DOI: https://doi.org/10.22555/pbr. v25i4.791 | Volume 25 Issue 4, January - March, 2024

Exploring Factors Shaping Resilience in Maritime Supply Chains and Their Effects on Supply Chain Customer Value: Insights from the Pharmaceutical Sector

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Abstract

Because of the existing risks, studying the maritime supply chain (MSC) is a complicated task. The interdependence of the global Supply Chain (SC) on other channel members makes it vulnerable to disruption. This research signifies the determinants such as improved Information and Communication Technology (ICT), Strategic Alliance (SA), and its effect on SC customer value within the context of the pharma industry. A structured questionnaire based on a five-point Likert scale was used to obtain responses from 98 participants. PLS-SEM was deployed as a research technique to evaluate the proposed research model. The findings indicate that the determinants such as sophisticated ICT and SA possess a considerable beneficial effect on SC resilience, which further affects MSC customer value substantially. The findings provide practitioners with useful implications to cope with uncertainties, increasing pharmaceutical SC customer value and benefiting patients and hospital pharmacies by facilitating on-time delivery of prescriptions and drugs.

Keywords: Supply chain resilience; pharmaceutical industry; customer value; maritime supply chain.

JEL Classification: M16

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1. Introduction

The pharmaceutical supply chain is used to manufacture and distribute prescription medications to patients. Though it might seem simple, managing a functional pharmaceutical supply chain is quite complicated and necessitates a lot of steps to be followed (Sabouhi et al., 2018). The pharmaceutical supply chain (PSC) comprises manufacturers, maritime transport chains, wholesale dealers, and pharmacy benefit managers.

As per UNCTAD (2021), transportation by sea serves to transport 80% of all commodities. Nevertheless, the Organization for Economic Cooperation and Development (OECD) asserts that it is closer to 90%. While maritime transport is recognized as the cornerstone of global trade, it transports a wide range of resources to industrial hubs (Zohaib & Zaidi, 2022). Maritime transport along with its operations significantly contributes economically across various industries. The blue economy's valuation and employment of maritime transport and its associated industries are 40% and 24% respectively (shipbuilding, maintenance, and port operations). However, UNCTAD predicts that maritime trade volume will increase by 2.4% in 2023. Indeed, the industry is resilient, and UNCTAD anticipates steady moderate growth in maritime commerce volume over the medium period (2024-2028) (Review of Maritime Transport 2023)

However, chain interruptions are more likely to occur at the maritime node. MSCs are more likely to experience disruptions due to a high degree of interdependence between stakeholders on the off-shore and land sides, or at the port, which disrupts the chain's overall performance and reduces the consumer's value at the downstream level (Kashav et al., 2022). Port disruptions may have consequences for the global supply chain, as well as the critical node of the shipping logistical chain (Wendler-Bosco & Nicholson, 2020). However, major man-made disasters as well as prevailing political or economic circumstances could be to blame for this disturbance. According to studies, SC interruptions affect organizations for around nine months out of the year (Scholten et al., 2020). Furthermore, supply systems are becoming increasingly vulnerable as a result of the growing global population. As a result, the pharmaceutical business faces increased pressure since the increasing demands require expedited supplies. Because of a large range of products and varied stakeholder interests, the pharmaceutical industry is also the most dynamic and complex when contrasted to the maritime industry. Businesses must make more effort to stay competitive and profitable in the face of the high level of change.

The pharmaceutical industry, a large global corporation, involving a large number of diverse global channel members is required to manufacture, develop, and market the medicines. Pharma Supply Chains (PSC) usually have five echelons: first-tier and second-tier producers, shipping networks, global and localized dispatch centers, and demand locations. For instance, clinics, hospitals, and pharmacies. Primary producers are responsible for refining and product recovery in the biological methods to create the required active ingredients (RAI), or chemical production involving segregation steps to accumulate the complex chemicals (Hasani et al., 2021). Additional production tasks like packing and completing SKU-based products are the responsibility of secondary manufacturers. Secondary manufacturers can be seen as manufacturing centers, whilst primary producers may be thought of as providers of raw ingredients. As a result, secondary producers contribute significantly to the creation of finished goods/ medicines (Sazvar et al., 2021), but they can only store a certain number of items at a time in a particular facility.

