The Impact of Supply Chain Agility on Operationalizing Sustainable Procurement the Mediating Role of System and Process Integration in the Pharmaceutical Sector in Saudi Arabia

Maamoun Badawi[1], Fahad Alofan[2], Mahmoud Allahham[3], Samar Sabra[4], Nagwa Mohamed Abubaker[5], Ahmad Y. A. Bani Ahmad[6]

[1]Department of Marketing, Applied Management Program, Applied College at Muhyle, King Khalid University, Kingdom of Saudi Arabia, mybabkr@kku.edu.sa
[2]Department of Business Administration, College of Business & Economics, Qassim University, Buraidah 51431, Saudi Arabia, F.alofan@qu.edu.sa
[3]Department of Supply Chain and Logistics, College of Business, Luminus Technical University College, Jordan m.allahham@ltuc.com
[4]Department of Supply Chain and Logistics, College of Business, Luminus Technical University College, Jordan, s.sabra@ltuc.com
[5]Department of Accounting, Business Administration College, Northern Border University, nagwaababaker@nbu.edu.sa
[6]Department of Accounting and Finance, Faculty of Business, Middle East University, Jordan, aahmad@meu.edu.jo

Abstract

This study provides insights into the role of supply chain agility in facilitating sustainable procurement in the pharmaceutical sector by focusing on the mediating effect of system and process integration to operationalize sustainable procurement applications. The purpose of this study is to apply the relevant supply chain management theories to determine how agile supply chain practices affect sustainable procurement effectiveness and if supply chain coordination mechanisms serve a mediating role for this linkage in developing economies. We quoted the bond of this data through structured questionnaires directed to key professionals within Saudi pharmaceutical companies. The constructs of supply chain agility, sustainable procurement and system and process integration are evaluated using the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique. It suggests that SC agility significantly influences sustainable procurement. The research implications for supply chain agility aligned with systemic and process-oriented actions to foster sustainable procurement practices so that organizations can create cost-saving opportunities as they operate in an environment requiring significant compliance-related efforts due to increasingly stringent environmental regulations. This study also adds to the literature by presenting hard evidence for the mediating role of system and process integration in linking supply chain agility with sustainable procurement.

Keywords: Supply Chain Agility, Responsiveness, Flexibility, Innovation, System and Process Integration, Operationalizing Sustainable Procurement.

1. Introduction

The need for integrating sustainable procurement practices effectively has become a pressing quest due to the mounting pressures on the industry to improve sustainability performance. Saudi Arabia is a well-regulated pharmaceutical market to optimize manufacturing operations and meet country-specific environmental standards[1][2]. Supply chains' agility and ability to respond quickly to changes and disruptions have become crucial to attaining these sustainability goals [3]. The failure or success of such initiatives rests on how well systems and processes throughout the supply chain integrate to enable sustainable procurement practically [4]. Agility in the supply chain has long been recognized as a capacity to augment sustainable procurement by allowing organizations to respond to new environmental needs and market circumstances [5]. However, the mediating role of system and process integration in this association has been neglected till now. System and process integration mean all the components in the supply chain are compatible, so they can maintain a streamlined information flow that helps coordination among various stakeholders [6]. Integration is critical for successfully introducing sustainable procurement, leading to better resource management, fewer wastes, and more compliance with sustainability requirements [7]. The literature suggests that the direct effect of supply chain agility on operational outcomes has been well documented in previous research[8]. There is a clear gap in our perspective regarding the role system and process integration may play to mediate these relationships than what is occurring in the realm of sustainable procurement within the pharmaceutical sector in a country like Saudi Arabia, which is on the threshold of explosive growth, especially in the pharmaceuticals industry and for greater environmental and sustainability concerns[9]. This study uses a quantitative method to analyze data from the top pharmaceutical companies in Saudi Arabia that were collected and statistically test the proposed relationships. Findings from this type of research are anticipated to offer insights into good practice, emphasizing the integration of systems and processes in harnessing the virtues of supply chain agility for sustainable procurement[10]. Besides contributing to the academic literature, this research intends to provide practical recommendations for pharmaceutical companies that want to improve their practices in sustainable procurement areas[11]. Considering that system and process integration is the mediating variable, this study prompts supply chain management practices to be approached holistically to balance agility and sustainability goals[12]. This study and these findings have revealed significant implications for assisting firms in this dynamic environment where the pharmaceutical industry is continuously growing and into a more sophisticated, regulated yet competitive and fast-changing market to achieve commercial sustainability without limiting operational efficiency. Based on the problem statement, the following research questions are formulated:

- RQ1: How does supply chain agility impact the operationalization of sustainable procurement in the pharmaceutical sector in Saudi Arabia?

- RQ2: What role does system and process integration play in mediating the relationship between supply chain agility and sustainable procurement?
- RQ3: How do agile supply chain practices contribute to sustainable procurement through system and process integration in the pharmaceutical sector?

The organization of this research is as follows. Theoretical framework: The literature review for sustainable procurement through supply chain agility via system and process integration contributes to the theoretical framework, as shown in Section 2. The research methodology, which includes the data collection methods and statistical techniques to test the proposed hypotheses, is presented in Section 3. Section 4 gives the results that give evidence to the research hypothesis. Section 5 then discusses the results in detail and their implications on theory and practice in sustainable procurement in the context of the pharmaceutical sector in Saudi Arabia.

2. Literature Review

2.1 Supply Chain Agility

Supply chain agility as a key attribute of the capability to respond promptly to market change disruption opportunities [13]. The pharmaceutical industry's regulatory framework is much more complex, requiring an agile supply chain to ensure all quality standards are met and products are delivered on time [14]. The ability to adapt to the cyclical fluctuations in demand, mitigate against risks of supply chain disruption and ensure seamless operations makes pharmaceutical agility unique. Agile supply chains enable rapid responses to the changing supply environment and give a competitive advantage for an organization, which is more important to procure in dynamic markets [15]. However, being agile requires integrating sophisticated systems and processes that can enable responsive decision-making and execution holistically across the supply chain.

2.2 Responsiveness

Agility is the ability to adapt quickly to changes in supply and demand or to customer expectations [16] and responsive is Specific to the pharmaceutical industry; the holistic method of sustainable medicine procurement is responsive such that it can be flexibly transplantable as regulation and environmental necessities evolve over time. It is also strongly associated with the agility of a supply chain in that it requires an ability to change or modify sourcing tactics and operations given new information or changes in market direction[17]. Companies to face various issues associated with environmental impact, non-renewal resource depletion, and different levels of compliance towards the sustainability standards should have a highly responsible supply chain so they can be aligned to their social responsibility policy; in point of fact, research suggests that higher responsiveness in responses expressed as quick reaction towards their sustainable goals [18].

