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ORIGINAL RESEARCH

Entrepreneurial Leadership, Supply Chain Innovation, and Adaptability: A Cross-national Investigation

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Abstract

This study investigates the effects of entrepreneurial leadership on supply chain innovation and supply chain adaptability. Based on theoretical foundations of the upper echelon theory and the dynamic capability theory, it also assesses the mediating role played by supply chain innovation in the relationship between entrepreneurial leadership and supply chain adaptability. Partial least squares structural equation modeling (PLS-SEM) was performed on survey data collected from 139 firms in Sudan, Japan, and China. The results reveal that entrepreneurial leadership had positive effects on supply chain innovation and supply chain adaptability despite varying business environments. The results also provided interesting findings regarding the moderating role of supply chain innovation as a mediator of the relationship between entrepreneurial leadership and supply chain adaptability. The findings of the study stress the importance of entrepreneurial leadership for firms' adaptability across nations. Although the number of countries included in this study was limited, these countries exhibit different cultural and structural settings. These findings suggest the possibility of the generalizability of the results. The findings also imply that firms should place greater emphasis on improving their supply chain processes and upgrading relevant technologies in order to facilitate the development of adaptable supply chains.

Keywords Entrepreneurial leadership · Innovation · Adaptability · Supply chain management

Mathematics Subject Classification 62H15 · 62J05 · 62P25 · 91C99

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1 Introduction

Industry changes and policy agendas are driven by concerns about the ability of supply chains (SCs) to face and adjust to environmental changes [1]. The constant need to spot and seize new opportunities is becoming a necessity for firms of all sizes, whether they operate in volatile or stable environments, and regardless of the nature of the products or services they offer [2]. The ability to adapt business resources to changing conditions, or *adaptability*, is crucial for the firms' survival in the current dynamic business environment. From a supply chain perspective, adaptability aims at accommodating shifts in market structures and modifying the supply network to changing strategies, products, and technologies by adjusting the design of the supply chain [3].

The vulnerabilities of the SCs worldwide have been exposed by the supply shock resulted from the recent COVID-19 pandemic, forcing firms to reassess their SC capabilities [4]. The crisis revealed the need of significant changes in the traditional supply network structures to make them more agile, adaptable, and aligned [5]. The giant Japanese automaker, Toyota, is one example of how market sensing and the ability to quickly adjust to environmental changes can guarantee survival and succeeding at turbulent circumstances. While competitors such as Honda and Nissan were facing huge losses due to the semiconductor chips' shortages caused by the COVID-19 pandemic, Toyota has managed to gain the upper hand over the disaster by replacing its just-in-time strategy with an efficient stockpiling of priority materials [6], a lesson learned from the 2011 earthquake and tsunami crisis that led to output delay of over 760,000 vehicles. Adaptable supply chains are, therefore, a powerful dynamic capability that can generate and sustain competitive advantages [7, 8]. As the competition is no longer between individual firms in today's networked business landscape, the dynamic capabilities of the entire supply chain, rather than of the individual firm, are to be considered [9].

Contemporary leaders are facing tremendous challenges in coping with such conditions. *Innovation*, an activity associated with survival and growth [10], is perceived as a significant catalyst in this pursuit. The willingness to engage in the development of new products, services, processes, and technologies is contingent upon the top management's decisions [11]. Therefore, having leaders with entrepreneurial orientations and behaviors can largely shape the future of firms. Innovation can be defined as the process of turning opportunities into new ideas and putting those into widely used practices [10], and it is thereby the specific tool of entrepreneurs [12]. Thus, *entrepreneurial leadership*, which is characterized by opportunity recognition and exploitation [2], goes hand in hand with innovation and is key to building adaptability in supply chains.

Applying the upper echelon's theory [13] and the dynamic capabilities theory [14] in the context of supply chain management (SCM), this study attempts to empirically investigate the effect of entrepreneurial leadership on supply chain innovation (SCI) and supply chain adaptability (SCA) and to assess the moderating role played by SCI in this relationship. The study was conducted using data from three countries: Sudan, Japan, and China. The rationale for choosing these countries rests on the similarities and differences in their societal structures (e.g., individualistic versus collectivistic) and developmental stages (developed versus developing). The outcomes of this study are expected to theoretically contribute to the advancement of research in the SCM and entrepreneurship fields and to provide empirical conclusions that can support practitioners in making more informed business decisions. The remaining of this study is organized as follows. First, a review of relevant literature leading to the development of the study hypotheses is presented. Next, the methodology used is explained, including data collection and analysis procedures. The hypotheses are tested, and results are explained in the following section. The paper then concludes by providing practical and research-related implications and suggested future directions.

