The Impact of SCRM strategies on supply chain resilience: A quantitative study in the Moroccan manufacturing industry

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Abstract— Both Supply Chain Risk Management (SCRM) and Supply Chain Resilience (SCRES) are emerging topics in the field of SCM which require more empirical studies. Many authors have tried to explore the link between the main supply chain risk mitigation strategies and SCRES. Through a quantitative study conducted in the Moroccan manufacturing industry context, this paper aims to shed light on the impact of flexibility, redundancy and collaboration on SCRES. Data was gathered through a questionnaire and analyzed using exploratory then confirmatory factor analysis using PLS-SEM. Findings show that redundancy practices have no significant impact on SCRES. On the contrary, increased flexibility and improved collaboration are considered to be the key factors to enhance the resilience of industrial supply chains.

Keywords—S*upply chain risk mitigation strategies, supply chain resilience, manufacturing industry, PLS-SEM.*

1. Introduction

Evolving in changing and turbulent environments; modern complex and global supply chains; are becoming more vulnerable than any time. The members of those structures are facing an increasing number of risks originating from different sources and threatening the supply chain performance outcomes both in the short-term and in the long-term because of their unpredictability and the severity of their impact. Thus, the aim of modern supply chain risk management (SCRM) is to allow supply chains to anticipate threats; respond to them quickly and cost effectively and recover to an equilibrium state after being disturbed. This implies the development of the resilience capability. Although the topic of supply chain resilience (SCRES) has been widely studied recently, the majority of researches have focused on defining the concept, highlighting its importance, or identifying its main characteristics. Therefore, there is a poor understanding of antecedents and outcomes of SCRES [1]. Moreover; it has been argued that the SCRES literature lacks also theoretical justification for the established frameworks and models. In order to fill these gaps, we aim through this survey based study to explore the way SCRM strategies implemented by companies could enhance SCRES. Thus, after a brief summary of literature we will present our conceptual model and hypotheses, and then expose the methodology and the results of the research.

2. Theoretical background

1.1. Supply chain risks

The expression SCR is used to refer to a negative deviation from the expected value of performance measures which results in undesirable impacts for the firm [2]. From all works that tried to classify the risk sources (e.g. [3]-[4]), the multi-level classification of [5] has received more attention. In this classification, the supply chain risk sources are presented in three main levels which are environmental risk sources, network-related risk sources and organizational risk sources. Several risk drivers are discussed in the literature; the major are the focus on efficiency (rather than effectiveness), the trend to globalization of the supply chains, to focused factories and to outsourcing, the lean management practices, etc. (e.g. [5]-[6]-[7]). The SCR could have a severe impact on supply chain performance indicators; it could lead to financial consequences, reputation damage and health and safety concerns [5].

1.2. Supply chain risk management

Since a long time, companies have widely deployed risk analysis techniques to refine their decision making process. However, the real challenge lies in extending this activity to all partners involved in the supply chains. As the vulnerability of the latters increases during last decades, supply chain risk management (SCRM) has received a growing interest from the community of researchers [8]. This activity leads the members of the

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supply chain, to identify potential sources of risk and implement strategies able to reduce supply chain vulnerability [5]. In practice, the SCRM results in traditional processes encompassing the main activities of risk identification /analysis, risk assessment (or evaluation), implementation of SCRM strategies and control and monitoring [5]. The SCRM practices identified in the SCRM literature are varied but can be summarized in four strategies mainly: Risk acceptance, Risk avoidance, Risk transfer and Risk reduction [10], [11]-[12]-[13].

1.3. The supply chain resilience (SCRES)

Several authors have commented on the multidisciplinary and multidimensional nature of resilience [14], [15]. In a supply chain context, the changing environment make the occurrences and consequences of risk unpredictable, especially for the extreme events with rare occurrences but severe impacts [16]. Evolving in such environments, firms are driven to seek ways to anticipate, absorb, and gain an equilibrium state after being disturbed. In such circumstances, the concept of resilience has emerged, implying the supply chain ability *to be prepared for umpredictible risk events, respond quickly to potential disruptions, recover from them and return to its original state or a new more desirable state after being disturbed* [17]. To build resilient supply chains, various practices can help. In a literature review, [18] identify twenty-four different strategies which were classified in proactive / reactive strategies. His study reveals that the most commonly cited strategies involve increasing flexibility, creating redundancy, and forming collaborative supply chain relationships. This result is consistent with previous researchers who have considered those strategies as the most critical for SCRES [19], [15].