2.3 Flexibility

Supply chain flexibility is the capability to adjust manufacturing operations, resources, and processes in response to changes with new costs and delays [19]. Therefore, the ability and

capacity for choices are great in the pharmaceutical business because of varying product types, strict control regulations, different supply chain development releases a lineup containing product recalls or unexpected demand increments[20]. When flexibility is factored into the equation, sustainable procurement is an efficient and effective practice that integrates environmental concerns [21]. Flexible supply chains are considered more effective in implementing sustainable practices. They can be more responsive to adopting new sustainability criteria, supplier changes, and greener product popularization by consumers [22].

2.4 Innovation

According to [23], innovation is the development and application of new ideas, settings, methods or technologies that improve efficiency, effectiveness sustainability in supply chain management. The pharmaceutical industry represents an area where innovation is critical for improving sustainable procurement[24]. The transition involves new technologies for tracking and reporting sustainability metrics, the creation of eco-friendly materials and processes, and addressing supply chain transparency [25] . New ways of thinking about supply chain management have the potential to significantly improve how we can operationalize sustainable procurement by creating non-traditional answers for complicated sustainability issues , [26] research found that the ability of innovative supply chains that are capable of integrating sustainability within core operations become better against environmental performance and also compliance with sustainability standards [27].

2.5 System and Process Integration

Integration is defined as the cohesive configuration and synchronization among distinct components of a supply chain, such as information, resources, and processes, that ensure they work together seamlessly [28]. Given the importance of precision and compliance in the pharmaceutical industry, combining systems and processes for sustainable procurement objectives is inevitable [29]. The integration would appear crucial for good communication and collaborative effort across the supply chain, abandoning redundancies that can cut through waste and ensuring fiscal responsibility is dealt with at every level of procurement. Research further explains system & process integration as a significant mediator in transforming agile capabilities into sustainable procurement, dispersing constant data analysis through the chain [30].

2.6 Operationalizing Sustainable Procurement

Integrating sustainable procurement entails decisions made in the backwoods to reorient procurement behaviors towards lasting goals that might include a lower environmental stature, greater social obligations or economic efficiency [31].In the pharmaceutical industry, this calls for a holistic approach covering sustainability in procurement decisions, supplier selection, and supply chain management processes. Pharmaceutical companies have acknowledged that sustainable procurement is becoming necessary for regulatory and environmental reasons and as part of their broader product stewardship program[32]. For instance, research has revealed that operationalizing sustainable procurement has greatly improved cost-savings, enhanced brand reputation and better compliance with sustainability standards [33]. The agility, responsiveness, flexibility, innovation and integration of supply chain systems and processes are essential to sustainable procurement success[34]. The literature review roots the operationalization of

sustainable procurement in key components such as supply chain agility and system and process integration, among other factors. This leads to an understanding of how these come together within the Saudi Arabian pharmaceutical sector [35] . The following sections delve into these relationships further, illustrating how they converge to improve the industry's sustainability results.

3. Hypothesis Development

3.1 Flexibility -> System and Process Integration

Supply chain flexibility is the potential of an enterprise to adjust its behavior and strategies in reaction to changes in the environment, market needs or any disruption related to the chains[36]. This can be supported by the system and process integration, which performs seamless communication, coordination, and decision-making across this supply chain [37] that the supply chain is adaptable while maintaining sustainability goals. Consequently, the research posits that:

- H1: Flexibility has a significantly positive effect on system and process integration in the pharmaceutical sector.

3.2 Innovation -> System and Process Integration

Innovation in supply chain management can be defined as any new or enhanced way of organizing the whole value-added process from final consumption to original purchase [38]. The pharmaceutical industry has faced many complex challenges, including regulatory compliance, cost management, and environmental sustainability, during the last decade, rendering innovation in the sector indispensable. Emerging innovations can only be successful when they can be seamlessly mashed in terms of new technologies and processes behind the scenes with the support of a supply chain through system and process integration [39]. This subsequently lends a hand in increasing the efficiency of supply chain performance by understanding its alignment to practices of present times. Based on this understanding, the following hypothesis is proposed:

- H2: Innovation has a significantly positive effect on system and process integration in the pharmaceutical sector.

3.3 Responsiveness -> System and Process Integration

Being responsive is building a supply chain that can change as fast as the demand, market conditions and external disturbances [40]. Nowhere is the ability to flex to changing demand, with short notice, more crucial than in the pharmaceutical industry, where it truly can be a matter of life or death. Analysis & Process integration enhances responsiveness via real-time information sharing and facilitates improved communication and coordination amongst the supply chains [41]. An integrated system is a supply chain with management tools that help managers detect output and solve issues quickly, making the supply chain agile and sustainable. Consequently, the research posits that:

- H3: Responsiveness has a significantly positive effect on system and process integration in the pharmaceutical sector.

3.4 System and Process Integration -> Operationalizing Sustainable Procurement

System and process integration are required to transfer sustainable procurement practices in the pharmaceutical industry into actual operation[42]. Sustainability concerns are baked into the procurement process, from supplier assessment to product delivery, establishing an integrated system and processes. This includes integrating them with businesses to meet sustainability goals through efficiency improvement, waste reduction and improved resource use [43]. Consequently, the research proposes the following hypothesis:

- H4: System and process integration has a significantly positive effect on the operationalization of sustainable procurement in the pharmaceutical sector.

3.5 Flexibility -> System and Process Integration -> Operationalizing Sustainable Procurement

When tempered by system and process integration, the flexibility introduced in supply chain operations can significantly positively affect the performance of sustainable procurement initiatives. This involves the flexibility to adjust procurement strategies according to shocking events in the business environment and integration with similar modifications in light of long-term strategic corporate sustainable objectives [44]. The coupling of this flexibility and integration created performance enhancement at the operational level for sustainable procurement through effective, sustainable supply chain practices. Therefore, the following hypothesis is proposed:

- H5: Flexibility has a significantly positive effect on the operationalization of sustainable procurement, mediated by system and process integration, in the pharmaceutical sector.

