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Does Supply Chain Analytics Impact Supply Chain Agility and Competitive Advantage? The Mediating Role of Robustness Capability

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Abstract
The present study has focused on analyzing the impact of Supply Chain Analytics (SCA) on supply chain agility and competitive advantage by investigating the mediating role of robustness capability in Jordanian pharmaceutical manufacturing. The sample population included professionals at the supply chain and logistics department levels. Since a random sampling technique was followed, data was collected through structured questionnaires. This analysis was conducted through SmartPLS 4.0 and tested the discriminant and convergent validity of the measurement model. From this, one can find out that SCA significantly impacts Supply Chain Agility ($\beta = 0.602$, $p < 0.001$) and Competitive Advantage ($\beta = 0.238$, $p < 0.01$). In addition, Robustness Capability was also another imperative mediator in those relationships, improving the general effect of SCA on the investigated outcomes with mediation effects of $\beta = 0.103$ ($p < 0.05$) for Supply Chain Agility and $\beta = 0.285$ ($p < 0.001$) for Competitive Advantage. Results thus indicate that firms should focus on integrating SCA with robust strategies that guarantee agility for sustained competitive advantage in the volatile Jordanian Pharmaceutical Industry.

Keywords: Supply Chain Analytics, Supply Chain Agility, Competitive Advantage, Robustness Capability, Jordanian Pharmaceutical Industry.

1 Introduction

Supply chain analytics' impact on agility and competitive advantage presents a critical area of study, especially in situations where organizations are eager to cross increasingly complex and volatile market environments. Big data-driven supply chain analytics capabilities have been found to enhance supply chain agility significantly, contributing to a firm's competitive advantage. Indeed, Dubey et al. (2019) provide empirical evidence that big data analytics capability positively influences supply chain agility and competitive advantage, thus showing the importance of such a capability for modern supply chain management. (Shamout, 2020) further corroborates this by mentioning that higher supply chain data analytics lead to increased agility across firms irrespective of size and age, fulfilling the evidence that analytics capability tends to act as a great equalizer in competitive contexts.

Moreover, the literature has identified supply chain agility as one of the promoters of resilience to improve firm performance. For instance, Hsieh (2023) indicates that supply chain agility provides a leeway through which organizations can respond quickly to changing circumstances, raising resilience and improving overall performance. This is particularly so in contemporary business, given that the pace of adaptation often may mean the difference between business success or failure. Pratondo et al. (2021) have gone a step further to explain that supply chain agility is an influence that extends well into ensuring sustainable performance, especially regarding small and medium enterprises (SMEs) in the post-pandemic COVID-19 outbreak.

Big data analytics integrated into supply chain processes support the emergence of agility and innovation. Chen (2019) talked about trust among the supply chain partners, which is developed through proper integration of information technology to ensure that the capabilities developed are enhanced in agility and innovation. In this case, it simply requires appropriate development of trust for leveraging analytics to become genuinely effective in boosting collaboration and information sharing, which is at the heart of agile supply chain operations. Furthermore, the results of Wamba and Akter (2019) support the contention that big data-driven analytics capability is increasingly becoming a disruptive driver in supply chain management while having deep consequences on agility and firm performance.

Another turning point is that the amalgamation of the agility and flexibility of the supply chain leads to a competitive advantage. Güngör GÜNGÖR (2021) explores how flexibility and agility act as mediators of the relationship between supply chain integration and firm performance, postulating that those organizations developing such competencies will be better positioned to respond to market demands. This argument is reiterated by the work of (Routroy et al., 2018), who equally believe that measuring agility in supply chains is an important activity that organizations undertake while remaining competitive in dynamic business environments. Again, the work of Patel et al. (2020) reinforces this notion of balance in the approach to agility and efficiency by stating that while agility is important for responsiveness, it is usually at the expense of efficiency; resources need thus to be managed judiciously.

In addition, supply chain literature has received increasing interest in resilience as a complement to agility. For Altay et al. (2018), resilience—the ability to cope with unexpected disturbances—is an essential characteristic of the agile supply chain. This relationship is vital for organizations that want to sustain performance under uncertainty. The view is further supported by the findings of Tarigan et al. (2021), showing that internal integration and supply chain partnership significantly increase resilience, leading to sustainable competitive advantage.

Beyond that, the organizational culture and structure add to its role in promoting agility. Lee & Rha (2016) cite the importance of understanding that developing ambidexterity as a dynamic capability helps firms achieve sustainability in their competitive advantage. This capability enables the organization to balance exploration and exploitation in light of disruptions in supply chains toward resilience. Meanwhile, Gupta et al. (2019) showed that innovative supply chain practices and information system agility contribute to the overall supply chain flexibility, adding another layer to the multifaceted nature of agility within supply chain management.