3. Conceptual model and Hypothesis development

Redundancy involves "*the strategic and selective use of spare capacity and inventory that can be invoked during a crisis to cope, e.g. with supply shortages or demand surges*" [20]. It is achieved by keeping buffer stocks in different parts of the supply chain (Extra inventory), contracting with a backup supplier [10], [21], designing a certain level of excess capacity in some key nodes of the network [22]-[23], etc. For many authors, redundancy is essential to the SCRES [20]-[10]-[22]-[23]-[24].[5] stresses the need to keep some extra-capacity in terms of stocks of raw materials, components and finished products to enable the company to prevent any disruption related to demand or supply. [26] estimates that a certain level of redundancy is always necessary to avoid what they call "the corporate anorexia" referring to the situation in which, a company is unable to cope with even minor disturbances. Thus, we suggest that:

H1: Redundancy practices help companies enhancing supply chain resilience

Flexibility is defined as "*the ability to take different positions to better respond to an abnormal situation and rapidly adapt to significant changes in the supply chain*" [27]. The literature reveals various flexibility practices that can enhance SCRES, such as postponement [25]-[12], flexible supply base [28], flexible transportation [12]-[29], flexible manufacturing [10], etc. This strategy is believed to be an antecedent of SERES [20]-[30]-[31]-[32]-[19]-[34] allowing it to create prompt adaptability during turbulence [35] and rapid response and recovery. Thus we suggest that:

H2: Flexibility practices help companies enhancing supply chain resilience

Collaboration refers to "*the ability to work effectively with other entities for mutual benefit in* areas such as forecasting, postponement and risk sharing" [36]. Aligned strategies, collaborative planning and forecasting, information sharing, integrated and optimized logistics process and collaborative training are all practices which can enhance collaboration in supply chains. Collaboration can reduce uncertainty, increase transparency and facilitate the creation and sharing of knowledge, such as about supply chain risks and uncertainties [10]. Collaboration can also enable supply chain partners to share the costs of building security and resilience [37]. Moreover, it influences the processes adopted by supply chain partners to ensure supply chain recovery [38]. For example, collaboration can facilitate the sharing of resources and other complementary skills necessary for recovery from a disruption [39]. Collaboration also enhances SCRES by enabling supply chain partners to support each other during a disruptive event [19] and to provide a flexible and coordinated response. Thus we suggest that:

H3: Collaboration practices help companies enhancing supply chain resilience

The figure 1 shows the conceptual model elaborated from the discussion above.

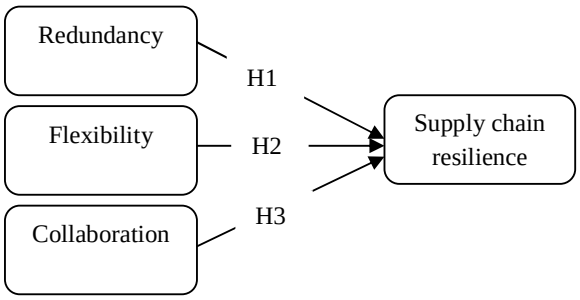

FIGURE 1. CONCEPTUAL MODEL

4. Methodology

A survey was carried out in the manufacturing companies in the North of Morocco. A questionnaire was developed; items for all constructs were generated and adapted from prior studies [23]-[40]-[41]-[24]-[4]-[42]-[43]-[44]-[45]. Items were reviewed by three academicians and discussed with four logistics managers who were asked to comment

on the appropriateness of the research constructs. Based on their feedback, some items were either modified or eliminated. The questionnaire has been tested on a sample of 20 respondents to ensure that they fully understand the questions and are not likely to refuse to answer. The final version of the questionnaire, measuring all the items (24 items) on a five point scale, was administrated to 223 target respondents. It was ensured that logistics managers participated in the study; otherwise, we have targeted other managers who are considered to be qualified to tell us about strategies implemented by theirs companies in order to increase supply chain resiliency. In total, 102 questionnaires were returned (with an effective response rate of 45.73%). However, usable responses accounted for only 95 questionnaires. The respondents' profiles are shown in table I.