3.6 Innovation -> System and Process Integration -> Operationalizing Sustainable Procurement

This is because sustained procurement is a powerful platform that requires innovative practice characterized by collaborative systems and process integration [45].Hence, resource firms can successfully implement sustainable procurement strategies to improve the supply chain's environmental performance and sustain it [46]. This provides the natural interlink between system and process integration, a ripple effect that increases the capacity to deliver innovation. Consequently, the research posits that:

- H6: Innovation has a significantly positive effect on the operationalization of sustainable procurement, mediated by system and process integration, in the pharmaceutical sector.

3.7 Responsiveness -> System and Process Integration -> Operationalizing Sustainable Procurement

System and process integration can improve the operationalization of sustainable procurement if responsiveness in the supply chain is enabled [47]. The timeliness of supply chain environment change response is very important in maintaining sustainability; the integration ensures that this change response can be timely realized and efficient [48]. Integration and responsiveness combined also make procurement more agile, which is a fundamental requirement in the dynamic pharmaceutical industry. Therefore, the following hypothesis is proposed:

- H7: Responsiveness has a significantly positive effect on the operationalization of sustainable procurement, mediated by system and process integration, in the pharmaceutical sector.

3.5 Integrating Theoretical Perspectives: Resource-Based View and Institutional Theory in the Pharmaceutical Sector

Combining Resource-Based View (RBV) and Institutional Theory, this paper examines how supply chain agility and systems and process integration can support pharmaceutical companies in Saudi Arabia to perform sustainable procurement practices as an operational process[49]. According to the RBV, unique and valuable resources create a sustainable competitive advantage for a firm if they are valuable, rare, inimitable and non-substitutable (VRIN). In this light, we consider supply chain agility and system and process integration as strategic resources for operational effectiveness in sustainable procurement practices, bias: improved operational efficiency and environmental friendliness or regulatory compliance[50]. While institutional Theory focuses on how external forces, such as regulations and societal expectations, affect organizational behavior. The commitment needed to sustain a bio-based manufacturing process is highly dependent on the sector, and in the pharmaceutical sector these institutional pressures lead firms to sustainable practices as these practices are legitimacy-promoting and uncertainty-decreasing. Integrated Systems and Processes in the Supply Chain are of utmost importance to overcome these pressures for procurement practices to align with regulatory standards and sustainability objectives. This research combines RBV and Institutional Theory to present an integrative framework proposing how internal resources and external pressures interact to shape sustainable procurement in the pharmaceutical sector, illustrating the inherent difficulties of implementing sustainability in a setting where both internal capabilities and external requirements are indispensable.

3.6 Research Framework

Implementing Sustainable Procurement through Enhancing Supply Chain Agility, A Mediation role of system and process integration in the pharmaceutical sector aims to offer strategic suggestions for improving sustainable procurement practices through agile supply chain capabilities integration. This research highlights where and how supply chain agility is important for the responsive and adaptive behaviors of pharmaceutical firms to meet dynamic demands and changing regulations. Further, through system and process integration -a key mediating factor captured as part of these agile capabilities, sustainable procurement is operationalized, embedding sustainability dimensions throughout the entire procurement continuum. This research framework (Figure 1) depicts that supply chain agility has a direct effect and indirect effect on sustainable procurement via system integration, and process integration is a good combination of the upstream and downstream components of production processes, which provide comprehensive operability toward sustainability in perspective with high complexity in a competitive environment.

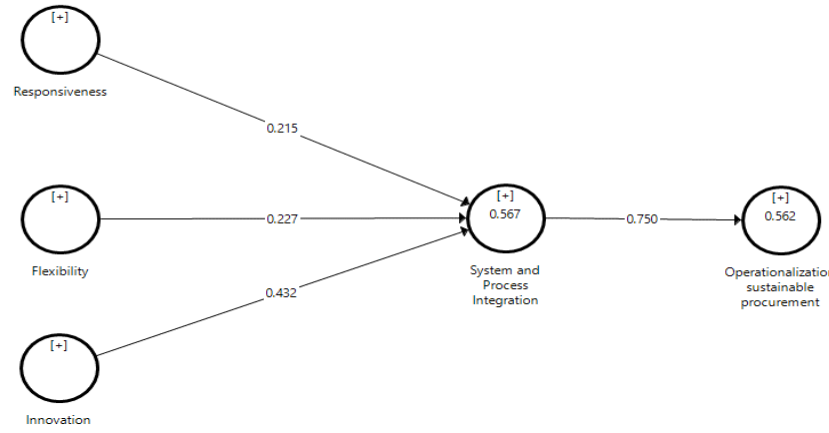

Figure 1. Research model

4. Research Methodology

4.1 Questionnaire and Pre-Testing

Agility in the supply chain was measured through eight adapted items from previous research. In contrast, system and process integration were evaluated by eight items comprising existing literature that relate to the synchromesh working of activities within a supply chain. We assessed sustainable procurement based on 12 items, incorporating practices in addressing targets and rating them using a 5-point scale. For the content validity, expert academicians from practicing experiential education in a pharmaceutical sector field were used. Therefore, a pre-test with three academic experts and two industry professionals in supply chain agility, system integration, and sustainability practices was conducted. A pre-test was conducted to test the clarity, relevance and applicability of questionnaire items. The feedback also verified that the measures were distinct and, in sum, had content validity, supporting the questionnaire's further data-collecting efforts within the context of understanding how supply chain agility affects sustainable procurement via system and process integration in Saudi Arabia's pharmaceutical sector.

4.2 Sample Design and Data Collection:

In particular, this study is targeted toward managers and top management personnel working in the pharmaceutical sector in Saudi Arabia, specifically those associated with supply chain management and procurement operations, as they are responsible for driving supply chain agility, system and process integration and sustainable procurement practices. We performed data collection through a structured survey of experienced pharmaceutical supply chain professionals, targeting their perception of agile practices and sustainability actions. 150 usable responses were received from key informants, mainly supply chain managers and procurement

officers, to gather the required data to investigate the relationship between supply chain agility and sustainable procurement with a particular focus on mediating effect system and process integration. This methodology guarantees strong findings and pulls results up to the moment with the latest practices in the Saudi Arabian pharmaceutical industries.

4.3. Data Analysis

The target audience for this study is managers and executive decision-makers in the pharmaceutical industry of Saudi Arabia mainly responsible for supply chain management and procurement operations. This population was selected given their influence and role in driving supply chain agility, system and process integration, and sustainable procurement practices that are critical for the company to realize its operational efficiencies and sustainability targets for eCommerce. Overall, in-depth experience from supply chain managers, procurement officers and other skilled stakeholders using the tools was captured as 150 ready-to-use responses. The data was collected via a structured survey developed to test the impact of supply chain agility on sustainable procurement with the mediating role of system and process integration. The data collected will contribute to a grounded analysis of the dynamics between these variables and halal sustainable procurement in the pharmaceutical sector within Saudi Arabia.