The marine supply chain has the responsibility of transporting inventory globally, including building ingredients, partially manufactured inventory (WIPs), and finished medications, as well as distributing them internationally. The primary DC and the regional distribution centers DCs are responsible for storing products to cater to the market demand. Local DCs can service more demand locations because they have a lesser capacity and are more dispersed than central DCs. Oftentimes, despite the utilization of cutting-edge technology and the development of innovative products, businesses are still unable to satisfy market demands issues and complexity of the marketplace (Ganguly & Kumar, 2019). The effect of maritime SC resiliency on customer value is investigated in this research study along with the elements that influence it. The pressure on the pharmaceutical business is continual and comes from a variety of nodes and entities that can affect its maritime MSC's node. Companies in this area should react instantly and effectively (Kanike, 2023) to cater to upcoming vulnerabilities.

The pharma sector ranks among the most tightly regulated in the world (Geremia et al., 2023), requiring businesses to follow a stringent set of rules to manufacture and market their goods. Unfortunately, because of all the regulations, some businesses feel needlessly constrained regarding their SCs. The current study focuses on the factors that influence MSC resiliency (MSCR) in a global SC setting and the impact of MSCR on the pharmaceutical sector's customer value. It is one of the most strictly regulated businesses in the world, with pharmaceutical corporations obliged to follow strict laws to synthesize and market their products. Furthermore, the pharmaceutical industry is continuously under stress because of disrupted variables affecting its maritime transportation network. As a result, pharmaceutical businesses must respond to disturbances swiftly and efficiently to avoid cascade interruptions. Unfortunately, growing uncertainty and stringent regulations keep the pharmaceutical SC underutilized. As a result, this study is guided by the following goals.:

- To identify factors impacting MSCR in the pharmaceutical sector.
- To assess the impact of MSC resilience on PSC customer value.

2. Review of the Literature

2.1 Theoretical background

As per the Resource-Based View (RBV), a company's internal, distinctive expertise (i.e., resource) is used to gauge performance through competitive advantage (Memon & Ooi, 2023). The RBV has already been extensively utilized in the domain of supply chain research to discover a variety of performance determinants. For instance, in the case of strategic capabilities (Ordanini & Rubera, 2008), Wu and Chiu (2015) highlighted innovative IT resources, Wong and Karia (2010) discussed strategic logistics abilities and, Wieland and Wallenburg (2013), emphasized SC resilience competence.

The modern era requires strategic collaboration with channel-wide members through investments in knowledge and resource-sharing abilities. In past studies, the ability of organizations to improve supply chain resilience was influenced by a variety of factors, including SC visibility (Brandon-Jones et al., 2014). However, SC-Resilience, which may improve operational performance, has also been noted as an organizational resource that supports enterprises in adapting to their surroundings (Ponomarov & Holcomb, 2009). Additionally, RBV can be used as a foundation to demonstrate how SC-Resilience affects the performance of cargo operations. Several forms of supply chain resilience fall within the scope of RBV's description of resources, including robustness (Wieland & Wallenburg, 2013), integration (Rodrguez-Dáz & Espino Rodrguez, 2006), and agility (Chiang et al., 2012), which probably raise the profitability of the firm, thus enhancing the customer value. In addition, this study introduces the Relational View (RV) as a supplement to the RBV.

The pharmaceutical industry's import and export departments are the primary unit of investigation in this research. Relational competencies, such as developed communications networks, relationship monitoring systems, and management systems, are significantly correlated with resilience, according to data from a case (Blackhurst et al., 2011) The relational view underpins this study's understanding of how good interpersonal skills might promote two dimensions of resilience.