The demand for integrating sustainability issues into supply chain agility frameworks is also growing. Regarding this fact, Ciccullo et al. (2018) argued that environmental and social sustainability must be incorporated into agile supply chain management paradigms. A holistic approach to agility reinforces interdependencies between competitive advantage and corporate responsibility. This perspective rhymes with increased awareness that sustainable practices favor societal outcomes and long-term business success.

Advanced analytics and data-driven decision-making processes are applied to enhance supply chain agility. Munir et al. (2023) discuss the potential of data analytics for organizational performance improvement and the development of agility, emphasizing dynamic capabilities that firms have to develop and which can then be changed by the firms in correspondence with the change in circumstances. The latter is all the more critical given worldwide supply chains, where every slight advantage gained by pressure through data might mean a giant leap ahead in competition.

The relationship between supply chain analytics, agility, and competitive advantage is complex and multidimensional. In other words, an organization that leverages the potentiality of big data analytics capability most efficiently enhances its agility, leading to resilience and performance. Further, flexibility, trust, and sustainability, when integrated into supply chain strategies, assure competitive advantage in today's dynamic business environment. The ability to imbue with analytics capabilities will remain central to the future of supply chain management as firms continue fighting their way through the vicissitudes of globalization and technological change.

2 Literature Review and Hypothesis Development

2.1 Supply chain Analytics (SCA) and Supply chain agility

Research also found that supply chain agility plays a significant role in ensuring that the supply chains are resilient. For instance, Jamaludin (2023) suggests that an agile supply chain can reinforce the relationship between supply chain ambidexterity balance between exploration and exploitation resilience; hence, this shows that these are foundational blocks in times of uncertainties and disruption. Similarly, Pratondo et al. (2021) indicate that the supply chain agility perspective guarantees a balance between resilience and sustainability of performance. Of course, the COVID-19 pandemic and the urge for adaptive supply chain strategies have again emphasized this latter view. This is in line with the findings of (Inman & Green, 2021), who identify that supply chain agility mediates environmental uncertainty and performance, further entrenching agility's integral role in driving robust supply chain outcomes.

Big data analytics integrated into the supply chain operation have also contributed to their agility. Empirical evidence by Dubey et al. (2019) shows that big data analytics capabilities positively influence supply chain agility and competitive advantage; hence, organizations using analytics in their operations are likely to be more responsive to changes in the market. That chimes with the view of

(Shamout, 2020), who lists supply chain visibility- a result of effective data analytics- as one factor that contributes to enhanced agility. On the other hand, Xu (2023) admits that big data analytics help make the supply chain ambidexterity positively impact resilience substantial enough to allow organizations to respond against complex environments.

Other facilitators of agility may include trust and cooperation among the partners in the supply chain. Good relationships and trust among supply chain members have been argued to enhance agility and innovativeness; hence, social dimensions related to supply chain management are as crucial as technical capabilities (Chen, 2019). This is again evidenced through the work of Ahmed et al. (2019), who identify knowledge management and collaborative practices as factors affecting supply chain agility. Accordingly, it is hypothesized that:

H_1. *SCA has positive impact on supply chain agility.*

2.2 Supply chain Analytics (SCA) and competitive advantage

One of the essential ways in which supply chain agility (SCA) leads to competitive advantage is through improved supply chain resilience and robustness. Organizations utilizing data analytics capability are better prepared to handle disruptions and uncertainties within their supply chains and achieve performance outcomes. For instance, firms with high levels of capability in data analytics tend to have minimal negative impacts on supply chain performance that are very critical in ensuring a competitive advantage (Kokkinou, 2023). Data analytics moderate a firm's competitive advantage in disrupting supply chains (Rezaei et al., 2022). This means that the ability to analyze information and act correctly upon it provides firms with resilience that solidifies their competitive positioning.

Moreover, a positive relation is found between supply chain management (SCM) practices and competitive advantages. The SCM practices are also positively related to total quality management (TQM), innovation of supply chains, and overall performance of the firm. Based on Mehregan (2023) and SCM practices resulting in competitive advantages through cost reduction, enhancement of quality, and swifter delivery as perceived by Sinaga et al. (2021), it ends. Additionally, integrating SCA into these practices further enhances the same in ensuring that data utilization in driving innovation and improvement within the operations is timely and quality (Shamout, 2019).

Big data analytics (BDA) are crucial in remodeling supply chain operations. BDA enhances the capability of the supply chains through intelligent insights extracted from big datasets, hence assuring improved performance metrics (Mubarik & Rasi, 2019). This ties to the evidence that big data facilitates decision-making and enables firms to develop agile supply chains, which are also well-coordinated, more so in a circular economy, as Giudice et al. (2020) observed. Harnessing big data gives the company one of the strategic assets that can be used to optimize its supply chain process and its competitive advantage. Thus, the resultant hypothesis arising from this study would be:

H_2. *SCA has a positive impact on competitive advantage.*

2.3 Robustness capability mediates the relationship between SCA and Supply chain agility

Supply chain agility refers to the ability to respond to demand or supply changes rapidly, a significant factor that will help a business entity sustain competitiveness in today's dynamic market environment (Patel & Sambasivan, 2021). This agility allows firms to efficiently adapt to disruptions and uncertainties now commonly occurring in contemporary supply chains because of globalization and technological advances (Patel & Sambasivan, 2021; Ahmad et al., 2023). However, agility might not be enough; it should be complemented by robustness capability, defined as the supply chain's ability to absorb disruptions but remain operational (Behzadi et al., 2017). Robustness is becoming increasingly considered a necessary complement for those organizations that pursue performance sustainability in the presence of disruptions (Barhmi, 2023).