2 Literature Review

2.1 Entrepreneurial Leadership

Entrepreneurial leadership is a style of leadership distinguished from other leadership styles by a focus on opportunity recognition and exploitation as entrepreneurial goals [2]. Some scholars, e.g., [15], view entrepreneurial leadership as a contextualized and situated form of leadership, occurring only in settings with certain conditions, such as those of small, yet rapidly growing businesses. Surie and Ashley [16] share a similar view and define entrepreneurial leadership as a type of leadership capable of sustaining innovation and adaptation in high velocity and uncertain environments. However, although representing a distinctive leadership style, recent scholars believe entrepreneurial leadership can be presented in any organization regardless of size, type, or age [2]. Defining entrepreneurial leadership requires a careful examination of the entrepreneurial behavior of leaders [17, 18]. The concept was conceptualized earlier by focusing on exceptional traits that enable leaders and business owners to lead their ventures successfully [17]. In recent studies, e.g., [2], the focus is on the competencies and roles required in creating innovative ideas and leading the process of innovation. Entrepreneurial leaders are, therefore, defined as those who are highly committed to value creation [16] by using their specific knowledge and competencies to maximize innovation and explore new opportunities [19].

2.2 Supply Chain Adaptability

Dynamic capabilities are the firm's ability "to sense and then seize new opportunities and to reconfigure and protect knowledge assets, competencies, and complementary assets with the aim of achieving a sustained competitive advantage" [20, p. 412]. In the pursuit of responding to dynamism in the external environment, dynamic capabilities offer the firm the ability to modify its distinctive and co-specialized resources [20]. As the management of supply chains offers plenty of opportunities for creating competitive advantages [21, 22], the concept of dynamic supply chain capabilities (DSCCS) has emerged [9]. Conceptualized differently than the firm-centric concept of dynamic capabilities, DSCCS is perceived as "embedded within the collaborative routines formed between multiple supply chain partners" [9, p. 188], providing collaborative opportunities for multiple partners to upgrade existing capabilities as well as form new ones.

Research on adaptability is based on the notion that firms' actions are either a response to changes in the environment or pursuit to create specific environments [23]. According to Birkinshaw and Gibson [24], organizational adaptability is "the ability to move quickly toward new opportunities, to adjust to volatile markets and to avoid complacency" [24, p. 47]. Earlier literature discussed adaptability as the capability of an individual firm. In line with recent literature discussing DSCCS, some scholars are now challenging this conceptualization by expanding the concept and positioning *supply chain adaptability* as more relevant to the nature and characteristics of the modern business environment. Viewed as the property of a supply chain that allows the members to cope with dynamics associated with the supply chain [25], SCA can be considered a dynamic capability which results from the firm's ability to reconfigure firm-level and supply chain-level resources [7, 26]. As firms strive to gain and sustain competitive advantage, SCA is a critical dynamic capability that has the potential to achieve this target [7, 23, 26].

2.3 Supply Chain Innovation

Innovation is a generic activity associated with survival and growth [10]. Achieving competitive advantage through innovation requires firms to approach innovation in its broadest sense, including both new technology and new ways of doing things [27]. Innovation within the supply chain, or *supply chain innovation*, can provide tremendous opportunities for enhancing competitiveness and performance [21]. SCI is perceived as the mindset and practice of creatively exploring and leveraging the opportunities existing in SCM for creating competitive advantages [28, 29]. It aims at improving efficiency in operations as well as service effectiveness by combining advances in technology with logistical and marketing process improvements [30]. The need for SCI can be triggered by typical problems such as low service levels, long lead-times, or high supply chain costs [31] as well as more dramatic changes in the external environment such as changes in relevant regulations, customer tastes, and the advent of new technologies.

The use of state-of-the-art technology to streamline SC processes holds promises of tremendous opportunities of improvement [21]. Tesco, the British grocery retailer, for example, was able to customize offerings to its numerous customers by utilizing the power of innovation. Using big data analytics to analyze purchase patterns of over 13 million customers allowed the third-largest retailer in the world to make store-level adjustments and predict shifts in customer behavior [32].

3 Hypothesis Development

According to Hambrick and Mason [13], organizational outcomes of a firm can be predicted based on the characteristics of its top management. This notion is consistent with the fact that top management is the primary decision-maker and thereby defines and shapes the future of the firm [11]. Major decisions, including the investment in improving current processes or the adoption of new technological innovations, are contingent upon the will of the top management [11]. As a result, the innovativeness of top management is a critical determinant of the level of process and technology-based innovations within a firm. It is also the role of top management to consciously monitor and ensure the alignment between the firm and its environment by adapting suitable technologies, organizational structures, and business processes [33]. Thus, enhancing the adaptability of the firm is affected mainly by the characteristics of its top management.

The style of leadership required for achieving adaptability is different from merely leading for change [34]. While the latter focuses on driving change top-down by inspiring others, e.g., [35], the former requires tapping into the potential of the organization to be flexible and adaptive in the face of surrounding uncertainty [34]. According to Teece [36], the dynamic capabilities of a firm is based on the leader's capacity to *sense* and *seize* opportunities occurring as a natural consequence of the dynamism of the environment. Entrepreneurial leaders, who are characterized by innovativeness, risk-taking, and vision, are therefore capable of configuring their firm-level resources and influence the configuration of the supply-chain level resources to achieve the required SCA. Consequently, we present the following hypothesis:

> H_1. Entrepreneurial leadership has a positive impact on supply chain adaptability.