2.2 SC-Resilience

According to Seddigh et al. (2023), PSCs are crucial for the growth of the medical and healthcare businesses. PSC's primary goal is to guarantee that pharmaceutical supply chains deliver on time, at the lowest possible cost, with a minimal stock out and the most efficient lead times. A company's SC orientation is defined as controlling the bidirectional flow chain's upstream and downstream flows, which has significant strategic outcomes (Modgil & Sharma, 2017a). (Zohaib & Zaidi, 2022) emphasized that when addressing PSC from a global context, regional diversity, localized compulsory norms, and conflicting organizational structures provide challenges. The strengthening of GSC (Global Supply Chain), shortened PLCs (product life cycles), technological advancements, and changing consumer demands lead to extremely competitive PSCs.

The relationship between sourcing management, supply adaptability, and SC performance has already been researched and proven to have a beneficial influence on the customer value of the SC (Tripathi et al., 2019). Gupta and Kayande (2023) focused on identifying vulnerabilities in the pharmaceutical product distribution network and established an adaptive model to help the pharmaceutical PSC improve its resilience. However, research has analyzed the impact of the COVID-19 crisis on supply risk (Bø et al., 2023; Zohaib et al., 2023), resilience, and reliability in food and PSCs. Additionally, Silva et al. (2023) explored the integration of resiliency in a decision-support system (DSC) to investigate how resilience-driven strategies improve pharmaceutical SC operations under various scenarios. Hence, it has been established that risk management across the SC is gaining significance for global PSC.

The creation of an agile SC will demand some qualities, particularly competency, responsiveness, velocity, and flexibility. Numerous factors, such as market research, consumer demand, feedback from all parties, and estimations, define PSC's adaptability (Olfat et al., 2014). In addition, MSC has been studied in both centralized and decentralized supply chain environments. However, Modgil and Sharma (2017b), claimed that the availability and accessibility of supply data may be advantageous for decentralized setups.

2.3 Advanced ICT and MSC Agility

The advanced ICT application refers to the use of technical systems such as Web-based optimization tools, customized modules, Warehouse Management Systems (WMS), Transportation Management Systems (TMS), Port Community Systems (PCS) & Enterprise Resource Planning systems (ERPs) etc. There must be synchronization between the flow of information and inventory flow to make the SC more flexible. As far as maritime SC is concerned, IT infrastructure deployment is mandatory in making the shipping vessels proactive by making forecasts regarding upcoming damages resulting in the rescheduling of shipping routes enhancing the maritime SC agility (Lam & Bai, 2016). Furthermore, the earlier research enunciates that maritime SC agility is increased by attaining port efficiency, which is possible through the greater quality of information exchange due to the significance of the transmission of information (Loh & Thai, 2014). Resultantly, advantages such as increased collaboration among other transportation modes and optimum resource utilization are obtained (Notteboom & Winkelmans, 2001), which in turn enhances the port integration within the entire network. It also assists in establishing maritime agility by setting up required protocols (Loh & Thai, 2014).

Therefore, the IT system plays a vital role in enabling firms to gain timely information and facilitates them to make the communication process more rapid among maritime SC stakeholders (Fischer-Preßler et al., 2020). Consequently, the risk factors are minimized by reducing uncertainties making the maritime SC responsiveness better towards forthcoming risk factors. The presented arguments lead to hypothesize:

H1(a): Advanced ICT systems possess a positive and significant effect on MSCA.

2.4 Advanced ICT and MSC Robustness

ICT system deploys technological infrastructure to attain chain-wide integration enhancing SC visibility. According to Lavastre et al. (2012), efforts to improve SC visibility through information sharing about potential risks aid in the execution of risk mitigation techniques. Consequently, a standardized and harmonized IT system may significantly contribute to information transmission throughout the value chain (Speier et al., 2011; Hall & Saygin, 2012). Furthermore, a review-based study concluded that SC robustness is attained via information exchange at lower echelons. Lastly, Zhang et al. (2012) also argued that the risk resistance capability of SCs is enhanced via advanced information systems.