Meanwhile, studies have found that the capability of robustness can mediate the relationship between supply chain agility (SCA) and the overall performance of the supply chain. For instance, robust capabilities enable the derivation of effective decisions that minimize risks and enhance innovative capability in a firm for adaptation (Shamout, 2020). This implies that a firm with high levels of robust capability can leverage its agility better in response to market changes and disruptions (Barhmi, 2023). Agility also combines with robustness in its meanings of supply chain resilience: a robust supply chain would also be resistant to shocks and able to adapt in light of new conditions and thus is more agile (Shamout, 2019).

Empirical research has also found that integrating risk management practices with supply chain operations allows robustness and enhances agility (Barhmi, 2023; Durach et al., 2015). For example, some research shows that robust risk management mechanisms enhance agility, particularly upon disruptions (Barhmi, 2023). This calls for a holistic approach encompassing agility and robustness in pursuit of superior supply chain performance. From the preceding literature review, the following hypothesis may be advanced:

H$_3$. *Robustness capability mediates the relationship between SCA and Supply chain agility.*

2.4 Robustness capability mediates the relationship between SCA and competitive advantage

In this respect, implementing robust capabilities, especially in supply chain management, has been argued to be a critical means to achieve supply chain agility (SCA). For example, supply chain risk management capabilities, because of their association with robustness and resilience, have, among other things, been found to enhance agility performance that realizes competitive advantage upon disruption (Barhmi, 2023). This concurs with Rezaee and Jafari (2016), who establish that dynamic capabilities, of which robustness forms one, impact the relation between a firm's resources and SCA in attaining a better performance. Indeed, adapting and responding to shifting markets allows for a competitive advantage and sustains such advantages over time, especially in any volatile environment (Teoh et al., 2021).

Muchlish and Tjahyono (2022) also said that Total Quality Management (TQM) supports mediation capability in the relationship between SCA and competitive advantage. They demonstrated in their study that transformational leadership, which relies on creating a culture for continuous improvement and change, mediates the effect of TQM on SCA in enhancing competitive advantage. It points out that organizations, in turn, benefit more from SCA through good leadership and management than from competitiveness by instilling robust capabilities in them.

The role of big data analytics capability (BDAC) in enhancing the agility of the supply chain further gives an indication of how robustness can play a mediating role in the SCA-competitive advantage relationship. Evidence by Dubey et al., (2019) showed that BDAC has a positive impact on both SCA and competitive advantage since an organization with high data analytics capabilities is in a position to perform well in meeting market challenges toward taking advantage of opportunities that come their way for competitive advantage. This indicates a growing interest in integrating technological advancement with robust operation frameworks for performance improvement.

H$_4$. *Robustness capability mediates the relationship between SCA and competitive advantage.*

3 Methodology

3.1 Research Design and Approach

The empirical research process starts with the formulation of a research design, which is like the blueprint of the study. It guides the analysis of the results and identifies what questions to investigate, what data is collected, and which data are relevant. According to Verleye (2019), three main types of research design exist: descriptive, explanatory, and exploratory.

According to Siedlecki (2020), descriptive research determines the relationship between independent and dependent variables and describes the effects. Explanatory research seeks to establish the reasons for such a phenomenon or the mechanisms underlying these relationships' establishment. It has, therefore, adopted a descriptive and exploratory research design to study the effect of supply chain analytics on supply chain agility and competitive advantage, considering the intervening role of robustness capability in Jordanian pharmaceutical manufacturing firms.

Descriptive research effectively summarizes data, giving insight into central tendencies and variability. This type of research mostly uses visual tools, such as scatter plots, graphs, and frequency tables, to display outliers and trends in the data.

3.2 Research Model

According to the objectives of this research model, the supply chain analytics (SCA) variable is directly related to the supply chain agility and competitive advantage variables. In addition, the researcher found the robustness capability as a mediator in the associations of SCA and supply chain agility and SCA and competitive advantage, as presented in Figure 1.