TABLE 1. RESPONDENT'S PROFILE

Respondent's characteristics	*Frequency*	*Percentage*
Gender		
- Male	81	85.26%
- Female	14	22.92%
Position		
- Logistics manager	44	46.31%
- Purchasing manager	09	09.47%
- Supply manager	23	24.91%
- Managing director	16	16.84%
- Plant manager	03	03.15%
Seniority		
- less than one year	5	05.26%
- between 1 and 5 years	42	44.21%
- between 5 and 10 years	29	30.52%
- more than 10 years	19	20.00%

5. DATA ANALYSIS and RESULTS

5.1. Exploratory factor analysis

Exploratory factor analysis by means of SPSS 20.0 was performed on the four variables of the model. Varimax rotation was used to determine the number of components factors [46]. Items having communalities lower than 0.4 (as recommended by [47] for a sample size of 90) and items having factor-loadings greater than 0.3 on more than one component were dropped from the measurement scale. The final results of the exploratory factor analysis provided in table II show a structure of four factors. These results indicate that all the measurement scales are one-dimensional which means that all items are thought to measure a single underlying construct [48]. Besides, all Cronbach alpha values are greater than 0.7 recommended by [49].

TABLE2. FACTOR STRUCTURE OF THE CONSTRUCTS

	Components				Cronbach'alpha
	1	2	3	4	
RESIL2	,891				
RESIL1	,837				
RESIL4	,819				
RESIL3	,800				0.935
RESIL5	,736				
RESIL6	,675				
RESIL7	,594				
COLL2		,720			
COLL5		,665			0.795
COLL1		,612			
FLEX4			,841		
FLEX2			,722		0.746
FLEX6			,670		
REDON1				,891	
REDON3				,842	0.818
REDON6				,713	

Extraction method : PCA ; Rotation method : Varimax with Kaiser normalization; KMO 0.832; Bartlett's test of sphericity = 0.000 ; Total variance explained 67.275 ; rotation has converged after 5 iterations.

5.2. Confirmatory factor analysis

To analyse data, the partial least squares technique (of structural equation modelling) was used. PLS is suitable for small sample sizes such as this one. Using Smart-PLS [50], the study first examined the measurement model to assess the internal consistency, convergent validity and discriminant validity of the four constructs. Internal consistency is ensured when the reliability of each measurement is > 0.7 [49]. To assess reliability, Cronbach's alpha and composite reliability were used. All the four variables have a Cronbach's alpha and composite reliabilities with acceptable values to confirm internal consistency of the data. Convergent validity is asserted when each construct has an AVE greater than 0.5 [51].
The results provided in table III show that the AVEs range from 0.659 to 0.726. That means that convergent validity is demonstrated.

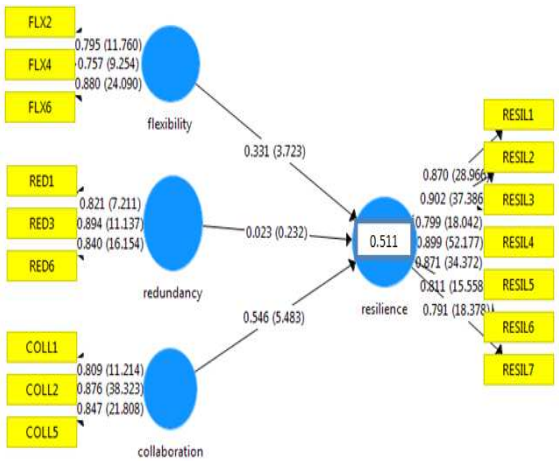

FIGURE. 2. *BOOTSTRAPPING PROCEDURE RESULTS.*

TABLE 3. RELIABILITY AND CONVERGENT VALIDITY

	Chronbach' alpha	Composite reliability	AVE
Collaboration	0.799	0.882	0.713
Flexibility	0.749	0.853	0.659
Redundancy	0.819	0.888	0.726
Supply chain Resiliency	0.936	0.948	0.723

Discriminant validity is asserted when each item has an item loading greater than 0.6 on its respective construct [48], when the square root of all the constructs is larger than all the other average variance extracted (AVEs) cross-correlations, and when no item loads highly on any other construct. The results also show that the values on the diagonal are higher than any value in the lower part to the diagonal which asserts discriminant validity. It is also clear that the items are highly correlated with their corresponding construct and weakly correlated with the other constructs. This confirms the discriminant validity of the measurement scales (Tables IV and V).