Nevertheless, With the development of contemporary technologies like Radio Frequency identification devices (RFID), Optical character recognition (OCR), and Global Positioning System (GPS), the efficiencies of SC have been enhanced more than ever before making them effective and cost-effective simultaneously. This has resulted in better implementation of contingency plans due to the reduced response time particularly in case of real-time situations (Blackhurst et al., 2005). Furthermore, IoT, defined as a dynamic system with the ability to regulate, track, and share useful information intelligently via smart interactions, has facilitated SC by effectively tracking and validating the consignment and providing information about their point of destination and expected arrival time (Galetsi et al., 2020). This leads to the visibility and transparency of information, reducing potential risk across the SC entities of the pharmaceutical industry integrating SC planning and production resulting in enhanced robustness.

H1(b): Advanced ICT system has a significant and positive effect on MSC Robustness.

2.5 Strategic Alliance and MSC Agility

The SC members' responsiveness can be enhanced via collaboration between the firm and SC partners (Gunasekaran et al., 2015), which is a preliminary step towards the development of strategic relationships. The focal firms must consider the relationship as an essential factor in making strategic contracts and sharing communication technologies (Gunasekaran et al., 2015). An organizational skill of dealing with agility entails the partner's ability to react to the dynamic environment and circumstances (Liu et al., 2018), which requires aligning the partner's strategy with that of the focal business. It has been claimed (Huo, 2012) that the degree of supply chain integration must be investigated to realize either make strategic partnership or mutually cater to the organizational processes, to reduce SC vulnerabilities and more aggressively manage risks (Liu et al., 2018). In the pharma industry setting, the strategic alliance between the firm and maritime partners can result in reducing the risk associated with shutdown maintenance and better responsiveness towards environmental vulnerabilities. Consequently, it may be posited that:

H2(a): The Strategic Alliance possesses a positive and significant effect on MSCA.

2.6 Strategic Alliance and MSC Robustness

Enhanced interaction due to strategic alliances and collaborations among SC entities leads to port integration with other channel members. However, such relationships require enhanced coordination and cooperation levels to realize collaborative actions (Loh & Thai, 2015). This leads to enhanced bonding among pharma and internal LSPs, i.e., organizations which are a part of the value chain, hence increasing the PSC's customer value (Zohaib & Zaidi, 2022). The supply chains must prevent sub-optimization and competition among channel members can be realized only if the entire chain recognizes the importance of forming strategic alliances that channel numbers (Green et al., 2006; Loh & Thai, 2015). This may lead to enhanced customer service levels, which are because of resource-sharing capabilities among channel entities.

Furthermore, it has been claimed that alliances enable better utilization of similar resources of channel members resulting in risk mitigation leading to increased stability. This is advantageous for SME shipping companies since it allows shippers to capitalize during income generation days via common earnings. Therefore, measures such as the development of strategic alliances and relationship management among supply chain entities must be taken into consideration to develop a robust SC. Hence it is posited that:

H2(b): The Strategic Alliance possesses a positive and significant effect on MSC Robustness.

2.7 MSC Resilience and SC Customer Value:

This research focuses on the customer value of the pharmaceutical SC to realize the effect of agility and robustness, i.e., MSC resilience. This refers to the value driven by SC for specific pharma businesses and their consumers, which has been demonstrated to represent a significant resilience-related performance feature.

The maritime SC agility necessitates that ports and shipping carriers are adaptable and respond quickly to any disturbances or vulnerabilities within maritime supply chains to reestablish their prior steady position. Since the Maritimes supply chain is so large and interconnected, it is especially vulnerable to shock waves and must be able to quickly and effectively adapt to shifting market conditions and fluctuating consumer needs (Dubey et al., 2018; Aslam et al., 2020). As a result, the global system of supply chains needs to be extremely flexible and responsive (Brusset, 2016). As an additional piece of evidence, Wielandand and Wallenburg (2013) argued that speed is the most crucial factor in a supply chain's flexibility to meet the needs of the customer on time. The adoption of chain-wide agility lessens instability and enhances firms' responsiveness to shifting market demands (Christopher & Peck, 2004b), this is because the other allows for a quicker response to changing market conditions, risk mitigation, and customer needs (Aslam et al., 2020). In this way, pharmaceutical companies benefit from timely delivery requirements being met because it allows them to run their supply chains more smoothly.