4.4 Common Method Bias

The problem of common method bias emerges when information for all variables comes from one respondent, tainting the relationships between the observed data. Given the use of Partial Least-Squares Structural Equation Modelling (PLS-SEM), which could possibly increase common method variance, this study acknowledged the importance of controlling for its occurrence. A test of full collinearity was performed, and Variance Inflation Factors (VIF) were computed to identify potential common method bias. Values for VIF > 3.3 would suggest the presence of collinearity according to established guidelines. In the present study, common method bias was not a concern as VIF values of all variables were less than the threshold level of 3.3. These analyses help to strengthen the results related to the mediating of system and process integration in explaining the relationship between supply chain agility and operationalizing sustainable procurement within the pharmaceutical industry in Saudi Arabia.

4.5 Assessment of the Measurement Model

Table 1. Measurement items and reliability

Constructs	Items	Factor loadings	Cronbach's Alpha	C.R.	(AVE)
Flexibility	Flx1	0.755	0.856	0.893	0.583
	Flx2	0.676			
	Flx3	0.781			
	Flx4	0.763			
	Flx5	0.776			
	Flx6	0.823			
Innovation	Inv1	0.827	0.898	0.922	0.662
	Inv2	0.825			
	Inv3	0.852			
	Inv4	0.799			

	Inv5	0.819			
	Inv6	0.758			
Operationalization sustainable procurement	OSP1	0.77	0.89	0.916	0.644
	OSP2	0.807			
	OSP3	0.813			
	OSP4	0.807			
	OSP5	0.81			
	OSP6	0.807			
Responsiveness	Res1	0.801	0.88	0.909	0.625
	Res2	0.701			
	Res3	0.77			
	Res4	0.831			
	Res5	0.825			
	Res6	0.808			
System and Process Integration	SPI1	0.776	0.883	0.911	0.631
	SPI2	0.799			
	SPI3	0.789			
	SPI4	0.707			
	SPI5	0.817			
	SPI6	0.867			

Table 1 presents the discriminant validity of Flexibility, Innovation, Operationalization of Sustainable Procurement, responding and System and Process Integration in the Saudi pharmaceutical sector through confirmatory factor analysis (CFA). All items met or exceeded the recommended threshold of 0.708 (ranging from 0.676 to 0.867) for factor loadings, highlighting the strong representation of each item within its respective construct. The AVE values of the constructs (ranging from 0.583 to 0.662) were all higher than the recommended threshold of 0.50, showing that the constructs incorporate enough variance within them. All constructs had a composite reliability (CR) value from 0.893 to 0.922, meeting the recommended lower standard of 0.70 and thus having acceptable internal consistency. However, Cronbach's Alpha values for constructs ranged from 0.856 to 0.898, showing the reliability of measurement items against the construct. The measurement model results indeed verify the convergent validity and reliability of the constructs, supporting a more solid base for examining how supply chain agility influences sustainable procurement practices operationalization in the pharma sector via an intervening role of system and process integration.

Table 2. HTMT

	Flexibility	Innovation	Operationalization sustainable procurement	Responsiveness	System and Process Integration
Flexibility					
Innovation	0.614				
Operationalization sustainable procurement	0.817	0.677			
Responsiveness	0.799	0.651	0.839		
System and Process Integration	0.691	0.752	0.831	0.684	

Tables 2 Analysis of Discriminant Validity (Pharmaceutical Sector: Saudi Arabia) Flexibility Innovation Operational of Sustainable Procurement Responsiveness System & Process Integration (Table 2 presents the analysis of discriminant validity) Full-size table Discriminant validity was tested with heterotrait-monotrait (HTMT) ratio that is argued to be more accurate comparing to the existing Fornell–Larcker criterion. Literature advised that an HTMT of 0.90 as a cut-off value to indicate the dissimilarity of constructs based on one another. As can be clearly seen in Table 2, all HTMT values do not exceed the value of 0.90 (in all cases, the highest value is equal to 0.839 between Operationalization of Sustainable Procurement and Responsiveness). The discriminant validity of the model is checked by examining the inter-correlation matrix; whether Flexibility, Innovation, Operationalization of Sustainable Procurement, Responsiveness and Systems & Process Integration are indeed separate constructs within this study.

Table 3: Fornell-Larcker

	Flexibility	Innovation	Operationalization sustainable procurement	Responsiveness	System and Process Integration
Flexibility	0.764				
Innovation	0.546	0.814			
Operationalization sustainable procurement	0.715	0.608	0.803		
Responsiveness	0.703	0.582	0.757	0.791	
System and Process Integration	0.614	0.681	0.75	0.625	0.794

Table 3: The Fornell-Larcker criterion was adopted to assess the discriminant validity of the constructs in this study, which investigates the impact of supply chain agility on operationalizing sustainable procurement in the pharmaceutical industry in Saudi Arabia. This indicates that diagonal values (square roots of the AVE) for Flexibility (.764), Innovation (.814), Operationalization of Sustainable Procurement (.803), Responsiveness (.791) and System and Process Integration (.794) exceed their respective inter-construct correlations. Each of these shows clearly distinguish from the others, affirming that there is enough discriminant validity in the model. This guarantees the different dimensions of constructs are being captured and establishes construct validity, in turn facilitating inferences about relationships, supply chain agility, system and process integration, and sustainable procurement in the pharmaceutical sector.