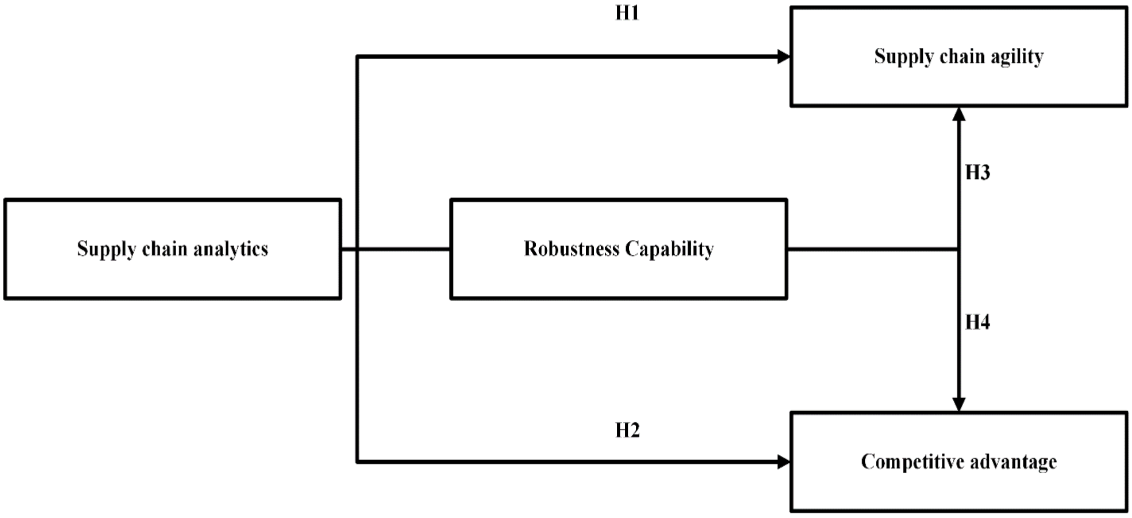

Fig. 1. Study Model

3.3 Data Collection and Distribution

An online survey methodology was employed to collect empirical data to validate the research model. This methodology, as reiterated by Yang et al. (2021), can guarantee that adequate data is collected on a large scale. Hence, it is an integral element in solving the research problem. It also ensures rapid response rates, ensuring cost-effectiveness and time efficiency.

3.4 Population and Sampling

The target population is the total number of those who, whether as persons, events, or things, have in common one factor from which the generalization by the researcher is intended to be made. In this research study, the target population comprises all the pharmaceutical manufacturing companies in Jordan. The populations in previous studies were stratified by Bahrami and Shokohyar (2022) to collect the data from the people who had the best understanding of supply chain analytics, its impact on supply chain resilience and competitive advantage, and the potential role of robustness capability. A simple random sampling method was applied to select the study sample, and then the questionnaire was electronically distributed via email and WhatsApp messages. In total, 192 questionnaires were collected and analyzed. The demographic information from the respondents was gender, age, education, and experience.

4 Analysis Results

4.1 Respondents Profile

The significant characteristics of the sample population reflected in the demographic data summarized in Table 1 include a majority of the genders, where 59.9% were males, and 40.6% were females, indicative of a male-dominated workforce in Jordanian pharmaceutical manufacturing companies, at least in the supply, logistics, and information technology departments. The distribution of the respondents' ages shows that the majority of the participants were between the ages of 30 and 40, accounting for 40.1%, while the participants aged between 41 and 50 were 34.9% of the sample. The percentage of the respondents who had not attained the age of 30 was 16.1%, while 8.9% of the respondents were over 50. That, therefore, infers that the population's age distribution largely follows the young and middle-aged workforce in these findings.

The data on the level of education indicated that 51% of the respondents had a bachelor's degree, 35.9% had a master's degree, and an additional 13% held a doctorate degree. This would be an educated sample with an emphasis on higher education. 3.9% of the respondents have between 11 and 15 years of work experience, while 28.1% fall between 5 to 10 years. Those between 16 and 20 years

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of work experience constitute 15.6 percent of the sample, while those below five years of work experience constitute 13.5 percent. The last group, 9.9%, falls over 20 years. This range in experience may indicate a significant variation in the level of professional experience among respondents.

Table 1 Respondents Profile

Demographic Category	Subcategory	Frequency	Percentage (%)
Gender of Respondents	Male	115	59.9
	Female	77	40.6
	Total	**192**	**100**
Age of Respondents	Under 30	31	16.1
	30-40	77	40.1
	41-50	67	34.9
	Over 50	17	8.9
	Total	**192**	**100**
Education Level	Bachelor's Degree	98	51.0
	Master's Degree	69	35.9
	Doctorate Degree	25	13.0
	Total	**192**	**100**
Experience	Less than 5 years	26	13.5
	5-10 years	54	28.1
	11-15 years	65	33.9
	16-20 years	30	15.6
	More than 20 years	19	9.9
	Total	**192**	**100**

4.2 Measurement of the Research Model

Results from the measurement model emphasize the reliability and validity of the constructs measured in this study, as shown in Table 2. All items within constructs such as Supply Chain Analytics (SCA), Supply Chain Agility (SCAG), Robustness Capability (RC), and Competitive Advantage (CA), had factor loadings above the threshold of 0.70, indicating that each item is a firm representative of its underlying construct. Outer weights illustrate each item's contribution to its respective construct with values ranging from 0.452 to 0.611.