As an essential component of resilience, robustness is crucial to the improvement of the global supply chain network. Maritime organizations that are well-prepared proactively through risk mitigation measures perform significantly better than other network agents. According to Hendricks et al. (2008), firms that prepare for their risks beforehand incur fewer losses. Moreover, according to Hendricks and Singhal (2005), Businesses do not immediately recover from the detrimental consequences of vulnerabilities. However, according to Hendricks et al. (2008), prepared businesses are less affected by disruptions. Therefore, the SC must be robust enough to accommodate the vulnerabilities.

Consequently, it may be hypothesized:

H3: MSC Agility has a positive and significant relationship with customer value of the Supply chain.

H4: MSC Robustness has a positive and significant relationship with customer value of the Supply chain.

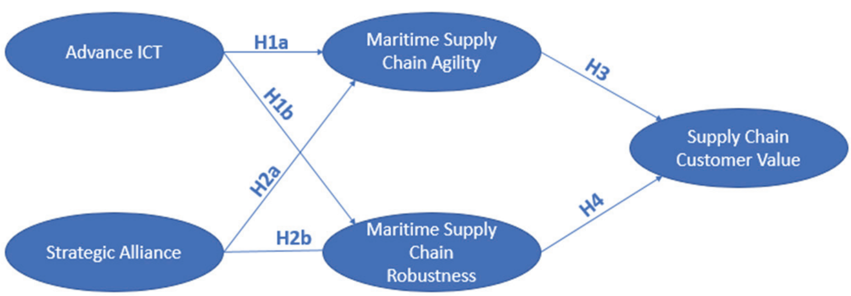

Figure 1: Conceptual Framework

3. Methodology

3.1 Sample Design and Data Collection

The inquiry employs a quantitative strategy based on a deductive methodology. The study's target demographic consisted of professionals working in the import and export departments of pharmaceutical companies and top hierarchy having past exposure to impex operations.

The sample size was calculated using the Daniel Sooper calculator (a web-based tool utilized for Sample Size Calculator for Structural Equation Models). The information was gathered from 113 respondents utilizing an online survey. However, only 98 responses were qualified after removing an outlier. Respondents were instructed to register their responses on a Likert scale ranging from 1 to 5. Individuals were contacted personally and provided with direct online access to fill out the survey. Using two components of the survey, a 5-point Likert scale questionnaire was designed. The preliminary part of the questionnaire comprised the questions related to the respondents' demographics, such as age, academic qualification, and professional experience; however, the elements influencing MSCR were evaluated in the second segment, which had 24 items. The responses were statistically analyzed via Smart PLS (Ver 4.0) via the deployment of the PLS-SEM technique. The outer and the inner model was validated, and further hypothesis testing was performed with 5000 iterations.

The research questionnaire was created using the combination and alteration of previously published measurement items. Each component's items were scored on a five-point Likert scale ranging from "strongly disagree" to "strongly agree,". Brandon-Jones et al. (2014), devised a four-item scale for measuring the 'Advance IT System' The Strategic Alliance was examined by adapting four questions from Sambasivan and Yen (2010) scale and developing three items to assess framework-related goals. For MSC Agility, the construct was examined using five adopted scale items (Whitten et al., 2012; Lotfi & Saghiri, 2018). In addition, Maritime SC's Robustness was examined by adopting one item from Brandon Jones et al. (2014) and four items from Wieland and Wallenburg (2013). Four SC Customer Value items were devised to evaluate the proposed model.

3.2 Demographics

This preliminary section includes age, gender, educational qualification, and experience. Table 1 shows the results. Male participants comprised 46.6% of the total sample, while female respondents were almost 53.4%. The age distribution of the participants indicates that 44.8% belonged to the age group of 18-25, 34.5% fell under 26 to 35, 15.5% were between the age group of 36-50, and merely 5.2% were above 50.

According to the segmentation of respondents by qualification, 31% were graduates and 69% had a master's degree. Based on the distribution of responders by experience, 51.2% had one to five years of experience, and 34.69% had six to ten years. The evaluation also revealed that 14.12% of the population had more than ten years of experience.