The ability to recognize new opportunities and spot major shifts, trends, and changes in the surrounding environment can lead to an increased level of firm innovativeness [10, 12, 17]. Following this notion, the relationship between entrepreneurial leadership and innovation has been empirically studied from several perspectives. Initially, entrepreneurial leadership was suggested to drive the organizations' demand for innovation [37]. Throughout the innovation process, which generally consists of idea generation, selection, development, and diffusion, a positive effect of entrepreneurial leadership has been confirmed on all phases of the innovation process [38]. More specifically, as found by Oke et al. [39], leaders who actively create an environment and culture that fosters change and growth encourage both the conceptualization process, the exploratory activities in general, and a variety of exploitative activities of a firm. Exploring new ideas, risk-taking, and creativity, some of the most critical dimensions of entrepreneurial leadership, are found to affect innovation productivity positively and enhance a firm's science-based research initiatives, which can lead to more influential innovations [40]. Despite the intensive study of entrepreneurial leadership's effect on different types and stages of innovation, its effect on supply chain-related innovation is relatively scarce. We test this effect by proposing the following hypothesis:

H_2. Entrepreneurial leadership has a positive impact on supply chain innovation.

The key to building an adaptable firm is to invest in processes and structures that facilitate speed, adaptation, and robustness [41]. The firm's *willingness* to reshape its supply chain when necessary [42] is mainly dependent upon its *ability* to perform such reshaping. Since SCI involves process improvements as well as relevant technology adoption [28], we can postulate that it is capable of providing such ability. When firms renovate their supply chain processes to be more agile, their sensitivity to market changes and their ability to respond to these changes improve rapidly and efficiently [43]. As for technology, advanced information technology (IT) systems were found to increase the speed of supply chains in the healthcare industry [44]. Also, applying advanced planning systems in supply chains can significantly enhance the speed of information flow and demand visibility [45]. This increased visibility and coordination is vital for firms' ability to achieve adaptability as it increases the capacity of sensing as well as seizing opportunities in the external environment. Based on the previous reasoning, we propose the following hypotheses:

H_3. Supply chain innovation has a positive impact on supply chain adaptability.
H_4. Supply chain innovation mediates the positive relationship between entrepreneurial leadership and supply chain adaptability.

4 Methodology

4.1 Sample and Data Collection

Data for this research was collected from samples of firms working in Sudan, Japan, and China. These countries were chosen due to their varying cultural values and developmental stages, which will allow for examining the relevance of our proposed relationships across nations. According to the seminal framework of Hofstede [46], culture can be defined based on four main cultural dimensions: power distance, which reflects the level of acceptance of unequal power distribution; individualism, which measures to the degree to which people in a society are integrated into groups; uncertainty avoidance, which reflects a society's tolerance for ambiguity; and masculinity, which indicates a preference in society for achievement, heroism, assertiveness, and material rewards for success [48]. Concerning entrepreneurship and innovation in societies, individualism and uncertainty avoidance are the most relevant dimensions, with individualism being a booster while uncertainty avoidance being an inhibitor [44, 45]. More specifically, individualism is positively associated with initiating change and encouraging the adoption of innovation [49]. This indicates that highly individualistic societies have a higher rate of innovation in general. On the other hand, uncertainty avoidance was linked to resistance to innovation [48]. The high formalization and regulatory structures usually restrict the adoption of new innovation and postpone it until its value has already been established in the market [49, 50].

Sudan is the most individualistic nation [52] in our samples, followed by Japan, which is “not as collectivistic as most of her Asian neighbors” [53], leaving China as the most collectivistic society among the three countries [48]. In terms of uncertainty avoidance, the Chinese people are characterized by being “comfortable with ambiguity [as well as being] adaptable and entrepreneurial” [53]. In the Sudanese society, however, people “make relatively safer and less risky decisions” [, p. 450], consistent with their relatively high score of uncertainty avoidance. As for Japan, it is considered “one of the most uncertainty avoiding countries on earth [which explains] why changes are so difficult to realize in Japan” [52, 53].

Apart from culture, the three countries also differ in their level of development. Gross domestic product (GDP) and Human Development Index (HDI) are two indicators that are commonly used to measure the development levels of countries. Classified among the top seven largest economies in terms of GDP based on market exchange rates [54] and one of the top 20 countries by Human Development Index (HDI) [55], Japan is the most developed country in our sample. China and Sudan are both classified in the category of emerging markets and developing economies [54]. From a human development perspective, China is ranked among the High Human Development countries, while Sudan is ranked among the Low Human Development countries [55].

After the selection of target countries, a survey instrument was developed. First, the English version of the questionnaire was developed based on pre-validated measures. Next, the questionnaire was translated into Arabic, Japanese, and Chinese languages by native PhD students and professors. Pilot testing was conducted to ensure the questions and their translations were suitable and accurate. The translated versions were back-translated to English for further evaluation of accuracy and comprehension. After the translations were deemed satisfactory, a website was created containing all versions of the questionnaire.