These Variance Inflation Factor (VIF) values range from 1.8 to 2.4, suggesting no multicollinearity issue in the model and thus further strengthening the results. For all constructs, the overall Cronbach's alpha values are above 0.90, indicating excellent internal consistency and reliability; this confirms that items within each construct are highly interrelated and represent the same underlying concept. The composite reliability scores are also well over 0.90, corroborating that the constructs are reliable and consistent.

Average Variance Extracted (AVE) values for each construct are above 0.50; hence, the constructs explain more variance than error, showing strong convergent validity. The AVE values precisely demonstrate that the latent constructs they represent capture a considerable portion of the variation in observed variables. Overall, the table confirms that this measurement model is reliable and valid, supporting the hypotheses on the relationship between supply chain analytics and supply chain agility, robustness, capability, and competitive advantage.

Table 2.Measurement of the Research Model

Variable	Items	Factor Loading	Outer Weights	VIF	Cronbach's Alpha	Composite Reliability	AVE
Supply Chain Analytics (SCA)	SCA1	0.711	0.529	2.1	0.915	0.930	0.612
	SCA2	0.774	0.475	2.2			
	SCA3	0.773	0.510	2.3			

	SCA4	0.764	0.488	2.0			
	SCA5	0.693	0.452	2.4			
	SCA8	0.767	0.501	2.1			
	SCA9	0.829	0.523	2.3			
	SCA10	0.709	0.472	2.2			
Supply Chain Agility (SCAG)	SCAG1	0.774	0.526	1.9	0.899	0.918	0.635
	SCAG2	0.758	0.513	2.0			
	SCAG3	0.801	0.540	2.1			
	SCAG4	0.786	0.529	2.3			
	SCAG5	0.679	0.467	2.1			
Robustness Capability (RC)	RC1	0.763	0.592	1.8	0.910	0.927	0.657
	RC2	0.839	0.611	1.9			
	RC3	0.751	0.573	2.0			
	RC4	0.801	0.602	1.9			
	RC5	0.822	0.619	2.1			
	RC6	0.800	0.609	2.0			
Competitive Advantage (CA)	CA1	0.813	0.482	2.0	0.903	0.920	0.648
	CA2	0.797	0.469	2.1			
	CA3	0.790	0.465	2.2			
	CA4	0.798	0.471	2.3			
	CA5	0.777	0.458	2.1			

4.3 Structural Model

The analysis of the structural model shows the relationship between the studied variables. Meanwhile, Figure 2 below shows how Supply Chain Analytics (SCA) influences the variables of Supply Chain Agility and Competitive Advantage using Robustness Capability as a mediating variable. SmartPLS evaluated the model, and the results were summarized in the path model presented in Figure 4.1 below. This model shows how the studied variables are approximately causally related through path coefficients, β, p-values, and t-statistics used in testing the research hypotheses.

Two necessary cuttings were observed in analyzing the structural model: the explained variance of the dependent variables-R^2 (R2) and the standardized path coefficients (standardized path coefficients-β). The coefficient of determination-R^2 (R2) presents the proportion of the dependent variables' variance explained by the independent variables. The values are critical in showing the model's explanatory power.

What were sought explicitly were the R^2 values for the constructs of Supply Chain Agility, Robustness Capability, and Competitive Advantage. To that effect, the R^2 value of Competitive Advantage was 0.482; hence, SCA accounts for a 48.2% variation in Competitive Advantage. In the same way, the R^2 value for Supply Chain Agility was 0.526, implying that Supply Chain Analytics explains 52.6% of the variation in Supply Chain Agility.

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Taking the conventional and widely accepted cutoffs for R^2 values, an R^2 value of 0.75 signifies a substantial level, 0.50 is rated at a moderate level, and 0.25 is considered weak. By these measures, this study's R^2 for Supply Chain Agility is rated as moderate since it represents substantial variation in the dependent variable being explained. The R^2 value for Competitive Advantage, though still at a moderate level, reaches very close to the threshold beyond which this R^2 will be considered substantial. Though the explicit value of R^2 for Robustness Capability was not provided, it is suggested to be close to weak, meaning this variable possesses lower explanatory power inside the model.