TABLE. 4. DISCRIMINANT VALIDITY- FORMER AND LARCKER CRITERION

	collaboration	*flexibility*	*redundancy*	*resilience*
collaboration	*0.844*			
flexibility	*0.246*	*0.812*		
redundancy	*0.376*	*0.267*	*0.852*	
resilience	*0.436*	*0.472*	*0.316*	*0.850*

TABLE. 5. DISCRIMINANT VALIDITY – CROSS LOADINGS

	Collaboration	Flexibility	Redundancy	Resilience
COLL1	0.809	0.193	0.387	0.466
COLL2	0.876	0.183	0.290	0.376
COLL5	0.847	0.248	0.290	0.361
FLX2	0.254	0.795	0.194	0.297
FLX4	0.094	0.757	0.262	0.318
FLX6	0.242	0.880	0.207	0.388
RED1	0.276	0.144	0.821	0.153
RED3	0.361	0.266	0.894	0.306
RED6	0.306	0.236	0.840	0.297
RESIL1	0.408	0.355	0.285	0.870
RESIL2	0.421	0.342	0.244	0.902
RESIL3	0.323	0.295	0.250	0.799
RESIL4	0.442	0.456	0.360	0.899
RESIL5	0.472	0.462	0.278	0.871
RESIL6	0.450	0.402	0.231	0.811
RESIL7	0.418.	0.499	0.283	0.791

Our major aim is then to test the proposed structural model and the hypothesized relationships between the four constructs [47]. The information "R squared" (R2) and path coefficients (β) are provided in the figure below. The R2 value has to be greater than 0.1 following the recommendations of [52]. The significance of path coefficients are tested following guidelines of [53] using the bootstrapping procedure (with 500 subsamples) [54]. A path coefficient is considered to be significant if its t-statistic value is greater than 1.96 (p<1%), 2.57 (p<5%) or 1.64 (p<10%). The output the βs and the R2 are shown in Figure 1.The results show that the coefficient of determination "R2" is 0.511 for the endogenous latent variable (supply chain resilience). This means that the three latent variables (flexibility, redundancy and collaboration) together explain 51.10% of the variance in supply chain resilience. The inner model suggest also that collaboration has the strongest effect on SCRES (β=0.546), followed by flexibility (β=0.331). Those path relationships are considered to be statistically significant with t-values of 5.483 and 3.723 respectively. However the hypothesized path relationship between Redundancy and SCRES is not statistically significant (β=0.023; T-statistic = 0.232). Confirming hypotheses H2 and H3, we can conclude that collaboration and flexibility practices have a significant positive effect on supply chain resilience, but redundancy does not predict SCRES directly. The table below provides a summary of hypotheses testing results.

TABLE 6. HYPOTHESES TESTING RESULTS

Hypothesis	***Path β***	***T-value***	***Supported?***
H1: redundancy practices help companies increase supply chain resilience	0.023	0.232	No
H2: flexibility practices help companies increase supply chain resilience	0.331	3.723	Yes
H3: collaboration practices help companies increase supply chain resilience	0.546	5.483	Yes

6. Conclusion

This study tested three hypotheses to examine the interrelationship among supply chain resilience and three SCRM strategies which are collaboration, flexibility and redundancy using data from 95 respondents. It has been demonstrated that flexibility and collaboration help companies building resilient supply chains. The results show that collaboration is the key to uniting supply chain partners' combined efforts to overcome disruption and crises. A focal firm is often unable to detect the root cause of disruptions, mitigate the effect of actual problems, and resume business operations by reconfiguring supply chain resources alone. Collaboration is required during all phases of supply chain resilience formulation. Besides, increasing flexibility through flexible supply base, flexible transportation and flexible manufacturing process is considered to be a more efficient way to increase supply chain resiliency than investing in redundancy. Maintaining safety stock and slack capacity remain a costly solution to achieve SCRES. Even though this study contribute to the enrichment of emergent disciplines (SCRM and SCRES), it is not free from limitations; the data for the study consisted of responses from single respondents in an organization which may generate some measurement inaccuracy and maybe a cause for possible response bias [55]. Future research should seek using multiple respondents from each participating organization to enhance the accuracy of research conclusions. Also, our unit of analysis was the organization which has a lot of drawbacks; future research should be conducted using the supply chain as unit of analysis as recommended by [18].

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