The procedure for data collection varied across the countries due to cultural and structural settings. In Japan, an address database for firms in Osaka city and a random sampling technique were used to develop a list of 584 firms. Covering letters, including a QR code to the Japanese questionnaire version on the website, were sent by mail to the firms. Three mails were returned due to wrong/invalid addresses, resulting in a sum of 581 sent mail. In a total of a 3-week waiting period, 46 valid questionnaires were filled, yielding around 8% response rate. In Sudan, the city of Khartoum was the target for data collection. Since English is the second language of the country, both Arabic and English versions of the questionnaire were hand-delivered to 146 managers from 66 firms. A total of 134 questionnaires were retrieved from all 66 companies. Questionnaires with more than 20% missing responses were discarded. Questionnaires from the same firm were reduced to one using the criteria of “middle manager with the longest experience” for respondents, resulting in 64 valid responses with a response rate of 82%. In China, e-mails containing a cover letter and QR code to the Chinese versions of the questionnaire were sent to managers of firms in Shanghai city. Questionnaires were sent to 50 managers, and the valid responses used in this study are 29 responses (58% response rate). Table 1 provides a summary of respondents' profiles and firms' characteristics for the three countries.

4.2 Measures

An extensive literature review has been conducted to examine existing measures of constructs under study. Whenever relevant, previously validated measures have been used. In some cases, items were slightly modified to suit the study. Questions

Table 1 Respondents' profiles and firms' characteristics

Respondents' profiles	Sudan ($n=64$)		Japan ($n=46$)		China ($n=29$)	
Management level	Frequency	%	Frequency	%	Frequency	%
Senior management	14	22	23	50	7	24
Middle management	40	63	13	28	9	31
Operational management	5	8	10	22	13	45
Missing responses	5	8	0	0	0	0
Years of experience	Frequency	%	Frequency	%	Frequency	%
More than 20 years	6	9	18	39	2	7
10–20 years	22	34	15	33	2	7
5–9 years	15	23	6	13	7	24
Less than 5 years	15	23	7	15	17	59
Missing responses	6	9	0	0	1	3
Firms' characteristics	Sudan ($n=64$)		Japan ($n=46$)		China ($n=29$)	
Industry	Frequency	%	Frequency	%	Frequency	%
Food and beverage	12	19	1	2	0	0
Petroleum, chemical, and medical	15	23	11	24	0	0
Wood, paper, plastic, and nonmetallic products	3	5	8	17	8	28
Electrical and electronic products	1	2	7	15	7	24
Primary and fabricated metal industries	1	2	6	13	1	3
Machinery	3	5	6	13	1	3
Finance and insurance	5	8	0	0	1	3
Wholesale and retail	5	8	1	2	5	17
Telecommunication	8	13	0	0	1	3
Other	11	17	6	13	5	17
Number of employees	Frequency	%	Frequency	%	Frequency	%
Less than 100	10	16	3	7	10	34
100–199	17	27	14	30	3	10
200–499	15	23	15	33	2	7
500–1,000	14	22	7	15	5	17
More than 1,000	6	9	7	15	9	31
Missing responses	2	3	0	0	0	0

included in the questionnaire are presented in the Appendix. All questionnaire items were based on a 7-point Likert scale (1 = strongly disagree/much worse, 7 = strongly agree/much better). Entrepreneurial leadership was measured using the ENTRLEAD scale developed by Renko et al. [2]. The items reflect innovativeness, passion, risk-taking, and vision of the top management. Respondents were asked to select the perceived level of entrepreneurial leadership of their top management. SCI was measured using items based on Kim et al. [56], Kwak et al. [57], and Stentoft and Rajkumar [31]. The items assess the firm's level of process innovativeness and the utilization of the most advanced technology in managing supply chain processes. SCA was measured using items adapted from Pu et al. [58], who adopted them from Gibson and Birkinshaw [59] and Im and Rai [60]. The items reflect the firm's ability to adapt their supply chain relationships, business priorities, and activities in order to respond to different changes in the market and the external environment. Control variables were added in this analysis to control for interpretational confounds. Those included firm size (measured as the number of employees), a dummy variable for industry coded 1 for manufacturing firms, and 0 for non-manufacturing firms, as well as two country dummy variables, to control for country-specific differences. The first country dummy was coded 1 for Japan and 0 for Sudan and China (Japan), while the second country dummy was coded 1 for China and 0 for Japan and Sudan (China), leaving Sudan as the reference group. Table 2 presents the descriptive statistics and correlations among the study variables for the pooled samples.