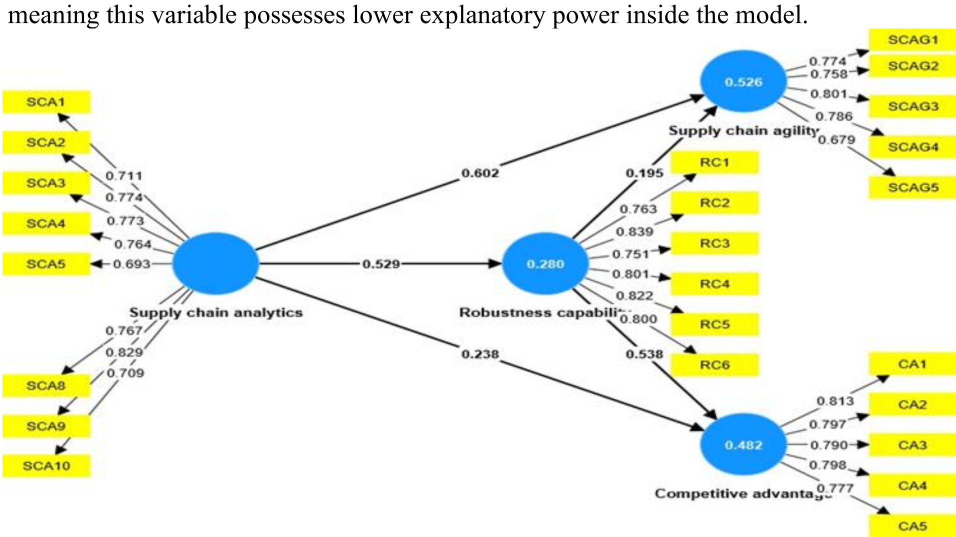

Fig. 2. Study SEM model

4.4 Hypothesis testing

From the structural model analysis, some valuable insights were derived regarding the relations between Supply Chain Analytics (SCA) and Supply Chain Agility, Competitive Advantage, and the mediating effect of Robustness Capability. The magnitude of the direct effects of SCA on Supply Chain Agility and Competitive Advantage was considerable, with strong positive associations. The path coefficient for SCA influencing Supply Chain Agility was 0.602 with a p-value of 0.000, indicating that the relationship was strong and positive. The impact of SCA on competitive advantage was significant as well. The path coefficient was 0.238, with a p-value of 0.004. Again, while the influence on agility was strong, the relationship was somewhat weak.

The following hypothesis testing results prove significant associations among Supply Chain Analytics (SCA), Supply Chain Agility, Competitive Advantage, and the mediation of Robustness Capability, as shown in Table 3. In H1, analysis has indicated that SCA is strongly and positively related to positively impacting supply chain agility, with a path coefficient of 0.602. The T-statistic for this relationship is 8.015, and the P-value is 0.000, confirming that this hypothesis is accepted. H2: SCA also positively affects Competitive Advantage, though to a lesser extent, with a path coefficient of 0.238. The T-statistic is 2.869, and the P-value is 0.004, thus showing that this hypothesis is also accepted.

This is also supported by the mediation analysis, which indicates the role of Robustness Capability. In the mediation effect of H3, Supply Chain Analytics (SCA) had a significant effect on the Supply Chain Agility, and the path coefficient is 0.103 while the T-statistic is 2.099 and the P-value is 0.036; hence, this hypothesis is accepted. Lastly, H4-for Robustness Capability, the mediator between SCA and Competitive Advantage path coefficient is 0.285, the T-statistic is 4.346, while the P-value is 0.000, confirming this hypothesis has also been accepted.

These results from direct analysis and mediation analysis confirm that supply chain analytics strongly enhances supply chain agility and competitive advantage. However, the mediating effect of robustness capability is essential, as it increases the impact of SCA in these outcomes, particularly in strengthening competitive advantage. Consequently, these findings confirm that the critical potential of value creation through analytics with robustness capabilities in supply chain management will drive superior performance with a competitive advantage in the marketplace.

Table 3. Hypothesis Test Analysis

	Paths	Path coefficients	Sample Mean (M)	Standard Deviation	T Statistics (|O/STDEV|)	P Values	Results

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		(β)		(STDEV)			
1	Supply chain analytics -> Supply chain agility	0.602	0.604	0.075	8.015	0.000	Accepted
2	Supply chain analytics -> Competitive advantage	0.238	0.23	0.083	2.869	0.004	Accepted
3	Supply chain analytics -> Robustness capability -> Supply chain agility	0.103	0.105	0.049	2.099	0.036	Accepted
4	Supply chain analytics -> Robustness capability -> Competitive advantage	0.285	0.293	0.066	4.346	0	Accepted

5 Discussion

The results of this research establish the pivotal contribution of Supply Chain Analytics (SCA) to nurturing gains in supply chain agility and competitive advantage, with Robustness Capability as a potent mediator between them. The result shows that SCA is favorable toward supply chain agility ($\beta = 0.602$, $p < 0.001$), proving that firms that can make the most out of analytics are in a strategic position to respond quickly to market changes. This finding is consequently supported by previous studies emphasizing agility as one of the leading drivers of sustained competitiveness in dynamic environments (Ahmad et al., 2023; Wamba & Akter, 2019). Also, SCA positively influences Competitive Advantage, $\beta = 0.238$, $p < 0.01$; this assures that data-driven decision-making enhances a firm's market position. This supports the idea that in an environment enriched with data, analytics is critical to a competitive advantage (Rezaei et al., 2022).

