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Strategic Impact of Industry 4.0 and Big Data on Supply Chain Efficacy in Pakistani Automobile Manufacturing

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Abstract

The research aims to scrutinize the influence of Industry 4.0 indicators and Big Data Analytics in innovating and transforming supply chain processes in the manufacturing sector of Pakistan, highlighting how Industry 4.0 factors alter supply chain activities. This study was conducted within the manufacturing industry, specifically targeting employees from the automobile sector in Karachi, Pakistan. Data was collected through online Google Forms, utilizing a closed-ended questionnaire deployed on a Likert scale, to explore various independent variables and their impact on supply chain performance. Survey responses indicate that the variables—supply chain flexibility, supply chain agility, research and development, role of MIS, leadership style, and big data analytics—predominantly influence supply chain performance, albeit with one insignificant relationship noted between leadership style and supply chain performance. The research also affirms the significant mediating impact of supply chain performance indicators on organizational performance. The research may confront limitations related to its generalizability across varied industries and regions due to potential disparities in technological adoption and regulatory frameworks, and the exclusive focus on supply chain performance as the sole mediator might overlook alternative pathways through which the independent variables could influence organizational performance. The insights derived from this research could serve as a guide for managers and manufacturing organizations to comprehend the transformations invoked by Industry 4.0, offering a lens through which to perceive shifts in supply chain performance and activities. The study offers a pivotal examination of the evolution in supply chain practices induced by Industry 4.0 and Big Data Analytics within the context of Pakistan's manufacturing arena, thereby providing a valuable resource for practitioners and academicians to understand and navigate the landscape of digitally transformed supply chains.

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Keywords: Big Data Analytics, Industry 4.0, Supply chain performance, supply chain agility and flexibility, Role of MIS, R&D & Organizational Performance.

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INTRODUCTION

Amidst a technological revolution, the Pakistani automobile manufacturing sector grapples with transformative shifts driven by Industry 4.0 and Big Data, reshaping supply chain paradigms. The implementation of these technologies has catalyzed substantive changes in supply chain activities and methodologies, especially within manufacturing firms aiming to harness emerging techniques and technologies (Skender, Mirkovic, &

Prudky, 2021). With digitalization and automation at the forefront, stemming from the integration of Industry 4.0 applications, supply chain processes evolve, enabling network agents to autonomously communicate and exchange data, thus refining their capacities and augmenting their operational efficacy (Abdirad & Krishnan, 2021). Serving as a cornerstone for the industrial revolution and innovation, Industry 4.0 not only modifies attitudes towards production and manufacturing but also amplifies supply chain activity, paving the way for enhanced technological utilization, improved production efficiency, and bolstered business growth by optimizing time and efficiency (Abdirad and Krishnan, 2021). Navigating through the digital transition, this research adopts a critically evaluative and explorative lens towards the integration of Industry 4.0 and Big Data in the Pakistani automobile manufacturing sector, emphasizing its transformative impact on production processes and supply chain management. Engaging with the multifaceted repercussions of technological advancements, the study seeks to untangle the intricate web of how enhanced digitalization and data-driven decision-making inform, modify, and potentially optimize manufacturing practices and supply chain activities.

Grounded in the belief that technology and innovation serve as pivotal drivers, the exploration dives deep into unraveling the strategic alignments, efficiencies, and possible disjunctions brought forth by Industry 4.0, thereby not only analyzing the shift in manufacturing paradigms but also critically assessing its ripple effects on supply chain efficacy and organizational performance. Leveraging a synergistic interplay between technological adoption and supply chain adaptations, the research endeavors to carve out insights that could illuminate pathways for harmonizing technology and strategy, aiming to augment operational efficiency, elevate production quality, and fortify the competitive stance of automobile manufacturers in Pakistan.

The manufacturing sector wants to increase its performance and supply chain efficiency with an increase in robustness and capacity. The use of machine learning has noticed a greater increase in the efficiency of production, and I4.0 focuses on considering the entire level of the supply chain with manufacturing (Yu et al., 2022). The I4.0 focuses on increasing the digital supply chain and essential components of digital technology and digitalization of the supply chain. Smart management of the supply chain is also an essential component. Logistics 4.0 and the implementation of I4.0 are the core principles that count for value addition and focus on the general management of logistics and supply chain activities (Jonsson, 2021).