5 Analysis and Results

The partial least squares structural equation modeling (PLS-SEM) technique was chosen to assess the quality of the research model and test the proposed hypotheses. It assesses the outer measurement model (relationships between latent variables

Table 2 Descriptive statistics and correlations

Construct	Mean	SD	1	2	3	4	5	6
1. Japan	0.33	0.47						
2. China	0.21	0.41	-0.36*					
3. Manufacturing	0.71	0.46	0.42*	-0.09				
4. Firm size	2550.32	15,864.32	-0.08	0.23*	-0.10			
5. EL	5.40	1.14	-0.23*	0.02	-0.14	0.04		
6. SCI	4.72	1.41	-0.51*	0.09	-0.29*	0.04	0.59*	
7. SCA	4.48	1.36	-0.53*	0.02	-0.24*	-0.02	0.49*	0.67*

n = 139

Japan country dummy variable where Japan is coded as one and others coded as 0, *China* country dummy variable where China is coded as one and others coded as 0, *EL* entrepreneurial leadership, *SCI* supply chain innovation, *SCA* supply chain adaptability

*Significant at 0.05 significance level

Table 3 Constructs' reliability and convergent validity

Construct	Items	Loadings	α	CR	AVE
Entrepreneurial leadership	EL1	0.788	0.89	0.89	0.58
	EL2	0.656			
	EL3	0.850			
	EL4	0.613			
	EL5	0.855			
	EL6	0.789			
Supply chain innovation	SCI1	0.879	0.89	0.89	0.68
	SCI2	0.818			
	SCI3	0.845			
	SCI4	0.739			
Supply chain adaptability	SCA1	0.865	0.93	0.93	0.82
	SCA2	0.885			
	SCA3	0.959			

and their indicators) and the inner structural model (the relationships between latent variables) in a single, systematic, and comprehensive way [61]. The analysis was conducted using RStudio [62], the integrated development environment (IDE) of the R language and environment for statistical computing and graphics.

5.1 Measurement Model Assessment

5.1.1 Reliability and Validity

The first step in evaluating a PLS-SEM model is to validate the measurement model [63]. The measurement model measures the consistency and validity of the observed variables. Tables 3 and 4 present the reliability and validity scores of the constructs. As shown in Table 3, most indicators had factor loadings higher than the cut-off criteria of 0.70 [63]. Two indicators had loadings slightly below 0.70, which are EL2 (0.656) and EL4 (0.613), and they were both significant at the 0.05 significance level. Cronbach's alpha (α) scores and composite reliability (CR) scores for all constructs exceeded the minimum requirement of 0.70. The scores of the average variance extracted (AVE) were also above the cut-off criteria of 0.50 [64]. These results confirm the reliability and convergent validity of the measurement model.

Table 4 Constructs' discriminant validity—Heterotrait-Monotrait Ratio of Correlations (HTMT)

Construct	1	2	3
1. Entrepreneurial leadership	1.00		
2. Supply chain innovation	0.66	1.00	
3. Supply chain adaptability	0.53	0.74	1.00

The Heterotrait-Monotrait Ratio of Correlations (HTMT) was used to assess the discriminant validity. HTMT is a more accurate measure of discriminant validity than merely comparing the cross-loadings or the Fornell and Larcker [65] method [66]. As shown in Table 4, the constructs of the study exhibit acceptable validation for the discriminant validity as the scores are far below the recommended threshold of 0.90 [66]. Finally, to detect the presence of the multicollinearity issue, the variance inflation factor (VIF) scores of the indicators and constructs were checked. VIF scores ranged from 1 to 4, far below the threshold of 10, indicating no presence of multicollinearity.

5.1.2 Common Method Bias

As the data was collected from single informants, the presence of common method bias was expected. Several measures have been taken to manage this issue. First, constructs were clearly defined in the questionnaires, and a brief introduction was provided at the beginning of each section. To test for the presence of common method bias after the data was collected, the VIF scores of constructs were checked. The occurrence of a VIF greater than 3.3 is proposed as an indication that a model may be contaminated by common method bias [67]. The highest VIF score for constructs was 1.54, indicating that the model is free of common method bias.

5.1.3 Endogeneity Bias

The results of the proposed structural relationships may be biased if an endogeneity issue is present, causing a problem in hypothesis testing [68]. Referring to the Gaussian copula approach introduced by Park and Gupta [69], we followed the procedure described by Hult et al. [70] to check for this issue. First, we confirmed that independent variables (entrepreneurial leadership and SCI) are not normally distributed using the Kolmogorov–Smirnov test with Lilliefors correction [71] on the standardized composite scores of the constructs. This step is necessary to meet the assumptions of the Gaussian copula approach [70]. The *p* values for both variables were below 0.05 (entrepreneurial leadership = 0.0002, SCI = 0.0046), indicating the possibility of considering them endogenous in the Gaussian copula analysis. Next, two regression models are created in which the independent variable entrepreneurial leadership (model 1) and SCI (model 2) are considered as possibly exhibiting endogeneity. A third model (model 3) was also created, which includes the combination of the two endogenous variables in our PLS path model. The constructs standardized composite scores have been used to compute the Gaussian copula of the partial regressions in the structural model. We used the R code written by Hult et al. [70] specifically for this analysis and the boot package by Canty and Ripley [72] to run this part of the analysis. As shown in Table 5, none of the constructs' Gaussian copula is significant, indicating that the endogeneity issue is not a concern in this study.