This study further reveals that Robustness Capability significantly mediates the relationship between SCA and Supply Chain Agility, with a path coefficient of $\beta = 0.103$, $p < 0.05$, and Competitive Advantage with a path coefficient of $\beta = 0.285$, $p < 0.001$. The implication here is that while SCA directly enhances the ability of a firm to be agile and competitive, such an advantage is better enhanced if the firm has a good robustness capability. This becomes quite important in environments where disruption is much more likely, given that robustness keeps operations going and maintains performance.

Figure 3 shows the moderating effect of Robustness Capability between SCA and Supply Chain Agility. In this interaction plot, two lines represent low and high levels of Robustness Capability. From this, it can be seen that with low Robustness Capability, the relationship of SCA with Supply Chain Agility stays relatively weak, as indicated by the gentler slope of the blue line. However, for high Robustness Capability, the relationship gets very strong, as reflected by the higher slope of the red line. This interaction effect implies that with a higher robustness capability of firms, analytics can positively influence agility to make their supply chains responsive and resilient to changes (Barhmi, 2023).

This finding is again supported by the previous literature, highlighting the interaction effect of agility and robustness for superior supply chain performance. For example, Barhmi (2023) asserted, "robustness stabilizes the operations during disruptions and positively influences the performance outcomes of agility, thus leading to a superior overall performance.". Moreover, the figure indicates that though SCA is critical, its power is considerably amplified when linked to solid strength capabilities results also derived in studies by Dubey et al.(2019), and Behzadi et al. (2017). This interaction effect underlines the strategic relevance of building agility and robustness within supply chains to maintain competitive advantage.

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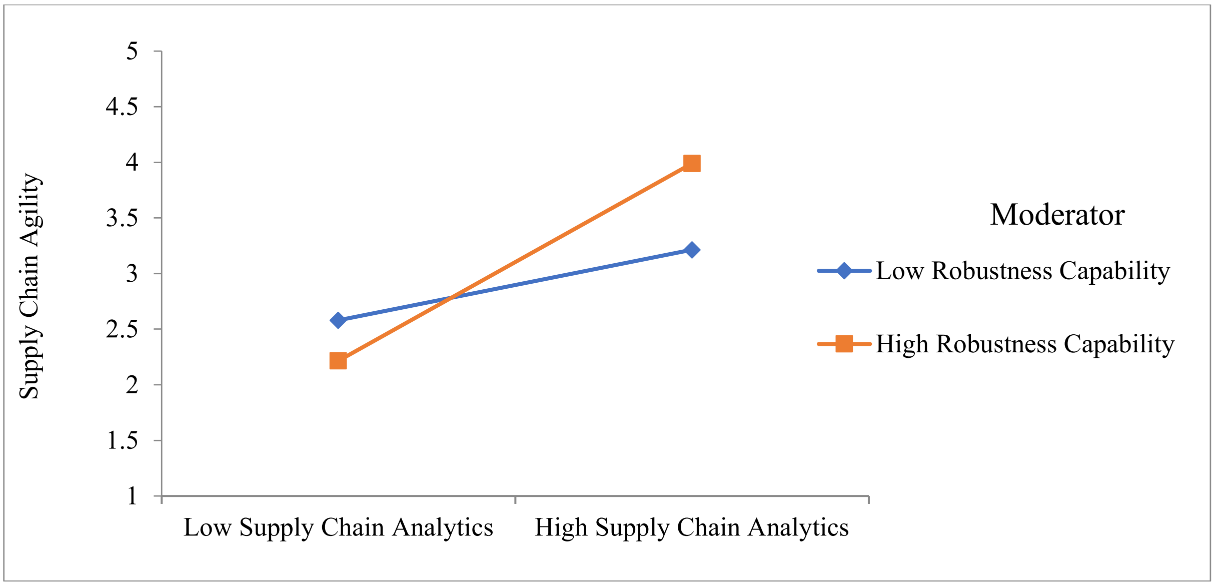

Fig. 3. Interaction Diagram (SCA, SCAG, and RC).

Figure 4 shows how Robustness Capability moderates the relationship between Supply Chain Analytics (SCA) and Competitive Advantage. The interaction plot shows two lines for low and high Robustness Capability, respectively. The blue line, describing low Robustness Capability, is a weaker relationship between SCA and Competitive Advantage since it is less steep. However, the red line, standing for high Robust Capability, shows a relatively stronger association, as seen by the steeper slope in that line. This means that if, under positive signs between SCA and Competitive Advantage, the Robust Capability makes the signs optimistic, then when Robustness is high, the signs will be more significant.

These results suggest that SCA is an essential determinant for Competitive Advantage but that its effectiveness significantly rose when complemented by high Robustness Capability. Such evidence supports previous research that emphasized the role of robustness in maintaining competitive advantage, especially in unassured and threatening environments. For instance, Behzadi et al. (2017) outlines the need for coherent strategies to deal with disruptions, while Dubey et al. (2019) defined robustness and analytics as equal to a high-performance outcome. The figure reinforces this strategic imperative in that it stipulates both agility and robustness as the critical factors in how supply chains realize and sustain competitive advantage.