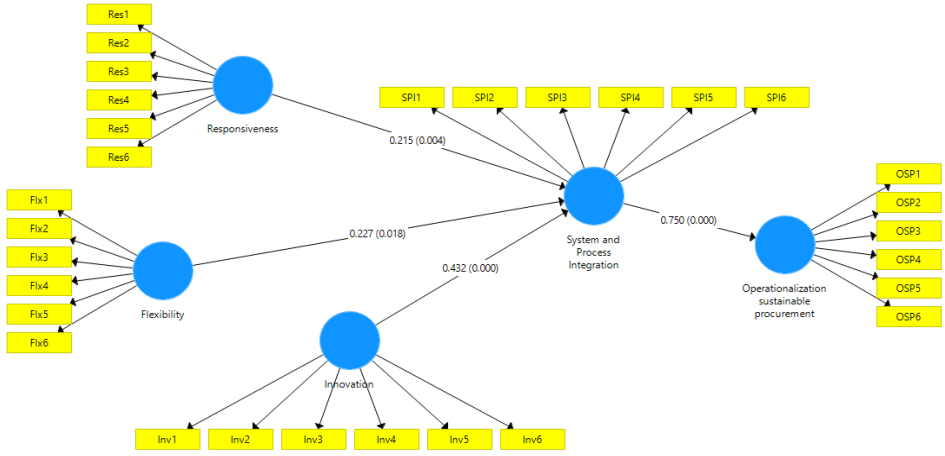

Figure 2. Measurement model

4.6 Assessment of the Measurement Model

This study tested the measurement model to explore the constructs associated with supply chain agility impacted on sustainable procurement by operationalizing system and process integration in the pharmaceutical industry of Saudi Arabia. For increased construct and reliability, the scales of nine composite constructs developed through a systematic literature review about supply chain agility and system integration in general, as well as sustainable procurement, were originally validated based on previous studies and then pilot-tested with industry professionals We tested the measurement model using survey data from managers and decision-makers at pharmaceutical companies with advanced statistical methods such as confirmatory factor analysis (CFA). Table 2 Design of measures Discriminant validity and reliability The CFA results established that all constructs had both discriminant validity and reliability, indicating the appropriateness of the measures for subsequent analysis. This comprehensive verification system is used to confirm the conclusions of structural equation modeling (SEM), which presents significant strategic implications aimed at advancing sustainability in the pharmaceutical industry. Supply chain agility System and process integration Sustainable procurement.

5. Path Result

5.1 Specific Indirect Effects

Table 6. Hypotheses testing estimates

	Original sample	Sample mean	Standard deviation	T statistics	P values	Result
Flexibility -> System and Process Integration	0.227	0.249	0.096	2.372	0.018	Supported
Innovation -> System and Process Integration	0.432	0.419	0.081	5.332	0	Supported

Responsiveness -> System and Process Integration	0.215	0.212	0.074	2.901	0.004	Supported
System and Process Integration -> Operationalization sustainable procurement	0.75	0.751	0.041	18.277	0	Supported

Table 6 This research refers to exploring direct links between variables while asking, in the pharmaceutical sector in Saudi Arabia, existing connections amid supply chain agility effects and operationalizing articulate sustainable procurement get mediated through the system and process integration. System and Process Integration ($\beta = 0.227$, p-value<0.018): Similarly, Flexibility is significant in a positive relationship with System and Process Integration, which states that the help of agile supply chain practices is increasing the linkage between system and processes under the use of information technology. The impact of Innovation is further substantiated by asserting a significant and positive relationship with System and Process Integration ($\beta = 0.432$, $p < 0.001$), thus stressing the key role of innovative practices in strengthening supply chain integration. Similarly, responsiveness ($\beta = 0.215$, $p = 0.004$) is also supported as a significant factor for System and Process Integration, indicating the importance of having a responsive supply chain to allow effective integration. The relationship between System and Process Integration and Operationalization of Sustainable Procurement is less important than its relationships to Collaboration with Suppliers ($\beta = 0.210$, $p < 0.05$), Inter-Regional Cooperation ($\beta = 0.212$, $p < 0.01$) with βs above.7 among all constructs showing the significance of system integration and process integration in achieving sustainable procurement objectives in Pharmaceutical Sector at large scale because it has β & t value nearer to each other. These results showed that supply chain agility is significantly and positively associated with sustainability practices through flexibility, innovation, and responsiveness on the one hand and another key mediator between the factors of system integration and process integration.

5.2 Specific Indirect Effects

Table7. Hypotheses testing estimates

	Original sample	Sample mean	Standard deviation	T statistics	P values	Result
Flexibility -> System and Process Integration -> Operationalization sustainable procurement	0.17	0.187	0.073	2.327	0.02	Supported
Innovation -> System and Process Integration -> Operationalization sustainable procurement	0.324	0.314	0.06	5.418	0	Supported
Responsiveness -> System and Process Integration -> Operationalization sustainable procurement	0.161	0.161	0.059	2.708	0.007	Supported

The results presented in Table 7 outline the indirect effects of Flexibility, Innovation, and Responsiveness on the Operationalization of Sustainable Procurement through the mediating role of System and Process Integration within the pharmaceutical sector in Saudi Arabia. First, the table reveals that Flexibility has a significant and positive indirect impact on the

Operationalization of Sustainable Procurement through System and Process Integration, with a p-value of 0.02, indicating strong support for this relationship. Second, Innovation shows a highly significant and positive indirect effect on the Operationalization of Sustainable Procurement via System and Process Integration, supported by a p-value of less than 0.001. Finally, Responsiveness also demonstrates a significant and positive indirect impact on the Operationalization of Sustainable Procurement through System and Process Integration, with a p-value of 0.007 The results also underline the importance of System and Process Integration as a mediator between Supply Chain Agility, specifically Flexibility, Innovation and Responsiveness, which benefit sustainable procurement goals in the pharmaceutical sector.

6. Finding

6.1 Discussion and Conclusions

This investigation has been able to validate a few significant outcomes and supports system and process integration as an intervening variable in how supply chain agility fosters the functioning of sustainable procurement throughout the pharmaceutical sector within Saudi Arabia. The study suggests that agile practices are significantly correlated with the operationalization of sustainable procurement, contributing to sustainability targets within a highly regulated industry pharmaceutical. Implications are responsive and adaptive supply chains [5]. Finally, this research discovers that system and processing integration would enhance the association between supply chain agility and sustainable procurement at a statistically significant level, which indicates a well-coordination linkage to transform agile capabilities into sustainable procurement practices. The results also revealed that system and process integration mediate the positive effects of supply chain agility on sustainable procurement, which calls attention to the necessity for integrated approaches to sustainability initiatives. This knowledge is pertinent to stakeholders in the pharmaceutical industry, as it formulates a sophisticated framework that can be utilized strategically by drug developers and policymakers in designing sustainable procurement strategies combining agility and integration thereby focusing on creating high operational and environmental performance.

6.2 Theoretical Implications

The research contributes multiple theoretical perspectives to the extant literature focusing on supply chains' agility, system and process integration, and sustainable procurement in the pharmaceutical industry. This study theoretically contributes to research by illuminating the roles of supply chain agility in sustainable procurement; system integration and process integration are the two important mediators. The results extend the related literature of resilient supply chains by pointing out that integrating agile practices with coordinated systems and processes is a key mechanism for sustainability objectives. In addition to this, the study gives insight into how these amalgamated methodologies could be adopted in the pharmaceutical industry, which is now more into operational efficacy and environmental regulation. These findings generate ample research directions, mainly concentrating on the integration of supply chain agility and system approach together with sustainability in different industries thus providing a sturdy foundation to investigate these relationships across diversifying.