Table 5 Results of the Gaussian copula approach

Variable	Original model		Model 1 (endogenous variable: EL)		Model 2 (endogenous variable: SCI)		Model 3 (endogenous variables: EL and SCI)	
	Value	*p* value	Value	*p* value	Value	*p* value	Value	*p* value
EL	0.138	0.076	0.134	0.234	0.142	0.074	0.089	0.471
SCI	0.596	0.000	0.596	0.000	0.783	0.000	0.799	0.000
C_{EL}			0.003	0.963			0.042	0.571
C_{SCI}					-0.153	0.295	-0.170	0.278

EL entrepreneurial leadership, *SCI* supply chain innovation

5.2 Structural Model Assessment

After confirming the reliability and validity of the measurement model, the next step in PLS-SEM is to assess the inner structural model, which includes assessing the model's predictive accuracy and the relationships between the constructs. The key criteria used are the coefficient of determination (R^2) and the size and significance of the path coefficients (β's) [63]. We conducted this part of the analysis using SEMinR package [73] in RStudio.

5.2.1 Model's Predictive Accuracy

R^2 is a measure of the variance explained in the endogenous variables and is thus a measure of the model's predictive accuracy [74]. No clear-cut threshold scores are described in the literature as it depends on several factors, including the field of study and the number of predictor constructs [75]. R^2 values of 0.75, 0.50, and 0.25 can be considered substantial, moderate, and weak, respectively [47, 76]. Based on this classification, the model of this study exhibits moderate predictive accuracy as the model explained 60% ($R^2 = 0.62$, adjusted $R^2 = 0.60$) of the variance in the endogenous construct SCA and more than 40% ($R^2 = 0.44$, adjusted $R^2 = 0.43$) of the variance in the endogenous construct SCI.

5.2.2 Hypothesis Testing

We used the bootstrapping method (5000 resamples) to calculate *t* statistics and confidence intervals in order to test the study hypotheses. The control variables' effects were assessed first. Both country dummy variables (Japan and China) had negative effects on SCA. This means that compared to the Sudanese companies (the reference group), firms working in Japan (β = -0.311, *t* = -3.714) and China (β = -0.132, *t* = -2.024) have lower levels of SCA. Although this result might seem confusing, a reasonable explanation is possible. The degree of dynamism and environmental uncertainty is certainly higher in a county like Sudan, which is characterized by unstable political and economic situations. This reality puts higher pressure on firms operating in Sudan to monitor and respond to anticipated changes constantly and closely, leading to higher levels of adaptability.

The effect of control variables, firms' size and industry, were examined next. The firms' size was not found to be associated with SCA (β = -0.045, t = -0.923), and there was no evidence that manufacturing and non-manufacturing firms differ significantly in their SCA levels (β = 0.039, t = 0.504). Contrarily to our expectations, these results conclude that these firm characteristics have no effect on its SC adaptability.

We then examined the study hypotheses. The first hypothesis (H_1) predicted a positive direct impact of entrepreneurial leadership on SCA, which was supported by the findings (β = 0.420, t = 5.345). When observing the direct impact of entrepreneurial leadership on SCI (H_2), the findings endorsed this path as well (β = 0. 662, t = 10.166), and H_2 was supported. Furthermore, the effect of SCI on SCA was also positive and significant (β = 0. 517, t = 4.131), providing support for H_3. A summary of the hypotheses' results is provided in Table 6.

After all direct paths were examined, the mediating effect of SCI on the relationship between entrepreneurial leadership and SCA (H_4) was assessed. The bootstrapping method was used to test the mediation, i.e., the importance of the indirect effect. The 25% and 97.5% confidence intervals for the mediated path at 0.05 significance level were 0.177 and 0.549, respectively, providing support for H_4. For further confirmation and to determine whether the mediation effect is partial or complete, the procedure suggested by Baron and Kenny [77] was also used. First, we confirmed the significance of the direct paths between the independent variable (entrepreneurial leadership) and both the dependent variable (SCA) and the mediator (SCI), as well as the direct path between the mediator and the dependent variable, as shown in Table 6. Next, we evaluated the effect of the mediator by introducing it and observing the effect on the direct relationship between the independent variable and the dependent variable. The reduced path coefficient from 0.420 (significant at p = 0.01) to 0.131 (insignificant at p = 0.05) indicates a complete mediating effect.