The various supply chain agents elaborate on the needs of the chain in the supply chain, and the relationship focuses on the context of logistics in particular and supply chain activities in general. The various supply chain agents focus on relationships with other departments and interconnectivity, which is also part of their focus (Assaqty, Gao, Hu, Ning, Leung, Wen, & Chen, 2020). The perspective of I4.0 is the current state of the art and needs a broader focus on the complete activities of the supply chain, relationships between various supply agents, collaboration with other departments, change, and real-time consideration to save the environment and people (Dev, Shankar, Qaiser, 2020). Firm performance is affected by organizational supply chain services, and supply chain activities play a pivotal role in the development of organizational competence. The supply chain services include inventory management, warehousing, production and manufacturing, distribution, and logistics services (Nazir, Ali, & Shah, 2023). Supply Chain Logistics Services and Supply Chain Agility are the key functions of the supply chain that

affect the performance of the firm (Shah, Zhang, Tanveer, Ali, & Saleem, 2023). The organizations are focusing on their core competencies and developing supply chain structures to reduce costs and improve production and operation efficiency. Various business demands for a higher degree of individualization to the requirements, focus on end users, and a more competitive edge over others (Diri, Koç, & Özceylan, 2020). Outsourcing third-party logistics is a recent phenomenon used by organizations to enhance their logistics services and increase efficiency in delivering products and services to customers (Khan et al., 2023). The firms facing issues of technology, implementation of processes, and capabilities of logistics are, due to this, focusing on outsourcing the logistics services and using third parties to improve efficiency and growth in the organizations (Shah et al., 2023). Firm performance is affected by organizational supply chain services, and supply chain activities play a pivotal role in the development of organizational competence (Ghauri, Khan, Khan, & Afandi, 2022). The supply chain services include inventory management, warehousing, production and manufacturing, distribution, and logistics services. Supply Chain Logistics Services and Supply Chain Agility are the key functions of the supply chain that affect the performance of the firm (Zafar, Khan, & Khan, 2022). The organizations are focusing on their core competencies and developing supply chain structures to reduce costs and improve production and operation efficiency.

Third-party logistics (3PL) services provide organizations with the capability to excel in their logistics services and gain a competitive edge over others. This paper presents the key aspects of supply chain management practices based on 3PL and their impact on business performance in the automobile sector based on the existing theoretical framework (Banker, Mashruwala, & Tripathy, 2017). Globalization poses a lot of challenges for organizations, and now the competition is global, and customers demand quality products and services with ease. The firm faces a lot of challenges in meeting customers' requirements, facing competition, and adopting technological advancements (Khan, Zaman, & Rais, 2022). The modern distribution has been changed remarkably, and a complex set of customers are associated with the products and services. Changes in distribution systems lead to changes in management style and in organizational settings as well (Ahmed and Sattar, 2019). Various business demands demand a higher degree of individualization to the requirements, focusing on end users and a more competitive edge over others. The collaboration with new and more advanced forms of logistics providers, more advanced forms of logistics, and service providers required advanced forms of third-party logistics providers (Nantee & Sureeyatanapas, 2021).

The advent of Industry 4.0 and Big Data Analytics has ushered a transformative shift within organizational structures, particularly in the realm of supply chain management in the manufacturing sector. This research zeroes in on Pakistan's automobile manufacturing sector, a pertinent domain wherein technological progress via Industry 4.0 indicators could critically enhance operations. The focus predominantly lies in deciphering how core components of Industry 4.0 and big data analytics can systematically improve supply chain flexibility, agility, and overall performance. Data will be diligently curated from supply chain managers, furnishing firsthand insights into operational workflows and managerial methodologies.

Despite the expansive literature on supply chain management, achieving optimal performance through reliability, flexibility, and responsiveness remains a challenging paradigm (Bititci et al., 2012). Especially in a setting like Pakistan's automobile manufacturing sector, the dynamic external and internal variables of supply chain factors can substantially sway industry outcomes. The infusion of Industry 4.0 has undoubtedly amplified manufacturing and supply chain activities, paving the path towards organizational excellence (Abdirad & Krishnan, 2021). However, the evolving business environment, spiked by ever-increasing customer demands and technological shifts, demands a comprehensive analysis to navigate through the complexities and harness Industry 4.0 to bolster supply chain competitiveness (Skender et al., 2021). In line with the above discussion the study has planned to achieve the following research objectives:

- **Unveil the Dynamics:** Investigate the nuanced impact of supply chain flexibility on supply chain performance, focusing on how adaptability within supply chain processes influences overall efficacy and responsiveness.
- **Agility Analysis:** Examine the pivotal role of supply chain agility in refining supply chain performance, evaluating how an agile model fosters a resilient and adaptable supply chain in a fluctuating market environment.
- **Data-driven Decisions:** Analyze the implications of big data analytics on supply chain performance, studying how data-driven decisions propagate strategic and operational benefits within the supply chain.
- **Technological Involvement:** Scrutinize the impact of the role of MIS (Management Information Systems) on supply chain performance, exploring how MIS interfaces and technologies streamline and optimize supply chain operations.
- **Leadership Exploration:** Investigate the correlation between varying leadership styles and supply chain performance, determining how strategic leadership can potentially enhance or impede supply chain efficacy.

