and SC performance [9], our study shows the contingency effects of SC flexibility dampen the positive relationship between SC visibility, SC agility, and SP (H5a - H5c). As SC flexibility increases, there is a corresponding decrease in the impact of SC visibility on SC agility and a firm's SP. Similarly, increased SC flexibility is associated with a diminished impact of SC agility on SP, leading to a weakened overall SP of the firm. In other words, the empirical evidence shows that increased SC flexibility within a company has an impact on and

diminishes the sustainability advantages derived from other SC capabilities. Our results may imply that achieving both high SC capabilities and SC flexibility may involve trade-offs. For instance, today, many companies rely on the technologies to improve SC visibility and SC agility, those new technologies, equipment, and the necessary staff training are expensive. Investments made to enhance flexibility may divert resources from improving visibility and agility, leading to a situation where the positive effects of SC capabilities are compromised. As discussed before, while flexibility is valuable, finding the right balance is essential to ensure that adaptability does not compromise long-term sustainability objectives. As previously mentioned, SC flexibility exhibits a positive correlation with other SC capabilities. Organisations need to integrate flexibility within a framework that aligns with sustainable practices and goals, fostering resilience without sacrificing economic, environmental and social responsibility. Therefore, we argue that increasing SC flexibility cannot always help an organisation's SP, furthermore, firms with high SC flexibility may perform worse than firms with low SC flexibility in terms of SP. This finding addresses the research question posed in this study.

Merschmann and Thonemann [3] suggest that companies that align their SC flexibility with the level of uncertainty they face tend to achieve superior performance compared to those that do not achieve such alignment. Our study further affirms that the contingency effects of SC flexibility may dampen SP. This outcome may prompt managers and researchers to reassess how to effectively implement flexibility in supply chains post-COVID-19. SC flexibility is broadly viewed as a major response to SC uncertainty and risk [3, 64]. In addition, SC visibility, and SC agility are often considered an important firm’s ability to manage SC uncertainty and risk [5, 23, 33, 50].

Our study shows that the contingency effects of the EU are insignificant in this model. Under varying conditions of environmental uncertainty, the impact of the SC capabilities on a firm’s SP remains consistent, showing no significant change. This observation underscores the notion that these capabilities play a supportive role across different companies, enabling them to withstand environmental uncertainty and maintain stable performance. The results are consistent with the prior studies, meanwhile, it affirms that SC visibility, SC agility, and SC flexibility may mitigate the contingency effects of SC uncertainty.

6.1. Theoretical implications

Applying the RBV, the Triple Bottom Line approach, and the Contingency Theory, the study revisits the important concepts of SC capabilities including SC visibility, SC agility and

SC flexibility [14]. Additionally, it presents a comprehensive research framework to address SC capabilities, EU, and SP. It describes how SC capabilities would interact with each other and lead to an improved firm's SP. Use contingency theory to determine how the identified resources align with the organisation's industry, competitive environment, and strategic goals. Tailor SC strategy to leverage SC capabilities and resources in ways that align with external factors and contingencies. In our study, we incorporate the contingent effects of SC flexibility and EU. The findings not only provide empirical support for our hypotheses but also advance the integration of RBV, the Triple Bottom Line approach, and Contingency Theory within a business model framework. This may imply that key aspects of the impact should be taken into account to develop a sustainable business framework. Furthermore, SC flexibility is an important SC concept, the study affirms that SC flexibility does not always provide benefits in SC operations. More specifically, the contingency effects of SC flexibility negatively moderate the relationships between SC capabilities and sustainability. This may draw attention to rethink the SC flexibility in sustainable SC management. By combining RBV, the Triple Bottom Line approach, and Contingency Theory, we create a dynamic framework that promotes sustainable competitive advantage by leveraging relevant capabilities and resources, considering multiple dimensions of sustainability, and adapting to the evolving business landscape.

6.2. Managerial implications

The study contributes to practice and practitioners. In a business context, flexibility often involves the capacity to adjust operations, processes, or strategies in response to changing market conditions, customer needs, or other environmental factors. However, excessive SC flexibility could potentially pose challenges and lead to decision-making paralysis. If there are too many options or if decisions are constantly revisited, it may slow down the decision-making process, impeding timely actions and negatively affecting performance. An unavoidable consequence of increasing flexibility is increased complexity [4, 83], this would bring adverse impacts on a SC system [4]. In addition, companies have to increase costs to obtain SC flexibility [22]. Sometimes we can hear - do not give people a chance to choose, because this may cause unnecessary trouble or delay. Flexibility can potentially lead to divergence. The rationale behind this perspective could be rooted in the belief that decision-making can lead to complications, and limiting choices may streamline processes such as standardisation and routine can contribute to efficiency, and a high degree of flexibility can result in inconsistent processes, this may disrupt workflows and hinder overall SP. For example: when companies possess lower SC flexibility, it may be more straightforward for managers to establish routine

processes to mitigate uncertainties and risks and improve performance. However, SC flexibility is important [9, 13, 63]. While supply chain flexibility is essential for agility, it must be balanced with sustainability objectives to ensure that short-term gains do not come at the expense of long-term environmental and social impacts. We also observed that SC flexibility positively influences other supply chain capabilities in this study. Different industries have different SCs, so managers must pay attention to flexibility in different SCs, and rethink/redesign SC flexibility by using new ideas to adapt the business sustainable development in the industries.