Table 1
Demographic Profile

		Count	**Table N %**
Gender	Male	46	46.6%
	Female	52	53.4%
Age	18-25	44	44.8%
	26-35	34	34.5%
	36-50	15	15.5%
	36-50, Above50	5	5.2%
Qualification	Graduation	30	31.0%
	Masters	68	69.0%
Experience	1 to 5 Years	50	51.02%
	6 to 10 Years	34	34.69%
	Above 10 Years	14	14.2%

4. Results

This empirical study focuses at the relationship among maritime elements that affect SCR and customer value of the supply chain. Data from the target audience was collected through questionnaire-based surveys. This data was evaluated and assessed after initial screening and Smart PLS 4.0 was used to draw meaningful conclusions. To investigate the predeveloped hypotheses, the models' reliability and validity were computed and analyzed.

4.1 The Evaluation of Measurement Model

Utilizing construct validation and reliability analysis, the outer model was evaluated via content, discriminant, and convergent validities according to their respective standards. The calculated results are reported and presented as follows for the current study:

4.1.1 Reliability Analysis

Reliability analysis is conducted to investigate the internal consistency of the model via the Cronbach alpha i.e., the measure to realize the internal consistency. The required minimum threshold for the Cronbach alpha is 0.7 (Hair et al., 2016). In the current study, all construct values are found to be greater than the required threshold of 0.7, which is acceptable as per the required benchmark, however, in the case of Advanced ICT, this value was found to be 0.6, which is also considered adequate (Pallant, 2020). Below Table 2 represents the Cronbach Alpha values of the model constructs:

Table 2
Internal Consistency Reliability via Cronbach's Alpha

Constructs	Cronbach's Alpha
Advanced ICT	0.6
SA	0.806
MSC Agility (MSCA)	0.760
MSC Robustness (MSCR)	0.847
SC Customer Value (SCCV)	0.845

* Representing the Chronach Alpha values of the model constructs.

4.1.2 The Content Validity

The factor analysis step of the content validity test entails examining the factor loadings of the observed variables i.e., items forming latent variables. Factor loadings are referred to describe the coefficients that show the link between both the constructs and their associated indicators (Bagozzi & Yi, 2012). The outcomes of this study exhibit conformance to the requirement of all the items, which demonstrated a strong correlation among constructs along with the corresponding indicators. Below Table 3 represents the Standardized Outer Loading values of the constructs:

Table 3
Factor Loadings

	Advanced ICT	S.A	AG	Robust	MSCP
Advanced ICT_1	0.763				
Advanced ICT_2	0.723				
Advanced ICT_3	0.745				
S.A 1		0.727			
S.A 2		0.708			

To be continue

S.A 3	0.780			
S.A 4	0.749			
S.A 5	0.782			
AG-1		0.770		
AG-2		0.872		
AG -4		0.820		
Robust-1			0.782	
Robust-2			0.868	
Robust-3			0.845	
Robust-5			0.803	
SCCV 2				0.754
SCCV 3				0.815
SCCV 4				0.900
SCCV 5				0.832

*Represents the standardized outer loading (item) values of the model constraints.

4.1.3 Convergent Validity

Following that, the convergent validity of the hypotheses was evaluated to determine the outer model. Quantitatively, the factor loading values aid in determining the authenticity of the variables under consideration. Moreover, the convergent validity is reflected via the Composite Reliability (CR) value. Not only CR but Average Variance Extracted (AVE) also evaluates the model's convergent validity. There exists sufficient convergent validity if the values of the latent variables are more than 0.5, suggesting that the component represents fifty percent of the variance. (Chin, 1998). Table 4 below represents the Convergent validity values utilizing two parameters i.e., Average Variance Extracted (AVE) and composite reliability:

Table 4
Assessing Convergent Validity via CR and AVE

	CR	AVE
Advanced ICT	0.788	0.553
SA	0.865	0.562
MSCA	0.861	0.675
MSCR	0.895	0.681
SCCV	0.896	0.684

4.1.4 Discriminant Validity

Finally, discriminant validity aids in the comprehension of the correlation between dissimilar variables. Criteria utilized for the assessment of validation of the discriminant. HTMT and Fornell and Larcker tests were performed to measure the required validation. The AVE's square roots of alike combinations should be bigger than the correlation values of unlike pairs (Fornell & Larcker, 1981). Similarly, HTMT values must be below 0.85 to reflect the distinction between the different sets (Henseler et al., 2015). The below Table 5 outcome exhibits that the model adequately represents the presence of discriminant validity by meeting both the mentioned criteria.