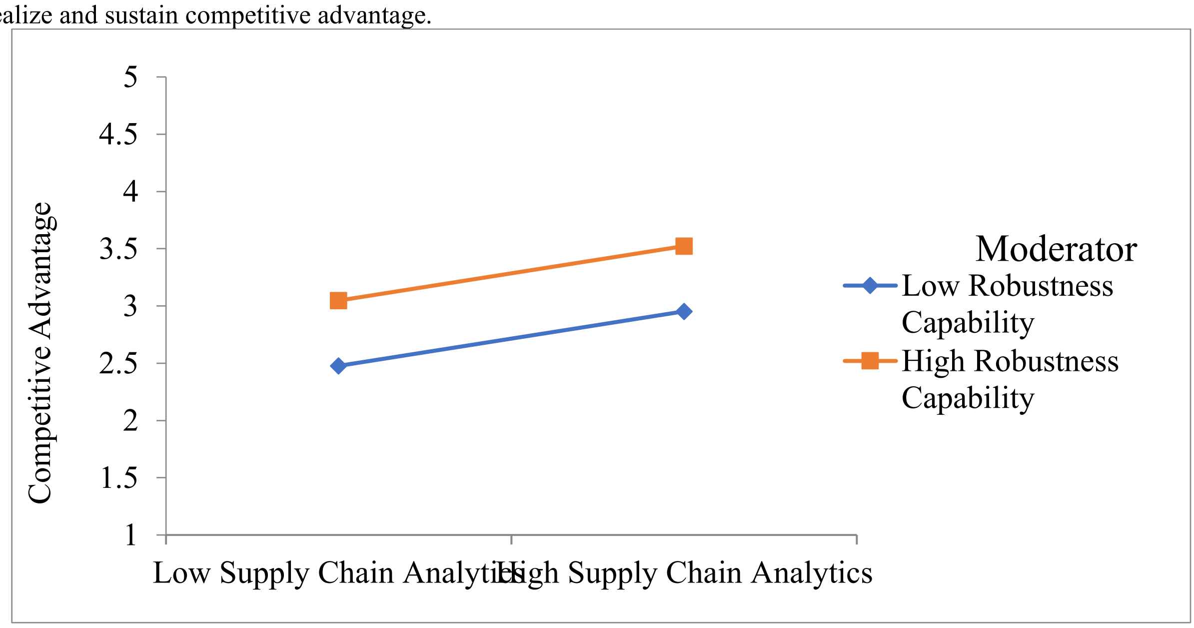

Fig. 4. Interaction Diagram (SCA, SCAG and CA).

Therefore, these results have shown that firms should adopt advanced analytics and work out robustness in their supply chains. Agility combined with robustness thus creates a much more resilient framework-competitive firms can prosper even under uncertain conditions. In summary, this research supports the idea that supply chain analytics enhance firms' agility and competitive advantage. This effect is further bolstered if the Robustness Capability is present; a firm must build agile and robust supply chains to achieve long-term success.

Conclusion

The research, therefore, finds that Supply Chain Analytics (SCA) considerably enhances both Supply Chain Agility and Competitive Advantage in the Jordanian pharmaceutical manufacturing industry. The research's contribution lies in evidence that, apart from the direct positive influences of SCA on the results mentioned above, Robustness Capability serves as an important intervening variable that further increases such benefits. This underlines the need to integrate SCA with robustness strategies in developing agile supply chains that can sustain high-performance levels despite disruptions and market volatility.

Practical Implications

The outcome of this study represents necessary inputs for managers, practitioners, and decision-makers in the pharmaceutical industry. Recognizing the importance of SCA and robustness capability will competitively improve the position of organizations. These results would thus suggest that companies should develop and integrate advanced analytics capabilities into their supply chain operations while building on robustness to mitigate the risks. These significant practices complement responsiveness and ensure competitive advantage in today's dynamic market environment. However, the mentioned strategies cannot be effectively implemented without an enabling organizational culture of innovation, risk-taking, and proactiveness in decision-making.

Limitations

Although the current research guides some critical insight, it does have certain limitations. First, the research setting lies within Jordanian pharmaceutical manufacturing companies; hence, generalization to other industrial sectors or different geographical settings may not be very apparent. The scope may thus be increased further in future studies by selecting other fields of corporate activities, such as services or marketing or similar dynamics across different geographical areas. For example, the study has been based on self-response data generated via questionnaires, which could introduce bias. Further studies should adopt more diversified data collection methods, such as in-depth interviews or on-site observations, to validate and deepen the results. Third, though this study adopts the quantitative analysis perspective, qualitative research investigates how companies may realize and manage SCA and Robustness Capability. This could involve case studies or interviews with industry leaders and a deeper understanding of the processes.

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