Table 6 Results of the hypothesis testing

Hypothesized paths		β	*t* value	Confidence intervals	
				2.5%	97.5%
H1	EL → SCA	0.420	5.345***	0.260	0.571
H2	EL → SCI	0.662	10.166***	0.531	0.786
H3	SCI → SCA	0.517	4.131***	0.260	0.760
H4	EL → SCI → SCA			0.177	0.549

EL entrepreneurial leadership, *SCI* supply chain innovation, *SCA* supply chain adaptability

$^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table 7 Country-level analysis

(a)				
Endogenous constructs		R^2 (Adjusted R^2)		
		Sudan ($n=64$)	Japan ($n=46$)	China ($n=29$)
SCI		0.43 (0.42)	0.14 (0.12)	0.48 (0.46)
SCA		0.19 (0.13)	0.54 (0.50)	0.74 (0.70)
(b)				
Hypothesized paths	Path coefficients			
	Sudan ($n=64$)		Japan ($n=46$)	China ($n=29$)
Industry → SCA	0.054		NA⁺	-0.233
Firm size → SCA	-0.034		-0.243	-0.130
EL → SCA (direct path)	0.261*		0.140	0.360**
EL → SCA (total path)	0.406***		0.415***	0.803***
EL → SCI	0.679***		0.399**	0.722***
SCI → SCA	0.210		0.695***	0.620**
EL → SCI → SCA	0.144		0.274**	0.443**

EL entrepreneurial leadership, *SCI* supply chain innovation, *SCA* supply chain adaptability

*$p<0.10$; **$p<0.05$; ***$p<0.01$

⁺The variance in the dummy variable "Industry" for Japan was 0

5.2.3 Country-Level Analysis

To gain more insights about the nature of the relationships in our model, we conducted individual analysis for each country. The predictive accuracy of the three models, measured by the R^2 scores, and the hypotheses testing results are presented in Table 7.

In section (a) of Table 7, we present the predictive accuracy of individual countries' models. In Sudan, the percentages of the explained variance in the two exogenous constructs, SCI and SCA, were 42 and 13, respectively. These results indicate a moderate predictive accuracy for SCI and a weak one for SCA. In Japan, the results were quite the opposite, with adjusted R^2 scores of 0.12 and 0.50 for SCI and SCA, respectively. Again, these results indicate that the model was able to capture only 12% of the variance of SCI, and about half of the variance in SCA. Finally, the predictive accuracy of the model for the Chinese sample was moderate and substantial for SCI and SCA, respectively. The model predicted 46% and 70% of the variance in SCI and SCA, respectively.

We then proceeded to the hypothesis testing for each country sample. The results are presented in section (b) of Table 7. As with the pooled sample model, control variables (industry and firm size) did not show any significant effects for any of the samples. The direct and mediation paths, however, revealed interesting findings. In Sudan, the effects of EL on both SCI (β = 0.261, p value < 0.10) and SCA (β = 0.679, p value < 0.01) were significant. However, no evidence to support the impact of SCI on SCA was provided (β = 0.210, p value > 0.10). This result means that the proposed mediating role of SCI in the relationship between EL and SCA is not established in Sudan.

For Japan and China, all three paths (EL → SCA, EL → SCI, and SCI → SCA) were significant, confirming the mediating role of SCI. Nevertheless, the mediation types were different. In Japan, the indirect path EL → SCI → SCA was significant (β = 0.274, p value < 0.05), indicating the presence of the mediation. However, the direct path of EL on SCA was not significant (β = 0.140, p value > 0.10). This means that the introduction of SCI as a mediator "absorbed" the impact of EL completely, i.e., showing a complete mediation [73]. In China, although the mediation effect of SCI is present (β = 0.443, p value < 0.05), it is only partially affecting the relationship of EL on SCA. The direct path from EL to SCA is still significant (β = 0.360, p value < 0.05) after the introduction of SCI as a mediator. In other words, the impact of EL on SCA is partially transferred through SCI.

6 Discussion and Conclusions

To remain competitive, firms must develop an adequate ability to sense and seize opportunities in their external environment. This ability is considered one of the distinguishing traits of entrepreneurial leaders, and thereby it is believed that these leaders have the potential to guide their firms to achieve higher competitive advantage. Additionally, innovation in SC processes and the active adoption of relevant technologies is suggested to be a facilitating factor for developing adaptability in SCs.

This study investigated the impact of entrepreneurial leadership on driving adaptability of SCs directly and indirectly by proposing a mediating role of supply chain innovation. The findings reveal that, despite the varying cultural and institutional characteristics of the countries chosen as the context for this study, i.e., Sudan, Japan, and China, the impact of entrepreneurial leadership was consistently unmistaken. In all three countries, EL was found to drive both innovation and adaptability of SCs.

Nevertheless, the proposed mediation effect was not the same for the three countries. In Japan, the effect of EL on SCA was completely absorbed by the introduction of SCI. In other words, when companies make the decision to pursue innovation in their SCs, the job of the entrepreneurial leaders is completed, and their presence is no longer critical to achieve adaptability. This finding can be explained given the unique characteristics of the Japanese society. As described earlier, the culture in Japan deeply rooted into everyday aspect of life, including business. With a high uncertainty avoidance and the resulting intensive documentation to maximum predictability, change is very difficult to realize [53]. In these situations, the role of leaders with entrepreneurial orientation is critical to drive the change. However, once firms adopt the new technology and engage in its utilization, the same level of diligence will occur, and procedures will be prescribed in great detail to ensure minimal variation, which will render the role of EL redundant until the next time an innovation is needed. Hence, SCI will take over the role of EL in achieving adaptability, explaining the complete mediation.