Table 5(a)*
Assessing Discriminant Validity via Fornell and Larcker method

	Advanced. ICT	**SA**	**MSC Agility**	**MSC Robustness**	**SCCV**
AdvancedICT	0.744				
S.A	0.181	0.750			
MSC_Agility	0.341	0.242	0.822		
MSC_Robustness	0.253	0.296	0.362	0.825	
SC Customer Value	0.274	0.474	0.324	0.390	0.827

* Represents the discriminant validity via Fornell and Larcker criterion

Table 5(b)
Assessing Discriminant Validity via HTMT ratio

	Advanced. ICT	SA	MSC Agility	MSC Robustness	SCCV
Advanced. ICT					
SA	0.248				
MSCA	0.498	0.304			
MSCR	0.326	0.320	0.442		
SCCV	0.387	0.561	0.395	0.443	

*Represents the discriminant validity via HTMT Ratio

4.2 Path Analysis (Outer Model)

The structure model in the current study explains the extent and significance of relationships among constructs., the developed model examines antecedents of maritime supply chain resilience such as modern information and communication technology and strategic relationships influencing maritime SC resilience. and its effect on SC customer value. The path coefficient p-values in Table 6 represent the strength of the relationship. Furthermore, R2 values were calculated to determine the predictive power of the constructs. Lastly, all of the model hypotheses formulated were found to be statistically significant. Furthermore, the R2 showed that adv. ICT and SA determined 15% of MSCA and 12.9% of MSCR. Notwithstanding, agility, and robustness explained 19.1% of SCCV. Below Table 6 provides the significance values of the relationships and the path coefficients.

Table 6
*Hypothesis Testing***

Hypotheses	Coefficient	P-Values	Result
Adv. ICT → MSCA	0.307	0.002	Supported*
Adv. ICT → MSC Robustness	0.206	0.016	Supported*
SA → MSC Agility	0.186	0.086	Supported*
SA → MSC Robustness	0.259	0.004	Supported*
MSC Agility → SCCV	0.211	0.096	Supported*
MSC Robustness → SCCV	0.313	0.009	Supported*

* The confidence interval is considered to be 90%.
** Table 6 provides the significance values of the relationships and the path coefficients.

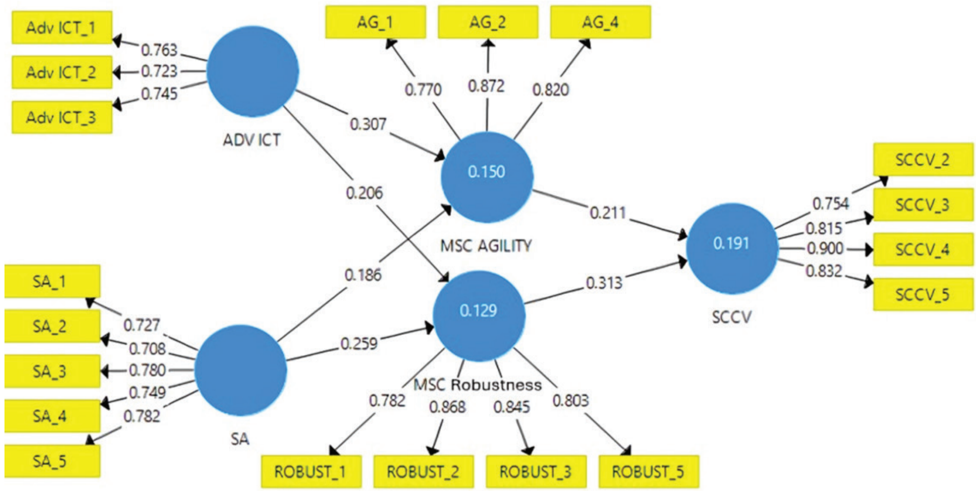

Figure 2: Representing outer loadings values and the values of R2 exhibiting variables' predictive power

5. Discussion

Sectors have recognized the need to establish an agile and resilient organization in the face of a very uncertain global market, increased variability in customer demand, and global transport chain vulnerabilities. This study emphasizes the importance of industry interdependence, particularly in the pharmaceutical business and the maritime chain, by illustrating the impact of MSCR on pharmaceutical SCP.