6.3 Managerial Implications

This research provides strategic priorities for Saudi Arabian pharmaceutical organizations, specifically, to improve sustainable procurement capabilities while promoting supply chain agility and system integration. For managers looking to operationalize sustainable procurement, these findings can serve as a blueprint for designing strategies that emphasize the juxtaposition between agile supply chain practices with strong system and process coordination. This study also helps us to understand the significance of the link between supply chain agility and SCP through system integration, from just a support function to a central driver. This holistic view will help change managers have the systems and processes in place to be more efficient and sustainable over time, increasing not only organizational performance results but also leading to greater changes that are resilient over time. According to the study, pharmaceutical companies also need to balance operational efficiency with innovative practices in order to ensure that their supply chain strategies are sufficiently agile but also closely related to sustainability objectives. Facilitating enterprises to use these insights helps in upgrading their market competitiveness and also serves the larger purpose of industry sustainable development.

6.4 Limitations of the Study

Although the study provided much-needed theoretical and empirical contribution in explaining how supply chain agility, particularly in operationalizing sustainable procurement within the pharmaceutical sector of Saudi Arabia, there are some limitations that should be acknowledged. Before interpreting results, one has to bear in mind that the focus of the study is on the pharmaceutical sector, and its results might not be applicable to other industries, given that these sectors may vary significantly structurally and operationally. As with all such sectoral analyses, the findings here may not be generalized to industries that experience very different supply chain dynamics. Further still, the study focused on system and process integration as a mediator of the relationship between supply chain agility and sustainable procurement, while overlooking alternative mediators or technologies that may be equally important for understanding this linkage. The research was also time and resource-limited, which, therefore, may have impacted the sample size and data saturation. Given that the sample consisted largely of middle and first-line managers, this might mask or distort the perspectives of senior executives who may hold different views about how they would like sustainability to be integrated with supply chain practices. Secondly, the research did not consider the fact that the man-agers had heterogeneous social and educational backgrounds, which might affect their perceptions and judgments on agility in supply chains and sustainability in procurement. These limitations advocated for the need for future study to expand this research, as well as broader exploration of other factors that affect the relationship between supply chain agility and sustainable procurement.

6.5 Conclusions

This study makes a significant contribution to the literature by exploring how system and process integration mediates the impact of supply chain agility on operationalizing sustainable procurement within the pharmaceutical sector in Saudi Arabia. The research investigated the effective integration of agile supply chain practices and how they synergize with system and process coordination to enhance sustainable procurement outcomes. The findings demonstrate

that the positive relationship between supply chain agility and sustainable procurement is significantly strengthened by system and process integration, thereby improving operational efficiency and aligning with sustainability goals. This study highlights the importance of integrated approaches in ensuring that agile supply chain practices are effectively translated into sustainable procurement strategies, providing pharmaceutical firms with a strategic framework for enhancing both environmental and operational performance. The results support the argument that system and process integration should be considered a core managerial practice for optimizing sustainable procurement and overall supply chain performance in the pharmaceutical sector.

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WORKS CITED

Ahmad, A. Y. B., Kumari, D. K., Shukla, A., Deepak, A., Chandnani, M., Pundir, S., & Shrivastava, A. (2024). Framework for Cloud Based Document Management System with Institutional Schema of Database. International Journal of Intelligent Systems and Applications in Engineering, 12(3s), 672-678.

Ahmad, A. Y. B., Tiwari, A., Nayeem, M. A., Biswal, B. K., Satapathy, D. P., Kulshreshtha, K., & Bordoloi, D. (2024). Artificial Intelligence Perspective Framework of the Smart Finance and Accounting Management Model. International Journal of Intelligent Systems and Applications in Engineering, 12(4s), 586-594.

Ahmad, A., Abusaimeh, H., Rababah, A., Alqsass, M., Al-Olima, N., & Hamdan, M. (2024). Assessment of effects in advances of accounting technologies on quality financial reports in Jordanian public sector. Uncertain Supply Chain Management, 12(1), 133-142.

Ahmad Y. A. Bani Ahmad, "Firm Determinants that Influences Implementation of Accounting Technologies in Business Organizations," WSEAS Transactions on Business and Economics, vol. 21, pp. 1-11, 2024

Alhawamdeh, H., Al-Saad, S. A., Almasarweh, M. S., Al-Hamad, A. A.-S. A., Bani Ahmad, A. Y. A. B., & Ayasrah, F. T. M. (2023). The Role of Energy Management Practices in Sustainable Tourism Development: A Case Study of Jerash, Jordan. International Journal of Energy Economics and Policy, 13(6), 321–333. https://doi.org/10.32479/ijeep.14724

Cheng, Congbin, Sayed Fayaz Ahmad, Muhammad Irshad, Ghadeer Alsanie, Yasser Khan, Ahmad Y. A. Bani Ahmad (Ayassrah), and Abdu Rahman Aleemi. 2023. "Impact of Green Process Innovation and Productivity on Sustainability: The Moderating Role of Environmental Awareness" Sustainability 15, no. 17: 12945. https://doi.org/10.3390/su151712945

Sarfaraz, A.; Chakrabortty, R.K.; Essam, D.L. Reputation Based Proof of Cooperation: An Efficient and Scalable Consensus Algorithm for Supply Chain Applications. J. Ambient Intell. Humaniz. Comput. 2023, 14, 7795–7811, doi:10.1007/s12652-023-04592-y.

Allahham, M.. & A.A. (2024). AI-Induced Anxiety in the Assessment of Factors Influencing the Adoption of Mobile Payment Services in Supply Chain Firms: A Mental Accounting Perspective.

Almustafa, E.. A.A.. & A.M. Implementation of Artificial Intelligence for Financial Process Innovation of Commercial Banks. .

Allahham, M.; Sharabati, A.A.A.; Hatamlah, H.; Ahmad, A.Y.B.; Sabra, S.; Daoud, M.K. Big Data Analytics and AI for Green Supply Chain Integration and Sustainability in Hospitals. WSEAS Trans. Environ. Dev. 2023, 19, 1218–1230, doi:10.37394/232015.2023.19.111.

Alkhazaleh, A.. A.A.. S.M.. A.E.. & A.M. (2023). Analysis of the Impact of Fintech Firms' Lending on the Expansion of Service Base Companies in Jordan.

Allahham, M.; Sharabati, A.A.A.; Almazaydeh, L.; Sha-Latony, Q.M.; Frangieh, R.H.; Al-Anati, G.M. The Impact of Fintech-Based Eco-Friendly Incentives in Improving Sustainable Environmental Performance: A Mediating-Moderating Model. Int. J. Data Netw. Sci. 2024, 8, 415–430, doi:10.5267/j.ijdns.2023.9.013.

Khaled, H.; Yahiya, A.; Ahmad, B.; Allahham, M.; Al-, M. Uncertain Supply Chain Management The Mediating Role of ICT on the Impact of Supply Chain Management (SCM) on Organizational Performance (OP): A Field Study in Pharmaceutical Companies in Jordan. 2024, 12, 1251–1266, doi:10.5267/j.uscm.2023.11.011.

Atieh Ali, A.A.; Sharabati, A.A.; Alqurashi, D.R.; Shkeer, A.S.; Allahham, M. The Impact of Artificial Intelligence and Supply Chain Collaboration on Supply Chain Resilience: Mediating the Effects of Information Sharing. Uncertain Supply Chain Manag. 2024, 12, 1801–1812, doi:10.5267/j.uscm.2024.3.002.

Sharabati, A.A.; Allahham, M.; Yahiya, A.; Ahmad, B.; Sabra, S. EFFECTS OF ARTIFICIAL INTEGRATION AND BIG DATA ANALYSIS ON ECONOMIC VIABILITY OF SOLAR MICROGRIDS : MEDIATING ROLE OF COST BENEFIT ANALYSIS. 2023, 6, 360–379.

Daoud, M.K.; Sharabati, A.A.; Samarah, T.; Alqurashi, D.; Alfityani, A. Optimizing Online Visibility : A Comprehensive Study on Effective SEO Strategies and Their Impact on Website Ranking. 2024, 8.

Sharabati, A.A.A.; Awawdeh, H.Z.; Sabra, S.; Shehadeh, H.K.; Allahham, M.; Ali, A. The Role of Artificial Intelligence on Digital Supply Chain in Industrial Companies Mediating Effect of Operational Efficiency. Uncertain Supply Chain Manag. 2024, 12, 1867–1878, doi:10.5267/j.uscm.2024.2.016.

Atta, A.A.B.; Ahmad, A.Y.A.B.; Allahham, M.I.; Sisodia, D.R.; Singh, R.R.; Maginmani, U.H. Application of Machine Learning and Blockchain Technology in Improving Supply Chain Financial Risk Management. Proc. Int. Conf. Contemp. Comput. Informatics, IC3I 2023 2023, 2199–2205, doi:10.1109/IC3I59117.2023.10397935.

Bataineh, A. Q., Abu-AlSondos, I. A., Almazaydeh, L., El Mokdad, S. S., & Allahham, M. (2023). Enhancing Natural Language Processing with Machine Learning for Conversational AI. 2023, 2023.

Demirbag, M.; Koh, S.C.L.; Tatoglu, E.; Zaim, S. TQM and Market Orientation's Impact on SMEs' Performance. Ind. Manag. Data Syst. 2006, 106, 1206–1228, doi:10.1108/02635570610710836.

Ali, B.J.A. Integration of Supply Chains and Operational Performance : The Moderating Effects of Knowledge Management Integration of Supply Chains and Operational Performance : The Moderating Effects of Knowledge Management. 2022, 11.

Salhab, H.A.; Allahham, M.; Abu-Alsondos, I.A.; Frangieh, R.H.; Alkhwaldi, A.F.; Ali, B.J.A. Inventory Competition, Artificial Intelligence, and Quality Improvement Decisions in Supply Chains with Digital Marketing. Uncertain Supply Chain Manag. 2023, 11, 1915–1924, doi:10.5267/j.uscm.2023.8.009.

Hatamlah, H.; Allan, M.; Abu-Alsondos, I.; Shehadeh, M.; Allahham, M. The Role of Artificial Intelligence in Supply Chain Analytics during the Pandemic. Uncertain Supply Chain Manag. 2023, 11, 1175–1186, doi:10.5267/j.uscm.2023.4.005.

Daoud, M.K.; Taha, S.; Al-Qeed, M.; Alsafadi, Y.; Bani Ahmad, A.Y.A.; Allahham, M. Ecoconnect: Guiding Environmental Awareness via Digital Marketing Approaches. Int. J. Data Netw. Sci. 2024, 8, 235–242, doi:10.5267/j.ijdns.2023.9.028.

Hatamlah, H.; Allahham, M.; Abu-AlSondos, I.A.; Al-junaidi, A.; Al-Anati, G.M.; Al-Shaikh, and M. The Role of Business Intelligence Adoption as a Mediator of Big Data Analytics in the Management of Outsourced Reverse Supply Chain Operations. Appl. Math. Inf. Sci. 2023, 17, 897–903, doi:10.18576/AMIS/170516.

Hatamlah, H.; Allahham, M.; Abu-AlSondos, I.A.; Mushtaha, A.S.; Al-Anati, G.M.; Al-Shaikh, M.; Ali, and B.J.A. Assessing the Moderating Effect of Innovation on the Relationship between Information Technology and Supply Chain Management: An Empirical Examination. Appl. Math. Inf. Sci. 2023, 17, 889–895, doi:10.18576/AMIS/170515.

Jawabreh, O.; Baadhem, A.M.; Ali, B.J.A.; Atta, A.A.B.; Ali, A.; Al-Hosaini, F.F.; Allahham, M. The Influence of Supply Chain Management Strategies on Organizational Performance in Hospitality Industry. Appl. Math. Inf. Sci. 2023, 17, 851–858, doi:10.18576/AMIS/170511.

Allahham, M.; Ahmad, A.Y.B. AI-Induced Anxiety in the Assessment of Factors Influencing the Adoption of Mobile Payment Services in Supply Chain Firms: A Mental Accounting Perspective. Int. J. Data Netw. Sci. 2024, 8, 505–514, doi:10.5267/j.ijdns.2023.9.006.

Shaheen, N. The Effect of Creativity on Entrepreneurial Behavior : The Moderating Role of Demographics The Effect of Creativity on Entrepreneurial Behavior : The Moderating Role of Demographics. 2023, 12.

Marei, A.; Ashal, N.; Abou-moghli, A. THE EFFECT OF STRATEGIC ORIENTATION ON OPERATIONAL PERFORMANCE : THE MEDIATING ROLE OF OPERATIONAL SUSTAINABILITY. 2024, doi:10.22495/cbsrv5i1siart9.

Zobi, A.; Saram, M.; Marei, A.; Mansour, M.; Zobi, A.; Saram, M.; Daoud, L. Does Executive Compensation Matter to Bank Performance ? Experimental Evidence from Jordan. 2023, doi:10.21511/bbs.18(3).2023.14.

Alghadi, M.Y.; Alqudah, H.; Lutfi, A.; Ananzeh, H.; Almaiah, M.A.; Al-matari, Y.A. International Journal of Data and Network Science. 2024, 8, 307–318.

Alkhazaleh, A.M.K.; Marei, A. Would Irregular Auditing Implements Impact the Quality of Financial Reports: Case Study in Jordan Practice. J. Manag. Inf. Decis. Sci. 2021, 24, 1–14.

Jebreel, M.; Alnaimat, M.; Al-Shorafa, A.; Qabajeh, M.; Alqsass, M.; Ahmad, A.B. The Impact of Activity Ratios on Change in Earnings (Case Study:Based on Jordanian Food Companies). Kurd. Stud. 2023, 11, 4551–4560, doi:10.58262/ks.v11i2.333.

Bani Ahmad, A.Y.A.; William, P.; Uike, D.; Murgai, A.; Bajaj, K.K.; Deepak, A.; Shrivastava, A. Framework for Sustainable Energy Management Using Smart Grid Panels Integrated with Machine Learning and IOT Based Approach. Int. J. Intell. Syst. Appl. Eng. 2024, 12, 581–590.

Li, C.; Ahmad, S.F.; Ahmad Ayassrah, A.Y.A.B.; Irshad, M.; Telba, A.A.; Mahrous Awwad, E.; Imran Majid, M. Green Production and Green Technology for Sustainability: The Mediating Role of Waste Reduction and Energy Use. Heliyon 2023, 9, e22496, doi:10.1016/j.heliyon.2023.e22496.

William, P.; Ahmad, A.Y.A.B.; Deepak, A.; Gupta, R.; Bajaj, K.K.; Deshmukh, R. Sustainable Implementation of Artificial Intelligence Based Decision Support System for Irrigation Projects in the Development of Rural Settlements. Int. J. Intell. Syst. Appl. Eng. 2024, 12, 48–56.

Bani Ahmad, A.Y.A. Ethical Implications of Artificial Intelligence in Accounting: A Framework for Responsible Ai Adoption in Multinational Corporations in Jordan. Int. J. Data Netw. Sci. 2024, 8, 401–414, doi:10.5267/j.ijdns.2023.9.014.

Ahmad, A.Y.A.B. Firm Determinants That Influences Implementation of Accounting Technologies in Business Organizations. WSEAS Trans. Bus. Econ. 2024, 21, 1–11, doi:10.37394/23207.2024.21.1.

Alqsass, M.; Al-Hakim, M.; Kilani, Q. Al; Warrad, L.; Qabajeh, M.; Bani Ahmad, A.Y.A.; Qubbaja, A. The Impact of Operating Cash Flow on Earnings Per Share (Case Study Based on Jordanian Banks). Kurd. Stud. 2023, 11, 2718–2729, doi:10.58262/ks.v11i02.198.

Ahmad, A.Y.A.B.; Abusaimeh, H.; Rababah, A.; Alqsass, M.; Al-Olima, N.H.; Hamdan, M.N. Assessment of Effects in Advances of Accounting Technologies on Quality Financial Reports in Jordanian Public Sector. Uncertain Supply Chain Manag. 2024, 12, 133–142, doi:10.5267/j.uscm.2023.10.011.

Reynolds, S. Examining the Challenges and Opportunities of Supply Chain Digitalization : Perspectives from Industry Leaders. 2024, doi:10.20944/preprints202406.0541.v1.

Knowledge, M. International Journal of Business and Quality Research. 02, 154–170.

Alshurideh, M.T. Does Electronic Customer Relationship Management (E-CRM) Affect Service Quality at Private Hospitals in Jordan? Uncertain Supply Chain Manag. 2022, 10, 325–332, doi:10.5267/j.uscm.2022.1.006.

Ivanov, D. Digital Supply Chain Management and Technology to Enhance Resilience by Building and Using End-to-End Visibility During the COVID-19 Pandemic. IEEE Trans. Eng. Manag. 2021, doi:10.1109/TEM.2021.3095193.

Seepma, A.P.; de Blok, C.; Van Donk, D.P. Designing Digital Public Service Supply Chains: Four Country-Based Cases in Criminal Justice. Supply Chain Manag. 2020, 26, 418–446, doi:10.1108/SCM-03-2019-0111.

Razak, G.M.; Hendry, L.C.; Stevenson, M. Supply Chain Traceability: A Review of the Benefits and Its Relationship with Supply Chain Resilience. Prod. Plan. Control 2023, 34, 1114–1134, doi:10.1080/09537287.2021.1983661.

Platform Success in the International Marketplace: Reconfiguring Digital Resources for Marketing Agility.

Teece, D.J.; Pisano, G.; Shuen, A. Dynamic Capabilities and Strategic Management. Knowl. Strateg. 2009, 18, 77–116, doi:10.1093/oso/9780198781806.003.0019.

Piotrowicz, W.D.; Ryciuk, U.; Szymczak, M. Lean and Agile Metrics. Literature Review and Framework for Measuring Leagile Supply Chain. Int. J. Product. Perform. Manag. 2023, 72, 1560–1583, doi:10.1108/IJPPM-10-2020-0560.

Lu, W.; McFarlane, D.; Giannikas, V.; Zhang, Q. An Algorithm for Dynamic Order-Picking in Warehouse Operations. Eur. J. Oper. Res. 2016, 248, 107–122, doi:10.1016/j.ejor.2015.06.074.

Alshawabkeh, R.O.; Abu Rumman, A.R.; Al-Abbadi, L.H. The Nexus between Digital Collaboration, Analytics Capability and Supply Chain Resilience of the Food Processing Industry in Jordan. Cogent Bus. Manag. 2024, 11, doi:10.1080/23311975.2023.2296608.

Puspita, L.E.; Christiananta, B.; Ellitan, L. The Effect of Strategic Orientation, Supply Chain Capability, Innovation Capability on Competitive Advantage and Performance of Furniture Retails. Int. J. Sci. Technol. Res. 2020, 9, 4521–4529.