The Chinese, on the other hand, are more "adaptable and entrepreneurial" in nature and feel less threatened by ambiguity [53]. These traits allow them to move quickly towards new opportunities without fear of the unknown. Nevertheless, the guidance of entrepreneurial leaders in necessary to direct the effort of the firm with a clear vision of the future, which is a key characteristic of entrepreneurial leaders [2, 17]. In this sense, the role of those leaders continues even after the new technology is adopted and utilized. In other words, the role of EL will be partially transferred via the use of innovation, i.e., result in partial mediation.

Finally, in Sudan, although the role of EL is established as a driver of innovation and adaptability in Sudanese SCs, innovation was not found to affect adaptability. The underdevelopment in SC technology infrastructure [1] associated with the complex economic and political situation in Sudan is believed to make the role of technology innovation less relevant.

7 Theoretical Contributions

The findings of this study provide several contributions to extant literature. Previous research acknowledged the importance of leadership in developing adaptable supply chains [26]. However, the effect of entrepreneurial leadership as a distinctive type of leadership was not directly examined as a driver of adaptability. Also, the method by which leadership affects adaptability, i.e., the mediation effect, was not fully explored. We contribute to the growing literature about entrepreneurial leadership by examining its role as an antecedent to innovation and adaptability in supply chains, and the possible role of innovation as a catalyst to achieve adaptability.

Our empirical findings established a positive impact of entrepreneurial leadership on achieving innovation and adaptability. This finding was consistent across countries with different cultural values and levels of development. Such a conclusion indicates that the advantages of entrepreneurial leadership are confirmed not only across firms of varying characteristics such as type and age, e.g., [2], but also across varying business environments in which these firms operate.

Moreover, although researchers have investigated the effect of entrepreneurial leadership on different aspects of innovation, such as organizations' demand for innovation [37], the innovation process [38], and innovation productivity [40], the effect on supply chain-related innovation, in particular, was neglected. We bridge this gap by acknowledging the significance and distinctiveness of supply chain innovation.

Additionally, few if any studies have utilized data from developing countries, especially from Sudan, to test these proposed relationships in this study. We contribute to enriching literature by providing data from a less researched country, encouraging cross-cultural studies.

8 Managerial Implications

From a managerial perspective, the findings of this study provide useful insights for managers and practitioners regarding the development of an adaptable supply chain using technology-based SC innovation. First, the distinctive characteristics of entrepreneurial leaders such as innovativeness, creativity, and vision are emphasized, as they were found to improve SCA and SCI significantly regardless of culture and development level of the country. These results encourage leaders to be more open to new ideas and technologies, and the risks associated with them, in their pursuit to enhance their supply chains.

Additionally, building adaptable supply chains through process and technology innovation is not always cost-efficient in the short-term, and their fruits can mostly be reaped in the long-term [51]. Since managers are responsible for maintaining costs under control, the findings of this study provide the needed reassurance that foregoing short-term cost optimization would eventually lead to improved and sustainable supply chain-wide adaptability.

9 Limitations and Future Research Directions

The use of self-reported, perceptual data is the dominant practice in the majority of management research. However, the bias inherent in such data type cannot be avoided entirely, despite the substantial efforts undertaken during data collection and analysis. Therefore, conclusive evidence can further be established through future longitudinal research.

To the best of our knowledge, there is no coherent and validated measure of SCI in previous literature. In our study, we used selected indicators based on their relevance to the construct to be measured. Researchers are encouraged to develop and validate a scale for measuring SCI to ensure receiving comparable results when studying this construct in further research, as such endeavor is beyond the scope of this study.

Appendix Questionnaire

Supply Chain Adaptability

Based on your personal judgment, please indicate your performance compared to your closest competitor(s) in the following during the past 3 years.

1. Ability to adapt existing supply chain relationships to respond quickly to changes in our market.
2. Ability to adapt existing supply chain processes to rapidly respond to shifts in our business priorities.
3. Ability to facilitate reconfiguration of supply chain activities to respond to changes in the external environment.

Entrepreneurial Leadership

Please indicate your level of agreement with these statements over the past 3 years.

1. Our top management often comes up with radical improvement ideas for the products/services we are selling.

2. Our top management often comes up with ideas of completely new products/services that we could sell.
3. Our top management takes risks.
4. Our top management has creative solutions to problems.
5. Our top management demonstrates passion for work.
6. Our top management has a vision of the future of our business.
7. Our top management challenges and pushes me to act in a more innovative way.
8. Our top management wants me to challenge the current ways we do business.

Supply Chain Innovation

Please indicate your level of agreement with these statements over the past 3 years.

1. We use the most advanced Enterprise resource planning (ERP) systems for managing our core SC processes.
2. We use the most advanced Information Technology systems (other than Enterprise Resource Planning (ERP) for managing our core SC processes.
3. We adopt technology for real-time tracking.
4. State-of-the-art technology is incorporated into our SC processes (e.g., Internet of Things or Artificial Intelligence).

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Declarations

Competing Interests The authors declare no competing interests.

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