SC visibility enables companies to improve SC agility and a firm's SP simultaneously. SCs characterised by extensive visibility tend to exhibit greater agility and sustainability compared to SCs with limited visibility. Our results also suggest that to achieve better a firm's SP, it is significant to look at the big picture of end-to-end SC operations. This enables the identification of areas where sustainability improvements can be made. This holistic perspective helps uncover inefficiencies, waste, and environmental impacts that might not be apparent when only focusing on specific segments of the SC.

SCs are anticipated to grow in complexity in the aftermath of the COVID-19 pandemic [113], managers should possess a comprehensive understanding of and embrace SC digitalisation and emerging technologies to effectively bolster SC operations. By harnessing these new technologies, they can enhance various aspects of SC capabilities [40, 114]. Moreover, our results suggest that SC capabilities (visibility, agility, and flexibility) play a significant role in effectively countering the EU. This may provide insights into SC uncertainty management post-COVID-19, and managers must apply and adapt these principles of visibility, flexibility, and agility to various contextual situations.

7. Conclusion

In this study, we have provided empirical justification for a framework that identifies the importance of SC visibility, SC agility, SC flexibility, EU, and its association with SP. More importantly, the revealed effects of SC flexibility indicate that it has a negative moderating influence on the relationships among SC visibility, SC agility, and SP. This offers answers to our research question, SC flexibility does not always result in positive impacts on the improvement of a firm's SP by other SC capabilities. The increasing recognition of flexibility as a key strategic issue in many industries reflects the dynamic and unpredictable nature of today's business environment. Flexibility, particularly within the SC, is crucial for

organisations to navigate uncertainties and risks, respond to changes, and achieve SP. It should be carefully planned to align with sustainability goals based on capability fit.

Our results have significant implications for both managerial practices and academic research. While the benefits of flexibility are thoroughly examined, it is equally essential to consider the potential drawbacks. When planning for SC flexibility, managers must carefully align these initiatives with sustainability goals, considering capability fit to ensure that flexibility enhances rather than compromises SP. This integrated approach contributes to the long-term resilience, competitiveness, and ethical standing of the organization. This study also emphasises the importance of SC visibility in enhancing SP through SC agility. Merschmann and Thonemann [3] indicate that there is no unequivocal answer to the question of whether or not flexibility is beneficial from the SC perspective. Researchers have reported diverse outcomes in the literature [13, 23]. In accordance with our findings, SC flexibility should align with the organisational goals, capabilities, surrounding environment and the values of stakeholders to achieve optimal performance. In our analysis, we also identify that the contingency effects of the EU are insignificant in the research model. These findings align with conclusions drawn from previous research [23, 33, 64].

The study revisits and combines the RBV, the triple bottom line approach and the contingency theory into a framework and advances existing theory from a SC perspective. Ensuring adaptability is crucial for handling uncertainties and risks in the SC. Nevertheless, in the context of achieving enduring sustainable development, caution is advised for managers when employing flexibility in the SC. All this may inspire both academics and practitioners to rethink and find suitable ways to manage new challenges and capture opportunities post-COVID-19.

7.1. Research limitations and further research

The study is subject to certain limitations. Firstly, the cross-sectional survey research design may receive criticism, this may be one of the research limitations. However, we have carefully designed the research to minimise the research biases and ensure the research's reliability and validity. Secondly, the study's scope does not narrow down to a specific industry or sector; rather, it examines the organisational phenomenon across diverse SCs. Thirdly, the sample companies were chosen using online platforms; however, those companies not utilizing the internet may have been omitted from the study. The empirical data may potentially restrict the generalisability of the research findings. Fourthly, the partial mediating role of SC agility between SC visibility and SP may imply a research limitation, as it cannot fully explain the

mechanisms in this research model. Having said that, these research limitations may lead to further research opportunities. For example: the research framework may be further tested in different contexts. Besides, different capabilities and/or constructs can be introduced to refine the research model. SC flexibility should be further investigated in different circumstances to verify its impacts on the SCs.

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