The Role of Advanced Technologies and Cost Strategies in Building Efficient, Sustainable Automotive Supply Chains

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Abstract

This paper aims to investigate the impact of Supply Chain Manager Capability, Advanced Manufacturing Technology, Sustainable Supply Chain Practices, and Cost Leadership Strategies on Sustainable Performance (SP) of a firm. Additionally, the study seeks to identify the mediating role of Leagile practices in achieving sustainability objectives, particularly in the automotive sector of Pakistan. This study employed a quantitative approach to collect data from executives, managers, and directors working in the automotive supply chain process. A sample size of 254 respondents was selected, and the data were analyzed through Partial Least Squares Structural Equation Modeling (PLS SEM). The results showed that AMT has a positive impact on sustainable performance. In comparison, Leagile strategy plays a mediating role in enhancing supply chain efficiency (SCE), which can lead to sustainable performance of the firm. Moreover, it also proves that SCE is an essential arbitrator, which highlights the need for operational efficiency in transforming strategic supply chain actions into results that are sustainable. Yet, the supply chain manager (SCM) had no direct impact on Leagile methods, and technical and systemic resources are more likely to be dominant here. The research has some practical implications for supply chain executives, especially in developing countries such as Pakistan, where resource limitations and regulatory compliance impose localized policies. Companies can become more adaptable, resilient, and competitive by leveraging advanced technologies, sustainability practices, and cost reductions within a well-defined supply chain infrastructure. In the future, the research provides a good ground to explore sustainable supply chain performance in other sectors

Keywords: *Advanced Manufacturing Technologies (AMT), Leagility (L), Sustainable Supply Chain Practices (SSCP), Cost Leadership Strategies (CLS), Supply Chain Manager (SCM)*

Introduction

Organizations today are facing a series of global challenges that have an immense impact on supply chain management. Market volatility is triggered by dynamic changes in the environment, shifting of consumer expectations, and how companies manage their supply chains. 'The effects of these unpredictable events are the disruption to supply chains in their structural weak points, often leading to inefficiencies and increases in cost (Donald et al., 2020). Also, growing demands for transparency and moral behavior demand that businesses consider sustainability as well as cost reduction in their supply chain activities (Reaidy et al., 2024). With supply chains becoming more and more complex and connected, there is an urgent need for companies to rethink how they can manage these multifaceted challenges.

The sustainability of the supply chain has become the foundation solution for the structural problem related to the supply chain process. Companies are now making green decisions and thinking about social impacts due to consumer demand for more sustainable production, as well as environmental standards. Implementing sustainable solutions increases the efficiency of operations, reduces risk, and creates resilience to disruption (Hazen et al., 2016). Lean, agile, and hybrid practices focus on supply chain efficiency and responsiveness as well as sustainability. The advancement of technology also opens new opportunities for businesses to streamline their supply chains to improve traceability and sustainability (Wang et al., 2022).

Leagility is also a hybrid approach, which is at once the lean approach and the agility paradigm. It ensures a fast change in designing supply chain processes that helps organizations to respond quickly to market shifts without waste (Khan, Zaman, Sheik, & Saeed, 2025). This methodology is especially relevant in the modern volatile business world where customer demand changes at high speeds and market dynamics are volatile, and it's important to balance the cost-effectiveness of operation with flexibility (Mason-Jones et al., 2000). Because today's companies are a bit faster-changing and unpredictable, strong agility in the supply chain process is critical for sustainability. Moreover, supply chain effectiveness is mainly based on the ability to manage processes and provide the products to satisfy customers. In short, higher effectiveness is a requirement for competitiveness and sustainability to deliver products on time and with high quality. In addition, the connection between supply chain efficiency and strategic initiatives like leagility points to a need for empirical analysis of how these constructs influence the overall business performance, especially in sustainability contexts.

Previous research considered lean and agile as different approaches to cost-efficiency and agility, and findings of these studies discuss their respective advantages and industry applications (Christopher & Towill, 2001; Naim & Gosling, 2011). In recent years, advanced manufacturing technologies (AMT) have been identified as promising for improving supply chain integration and performance, and competitive practices such as cost leadership have been identified as promising for supply chain performance (Soomro, Khan, & Shah, 2025). Hybrid models ("leagility": combination of lean and agile) have been theorized and confirmed empirically in relatively few studies, providing a basis to understand their place in current supply chains (Raut et al., 2021). But still, a lot of work is missing because almost all studies use lean or agile methods in isolation without looking at how they can work in conjunction with one another. Empirical work on leagility is still relatively few and conceptually heavily based, making it difficult to apply across sectors (Gupta et al., 2024). Second, we don't have any empirical data on the relationship between leagility and AMT and cost leadership strategies about supply chain performance and sustainability. It's also because there is no uniform model or consensus on the metrics for agility, which makes the assessment of supply chain results even more difficult (Zaman, Khan, Mubarik, Zaman, & Hanif, 2024). This study aims to overcome the gap by providing an integrated model to analyze the mediating role of leagile practices and supply chain efficiency on advanced manufacturing technology, SSCP, and cost leadership. The purpose is to determine how these factors can contribute to supply chain sustainable performance, with empirical results and practical lessons for multiple industries. The study is based on the following research questions

1. How does supply chain design help in the attainment of leagile practices?
2. How does the supply chain effectiveness contribute to SSCP in the context of leagile practices?
3. Does supply chain effectiveness play a mediating role in the development of the relationship between Leagile practices and Sustainable performance?
4. How do leagile practices and supply chain performance mediate the relationship between identified supply chain drivers and sustainable performance?

The current research contributes in many ways to supply chain management by filling critical gaps and addressing the research questions. First, it takes leagility as a mix model that includes both lean and agility, combining the advantages of both techniques. Thus, offers a new perspective on its use in a wide range of industries. Moreover, the study identifies and explores the supply chain design factors that drive leagility and provides practical tips for practitioners to make a good tradeoff between cost and responsiveness in the current dynamic environment. Secondly, it adds to the literature by empirically showing that supply chain effectiveness plays an important role in sustainable performance, providing a holistic view of how leagility, supply chain operations, and organizational outcomes relate. Third, a new model evaluates the mediatory impact of lean and supply chain performance that will help us arrive at integrated metrics and concrete, actionable approaches for sustainable performance improvement. This empirical strategy not only improves the theoretical definition of leagility but also provides the basis for a resilient supply chain that can adjust itself to changes in market conditions. And finally, the work also tries to prove the importance of emerging manufacturing technologies, cost leadership, and sustainable supply chain to solve the current problems of modern supply chain management in a real-world in impactful way.

Literature Review

Firm Sustainable Performance

Sustainable performance(SP) is defined as a system or business that can achieve and sustain high levels of performance for a long period of time without compromising the environment and social well-being (Henao et al., 2019). Academics hold that long-term performance does not just translate into monetary savings, but also generates value for the people, customers, suppliers, and society (De et al., 2020). These principles emphasize on sustainability that can leads organization to gain competitive position in a rapidly growing market.

Supply Chain Managers and Sustainable Performance

It is the responsibility of supply chain managers (SCM) to help organizations create long-term strategies to enhance the performance of the supply chain process. They have major roles in strategic planning, supplier management, logistics, stock management, and sustainability reporting. Proper coordination of supply chain activities with corporate strategy provides the best utilization of resources and cost-efficiency. Effective supplier management includes sourcing with trusted suppliers that are sustainable (Cormican & Cunningham, 2007).

Supply chain managers also adopt supply chain management software, IoT, and blockchain technologies to aid sustainability goals (Zhou et al., 2024). They also develop a sustainability culture through training and open reporting of results, which demonstrate the company's ownership in the long-term sustainability objectives (Tortorella et al., 2017).

H1: SCM has a significant impact on leagility

H1a: Leagility and Supply chain effectiveness mediate the relationship between the supply chain manager and sustainable performance.

AMT and Sustainable Performance

Advanced manufacturing technology (AMT) includes advanced systems and processes that provide improved operational effectiveness, accuracy, and sustainability (Stornelli et al., 2021). By optimizing the use of resources, reducing waste, and enabling supply chain transparency, these technologies make a difference for sustainable performance. Technologies like additive manufacturing (3D printing), advanced machining, and green industry can be used to make better use of materials while sustaining the environment (Azemi et al., 2019).

Moreover, IoT and blockchain allow for tracking everything live and ensure transparency and traceability in supply chains. Circular economy activities like remanufacturing and recycling reap the rewards of these improvements, extending the lifecycle of products and minimizing the carbon footprint, increasing automation, lowering emissions and pollutants, and increasing safety at work for employee well-being (Zhou et al., 2024). Globally, Germany's "Industry 4.0" has pushed the use of these technologies by promoting cyber-physical systems and smart manufacturing across its industry. These are to optimize energy use, reduce waste, and drive sustainability through digitalization (Schuh et al., 2020). Similarly, Toyota in Japan has implemented real-time automation and AI-driven systems to monitor waste streams and energy efficiency across its plants.

H2: AMT has a significant impact on Leagility.

H2a: Leagility and supply chain effectiveness mediate the relationship between advanced manufacturing technology and sustainable performance.

Sustainable Supply Chain Practices

Sustainable supply chain management is the integration of environmental, social, and economic dimensions throughout the life cycle of a product to provide value to the end customer. (Villena & Gioia, 2020). Source ethically and labor fairly from suppliers that meet socially responsible criteria. Green production means removing carbon footprints using green production processes, and circular economy means recycling, reuse, and remanufacturing (Kogg & Mont, 2012).

Having visibility into the origin of products, transparency, and traceability also adds accountability to the supply chain. Social and community-engagement activities are aimed at enhancing employee wellbeing and socially beneficial relations with the community. Furthermore, continuous KPI-driven improvements and sustainability solutions like IoT and manufacturing automation drive sustainable long-term environment and economic prosperity (Stornelli et al., 2021).

H3: SSCP has a significant impact on leagility.
H3a: Leagility and Supply chain effectiveness mediate the relationship between sustainable supply chain practices and sustainable performance.

Cost Leadership and Sustainable Performance

Cost leadership is the capability of an organization to produce and deliver the products at the lowest cost in the Industry without compromising the quality (Zaman, Khan, Mubarik, Zaman, & Hanif, 2024). Cost leadership across the supply chain focuses on cost visibility, process optimization, and strategic decisions for a stronger trading partner. Advanced supply chain costing systems enable companies to better determine and understand cost drivers so that operations can become more efficient, workflows become faster, and businesses are more competitive (Alyoubi & Yamin, 2021).

Moreover, the combination of cost leadership strategy with lean supply chain approach can even increase cost effectiveness by reducing waste, overproduction, and optimizing resources (Jones & Womack, 2016). This strategic integration not only results in cost reduction, but more collaboration and flexibility in supply chain networks making them more adaptable to market dynamics. Moreover, combining cost leadership and leagile practices also helps in driving long-term performance through cost effectiveness with agility and responsiveness.

H4: Cost leadership strategy has a significant impact on Leagility.
H4a: Leagility and Supply chain effectiveness mediate the relationship between cost leadership strategy and sustainable performance.

Leagility and Sustainable Performance

Leagile supply chain is the blend of lean and agile to meet the dual imperative of cost efficiency and agility. Lean is about reducing waste and using more resources, and agile makes supply chains capable of reacting quickly to changing demand and short product lifecycles (Naylor et al., 1999; Christopher & Towill, 2001). Leagility combines these paradigms to build mixed-type systems that can provide value with and without mobility. This is especially efficient in changing markets, where more classical approaches cannot keep up with volatility and complexity (Raut et al., 2021).

Moreover, some researches also proves that leagile systems enable supply chain performance by combining leading technologies, enabling collaboration and providing receptivity to market shifts (Nair & John, 2024). By optimizing the use of resources and remaining flexible, leagile supply chains are competitive in an environment that is ambiguous and multidimensional. Therefore, we hypothesized that

H5: Leagility has a significant impact on Supply chain efficiency.
H5a: Supply chain effectiveness mediates the relationship between Leagility and sustainable performance.

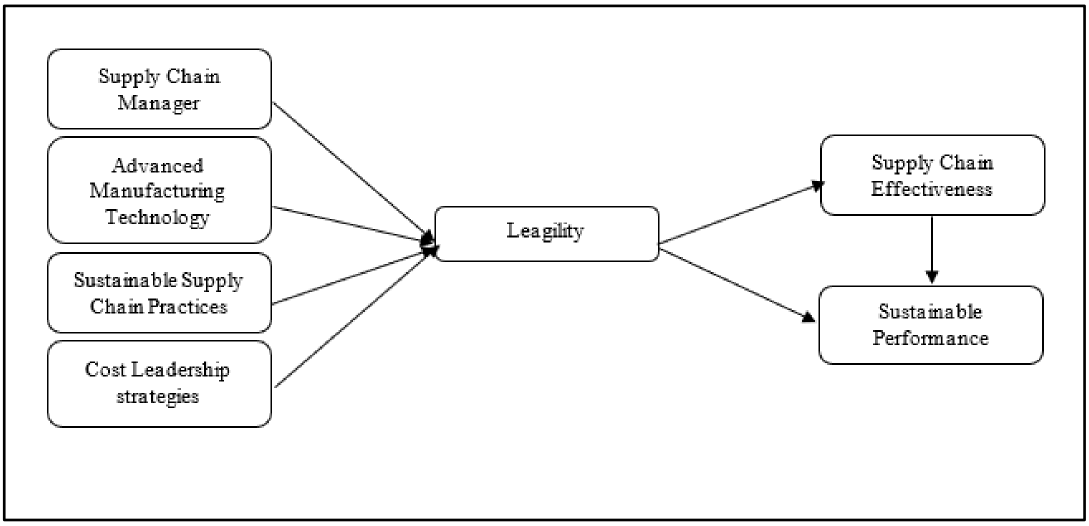
Supply Chain Effectiveness and Sustainable Performance

Supply chain effectiveness (SCE) is the ability of an organization to prepare itself towards innovation, rather than just satisfying a customer, and achieving business goals based on effective and adaptive operations. Supply chain interdependencies and collaborative technological process optimization for performance and sustainability are referred to by it (Ivanov, 2022; Wang et al., 2022). Organizations can create networks of supply chains that would deliver zero-interference with the environment and high value creation by innovation, eco-design, and alignment with stakeholders. Furthermore, advanced analytics and real-time decision support functionality lead to improved business productivity by making it possible to proactively manage uncertainties and disruptions from the point of the chain (Singh, 2023; Reaidy et al., 2024). This requires adaptive approaches with continuous learning and collaboration to make operational, strategic performance top-notch for sustainable performance (SP).

H6: Supply chain effectiveness has a significant impact on sustainable performance.

Figure 1

Conceptual Framework



Research Methodology

It discusses how the conceptual model was tested, which includes information about the research method, sample size, data collection instrument, test of reliability, and statistical methods to test the hypotheses. Primarily, this research aims to identify the impact of variables Supply Chain Manager (SCM), Advanced Manufacturing Technology (AMT), Cost

Leadership Strategy (CLS), and Sustainable Supply Chain Practices (SSCP) on Sustainable Performance (SP). Moreover, Leagility and Supply Chain Effectiveness (SCE) serve as the mediators. In this study, the proposed conceptual framework and hypotheses were tested using PLS-SEM. This software can also be used for exploratory studies (such as studies on complex relations among different constructs) and with small samples and non-normal data.

Research Design

In this research, the relationships between the variables were investigated using a quantitative research design. Primary data was collected through the distribution of survey questionnaires in the form of a Google form adapted from previous research. This deductive approach enables to performance of hypothesis testing and model validation.

Sampling Size

The data was collected from the employees working in the automotive sector of Pakistan, because their perspective is extremely important for organizational performance dynamics. A total of 254 respondents were selected for the sample that spanned across all levels of job functions, including trainees, officers, managers, and directors. This sample size is appropriate considering Hair et al. (2012), who stated that for models with more than six indicators, sample sizes exceeding 200 provide more robust results.

Sampling Technique

This study used non-random sampling, specifically convenience sampling, which is a type of purposive non-probability sampling. This non-probability sampling technique allows access to subjects without compromising the sample size of the population at large (Bougie & Sekaran, 2019). While limited, this strategy served well to include a wide spectrum of opinions within the study's confines. The reason for focusing on the automotive sector in Pakistan is that employees of this sector are key to understanding organizational performance dynamics, especially regarding supply chain and sustainability.

Scale and Measurement

A survey questionnaire was constructed based on previously discovered constructs. While variables were ranked according to a point Likert scale, "Strongly Disagree" to "Strongly Agree" on the respondents' scale. This method ensures better reliability and validity using validated measurement scales.

Statistical Tools and Techniques

Data analysis was conducted using the Statistical software SPSS (version 21) and Smart PLS. Reliability, exploratory factor analysis, correlation, and multiple linear regression were performed to find the mediating effect of Leagile and SCE on the sustainable performance of the firm. Additionally, data quality was assessed by normality, reliability, and validity tests.

Results and Analysis

4.1 Demographic Analysis

Demographic profile of respondents shows that (63%) of participants were males, while the rest of them were females. A large proportion of respondents approximately 86%) lie within the age bracket of 16-35 years, while the rest were older. Concerning designation (61%), participants worked as executive officers, while the rest of them fell under the position of assistant manager, manager, or director.

Descriptive Statistics

The data were tested for univariate normality through descriptive analysis. The normal acceptable range for skewness and kurtosis is ±2 (George & Mallery, 2019). The results discussed in Table 1 show that all constructs satisfied the condition for normality.

Table 1

Descriptive and Reliability Analysis

Constructs	Median	Skewness	Kurtosis	Cronbach's Alpha
SSCP	0.085	-0.637	-0.020	0.805
SP	-0.070	-0.283	-0.414	0.872
SCM	0.019	-0.599	-0.179	0.779
SCE	0.144	-0.446	-0.348	0.770
Leagility	0.025	-0.415	-0.102	0.730
CLS	-0.041	-0.194	-0.765	0.860
AMT	0.111	-0.242	-0.608	0.765

Reliability Analysis

To evaluate the internal consistency of the measurement scales, this study utilized Cronbach's Alpha as a statistical tool. A threshold value of 0.60 was adopted, indicating that constructs exceeding this benchmark are considered to possess acceptable reliability (Bougie & Sekaran, 2019). Reliability testing also plays a critical role in minimizing measurement errors and mitigating potential biases introduced by the researcher (Magno et al., 2024). Although the instruments applied in this study were derived from previously validated sources, it was deemed necessary to reassess their reliability due to contextual variations in cultural and demographic settings.

As indicated in Table 1, the construct Sustainable performance (SP*)* has the highest reliability value, which is 0.872, while Leagility shows the lowest Cronbach value among all constructs (0.730). Since all constructs yielded Cronbach alpha values well above the 0.60 benchmark, the data demonstrate that the internal consistency of all variables is reliable.

Bivariate Correlation

The strength of the relationship between variables has been assessed through the Pearson correlation coefficient. This technique is widely recognized for assessing linear relationships between continuous variables (Hair et al., 2012). Prior to conducting regression analysis, it is essential to verify the presence of multicollinearity among predictors, as high intercorrelations can distort regression estimates.

The correlation coefficient values between -1 to +1 show a strong linear relationship between indicators, and values approaching 0 suggest negligible associations. These coefficients help in identifying both the direction (positive/negative) and intensity (weak/moderate/strong) of the relationships (Magno et al., 2024). The results of the bivariate correlation are discussed in Table 2.

Table 2
Bivariate Correlation Results

Constructs	AMT	CLS	L	SCE	SCM	SP	SSCP
AMT	1.000						
CLS	0.591	1.000					
Leagility(L)	0.660	0.728	1.000				
SCE	0.724	0.546	0.614	1.000			
SCM	0.775	0.649	0.672	0.745	1.000		
SP	0.696	0.759	0.712	0.806	0.720	1.000	
SSCP	0.612	0.749	0.751	0.625	0.706	0.747	1.000

Table 2 shows that the strongest positive correlation was found between *Sustainable Performance* and *Supply Chain Effectiveness* (r = 0.806), suggesting a strong association. On the other hand, the weakest but still meaningful relationship existed between *Cost Leadership Strategy* and *Supply Chain Effectiveness* (r = 0.546). These findings provide valuable insights into the nature of the constructs and provide a foundation for subsequent regression analysis.

Convergent Validity

The term 'convergent validity' is used to measure whether each of the items purporting to measure the same construct is highly correlated. The study established convergent validity using AVE from the constructs. In this regard, constructs having AVE greater than 0.50 were classified to hold suitable convergent validity (Fornell & Larcker, 1981). Likewise, all the constructs also have variance explained exceeding 0.40 in EFA; all thus ensured convergent validity. The results of convergent validity are discussed in Table 3

Table 3
Assessment of Convergent Validity

Constructs	Cronbach's Alpha	Variance Explained
AMT	0.765	0.680
CLS	0.860	0.781
Leagility (L)	0.730	0.652
SCE	0.770	0.685
SCM	0.779	0.695
SP	0.872	0.565
SSCP	0.805	0.718

Discriminant Validity

Discriminant validity ensures that constructs measuring different concepts are distinct and separate from one another. Discriminant validity was analyzed using Fornell–Larcker criteria, which is based on the notion that the square root of Average Variance Extracted (AVE) for each variable should be greater than its correlation value with other variables (Fornell & Larcker, 1981). The results of discriminant validity are depicted in Table 4

Table 4
Discriminant Validity Testing

Constructs	AMT	CLS	L	SCE	SCM	SP	SCP
AMT	0.825						
CLS	0.591	0.884					
Leagility (L)	0.660	0.728	0.808				
SCE	0.724	0.546	0.614	0.828			
SCM	0.775	0.649	0.672	0.745	0.833		
SP	0.696	0.752	0.712	0.606	0.720	0.759	
SSCP	0.612	0.749	0.751	0.625	0.706	0.747	0.848

Hypothesis Testing

The entire model is evaluated using regression analysis. A p-value less than 0.05 is considered significant(Sarstedt et al.,2014). The results of the hypothesis testing are presented in Table 5

Table 5

Hypothesis Results

Hypotheses	B	T	Sig. Val.	Results
SCM -> Leagility (H1)	0.056	0.953	0.341	Not Supported
SCM -> Leagility -> SCE -> SP (H1a)	0.029	0.917	0.359	Not Supported
AMT -> Leagility (H2)	0.228	4.870	0.000	Supported
AMT -> Leagility -> SCE -> SP (H2a)	0.113	4.609	0.000	Supported
SSCP -> Leagility (H3)	0.355	7.778	0.000	Supported
SSCP -> Leagility -> SCE -> SP (H3a)	0.176	6.637	0.000	Supported
CLS -> Leagility (H4)	0.292	8.179	0.000	Supported
CLS -> Leagility -> SCE -> SP (H4a)	0.145	7.007	0.000	Supported
Leagility-> SCE (H5)	0.615	14.250	0.000	Supported
Leagility -> SCE -> SP (H5a)	0.497	11.780	0.000	Supported
SCE -> SP (H6)	0.807	40.351	0.000	Supported

Results and Discussion

The results revealed that SCM did not affect Leagile approaches as well, which led to the rejection of Hypothesis 1. These findings are significantly different from previous studies that highlighted how supply chain managers can foster operational flexibility and effectiveness (Jia et al., 2019).

On the other hand, Hypothesis 2, which predicted that AMT positively impacts Leagile strategies, was strongly supported. Advanced manufacturing technologies like IoT, AI, and 3D printing enable supply chains to balance agility and efficiency, two pillars of Leagile management. This finding matches (Zhou et al., 2024), who stressed the contribution of AMT in promoting a resilient supply chain process. AMT enables operational flexibility and optimization of resources that can be pivoted to changing supply chain environments. Furthermore, Hypothesis 3 of the SSCP-effect on the Leagile strategy was confirmed as well. Green strategies like ethical sourcing, green production, and waste minimization boosted Leagile's performance. These outcomes are consistent with previous studies, which have shown that sustainability in supply chain management helps in improving efficiency and creating environmental and social resilience (Sharma et al., 2024). Keeping things sustainable equips organizations with regulatory and social requirements, as well as building dynamic systems responsive to market pressures. It also confirmed Hypothesis 4 that CLS played a part in the Leagile approach, which is cost-based, enables resource management and performance, so Leagile systems have to expend their resources. This is in agreement with Raut et al. (2021), who also asserted that cost leadership allows companies to be more flexible and easier to stay competitive even at lower operating costs. It also revealed that Leagile practices radically increase SCE, which confirms Hypothesis 5. Leagile approaches that include both lean and agile practices are helpful to enhance a firm's responsiveness to manage market volatility. These findings align with Mohaghegh and Größler (2024), who describe Leagility as a parameter for firm supply chain effectiveness. Hypothesis 6 regarding SP's effect on SCE was also accepted. These findings showed just how crucial supply chain management is for sustainability goals. Sustainable supply chains prevent waste, control the environment, and ensure sustainable operations. The above observation is aligned with Ivanov (2022), according to which sustainability is highly dependent on supply chain efficiency

The study looked at the indirect influence of 5 constructs (SCM, AMT, SSCP, CLS, and Leagility) on sustainable performance (SP) through Leagile strategy and SCE. Hypothesis 1a, about the indirect impact of SCM, was discarded, which points to a declining managerial involvement in high-tech supply chains. However, hypotheses 2a and 3a were supported, demonstrating the indirect effects of AMT and SSCP in SP through Leagile and SCE. Modern technology, like IoT and AI, increases the flexibility and efficiency of resources, while green technologies like ethical sourcing and green production increase efficiency and flexibility, which creates sustainability. These findings are consistent with Reaidy et al. (2024), who discuss the positive effect of advanced technology on supply chain performance. Hypothesis 4a, about CLS's indirect impact, was also confirmed. Cost-cutting strategies optimize resources and workflows, thereby promoting Leagile and helping organizations to cut waste without compromising performance (Raut et al., 2021). Finally, Hypothesis 5a validated Leagility as impacting SP indirectly with SCE and highlights the value of hybrid strategies towards sustainability using lean/agile methods for waste minimization and sensitivity.

Practical and Managerial Implications

The research has some practical and managerial lessons for companies to focus on the adaptation of modern technologies to enhance the sustainability of the firm. The analysis of data shows how critical it is to incorporate the right kind of technology, sustainability, and value-added strategies, such as cost leadership, into the supply chain models. High-tech manufacturing processes, including IoT, blockchain, AI, and 3D printing, increase flexibility, visibility, and efficiency of operations and enable organizations to adjust in response to changing market dynamics (Zhou et al., 2024). Managers must be the ones to make sure they use these technologies as much as possible to create stable and reliable supply chains (Jalees, Khan, Zaman, & Miao, 2024). Ethical sourcing, green production, waste minimization, and others are all integral aspects of sustainable supply chains to satisfy environmental and social demand and ensure improved operational efficiencies. Taking these practices up to speed with circular economy models and training stakeholders can empower sustainability efforts (Ullah et al., 2024). Cost leadership solutions support all this by cutting operational costs while staying agile. Organizations can make the tradeoff between cost and responsiveness with lean manufacturing, energy efficiency, and waste reduction in order to remain competitive (Garcia-Buendia et al., 2024).

Leagility is the best way to balance costs and flexibility. Supply chain managers need to find ways to streamline the process while staying ahead of market demands. Supply chain performance is the essential connection that makes these strategies become sustainable. Delivery reliability, process efficiency, and resource optimization can lead to sustainable performance and reduce risks of environmental and social disruption (Dubey et al., 2021). Results indicate that supply chain managers have no direct influence on Leagile practices. However, their contribution to strategic decisions and innovation still counts. Managers need to invest in training and cross-functional teams to implement cutting-edge technologies and sustainability. Analytics-enabled decision support is also able to drive Leagile and supply chain efficiency through process optimization and forecasting of the market (Mohaghegh & Größler, 2024). The tailoring of plans for regional market conditions, such as Pakistan, is very much needed. Managers need to solve regional problems like limited resources and regulatory compliance, and capitalize on regional strengths like cost benefits. With a focus on cutting-edge technologies, sustainability, and cost reduction in unified supply chain infrastructures, companies can stay sustainable and competitive in competitive markets.

Conclusion and Recommendations

This paper aimed to assess how Advanced Manufacturing Technologies (AMT), Sustainable Supply Chain Practices (SSCP), Cost Leadership Strategies (CLS), and Supply Chain Managerial positions (SCM) affect Leagile strategies, Supply Chain Effectiveness (SCE), and Sustainable Performance (SP). The results indicate that AMT, SSCP, and CLS have positive and profound effects on Leagile strategies, leading to improved SCE and SP. But SCM had no direct impact on Leagile approaches, which implies that the modern supply chain increasingly relies not on managerial decisions but technology-driven systems. It also verified the mediators of Leagile strategies and SCE, proving that AMT and SSCP directly drive SP through their mediators. CLS also had a high indirect influence on SP, and therefore, it’s critical to get the costs right and save on resources.

These findings demonstrate the importance of Leagility for cost-effectiveness and agility, allowing supply chains to be agile in changing markets and sustainable at the same time. Practical implications would be achieved by the adaptation of emerging technologies such as blockchain, AI, and IoT devices that help in the optimal utilization of resources and enhance traceability. Moreover, cost leadership practices also promote resilience by lowering operating costs while maintaining flexibility. Such lessons are useful for small markets such as Pakistan, where local solutions and regional strengths matter. This paper supports the increasingly popular conversation about sustainable supply chain management by providing an integrated model that connects various routine operations with sustainability targets over time.

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