This study adopts the relational perspective, which has substantial implications for the interaction between the antecedents of maritime SC resilience and pharmaceutical SC's customer value. Previously, it was assumed that supply chain practices had to fit into stable corporate contexts. Nevertheless, Wieland and Wallenburg (2012) emphasized that agile and robust attributes, i.e. resilience and its dimensions, significantly impact the SC customer value Although various other aspects affect SC customer value the impact of agile and robust characteristics together is remarkably high. Currently, the pharmaceutical industry considers the availability of medications/vaccines to be vital for both commercial success and patient treatment. According to reports, seven of the top ten pharmaceutical items require temperature-controlled delivery. For example, flu vaccines and insulin must be kept at an extremely exact temperature to remain effective. It has been reported that a 2-degree Celsius difference can entirely damage a pharmaceutical product, resulting in a reduction in pharmaceutical consumer value. The scenario arose mostly as a result of late or low-quality shipments at the replenishment end. These two scenarios could be jeopardized at the maritime transport network's node, which is more susceptible to disturbances. As a result, this research explores the significance of MSC resilience and the drivers that may influence it.

Finally, it was discovered that maritime SC robustness possesses a significant impact on pharmaceutical SC consumer value. These findings show that steps to improve SC resilience across many parts of the organization are required to ensure optimal outcomes for PSCs. Building up the MSCR increases the customer value of PSC by reducing the probability of stockouts and low availability of medications at the downstream supply chain.

5.1 Managerial Implications

The pharmaceutical industry's managers are strongly urged to establish and enhance their Information and Communication Technology (ICT) infrastructure, particularly by integrating network capabilities for tracking and tracing. This initiative would not only enhance the overall visibility across the supply chain but also contribute to the development of a more agile and resilient supply chain. Furthermore, creating strategic alliances with international logistics companies can promote collaborative efforts to optimize maritime supply chains. To do this, pharmaceutical businesses need to link ERP systems with Port Community Systems and other modules. The PCS allows enhanced collaboration, integration and comprehensive port management (Zohaib et al., 2023), enabling supply chain stakeholders to benefit from increased transparency and improved planning and production scheduling. This may be achieved by realizing the channel-wide infrastructure and by enhancing the trust level. This may require fine-tuning of both the systems i.e., the ERP and PCS or by adding a module which may provide facilitation in integrating both the systems. Managers at the port and on the supply chain side may be authorized and share the data along with the process maps with the port to facilitate the integration.

Furthermore, the research findings emphasize the significance of building resilience within the pharmaceutical supply chain, given the critical importance of ensuring on-time delivery of pharmaceutical products to end consumers. By implementing measures to enhance SCR within an organization, it becomes feasible to prevent network vulnerabilities from triggering a domino effect within the supply chain, ultimately leading to increased value for end-consumers, including patients and hospital pharmacies, as well as the pharmaceutical companies themselves.

5.2 Future Research Avenues

In addition to present determinants impacting MSCR, additional factors, such as SC Relationship Management, Contingency Plan, and Monitoring & measuring, may be investigated and assessed within the context of the pharmaceutical sector to strengthen the PSCs. Based on the perspective of RV theory, coordination and collaboration may be analyzed to evaluate MSCR, unlike the RBV theory, which enunciates that factors such as SC connection, SC Ambidexterity, and SC alignment may be evaluated. These constructs' effect realization would provide a more comprehensive strategy with broader applicability.

Conflict of interest: The researchers have no competing interests.

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ANNEX I: