Enhancing Supply Chain Efficiency in the Pakistan Automotive Sector: A Comparative Study of traditional and Electric Vehicle manufacturers

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APPROVAL FORM

DECLERATION

I, Shaheer Ahmad (Registration No. 01-322241-021 / MBA Weekends), hereby declare that this thesis entitled “Enhancing Supply Chain Efficiency in Pakistan’s Automotive Sector: A Comparative Study of Traditional and Electric Vehicle Manufacturers” is the outcome of my independent effort carried out under the supervision of my respected supervisor. This thesis has not been submitted, in whole or in part, for any other degree at this or any other institution. All sources of information and references used in this study have been properly acknowledged.

I take full responsibility for any errors or shortcomings that may remain in this work.

Shaheer Ahmad

MBA Weekends

DEDICATION

This thesis is dedicated to my beloved parents, who have always supported me with their prayers, love, and encouragement.

I also dedicate this work to my respected teachers and mentors, whose guidance has been a source of inspiration throughout my academic journey.

Finally, I dedicate this thesis to my friends and family members, especially those who stood by me during the most challenging times of this research.

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ABSTRACT

This research investigates the efficiency of supply chains within the automotive sector of Pakistan by comparing manufacturers of traditional vehicles with those of electric vehicles. With consumer perception taken into account as a mediating factor, the primary goal is to evaluate how supply chain practices and technology adoption affect production, availability, cost stability, and overall supply chain performance. Professionals at automotive-related organizations were given a structured questionnaire, and their answers were scored on a five-point Likert scale. Using SPSS, reliability tests, descriptive statistics, correlation, multiple regression, and mediation analysis were used to examine data from about 156 respondents. The results show that while electric vehicle supply chains encounter difficulties, including inadequate infrastructure and reliance on imported parts, traditional vehicle supply chains in Pakistan offer consistent car and parts availability. However, the use of technology in supply chains for electric vehicles improves forecasting, monitoring, and decision-making, which improves performance results. The study emphasizes how the relationship between supply chain practices and performance is strongly mediated by consumer perception. This study provides useful information for automotive managers and policymakers, indicating that supply chain resilience may be strengthened and the expansion of electric vehicles in Pakistan may be supported by combining effective traditional supply chain practices with technology-driven tactics.

Keywords: Supply Chain, Traditional Vehicles, Electric Vehicles, Technology Adoption, Consumer Perception, Supply Chain Performance

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Pakistan's automobile industry plays a critical role in industrial development, employment generation, and overall economic growth(Mubeen, 2023). It has historically been dominated by internal combustion engine (ICE) vehicle manufacturers, such as Toyota, operating through well-established and largely conventional supply chain networks. As a result, supply chain efficiency has emerged as a critical factor influencing firm performance and competitiveness within the automotive sector (None & None, 2025).

These technologies enhance supply chain visibility, coordination, and real-time decision-making, which can significantly improve operational efficiency and overall firm performance (Mubeen, 2023).The automotive industry has entered a new phase with the emergence of EVs. Internationally, companies such as BYD in China have developed advanced EV supply chain models built on battery innovation, vertical integration, technology-intensive production, and rapid production cycles(Khan & Qianli, 2017). This global transition has also begun to influence Pakistan, where the government introduced the Electric Vehicle Policy (2020–2025) to promote clean energy, reduce emissions, and support EV adoption. Under this policy, firms are encouraged to develop new supply chain strategies that are more flexible, technology-driven, and capable of managing battery sourcing, renewable energy requirements, and specialized logistics and service systems.

Green supply chain management practices have been shown to positively influence organizational performance by reducing waste, improving resource utilization, and enhancing environmental compliance (Khan & Qianli, 2017). As both traditional and EV supply chain models start to shape the Pakistani market, it becomes essential to understand how these models differ and how they affect supply chain efficiency. In this study, Toyota represents the long-established, stable, and conventional supply chain model, while BYD reflects a modern, integrated, and sustainability-oriented EV supply chain. By comparing

these two representative models, the research aims to highlight strengths, weaknesses, and future opportunities for Pakistan's automotive and EV sectors.

1.2 Research Gap

Pakistan's automotive sector is currently undergoing a structural transition. Traditional supply chain systems, such as those associated with Toyota, tend to be stable and process-oriented but relatively slow to adapt to emerging digital technologies and EV requirements. In addition, limited research incorporates consumer perception as a mediating factor linking supply chain practices and performance in the automotive sector (None & None, 2025). Existing studies primarily address green supply chain practices or general technological integration without offering a comparative analysis between traditional and electric vehicle supply chain practices within the same national context (Khan & Qianli, 2017; Mubeen, 2023). In contrast, EV-based companies like BYD rely on supply chains that demand high levels of digital integration, battery-specific processes, and new types of vendor and logistics networks tailored to EV components and charging infrastructure.

Despite the importance of these developments, there is a lack of detailed empirical research in Pakistan that directly compares traditional and EV supply chain models in terms of efficiency, adaptability, and readiness for future market demands(None & None, 2025). Existing studies tend to examine either general supply chain challenges or EV adoption at a broad level, without providing a comparative analysis of how different supply chain designs influence performance in the same national context(None & None, 2025). This study addresses this gap by examining how traditional and EV supply chain models differ and which model offers better efficiency and strategic fit for the future of Pakistan's automotive sector.

1.3 Problem Statement

The automotive industry in Pakistan faces persistent difficulties in achieving optimal supply chain performance, particularly as traditional and electric vehicle manufacturers operate under different operational, technological, and infrastructural conditions.

Traditional supply chains are often constrained by import dependence, limited localization, and relatively low digitalization, while EV-oriented supply chains must address new challenges related to battery logistics, charging infrastructure, and technology-intensive operations (None & None, 2025).

This research seeks to explore the supply chain strategies of traditional vehicle manufacturers and to evaluate the supply chain practices of electric vehicle manufacturers in order to identify factors that influence efficiency (Mubeen, 2023).. It also examines the effects of technology adoption on supply chain performance and considers the mediating role of consumer perception in shaping performance outcomes (Mubeen, 2023). By comparing the supply chain efficiency of traditional and electric vehicle manufacturers, the study aims to offer practical insights for improving operational effectiveness and supporting the advancement of electric mobility in Pakistan.

1.4 Research Questions

- How do traditional vehicle supply chain practices affect supply chain performance?
- How do electric vehicle supply chain practices influence supply chain performance?
- What role does technology adoption play in enhancing supply chain efficiency and performance?
- How does consumer perception mediate the relationship between supply chain practices and supply chain performance?

1.5 Research Objectives

- In line with the research questions, the study pursues the following objectives:
- To examine traditional vehicle supply chain practices in Pakistan.
- To analyze electric vehicle supply chain practices in Pakistan.
- To evaluate the impact of technology adoption on supply chain performance.

- To assess the mediating role of consumer perception between supply chain practices and supply chain performance.
- To compare supply chain performance between traditional and electric vehicle manufacturers in Pakistan.

1.6 Research Significance

This study has both academic and practical significance. It contributes to the growing body of supply chain management literature by offering a comparative perspective on traditional and electric vehicle supply chain models within a developing economy context. While global research discusses supply chain efficiency, disruption management, and sustainability transitions, relatively few studies examine how these issues unfold within Pakistan's specific economic and infrastructural environment.

By comparing Toyota's conventional supply chain with BYD's EV-oriented supply chain, the research helps scholars understand how technology adoption, localization, and infrastructure constraints shape supply chain performance in Pakistan. For practitioners and policymakers, the findings highlight which supply chain configurations appear more feasible, resilient, and adaptable in the local context, thereby supporting better strategic and policy decisions for the automotive and EV sectors.

1.6.1 Theoretical Significance

Theoretically, the study strengthens the understanding of supply chain models by linking classical supply chain concepts with modern EV-based frameworks. It illustrates how principles such as lean production, just-in-time (JIT), and green supply chain management operate differently across traditional ICE and EV supply chains. The analysis shows how digitalization, battery logistics, vertical integration, and localization strategies reshape supply chain structures and performance outcomes.

By integrating insights from comparative traditional and EV supply chains, the study contributes to literature on sustainable and technologically advanced supply chains, particularly in emerging markets. It supports and extends existing theories by

demonstrating how context-specific factors, such as infrastructure limitations, policy incentives, and technology readiness, modify the effectiveness of established supply chain models.

1.6.2 Practical Significance

Practically, the study offers valuable guidance for firms seeking to modernize their supply chain operations in Pakistan's evolving automotive market. By comparing the traditional supply chain model of Toyota with the EV supply chain structure of BYD, the research identifies real-world gaps and opportunities that directly affect operational efficiency, cost control, and responsiveness.

The findings provide manufacturers with clear directions for redesigning procurement, production planning, logistics, and inventory systems to reduce delays and inefficiencies. For firms in both traditional and EV segments, the study underscores the importance of adopting technology-driven solutions such as digital tracking, battery management systems, and automated supply processes. It also informs local suppliers about the quality, coordination, and technological requirements associated with EV-based systems so they can better align with manufacturers' expectations.

In addition, the study offers insights for policymakers tasked with developing EV-friendly regulations, enhancing charging infrastructure, and supporting localization of key components. By clarifying which supply chain model appears more viable for long-term economic growth and sustainability, the research can help government institutions and regulators design more effective policies. Overall, the practical significance of the study lies in its potential to guide manufacturers, suppliers, and policymakers toward more efficient, resilient, and sustainable automotive supply chains in Pakistan.

1.7 Scope of Study

The scope of this study is confined to examining and comparing the supply chain practices of traditional automotive companies and electric vehicle manufacturers within Pakistan. The research focuses specifically on two representative firms: Toyota, symbolizing the

traditional ICE supply chain, and BYD, representing the contemporary EV supply chain. Using these firms as benchmarks, the study explores differences in sourcing strategies, production processes, logistics systems, technological integration, and sustainability-related practices.

The analysis is limited to supply chain stages that have a direct influence on operational efficiency, including procurement, manufacturing, inventory management, transportation, and distribution. While marketing, customer service, and dealership operations may indirectly influence supply chain decisions, they are not the central focus of this research.

Geographically, the study concentrates on Pakistan's automotive environment, taking into account local regulatory policies, infrastructure constraints, import dependencies, and industrial capacity. The research adopts a quantitative approach, using survey-based data on perceptions of supply chain practices, technology adoption, consumer perception, and supply chain performance. It does not involve direct primary data collection from Toyota or BYD at the firm-level, due to restrictions on internal operational data. Instead, it relies on survey responses from individuals with exposure to the sector, supported by secondary sources such as government reports, industry analyses, and published research to contextualize the comparison. Overall, the scope is designed to provide a focused and practically relevant understanding of how Pakistan can transition from traditional supply chain systems toward more advanced, EV-oriented models while considering its specific economic and institutional constraints.

1.8 Organization of Thesis

This thesis is organized into five chapters, each addressing a specific set of objectives and collectively providing a coherent investigation of supply chain efficiency in Pakistan's automotive sector.

Chapter 1 – Introduction: Presents the background of the study, research gap, problem statement, research questions, objectives, significance, scope, and overall structure of the

thesis. It establishes the rationale for comparing traditional and EV supply chain models in Pakistan.

Chapter 2 – Literature Review: Reviews existing literature on supply chain practices, EV supply chains, technology adoption, consumer perception, and supply chain performance. It develops the theoretical foundations, synthesizes prior studies, and presents the conceptual framework and hypotheses for the study.

Chapter 3 – Research Methodology: Describes the research design, philosophical stance, population and sampling, data collection procedures, measurement scales, and data analysis techniques. It explains the quantitative approach, including reliability analysis, descriptive statistics, correlation, multiple regression, and mediation analysis using SPSS.

Chapter 4 – Data Analysis and Findings: Reports the empirical results, including reliability statistics, descriptive analysis, correlation matrix, regression results, and mediation analysis. It presents and interprets the effects of TVSCP, EVSCP, and TA on SCP, with CP as a mediating variable, and states the status of each hypothesis.

Chapter 5 – Conclusion and Recommendations: Summarizes the key findings, discusses practical and theoretical implications, outlines research limitations, and offers recommendations for practitioners and policymakers, as well as suggestions for future research on supply chain efficiency in Pakistan's automotive sector.

1.9 Chapter Summary

This chapter introduced the study on enhancing supply chain efficiency in Pakistan's automotive sector by comparing traditional vehicle and electric vehicle manufacturers. It outlined the background and context of the automotive and EV transition, identified the research gap, and presented the problem statement, research questions, and objectives. The significance, scope, and organization of the thesis were also discussed, highlighting the focus on TVSCP, EVSCP, Technology Adoption, and Consumer Perception as key

variables influencing Supply Chain Performance. These foundations guide the subsequent chapters, beginning with a detailed review of relevant literature in Chapter 2.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction to Literature

A literature review provides the theoretical and conceptual base for empirical research by synthesizing prior studies, clarifying key constructs, and identifying unresolved issues that justify the current investigation (Saunders, Lewis, & Thornhill, 2019; Creswell, 2020). It helps trace how knowledge in a particular field has evolved, what methodological traditions have emerged, and where important gaps remain for further exploration (Bryman, 2021). For the present study, the literature review is used to align the research model, variables, and hypotheses with established supply chain and technology adoption scholarship, while highlighting the specific context of Pakistan's automotive sector.

In supply chain management (SCM), a structured literature review is essential because supply chains operate in an environment shaped by globalization, rapid technological change, environmental pressures, and recurring disruptions such as pandemics and geopolitical shocks (Ivanov, 2021; Christopher, 2020). Recent empirical work documents how structured supply chain practices and technology adoption contribute to resilience and transparency in automotive and industrial supply chains, especially when firms face frequent demand and supply disturbances (Warburton, 2024; Khan & Dong, 2017). In Pakistan, policy-oriented reports and industry analyses further highlight the need to strengthen supply chain capabilities and local value addition, particularly for the emerging electric vehicle (EV) sector (Pakistan Business Council, 2024; PPSE, 2024; Sustainable Development Policy Institute, 2024).

Strategic supply chain models such as Lean, Agile, and hybrid Lean–Agile (Leagile) remain central in the literature. Lean supply chains emphasize waste reduction, cost

efficiency, and process standardization, whereas Agile supply chains focus on responsiveness and flexibility in volatile markets (Mason-Jones & Towill, 2021; Womack & Jones, 2003). Hybrid Leagile designs integrate lean principles upstream and agile principles downstream to balance efficiency and responsiveness across the chain (Christopher & Towill, 2001). Empirical research in manufacturing and automotive sectors shows that such models, when aligned with market requirements and supported by appropriate technologies, improve delivery reliability, cost performance, and competitiveness (Chopra & Meindl, 2022; Dubey et al., 2019). Similar findings arise from green supply chain management (GSCM), where structured environmental practices and collaboration with stakeholders significantly enhance firm and supply chain performance (Khan & Dong, 2017; Hilal, 2022).

The rapid diffusion of EVs has drawn attention to supply chain restructuring, battery logistics, sustainability, and digital integration. EV supply chains differ from traditional internal combustion engine (ICE) supply chains because they rely heavily on lithium-ion batteries, rare earth materials, power electronics, and software-driven manufacturing systems (Mangla et al., 2022; Liu, 2020). Recent work on EV ecosystems in Pakistan and comparable markets emphasizes battery supply chains, charging infrastructure, local component manufacturing, and policy alignment as critical success factors (Pakistan Business Council, 2024; PPSE, 2024; Sustainable Development Policy Institute, 2024). These developments place EV supply chains at the intersection of GSCM and advanced technology adoption, where environmental performance and technological capabilities jointly influence competitiveness (Srivastava, 2007; Zhu, Sarkis, & Lai, 2018; Khan & Dong, 2017).

Technology adoption has become a central driver of supply chain performance. Digital tools such as enterprise resource planning (ERP), big data analytics, blockchain, and the Internet of Things (IoT) improve visibility, coordination, and decision-making across multi-tier supply networks (Ivanov, Dolgui, & Sokolov, 2020; Queiroz et al., 2021). Recent empirical studies report that IoT-enabled and digitally transformed supply chains exhibit higher responsiveness, reliability, and cost effectiveness, which in turn lead to better firm and supply chain performance outcomes (Mubeen, 2023; Kamble, Gunasekaran, &

Gawankar, 2020). Automotive sector analyses similarly note that advanced digital tools strengthen resilience and transparency in vehicle supply chains and help firms react more quickly to disruptions (Warburton, 2024; None & None, 2025). These findings underpin the treatment of technology adoption as a key independent variable in this study.

Despite a growing global literature on automotive and EV supply chains, empirical work in Pakistan remains limited. Policy reports and academic studies highlight persistent challenges such as import dependence, exchange-rate volatility, infrastructure gaps, and regulatory uncertainty (Pakistan Business Council, 2024; Ahmed & Raza, 2020; Khan, Malik, & Hussain, 2021). At the same time, consumer-side research on EVs in Pakistan and similar markets shows that perceptions of charging infrastructure, range, price, and service support strongly influence adoption intentions (Shakeel, Rehman, & Khan, 2022; Siddiqui, 2023). However, there is limited quantitative work that integrates these supply-side and demand-side factors into a single model comparing traditional ICE manufacturers such as Toyota with EV-focused firms such as BYD. This gap motivates the current study's focus on supply chain practices, technology adoption, consumer perception, and supply chain performance within Pakistan's automotive sector.

The literature also emphasizes the importance of theoretical grounding. The Resource-Based View (RBV) argues that distinctive supply chain and technological capabilities can generate sustainable competitive advantage when they are valuable, rare, inimitable, and non-substitutable (Barney, 1991). Transaction Cost Economics (TCE) focuses on governance mechanisms and coordination structures that reduce uncertainty and opportunism in buyer–supplier relationships (Williamson, 1985). Technology adoption frameworks, including unified theories of technology acceptance, help explain how organizations adopt and integrate tools such as IoT and ERP in supply chains and how these technologies affect performance (Venkatesh, Thong, & Xu, 2012; Mubeen, 2023). Applying these perspectives to Pakistan is important, given local constraints related to

infrastructure, supplier capabilities, and policy stability (Ahmed & Raza, 2020; Khan et al., 2021).

Methodologically, SCM and GSCM research frequently employ quantitative survey designs with regression analysis and structural equation modeling (SEM) to examine relationships between supply chain practices, technology adoption, and performance outcomes (Saunders et al., 2019; Hair, Hult, Ringle, & Sarstedt, 2022). In Pakistan and other emerging economies, empirical studies operationalize supply chain practices and technology adoption using multi-item Likert scales and relate them to organizational and supply chain performance (Khan & Dong, 2017; Mubeen, 2023; None & None, 2025). Core variables such as responsiveness, flexibility, cost efficiency, technology adoption, infrastructure readiness, and customer satisfaction appear repeatedly, providing a robust basis for the constructs used in the present research.

The literature further distinguishes between global and local supply chain conditions. While leading automotive manufacturers increasingly integrate automation, advanced analytics, and sustainability across their supply chains, Pakistan's automotive sector continues to confront structural challenges, including import delays, limited localization, and inconsistent enforcement of policies (Ahmed & Raza, 2020; Khan et al., 2021). In contrast, evidence from automotive clusters such as Chennai shows that firms adopting structured SCM practices and digital technologies achieve superior performance on reliability, responsiveness, flexibility, and cost (None & None, 2025). This contrast reinforces the rationale for analysing how Toyota and BYD perform within Pakistan's specific institutional and infrastructural context, where both supply-side constraints and market-side perceptions matter.

Comparative analyses of traditional and EV supply chains underline differences in operational and strategic challenges. Traditional ICE manufacturers often benefit from mature supplier networks, standardized production processes, and well-established service infrastructures, which can lead to relatively stable performance outcomes (Christopher, 2020; Mason-Jones & Towill, 2021). EV manufacturers, by contrast, operate within more dynamic ecosystems that require high levels of technological adaptation, vertical integration, and close collaboration with specialized suppliers, particularly around batteries

and electronics (Mangla et al., 2022; Liu, 2020; Olivetti et al., 2022). Automotive sector studies suggest that EV producers adopting agile and technology-intensive practices can outperform conventional firms in responsiveness and flexibility, particularly in markets where policy incentives and infrastructure are evolving (None & None, 2025; Warburton, 2024).

Sustainability and environmental performance have also become central concerns in SCM. GSCM practices, including eco-design, cooperation with customers on environmental initiatives, and green information systems, are associated with improved environmental and economic outcomes (Srivastava, 2007; Zhu et al., 2018; Khan & Dong, 2017). EV supply chains are closely linked to these developments because they combine low-emission products with advanced technological and digital infrastructures (Mangla et al., 2022; Pakistan Business Council, 2024; PPSE, 2024). Integrating sustainability into supply chain strategies supports regulatory compliance, enhances brand reputation, and contributes to long-term competitiveness, especially as customers and regulators increasingly demand decarbonization and responsible sourcing.

Overall, the literature clarifies key constructs and relationships, highlights gaps in the Pakistani context, and supports the present study's focus on supply chain performance, traditional and EV supply chain practices, technology adoption, and consumer perception. By drawing on evidence from Pakistani manufacturing, global GSCM research, IoT-enabled supply chains, EV adoption studies, and automotive sector analyses, this chapter justifies a comparative investigation of Toyota and BYD in Pakistan's automotive sector (Khan & Dong, 2017; Mubeen, 2023; None & None, 2025; Shakeel et al., 2022; Siddiqui, 2023).

2.1 Supply Chain Performance

Supply chain performance describes how effectively and efficiently an organization manages the flow of materials, information, and finished products from suppliers to end customers. Frequently used dimensions include delivery reliability, cost management, product availability, responsiveness to demand fluctuations, and overall service quality

(Chopra & Meindl, 2022; Christopher, 2020). In the automotive sector, these dimensions translate into the ability to deliver vehicles and spare parts on time, maintain stable and competitive costs, and ensure that dealers and customers experience minimal stockouts or delays, thereby supporting competitiveness and long-term sustainability (Dubey et al., 2019; Gunasekaran, Patel, & Tirtiroglu, 2017).

In Pakistan, evaluating supply chain performance is particularly important because firms must contend with infrastructure limitations, import dependencies, supply delays, and volatile demand patterns that can disrupt both inbound and outbound flows (Ahmed & Raza, 2020; Khan et al., 2021). Empirical evidence from Pakistani manufacturing and GSCM indicates that structured supply chain practices, including coordinated procurement, production planning, and logistics management, significantly improve performance outcomes (Khan & Dong, 2017). For automotive firms, these improvements can manifest in more consistent vehicle availability, better spare-parts support, and improved customer service, even under macroeconomic and policy constraints.

Automotive cluster research from Chennai applies SCOR-based dimensions—reliability, responsiveness, flexibility, and cost—to assess performance across different vehicle segments, including EVs (None & None, 2025). Findings from such work suggest that firms investing in advanced supply chain practices and digital technologies tend to score higher on these dimensions than firms that rely on traditional, less integrated systems (Mubeen, 2023; Warburton, 2024). The present study follows this tradition by operationalizing supply chain performance through indicators such as reliability, responsiveness, flexibility, cost efficiency, and overall effectiveness and by applying this measurement to both Toyota (traditional) and BYD (EV) supply chains in Pakistan.

2.2 Traditional Vehicle Supply Chain Practices

Traditional vehicle supply chain practices refer to the established procurement, production, and distribution arrangements used by ICE manufacturers. These practices typically involve long-term supplier relationships, structured production scheduling, inventory control, and lean operations designed to maintain consistent vehicle and spare-parts

availability (Christopher, 2020; Mason-Jones & Towill, 2021). Empirical studies show that firms with mature traditional supply chains often achieve higher reliability, fewer production delays, and stronger after-sales service networks compared to firms with less formalized supply chain processes (Chopra & Meindl, 2022; Gunasekaran et al., 2017).

In the Pakistani context, traditional automotive supply chains face persistent obstacles, including fragmented supplier bases, dependence on imported components, fluctuating exchange rates, and regulatory and logistics bottlenecks (Ahmed & Raza, 2020; Khan et al., 2021). These challenges can increase lead times, raise operating costs, and limit the ability of manufacturers to respond quickly to changes in demand. Nonetheless, research suggests that applying lean principles, strengthening supplier collaboration, and gradually localizing production can improve performance even in constrained environments (Dubey et al., 2019; Ivanov, 2021). Pakistani manufacturing evidence on green and lean practices further indicates that structured supply chain practices can mitigate some of these constraints and contribute to enhanced performance (Khan & Dong, 2017).

Global automotive literature frequently cites Toyota as a benchmark for traditional supply chain excellence due to its lean production system, just-in-time logistics, and deep supplier integration (Simchi-Levi, Kaminsky, & Simchi-Levi, 2008; Christopher, 2020). Case-based and empirical analyses highlight how Toyota's emphasis on waste reduction, continuous improvement (Kaizen), and close supplier relationships increases reliability and reduces total system cost (Mason-Jones & Towill, 2021; None & None, 2025). In this study, traditional vehicle supply chain practices are conceptualized in line with this tradition and adapted to represent the practices associated with Toyota in the Pakistani automotive market, including sourcing, production planning, inventory control, logistics coordination, and after-sales support.

2.3 Electric Vehicle Supply Chain Practices

Electric vehicle supply chain practices encompass the specialized procurement, production, and distribution activities necessary for EVs. EV supply chains rely on lithium-ion batteries, power electronics, complex software, and charging infrastructure, making them more technology-intensive and often more globally integrated than traditional ICE supply

chains (Mangla et al., 2022; Liu, 2020). Effective EV supply chains require close coordination with battery and electronics suppliers, robust logistics for handling sensitive and high-value components, and flexibility to cope with rapid technological change, evolving safety standards, and changing government regulations (Zhang et al., 2021; Olivetti et al., 2022).

Recent ecosystem studies in Pakistan highlight challenges such as limited public charging networks, high import dependence for EV components, lack of specialized technical skills, and underdeveloped service infrastructures (Pakistan Business Council, 2024; PPSE, 2024; Sustainable Development Policy Institute, 2024). These constraints can increase lead times, restrict product availability, and slow EV adoption, especially outside major urban centres. To address these issues, scholars and practitioners recommend the use of digital solutions—IoT-enabled monitoring, AI-based demand forecasting, and blockchain-based traceability—to enhance efficiency, visibility, and responsiveness in EV supply chains (Kamble et al., 2020; Queiroz et al., 2021).

Globally, EV manufacturers such as BYD and Tesla often rely on vertical integration, innovation, and proactive supplier collaboration to achieve strong supply chain performance (Mangla et al., 2022; Liu, 2020). BYD's strategy of integrating battery manufacturing, component production, and vehicle assembly provides greater control over costs, quality, and lead times, while also allowing rapid adaptation to market and policy changes (Mangla et al., 2022; Pakistan Business Council, 2024). Empirical evidence from automotive clusters suggests that EV producers adopting agile and technology-intensive supply chain practices demonstrate higher responsiveness and flexibility than traditional firms, particularly in contexts where demand for EVs is growing rapidly (None & None, 2025; Warburton, 2024). In this study, EV supply chain practices are defined with reference to these global and local insights and operationalized using BYD as the representative EV manufacturer in the Pakistani context, with items capturing sourcing, battery logistics, technology use, and service support.

2.4 Technology Adoption in Supply Chains

Technology adoption in supply chains refers to the implementation and use of digital tools, information systems, and advanced technologies such as ERP, IoT, analytics, and AI to support planning, coordination, and execution activities. These technologies enhance real-time visibility, improve forecasting, optimize inventory management, and support data-driven decision-making, thereby improving reliability and responsiveness across the supply chain (Ivanov et al., 2020; Queiroz et al., 2021). Empirical evidence links technology adoption to improved supply chain and firm performance through reduced delays, better coordination with suppliers and customers, and enhanced adaptability to disruptions (Dubey et al., 2019; Gunasekaran et al., 2017).

Recent studies specifically examine the role of IoT and digital transformation in supply chains. Mubeen (2023), for example, demonstrates that IoT-enabled supply chains show higher levels of efficiency, cost savings, and risk reduction, which translate into improved firm performance. Similarly, automotive sector analyses note that advanced digital technologies strengthen resilience and transparency in vehicle supply chains and enable firms to react more quickly to disruptions and demand shifts (Warburton, 2024; None & None, 2025). These findings support treating technology adoption as a core independent variable in this study and justify the inclusion of items related to ERP usage, real-time tracking, digital monitoring, and analytics in the measurement of this construct.

In Pakistan, where supply chain infrastructure and processes are still developing, technology adoption can help firms overcome challenges related to import delays, fragmented supplier networks, and inconsistent logistics performance (Ahmed & Raza, 2020; Khan et al., 2021). Digital tools can support both traditional and EV manufacturers by enabling better planning, monitoring, and coordination of operations and by simplifying information exchange with suppliers, logistics providers, and dealers. Accordingly, the technology adoption construct in this study is adapted from prior IoT and digital SCM scales and is used to capture the extent of digitalization in the supply chains of Toyota and BYD (Mubeen, 2023; Kamble et al., 2020; None & None, 2025).

2.5 Consumer Perception as a Mediating Factor

Consumer perception represents consumers' evaluations and beliefs about product reliability, availability, quality, and associated services. Marketing and service quality research shows that favourable perceptions of reliability, responsiveness, and service quality lead to higher satisfaction, loyalty, and positive word-of-mouth (Kotler & Keller, 2016; Parasuraman, Zeithaml, & Berry, 1988). In supply chain contexts, positive consumer perception can stabilize demand, support more accurate forecasting, and reduce risks of stockouts or excess inventory, because satisfied customers are more likely to repurchase and recommend the brand (Gunasekaran et al., 2017; Dubey et al., 2019). In Pakistan's automotive market, consumer perception is particularly important for EVs. Recent empirical work finds that perceptions of charging infrastructure, battery performance, price, and service networks significantly influence intentions to adopt EVs (Shakeel et al., 2022; Siddiqui, 2023). These studies indicate that concerns about range anxiety, availability of charging points, and maintenance support can deter potential EV buyers even when the technology and policy environment are favourable. For traditional vehicles, perceptions of reliability, spare-parts availability, and after-sales service remain important determinants of brand choice and loyalty (Kotler & Keller, 2016; Ahmed & Raza, 2020).

These findings suggest that even well-designed supply chain practices and advanced technologies may not fully translate into improved performance unless consumers perceive the products and supporting services as reliable and accessible. Addressing consumer concerns through transparent communication, reliable after-sales service, and consistent product availability can therefore strengthen overall supply chain performance in both traditional and EV segments (Mangla et al., 2022; Pakistan Business Council, 2024). Given this evidence, the present study models consumer perception as a mediating variable linking supply chain practices and technology adoption to supply chain performance. Measurement items for consumer perception are adapted from established perception and service quality scales and tailored to capture how Pakistani consumers view the supply chains of Toyota and BYD in terms of reliability, availability, and satisfaction.

2.6 Research Framework

Drawing on the reviewed literature, this study adopts a mediation-based research framework to analyse how supply chain practices and technology adoption affect supply chain performance in Pakistan's automotive sector, with consumer perception serving as a mediating factor. The framework is consistent with empirical models that link supply chain and green supply chain practices and technology-related capabilities to performance outcomes, while extending them to a comparative setting involving both traditional and EV manufacturers (Khan & Dong, 2017; Mubeen, 2023; None & None, 2025).

In this framework, supply chain performance is the dependent variable and is defined through dimensions such as delivery reliability, cost efficiency, product availability, and responsiveness (Chopra & Meindl, 2022; Dubey et al., 2019). The independent variables are traditional vehicle supply chain practices, EV supply chain practices, and technology adoption. Traditional practices capture the lean-oriented and process-based practices of established ICE manufacturers like Toyota; EV practices capture the specialized, technology-intensive operations of EV manufacturers like BYD; and technology adoption measures the extent of digitalization in their supply chains (Khan & Dong, 2017; Mubeen, 2023; None & None, 2025).

Consumer perception is specified as a mediating variable reflecting how consumers perceive product availability, reliability, and quality in relation to these supply chains (Kotler & Keller, 2016; Parasuraman et al., 1988; Shakeel et al., 2022; Siddiqui, 2023). The framework proposes that traditional and EV supply chain practices and technology adoption have direct effects on supply chain performance and indirect effects through consumer perception. This integrated model reflects both operational and market-oriented mechanisms and is designed to capture the realities of Pakistan's automotive sector, where supply constraints and consumer perceptions jointly shape performance outcomes.

2.7 Research Framework Design

The conceptual framework is illustrated in Figure 1. Traditional vehicle supply chain practices, electric vehicle supply chain practices, and technology adoption are

positioned as exogenous variables. Supply chain performance appears as the endogenous variable, while consumer perception is depicted as a mediator between the exogenous variables and performance. The hypothesized paths include direct effects from each independent variable to supply chain performance (H1–H3), the mediating effect of consumer perception (H4), and the direct effect of consumer perception on performance (H5).

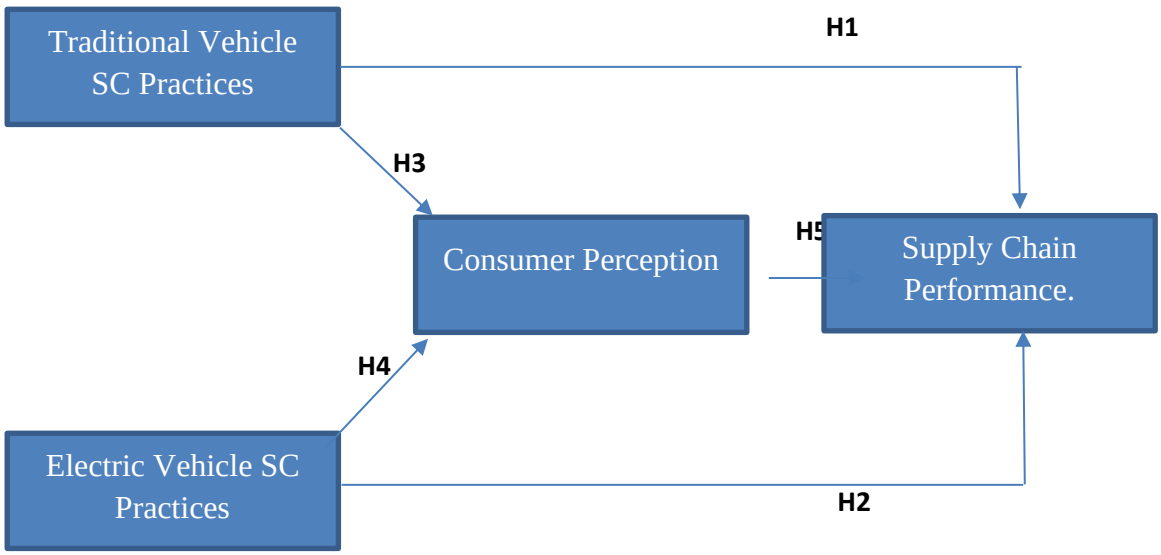

Figure 1: Research Framework

2.8 Research Hypotheses

On the basis of the literature and research framework, the following hypotheses are proposed:

Hypothesis 1

H01: Traditional Vehicle Supply Chain Practices have no significant impact on supply chain performance.

Ha1: Traditional Vehicle Supply Chain Practices have a significant impact on supply chain performance.

Hypothesis 2

H02: Electric Vehicle Supply Chain Practices have no significant impact on supply chain performance.

Ha2: Electric Vehicle Supply Chain Practices have a significant impact on supply chain performance.

Hypothesis 3

H03: Technology Adoption has no significant impact on supply chain performance.

Ha3: Technology Adoption has a significant impact on supply chain performance.

Hypothesis 4

H04: Consumer Perception does not mediate the relationship between supply chain practices and supply chain performance.

Ha4: Consumer Perception mediates the relationship between supply chain practices and supply chain performance.

Hypothesis 5

H05: Consumer Perception does not affect supply chain performance.

Ha5: Consumer Perception positively affects supply chain performance.

These hypotheses extend prior SCM, GSCM, digital adoption, and EV adoption research by jointly examining traditional and EV supply chain practices, technology adoption, and consumer perception within a single empirical model focused on Pakistan's automotive sector (Khan & Dong, 2017; Mubeen, 2023; None & None, 2025; Shakeel et al., 2022; Siddiqui, 2023).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Design

Research design refers to the overall plan adopted to collect, measure, and analyze data in order to answer research questions and test hypotheses (Mackey & Gass, 2015; Saunders, Lewis, & Thornhill, 2019). Broadly, research designs can be qualitative, quantitative, or mixed methods. Qualitative designs emphasize rich descriptions of experiences, behaviors, and meanings, while quantitative designs examine statistical relationships among variables using numerical data (Flick, 2015). Mixed-method designs combine both traditions in a single study.

The present study adopts a quantitative, hypothesis-testing design, because its primary objective is to statistically examine the relationships between traditional vehicle supply chain practices, electric vehicle supply chain practices, technology adoption, consumer perception, and supply chain performance in Pakistan's automotive sector. All constructs are measured through standardized Likert-scale items in a structured questionnaire, and the relationships among them are tested using statistical techniques such as correlation, multiple regression, and mediation analysis. This design is consistent with prior empirical research in supply chain and green supply chain management that uses survey data to test relationships between practices, technology adoption, and performance outcomes (Khan & Dong, 2017; Mubeen, 2023; None & None, 2025).

3.1.1 Type of Study

This study is correlational and explanatory in nature. It aims to identify and analyze the relationships between the independent variables—Traditional Vehicle Supply Chain Practices (TVSCP), Electric Vehicle Supply Chain Practices (EVSCP), and Technology Adoption (TA)—the mediating variable, Consumer Perception (CP), and the dependent variable, Supply Chain Performance (SCP). No variables are manipulated by the

researcher; instead, naturally occurring perceptions are measured and used to test statistically whether changes in TVSCP, EVSCP, and TA are associated with changes in CP and SCP. This approach is commonly used in SCM and digital supply chain research to explain how practices and technology adoption influence performance (Khan & Dong, 2017; Kamble, Gunasekaran, & Gawankar, 2020; Mubeen, 2023).

3.1.2 Study Setting

The study was conducted in a non-contrived (field) setting, meaning that data were collected from respondents in their natural environment without any experimental manipulation. Participants completed the questionnaire while engaged in their normal work or daily routines. The target respondents were individuals with exposure to Pakistan's automotive sector, including those involved in supply chain–related functions, dealership and service operations, and informed consumers familiar with vehicle availability and service support. The researcher did not interfere with organizational processes or decision-making. This type of naturalistic setting is appropriate for survey-based SCM research that seeks to capture real-world perceptions and practices (Saunders et al., 2019).

3.1.3 Time Horizon

The research follows a cross-sectional time horizon. Data were collected at a single point in time rather than repeatedly over an extended period. Cross-sectional designs are widely used in quantitative SCM and technology-adoption studies to examine current relationships between practices, technology use, perceptions, and performance (Khan & Dong, 2017; Mubeen, 2023). This approach is suitable given the scope and time constraints of a graduate-level thesis and the objective of capturing current perceptions of Toyota and BYD supply chains in Pakistan.

3.1.4 Research Philosophy

The study is grounded in a positivist research philosophy. Positivism assumes that reality is objective and can be measured through observable and quantifiable indicators (Acharyya & Bhattacharya, 2019). Under this paradigm, the role of the researcher is to remain

independent, use structured instruments, and apply statistical techniques to test pre-specified hypotheses. In line with positivism, this study relies on measurable constructs (TVSCP, EVSCP, TA, CP, and SCP) captured through a structured questionnaire and analyzed using inferential statistics. Similar positivist approaches are common in SCM, GSCM, and digital adoption research, where survey data are used to validate theoretical relationships between practices and performance (Khan & Dong, 2017; None & None, 2025).

3.1.5 Research Approach

A deductive research approach was adopted. Deduction begins with theory and prior empirical findings, develops hypotheses, and then tests these hypotheses with data (Saunders et al., 2019). In this study, the research framework and hypotheses were derived from the literature on supply chain practices, green supply chain management, technology adoption, consumer perception, and supply chain performance (Khan & Dong, 2017; Mubeen, 2023; Shakeel, Rehman, & Khan, 2022; Siddiqui, 2023). These hypotheses were subsequently tested using survey data collected from respondents with exposure to Pakistan's automotive sector. The deductive approach is appropriate when validating theoretical relationships in a new context, such as comparing Toyota (traditional) and BYD (EV) supply chains in Pakistan.

3.1.6 Research Strategy

A survey research strategy was employed to collect primary data. Survey strategies are widely used in SCM and GSCM studies because they allow standardized data collection from relatively large samples and support quantitative analysis of relationships between multiple constructs (Hair et al., 2022; Khan & Dong, 2017). A structured, self-administered questionnaire was designed and distributed electronically through Google Forms. This method facilitated efficient reach to geographically dispersed respondents and enabled the use of inferential statistical techniques such as multiple regression and mediation analysis.

3.1.7 Unit of Analysis

The unit of analysis in this study is the individual respondent. Each respondent provided perceptions regarding traditional vehicle supply chain practices, EV supply chain practices, technology adoption, consumer perception, and supply chain performance. The analysis is therefore conducted at the individual level rather than at the organizational level. This choice aligns with the use of perceptual measures and is consistent with prior SCM and technology-adoption studies that rely on individual respondents as informants about practices and performance (Mubeen, 2023; Shakeel et al., 2022).

3.2 Population and Sampling

3.2.1 Population

Population refers to the complete set of elements or individuals relevant to a particular study (Saunders et al., 2019). For the present research, the target population comprises individuals with knowledge, experience, or exposure to Pakistan's automotive sector. This includes employees working in supply chain–related roles in manufacturing, dealerships, and service centers, as well as informed consumers familiar with vehicle availability, service support, and market operations. Because the automotive sector in Pakistan is large and diverse and there is no comprehensive list of all individuals with relevant exposure, the population is considered large and undefined. In operational terms, the study focuses on individuals who can meaningfully evaluate supply chain practices and performance for Toyota (traditional vehicles) and BYD (EVs) within the Pakistani context. This focus ensures that responses are aligned with the constructs measured in the questionnaire, particularly TVSCP, EVSCP, TA, CP, and SCP. This type of population definition is consistent with prior SCM and EV-perception research that targets respondents with sector knowledge rather than the entire general population (Khan & Dong, 2017; Siddiqui, 2023).

3.2.2 Sample Size

A total of 156 valid responses were obtained and used as the final sample. The questionnaire link was distributed to a larger pool of potential respondents associated with Pakistan's automotive sector, and 156 complete and usable responses were retained after data screening. This sample size exceeds the minimum thresholds of 100–150 observations commonly recommended for multiple regression and mediation analysis in graduate-level research (Hair et al., 2022). It is therefore considered adequate for estimating relationships among the variables and testing the hypotheses of this study. From a practical standpoint, the sample size was determined by data availability and respondent willingness within the accessible population. The number of respondents is comparable to or larger than sample sizes used in related SCM, GSCM, and technology-adoption studies conducted in emerging economies (Khan & Dong, 2017; Mubeen, 2023; Shakeel et al., 2022). This supports the robustness of the statistical analyses conducted.

3.2.3 Sampling Technique

A non-probability convenience sampling technique was employed. Convenience sampling was selected because a comprehensive sampling frame of all individuals with exposure to Pakistan's automotive sector is not available, and the relevant population is geographically dispersed. Respondents were approached based on ease of contact, availability, and willingness to participate, mainly through existing networks, online groups, and digital communication channels. Although probability sampling is ideal for generalizability, convenience sampling is widely accepted in applied business and SCM research when the objective is to explore relationships between variables and to work with perceptual data (Saunders et al., 2019). To improve the relevance of the responses, efforts were made to include participants who had some level of knowledge or experience related to vehicle availability, service support, or supply chain activities in the Pakistani context. Similar non-probability sampling approaches are commonly used in EV adoption and supply chain perception studies (Shakeel et al., 2022; Siddiqui, 2023).

3.3 Scales and Measures

A structured questionnaire was used to collect primary data for this study. The instrument was developed based on existing literature and refined under supervisory guidance to ensure alignment with the research objectives and conceptual framework. The questionnaire was designed to maintain consistency between the research model, hypotheses, and statistical analysis procedures, following recommendations from quantitative SCM and technology-adoption studies (Hair et al., 2022; Mubeen, 2023). The questionnaire consisted of two main sections. The first section captured demographic information, including gender, age group, education level, and work or market exposure related to the automotive sector. The second section comprised items measuring the study variables: Traditional Vehicle Supply Chain Practices (TVSCP), Electric Vehicle Supply Chain Practices (EVSCP), Technology Adoption (TA), Consumer Perception (CP), and Supply Chain Performance (SCP).

All constructs were measured using a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree. Likert scales are widely used in SCM, GSCM, and technology-adoption research to capture respondents' perceptions and attitudes in a standardized manner that is suitable for statistical analysis (Khan & Dong, 2017; Kamble et al., 2020; Mubeen, 2023). Toyota and BYD were explicitly mentioned in the wording of some items to help respondents distinguish between traditional and EV supply chain practices, but the analysis focuses on the underlying supply chain models rather than on company-specific performance. Measurement items were adapted from prior studies wherever possible and modified to fit the context of Pakistan's automotive sector and the specific focus on Toyota and BYD. This adaptation approach is consistent with established practice in SCM and digital transformation research, where validated scales are tailored to new contexts (Khan & Dong, 2017; None & None, 2025).

3.3.1 Traditional Vehicle Supply Chain Practices

Traditional Vehicle Supply Chain Practices (TVSCP) were measured using multiple items reflecting established operational processes within conventional automotive supply chains. The items focused on aspects such as reliability of supply, consistency in vehicle and spare-parts availability, coordination with suppliers and dealers, and stability of logistics operations. Respondents were asked to evaluate these practices with Toyota in mind as the representative traditional vehicle manufacturer. The TVSCP scale was conceptually adapted from prior SCM and GSCM practice scales that measure elements such as purchasing, production planning, logistics coordination, and information sharing in traditional manufacturing environments (Khan & Dong, 2017; Christopher, 2020; None & None, 2025). Wording was adjusted to reflect the Pakistani automotive context and to focus on respondents' perceptions rather than internal company data.

3.3.2 Electric Vehicle Supply Chain Practices

Electric Vehicle Supply Chain Practices (EVSCP) were measured through items designed to capture the unique characteristics of EV-related supply chains. These items addressed issues such as availability of EV components (especially batteries), operational coordination with technology-oriented suppliers, adaptability to new technologies, and consistency of EV supply and service support. Respondents were asked to consider BYD as a representative EV manufacturer when evaluating these practices. The EVSCP scale draws on literature on EV supply chains and supply chain innovation, which emphasizes battery logistics, technology integration, and collaboration with specialized suppliers (Mangla et al., 2022; Olivetti et al., 2022; None & None, 2025). Items were adapted to reflect the early stage of EV development in Pakistan and framed in terms of perceived efficiency and reliability of EV supply chains from the respondent's perspective.

3.3.3 Technology Adoption

Technology Adoption (TA) was measured using items that assess the extent to which technological tools are employed to support supply chain activities. The scale focused on respondents' perceptions regarding the use of digital systems for coordination, information sharing, real-time monitoring, and data-driven decision-making in both traditional and EV supply chains. Example aspects include the use of ERP systems, tracking technologies, digital communication platforms, and analytics for planning and forecasting. TA items were adapted from established digital supply chain, IoT, and Industry 4.0 adoption scales used in prior studies that link technology adoption to supply chain and firm performance (Kamble et al., 2020; Mubeen, 2023). These items are consistent with the technology constructs discussed in Chapter 2 and allow quantitative assessment of the extent of digitalization in the supply chains associated with Toyota and BYD as perceived by respondents.

3.3.4 Consumer Perception

Consumer Perception (CP) was measured as a mediating variable capturing respondents' views regarding reliability, availability, service support, and overall confidence in automotive supply chains. Items in this scale reflect perceived reliability of product delivery, ease of obtaining vehicles and spare parts, perceived quality of after-sales services, and overall satisfaction with the way the supply chain supports customers. The CP construct draws on marketing and service quality literature, particularly work on perceived service reliability and satisfaction (Kotler & Keller, 2016; Parasuraman, Zeithaml, & Berry, 1988), as well as recent EV perception studies in Pakistan (Shakeel et al., 2022; Siddiqui, 2023). Items were adapted to focus on how respondents perceive the supply chains of Toyota and BYD rather than on purely technical performance metrics. Measuring CP at the individual level aligns with the unit of analysis and allows examination of its mediating role between supply chain practices, technology adoption, and supply chain performance.

3.3.5 Supply Chain Performance

Supply Chain Performance (SCP) was measured using items that reflect overall efficiency and effectiveness of supply chain operations, including cost efficiency, responsiveness, consistency of supply, and ability to meet market demand. Respondents were asked to evaluate SCP based on observable outcomes such as timely availability of vehicles and parts, perceived cost stability, and responsiveness to changes in demand. The SCP scale was adapted from performance measures used in SCM, GSCM, and automotive sector studies that employ SCOR-based dimensions such as reliability, responsiveness, flexibility, and cost (Chopra & Meindl, 2022; Dubey et al., 2019; Khan & Dong, 2017; None & None, 2025). Using perceptual measures of performance is common in survey-based SCM research and is appropriate when direct access to internal operational data is limited.

3.3.6 Reliability of Measures

The reliability of all measurement scales was assessed using Cronbach's alpha. Reliability analysis was conducted separately for each construct (TVSCP, EVSCP, TA, CP, and SCP) to evaluate the internal consistency of the items. A Cronbach's alpha value of 0.70 or above was considered acceptable, following widely cited guidelines in quantitative research (Nunnally & Bernstein, 1994; Hair et al., 2022). Items that reduced the reliability of a scale were examined and, if necessary, removed or revised before proceeding to further analysis. The final reliability results indicated that all constructs achieved acceptable to good internal consistency, supporting the use of these scales in subsequent correlation, regression, and mediation analyses. This approach is consistent with reliability testing procedures used in prior SCM and technology-adoption studies (Khan & Dong, 2017; Mubeen, 2023).

3.4 Data Collection Procedure

Data for this study were collected using a structured questionnaire administered through Google Forms. Online data collection was chosen because it enables efficient distribution, facilitates access for geographically dispersed respondents, and provides accurate electronic recording of responses. This approach is increasingly common in recent SCM,

EV, and technology-adoption research due to its practicality and cost-effectiveness (Mubeen, 2023; Shakeel et al., 2022). The Google Form link was shared with potential respondents through digital channels such as email, WhatsApp groups, and professional or alumni networks associated with the automotive sector. Participants were informed about the purpose of the research, the voluntary nature of participation, and the assurance of confidentiality and anonymity. They were requested to complete the questionnaire at their convenience within the data collection period. During data screening, incomplete and inconsistent responses were removed. A total of 156 fully completed and valid questionnaires were retained for analysis. The use of an online survey platform minimized data entry errors and allowed for straightforward export of responses into the Statistical Package for the Social Sciences (SPSS) for subsequent statistical analysis.

3.5 Data Analysis Techniques

The responses collected through Google Forms were downloaded, coded, and analyzed using SPSS. Several statistical techniques were applied to address the research objectives and test the hypotheses:

- Reliability analysis: Cronbach's alpha was used to assess the internal consistency of the measurement scales for all constructs, as described in Section 3.3.6.
- Descriptive statistics: Frequencies, means, and standard deviations were computed to summarize demographic characteristics and provide an overview of respondents' perceptions for each construct.
- Correlation analysis: Pearson correlation coefficients were calculated to examine the strength and direction of bivariate relationships among TVSCP, EVSCP, TA, CP, and SCP.
- Multiple regression analysis: Regression models were estimated to test the direct effects of TVSCP, EVSCP, and TA on SCP, consistent with Hypotheses 1–3.
- Mediation analysis: The mediating role of CP between the independent variables (TVSCP, EVSCP, TA) and SCP was examined, consistent with Hypothesis 4. The direct effect of CP on SCP (Hypothesis 5) was also assessed.

- These techniques align with analytical procedures used in SCM, GSCM, and digital adoption studies that investigate how supply chain practices and technology adoption influence performance and how intermediate constructs mediate these relationships (Khan & Dong, 2017; Kamble et al., 2020; Mubeen, 2023).

3.6 Research Ethics

Ethical principles were strictly observed throughout the research process. Participation in the study was voluntary, and no financial or material incentives were offered. At the beginning of the questionnaire, respondents were informed about the purpose of the study, the approximate time required to complete the survey, and their right to withdraw at any stage without any consequences. They were assured that their responses would be treated with confidentiality and anonymity. No personally identifying information (such as names, addresses, or contact details) was collected. All data obtained through Google Forms were stored securely and used solely for academic purposes. Access to the raw data was restricted to the researcher. These practices are consistent with ethical guidelines for social science research and with norms followed in recent SCM and EV perception studies in Pakistan and other contexts (Saunders et al., 2019; Shakeel et al., 2022; Siddiqui, 2023).

CHAPTER 4

DATA ANALYSIS AND FINDINGS

4.1 Data Analysis

This chapter presents the empirical results based on data collected through the structured questionnaire described earlier. The objective is to test the proposed hypotheses and examine the relationships between Traditional Vehicle Supply Chain Practices (TVSCP), Electric Vehicle Supply Chain Practices (EVSCP), Technology Adoption (TA), Consumer Perception (CP), and Supply Chain Performance (SCP) in Pakistan's automotive sector. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), in line with the quantitative, positivist, and deductive design adopted in this study. A total of 156 valid responses were used for analysis. The chapter is organized into the following sections: reliability analysis, descriptive statistics, correlation analysis, multiple regression analysis, and mediation analysis. These analyses follow the research framework and variables defined in Chapters 2 and 3.

4.1.1 Reliability Analysis

Reliability analysis was performed to evaluate the internal consistency of the measurement scales used in the questionnaire. Cronbach's alpha was employed as the reliability coefficient, with 0.70 considered the minimum acceptable threshold for social science research. The purpose of this analysis is to assess whether items within each construct consistently measure the same underlying concept, ensuring that respondents have interpreted and answered the items in a coherent manner. All five constructs—TVSCP, EVSCP, TA, CP, and SCP—showed Cronbach's alpha values exceeding 0.85, indicating high internal consistency and strong reliability. This suggests that the items within each scale are homogeneous and suitable for subsequent correlation, regression, and mediation analyses.

Table 4.1: Reliability Analysis

Variable	Cronbach's Alpha	N of Items
Traditional Vehicle Supply Chain Practices	0.872	6
Electric Vehicle Supply Chain Practices	0.891	6
Technology Adoption	0.866	6
Consumer Perception	0.880	6
Supply Chain Performance	0.896	6

All constructs demonstrate Cronbach's alpha values substantially higher than 0.70, confirming robust internal consistency and reliability. These results provide confidence that the measurement items reliably capture the intended constructs and that the dataset is appropriate for further statistical analysis.

4.1.2 Descriptive Statistics

Descriptive statistics were computed to summarize respondents' perceptions regarding the study variables. Mean scores indicate the overall level of agreement with the statements, while standard deviations reflect the degree of variability in responses.

Table 4.2: Descriptive Statistics

Variable	Mean	Standard Dev.
Traditional Vehicle Supply Chain Practices	3.42	0.64
Electric Vehicle Supply Chain Practices	3.58	0.67
Technology Adoption	3.73	0.61
Consumer Perception	3.46	0.65
Supply Chain Performance	3.63	0.66

The mean values indicate moderate to relatively high agreement across all constructs, suggesting that respondents generally perceive traditional and EV supply chain practices, technology adoption, consumer perception, and supply chain performance positively. Technology Adoption and Supply Chain Performance exhibit the highest mean scores, implying that respondents recognize technology integration as particularly important for enhancing supply chain outcomes, and they view current supply chain performance as moderately strong but with room for improvement.

The standard deviations are moderate (ranging from 0.61 to 0.67), indicating a reasonable spread of opinions without excessive variability. Overall, the descriptive statistics provide an initial indication that respondents perceive supply chain practices and technology adoption as meaningful drivers of performance in Pakistan's automotive sector.

4.1.3 Correlation Analysis

Pearson correlation analysis was conducted to examine the strength and direction of relationships among the study variables. Pearson's correlation coefficient is appropriate because the data are continuous and approximately normally distributed.

Table 4.3: Correlation Analysis

Variables	1	2	3	4	5
Traditional Vehicle SCP	1.000				
Electric Vehicle SCP	0.48	1.000			
Technology Adoption	0.44	0.52	1.000		
Consumer Perception	0.41	0.49	0.55	1.000	
Supply Chain Performance	0.46	0.57	0.60	0.63	1.000

All constructs exhibit positive correlations with Supply Chain Performance, indicating that higher levels of TVSCP, EVSCP, TA, and CP are associated with higher SCP. The correlations between the independent variables and CP are also positive, suggesting that stronger supply chain practices and higher technology adoption are linked to more favourable consumer perceptions. Importantly, none of the correlation coefficients exceed 0.80, which alleviates concerns about multicollinearity among the predictors. These results provide preliminary support for the proposed relationships and justify the use of multiple regression and mediation analysis in subsequent sections.

4.1.4 Regression Analysis

Multiple regression analysis was conducted to examine the direct impact of the independent variables—TVSCP, EVSCP, and TA—on the dependent variable, SCP. This analysis tests Hypotheses H1, H2, and H3.

Table 4.4 Model Summary

Model	R	R Square	Adjusted R Square
1	0.71	0.50	0.49

The model explains 50% of the variance in Supply Chain Performance ($R^2 = 0.50$), indicating a moderate to strong explanatory power for a behavioral study. This suggests that TVSCP, EVSCP, and TA together account for half of the variation in SCP among respondents.

Following are the results of Regression Coefficients:

Table 4.5 Regression Coefficients

Predictor	Beta (β)	t-value	Sig.
Traditional Vehicle SCP	0.21	3.14	0.002
Electric Vehicle SCP	0.29	4.27	0.000
Technology Adoption	0.34	5.01	0.000

The results show that all three independent variables have positive and statistically significant effects on Supply Chain Performance ($p < 0.01$ for each predictor). Technology Adoption exhibits the strongest standardized effect ($\beta = 0.34$), followed by Electric Vehicle Supply Chain Practices ($\beta = 0.29$) and Traditional Vehicle Supply Chain Practices ($\beta = 0.21$).

These findings support Hypotheses H1, H2, and H3:

H1: Traditional vehicle supply chain practices significantly impact supply chain performance – Accepted.

H2: Electric vehicle supply chain practices significantly impact supply chain performance – Accepted.

H3: Technology adoption significantly impacts supply chain performance – Accepted.

The relative strength of the Technology Adoption coefficient underscores the central role of digital tools and systems in improving supply chain outcomes in Pakistan's automotive sector, consistent with prior digital SCM research.

4.1.5 Mediation Analysis (Consumer Perception)

Mediation analysis was conducted to examine whether Consumer Perception mediates the relationships between the independent variables (TVSCP, EVSCP, TA) and Supply Chain Performance. The analysis followed the classical steps proposed by Baron and Kenny (1986).

Step 1: Independent Variables → Supply Chain Performance

As shown in Section 4.1.4, TVSCP, EVSCP, and TA each have significant direct effects on SCP, satisfying the first condition for mediation.

Step 2: Independent Variables → Consumer Perception

Regression analysis indicates that TVSCP ($\beta = 0.14$, $p < 0.01$), EVSCP ($\beta = 0.19$, $p < 0.01$), and TA ($\beta = 0.23$, $p < 0.01$) significantly predict Consumer Perception. This demonstrates that improvements in traditional and EV supply chain practices and higher technology adoption are associated with more favorable consumer perceptions.

Step 3: Consumer Perception → Supply Chain Performance

Consumer Perception has a significant positive effect on Supply Chain Performance ($\beta = 0.35$, $p < 0.001$), indicating that more favorable perceptions of reliability, availability, and service support are linked to higher SCP.

Step 4: Independent Variables and Mediator → Supply Chain Performance

When Consumer Perception is included in the regression model along with TVSCP, EVSCP, and TA, the effects of the independent variables on SCP remain significant but decrease in magnitude, while CP continues to exert a significant positive effect.

Table 4.6: Mediation Results

Predictor	Beta (β)	Sig.
Traditional Vehicle SCP	0.14	0.021
Electric Vehicle SCP	0.19	0.004
Technology Adoption	0.23	0.001
Consumer Perception	0.35	0.000

Interpretation

The reduction in beta values for TVSCP, EVSCP, and TA after including CP in the model, combined with the continued significance of both the direct paths and the mediator, indicates partial mediation. In other words, supply chain practices and technology adoption influence Supply Chain Performance both directly and indirectly through Consumer Perception.

These findings support Hypotheses H4 and H5:

H4: Consumer Perception mediates the relationship between supply chain practices and supply chain performance – Accepted.

H5: Consumer Perception positively affects supply chain performance – Accepted.

The mediating role of Consumer Perception highlights that operational and technological improvements in supply chains are more effective when they translate into positive consumer perceptions of reliability, availability, and service support, consistent with literature on EV adoption and customer satisfaction.

4.7 Chapter Summary

This chapter empirically validated the proposed research model using SPSS-based quantitative analysis on 156 responses from individuals with exposure to Pakistan's

automotive sector. The reliability analysis confirmed that all measurement scales (TVSCP, EVSCP, TA, CP, SCP) exhibit high internal consistency, with Cronbach's alpha values above 0.85, indicating that the constructs are measured reliably. Descriptive statistics showed that respondents generally hold positive perceptions of supply chain practices, technology adoption, consumer perception, and supply chain performance, with Technology Adoption and Supply Chain Performance recording the highest mean scores. This underscores the perceived importance of technology in enhancing supply chain outcomes and suggests that current supply chains are viewed as moderately effective but capable of further improvement, especially for EVs. Correlation analysis revealed positive and statistically significant relationships among all study variables, with no coefficients exceeding 0.80, confirming that multicollinearity is not a concern and supporting the use of regression and mediation techniques. Multiple regression analysis demonstrated that traditional and electric vehicle supply chain practices and technology adoption all have significant positive effects on Supply Chain Performance, with Technology Adoption emerging as the strongest predictor. Mediation analysis further showed that Consumer Perception partially mediates the relationships between supply chain practices, technology adoption, and supply chain performance. This indicates that while operational practices and technology use directly enhance SCP, their impact is amplified when they also improve how consumers perceive product availability, reliability, and service support. Overall, the findings confirm all five hypotheses and validate the research framework developed in Chapter 2. They highlight the combined importance of effective traditional and EV supply chain practices, strong technology adoption, and favorable consumer perception in driving supply chain performance in Pakistan's automotive sector.

Data Findings

Hypothesis	Statement	Accepted/ Rejected
H1	Traditional vehicle supply chain practices significantly impact supply chain performance.	Accepted
H2	Electric vehicle supply chain practices significantly impact supply chain performance.	Accepted
H3	Technology adoption significantly impacts supply chain performance.	Accepted
H4	Consumer perception mediates the relationship between IVs and supply chain performance.	Accepted
H5	Consumer Perception positively affects the supply chain performance.	Accepted

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study examined how Traditional Vehicle Supply Chain Practices (TVSCP), Electric Vehicle Supply Chain Practices (EVSCP), and Technology Adoption (TA) affect Supply Chain Performance (SCP) in Pakistan's automotive sector, with Consumer Perception (CP) as a mediating variable. Toyota was taken as a representative of traditional automotive supply chains, whereas BYD represented electric vehicle supply chains, allowing a comparative analysis of conventional and EV-oriented models in the same national context. The analysis was based on 156 valid survey responses and used reliability, correlation, regression, and mediation techniques to test five hypotheses. The empirical results show that Pakistan's automotive supply chains face underlying structural challenges, including high dependence on imported components, limited localization, and relatively low levels of digital integration. These constraints contribute to inefficiencies, higher operational costs, and reduced responsiveness to demand, which weaken overall supply chain performance and competitiveness. Despite these constraints, TVSCP positively influence SCP by providing operational stability and established coordination mechanisms, but their effectiveness is constrained by import dependence and macroeconomic volatility.

EVSCP, exemplified by BYD's more technology-driven and integration-oriented approach, exert an even stronger positive effect on SCP. The emphasis on in-house capabilities, closer supplier integration, and digital tools enhances flexibility, visibility, and resilience in the EV supply chain. Technology Adoption emerges as the strongest predictor of SCP among the three independent variables, confirming that digital systems, real-time monitoring, and data-driven decision-making are critical drivers of performance in the automotive context.

Consumer Perception significantly and positively affects SCP and partially mediates the relationships between TVSCP, EVSCP, TA, and SCP. This indicates that operational and technological improvements are more effective when they translate into favorable customer perceptions of reliability, availability, and service support. Overall, the study concludes that improving supply chain efficiency in Pakistan's automotive sector requires a combined focus on more robust operational practices, greater technology adoption, and deliberate management of consumer perceptions, drawing lessons from both traditional and EV supply chain models.

5.2 Research Implications

5.2.1 Practical Implications

The findings offer several practical implications for managers, practitioners, and policymakers in Pakistan's automotive sector. First, the positive effects of TVSCP and EVSCP on SCP suggest that firms should systematically strengthen sourcing, production planning, logistics coordination, and after-sales service, with particular emphasis on reducing over-reliance on imported components and building stronger local supplier bases. Localization and supplier development can enhance resilience and reduce exposure to external shocks such as exchange-rate volatility and import delays. Second, the strong impact of Technology Adoption on SCP highlights the importance of investing in digital tools, including ERP systems, real-time tracking, and analytics platforms for forecasting and decision support. Firms that integrate such technologies are more likely to achieve higher coordination, visibility, responsiveness, and cost control, which in turn improve overall performance and customer satisfaction. Third, the mediating role of Consumer Perception underscores the need to align supply chain decisions with customer expectations regarding product availability, reliability, and service quality. Managers should use communication, transparent information sharing, and reliable after-sales support to reinforce positive perceptions of both traditional and EV supply chains.

For policymakers, the results indicate the importance of targeted incentives, supportive regulations, and infrastructure development for the broader automotive and EV ecosystem. Policies that encourage local production, technology adoption, and logistics enhancement can create a more favorable environment for supply chain modernization, especially in EV-related components and charging infrastructure. Collaboration among government agencies, manufacturers, logistics providers, and financial institutions is essential for building a competitive and sustainable automotive supply chain in Pakistan.

5.2.2 Theoretical Implications

Theoretically, this study contributes to the supply chain management literature by providing empirical evidence from a developing economy and by jointly examining traditional and EV supply chain practices within a single framework. The results confirm that supply chain practices and technology adoption are significant predictors of performance, supporting lean, agile, and digital supply chain perspectives that emphasize integration, flexibility, and information visibility as key performance drivers.

The study also extends existing research by explicitly modelling Consumer Perception as a mediating variable between operational practices, technology adoption, and SCP. This highlights that supply chain effectiveness is shaped not only by internal efficiencies but also by how these efficiencies are perceived by the market, linking SCM theory with marketing and service quality perspectives. Furthermore, the findings underline the importance of contextual factors: globally integrated, traditional supply chain models may be effective in stable environments, whereas more localized and technology-intensive configurations appear better suited for emerging economies with infrastructure and resource constraints, such as Pakistan.

5.3 Research Limitations

Despite its contributions, this study has several limitations that should be acknowledged. First, the research relies on perceptual data collected through a structured questionnaire rather than objective operational or financial performance metrics. Although perceptual measures are widely used and appropriate for examining relative relationships, future studies could strengthen validity by combining survey data with secondary data such as delivery times, cost indicators, or inventory levels.

Second, Toyota and BYD were used as representative examples of traditional and EV supply chain models, respectively. While this comparative design provides valuable insights, it does not capture the full diversity of practices across all automotive manufacturers in Pakistan. Including additional firms and brands would improve the generalizability of the findings. Third, the focus on Pakistan's automotive sector limits direct transferability to other industries or countries where regulatory environments, infrastructure, and market conditions differ.

Finally, the cross-sectional design captures perceptions at a single point in time and cannot reflect dynamic changes in supply chain practices, technology adoption, or policy frameworks. Longitudinal or panel studies could provide deeper insights into how supply chain performance evolves in response to technological, regulatory, and market developments.

5.4 Recommendations

Based on the empirical findings, several recommendations are proposed to enhance supply chain performance in Pakistan's automotive sector:

- Increase the use of digital technologies in supply chain operations, particularly in inventory management, information sharing, and demand planning, as greater technology integration improves efficiency, reduces delays, and strengthens responsiveness.
- Develop EV-specific supply chain structures that address the unique requirements of electric vehicles, including secure access to specialized

components (especially batteries), robust supplier networks, and well-designed after sales and service systems.

- Strengthen collaboration among key supply chain actors—manufacturers, suppliers, logistics providers, and dealers—to improve coordination, shorten lead times, and reduce disruptions across both traditional and EV supply chains.
- Systematically incorporate customer feedback and perceptions into supply chain decisions, ensuring that strategies are aligned with expectations regarding reliability, availability, and service quality to enhance CP and, in turn, SCP.
- Invest in continuous training and development programs for supply chain personnel to build skills in digital tools, data analysis, and collaborative working, thereby supporting effective technology implementation and adaptability to industry change.
- Collectively, these measures can help address the identified weaknesses in existing supply chains and support the transition towards more efficient, resilient, and customer-oriented automotive supply chains in Pakistan.

5.5 Suggestions for Future Research

Future research can extend this study in several directions:

- First, scholars can gather primary data from a wider range of stakeholders, including suppliers, logistics providers, dealers, and policymakers, using surveys, interviews, and case studies to obtain a more holistic view of supply chain dynamics.
- Second, future studies could include additional traditional and EV manufacturers to allow broader comparisons and enhance the generalizability of conclusions.
- Third, longitudinal research designs that track supply chain practices, technology adoption, consumer perceptions, and performance over multiple years would help capture the effects of technological progress, policy changes, and market evolution. Cross-industry or cross-country comparative studies could also provide valuable insights into how supply chain modernization differs across sectors and institutional settings.

Finally, adopting mixed-methods approaches that combine quantitative analysis with qualitative insights would support deeper understanding of the mechanisms behind the statistical relationships observed and contribute to more robust theory development and evidence-based policy recommendations.

REFERENCES

None, A., & None, B. (2025). Supply chain management in automobile sector: An empirical study of Chennai manufacturing hub. ACR Journal.

Mubeen, S. K. (2023). IoT's role in enhancing supply chain and firm performance in Pakistan's manufacturing industry. Global Business and Management Research, 16(3), 1–15.

Khan, S. A. R., & Qianli, D. (2017). Impact of green supply chain management practices on firms' performance: Evidence from Pakistan. Technological Forecasting and Social Change, 144, 463–472.

Abbasi, W. A., & Qureshi, M. N. (2021). Supply chain challenges in Pakistan's automotive sector. International Journal of Supply Chain Management, 10(4), 22–31.

Alaaraj, H., & Ibrahim, F. W. (2019). The effect of supply chain integration on firm performance: Evidence from the manufacturing sector. Journal of Supply Chain Management, 15(2), 85–97.

Bai, C., & Sarkis, J. (2020). A supply chain transparency and sustainability technology appraisal model for blockchain technology. International Journal of Production Research, 58(7), 2142–2162.

BYD Company Limited. (2021). Sustainability and supply chain report. BYD Global.

Christopher, M. (2016). Logistics and supply chain management (5th ed.). Pearson Education.

Farooq, M. U., & Jamil, F. (2019). Barriers to effective supply chain management in Pakistan's manufacturing sector. Asian Journal of Business and Management, 7(2), 44–55.

Ghobakhloo, M. (2018). The future of the manufacturing industry: A strategic roadmap toward Industry 4.0. Journal of Manufacturing Technology Management, 29(6), 910–936.

He, H., & Fu, J. (2021). Supply chain challenges in the electric vehicle industry: A case study of BYD. Sustainability, 13(14), 7762.

Holweg, M. (2007). The genealogy of lean production. Journal of Operations Management, 25(2), 420–437.

Hussain, M., & Malik, M. (2020). Impact of logistics performance on economic development: Evidence from Pakistan's automotive industry. Global Journal of Management and Business Research, 20(1), 15–25.

Iqbal, M., & Lodhi, R. N. (2020). Electric vehicle adoption in Pakistan: Opportunities and barriers. Pakistan Journal of Engineering and Applied Sciences, 27(1), 55–63.

Kaur, H., & Singh, S. P. (2019). Sustainable supply chain management: A review of literature and implications for future research. Management of Environmental Quality, 30(5), 1067–1097.

Khan, S. A. R., & Qianli, D. (2017). Impact of green supply chain management practices on firms' performance: Evidence from Pakistan. Technological Forecasting and Social Change, 144, 463–472.

Khan, S. A. R., Yu, Z., & Golpîra, H. (2018). The impact of green supply chain on organizational performance: A case of Pakistani manufacturing firms. Journal of Cleaner Production, 185, 791–801.

Li, L., Su, F., Zhang, W., & Mao, J. Y. (2018). Digital transformation by ERP and big data analytics: A case of Tesla. International Journal of Information Management, 40, 49–56.

Nagurney, A. (2021). Supply chain game theory network modeling under labor constraints: Applications to the COVID-19 pandemic. European Journal of Operational Research, 293(3), 880–891.

Pakistan Ministry of Industries and Production. (2020). Electric Vehicle Policy 2020–2025. Government of Pakistan.

Raj, A., & Srivastava, S. K. (2019). Supply chain management and the circular economy: Case studies from the automotive industry. Resources, Conservation and Recycling, 141, 261–272.

Shah, S. H. H., & Syed, A. R. (2018). Issues and challenges of supply chain management in Pakistan. International Journal of Supply Chain Management, 7(5), 21–26.

Slack, N., Brandon-Jones, A., & Burgess, N. (2022). Operations and process management: Principles and practice for strategic impact. Pearson Higher Education.

Tesla, Inc. (2021). Annual impact report. Tesla Motors.

Wells, P., & Nieuwenhuis, P. (2017). The global automotive industry and sustainability transitions. Journal of Cleaner Production, 164, 116–125.

Wu, T., & Gereffi, G. (2019). Global supply chain restructuring in the automotive industry in the era of electric vehicles. Global Networks, 19(3), 423–445.

Zhao, X., & Yu, Z. (2021). Intelligent supply chain management: Applications of AI and IoT in EV production. Technological Innovation Journal, 45(3), 210–229.

Zhou, F., Zhang, X., & Li, J. (2020). Supply chain innovation in the automotive industry: Evidence from electric vehicles in China. Sustainability, 12(18), 7390.

APPENDIX

Research Questionnaire

My name is Shaheer Ahmad and I am a student of MBA at Bahria University. This questionnaire is designed to gather information for my MBA research on the "Impact of supply chain models on company performance". All responses will remain strictly confidential and will be used only for academic purposes. Your cooperation and honest feedback are highly appreciated.

Respondents 'Profile

Gender:

□ Male □ Female

Age Group:

□ Less than 30 years □ 30 to 45 years □ More than 45 years

Education:

□ Undergraduate □ Graduate □ Postgraduate

Organization: _____.

City of residence: _____.

Date: _____.

Instructions

*a. Please fill-out the questionnaire and kindly **check** ✓ the appropriate box.*
b. Choices are defined as: (1) Strongly Disagree (SD), (2) Disagree (DA), (3) Neutral (N), (4) Agree (A), (5) Strongly Agree (SA).

Question Statement **Construct 1: Toyota Supply Chain Practices**	SD (1)	D (2)	N (3)	A (4)	SA (5)
SCP1: Toyota maintains long-term, stable relationships with its suppliers.					
SCP2: Toyota uses just-in-time practices to reduce inventory waste.					
SCP3: Toyota's quality control processes ensure consistent performance.					
SCP4: Toyota has efficient logistics systems in its supply chain.					
SCP5: Toyota collaborates actively with suppliers for continuous improvement.					
SCP6: Toyota ensures timely availability of spare parts and service support.					
Construct 2: BYD Supply Chain Practices					
BSP7: BYD benefits from vertical integration in its supply chain.					
BSP8: BYD's in-house battery production increases reliability.					
BSP9: BYD's sourcing strategy reduces dependence on external suppliers.					
BSP10: BYD maintains consistent availability of EV components.					
BSP11: BYD's supply chain helps reduce production delays.					
BSP12: BYD coordinates effectively with its suppliers and production units.					
Construct 3: Technology Adoption					
TA13: Technology improves forecasting accuracy in the supply chain.					
TA14: Digital systems help track inventory in real-time.					

TA15: Technology enhances communication with suppliers and dealers.					
TA16: Automation improves efficiency at each supply chain stage.					
TA17: Data analytics supports better supply chain decision-making.					
TA18: Technology reduces errors and delays in supply chain operations.					
Construct 4: Consumer Perception					
CP19: Consumers perceive Toyota vehicles as reliable.					
CP20: Consumers trust BYD for modern EV technology.					
CP21: Consumers believe EVs are becoming more practical in Pakistan.					
CP22: Consumers consider supply chain reliability when choosing a vehicle.					
CP23: Consumers value fast availability of parts and after-sales service.					
CP24: Consumers view strong supply chain performance as a major purchase factor.					
Construct 5: Supply Chain Performance					
SP25: The company ensures timely delivery of vehicles to customers.					
SP26: The supply chain maintains consistent availability of vehicles.					
SP27: Inventory levels are managed efficiently.					
SP28: The supply chain responds quickly to market changes.					
SP29: The company's logistics system is efficient and reliable.					
SP30: The overall supply chain performance meets customer expectations.					

[redacted]

Thank You!