LITERATURE REVIEW

Supply chain performance is one of the most challenging themes in supply chain management literature (Bititci, Firat, and Garengo 2012). Supply chain performance is based on reliability, flexibility, responsiveness, quality, and management of assets; these are performance indicators of the supply chain. Performance is based on variety, innovation, time, price, and availability; improvement can be measured in terms of innovation, price, time, and availability (Bourlakis, 2014). Supply chain flexibility was one of the key factors that was analyzed in the research. Inventory network management can be a complex and simultaneously unstable measure. The eccentricities of both the inner and outside production network factors can fundamentally affect the results of a whole industry, or in this situation, Pakistan's drug industry (Ulutas, 2021).

The supposition was that the more adaptable an inventory network structure for the drug business is, the stronger it would be when confronting outside and inner shocks. Asset and output performance are factors that engage in the interior administration of an industry's inventory network organization (Khan, Jamil, & Khan, no date given). The dependability of on-time conveyances, quality control measures, and the general accomplishment of the progression of merchandise and administrations from one end of the inventory network organization to another were instances of the measures engaged with resource

and output performance (Putra, 2018). The third party serves as an integrator that fulfills needs with the resources available through 3PL providers. The business process management technique serves as an integrator between supply chain agility and firm performance. 3PL supports supply chain functions and helps organizations attain long-term capabilities (Win, 2008). The 3PL serves as an integrator between the organization and the logistics firm. The firm provides logistics and IT services together to track orders, ordering procedures, and delivery guidelines with 3PL services. The 3PL provides closer relationships between participants and supply chain cost-cutting initiatives and improves the flexibility of organizations to deal with supply and demand uncertainties (Ammara, 2012). The organization's supply chain activities involve flexibility to complete orders and marketing targets to achieve organizational goals. Supply chain agility refers to the smooth flow of supply chain activities with minimum cost and is especially important for supply chain activities (Khan, Rasheed, & Muhammad, 2022). Supply chain agility is flexibility in the manufacturing and distribution processes to achieve organizational objectives. Supply chain agility supports marketing activities to achieve marketing targets, gain organizational competence, and achieve long-term goals (Bokhari, 2017).

Today, the manufacturing industries work on technological progress, and organizations need to gain a competitive advantage with references to technology and innovation. The concept of 3PL is technological advancement and is considered innovation, so organizations must focus on their core competencies and outsourcing the activities that are required to maintain their relationships with suppliers and dealers (Zailani et al., 2017). But now, not confined to only those, 3PL additionally performs diverse cost-delivered sports activities like packaging, order processing, bar coding, and plenty of others (Jamil, Shah, Khan, & Imran, no date given). This research has been performed to evaluate the middle blessings of outsourcing logistics services and the way employers profit from the competitive aspect of using logistics services. Focusing on 3PLs is the present-day distribution network with prolonged use of records devices and control of stock as well as logistics on time, which helps modern forms of business and benefits for incorporation (Nantee & Sureeyatanapas, 2021). The 3PL is the daily management degree of operations by using the enterprise and is chargeable for every day operations and day-to-day activities of companies. The 4PL is the switch of know-how and enjoyment in addition to businesses examining the business and works as a body of workers of business and educating them to perform nicely (Bokhari, 2017).

The Supply Chain Agility and Flexibility project is working on further developing the production network execution and the board. The technique adjusts to deal with recent fads, volatilities, and changes in production network rehearsals. 3PL definitely affects firm execution. In the first place, 3PL permits senior administration to zero in on center capabilities and for the arrangement of more extensive production network administrations. Additionally, 4PL further develops client support, fabricates intensity, builds income, and decreases liabilities, operational expenses, working capital, and fixed capital. The administration of various coordination's suppliers is taken care of by a solitary association by utilizing 3PLs (Bokhari, 2017). The Supply Chain Agility and Flexibility Project is working on improving supply chain performance and management. The strategy adapts to work on new trends, volatility, and changes in supply chain practices. Managing supply chain performance based on managerial performance and management of time and resources is referred to as supply chain management. The

Supply Chain Agility and Flexibility Project is working on improving supply chain performance and management. The strategy adapts to work on new trends, volatilities, and changes in supply chain practices (Bokhari, 2017). The third celebration serves as an integrator that fulfills wishes for assets to be had through 3PL companies. The business procedure control technique serves as an integrator among deliver chain agility and corporation overall performance. 3PL aids supply chain capabilities and enables agencies to gain long-term capabilities (Win, 2008). The 3PL serves as an integrator between the enterprise and logistics corporation. The corporation brings logistics and IT services together to track orders, ordering methods, and shipping suggestions with the 3PL offerings. The 4PL provides closer courting of individuals and supply chain cost-cutting projects and enhances the ability of business enterprises to deal with deliverables and call for uncertainties (Ammara, 2012).

The enterprise supply chain activities involve flexibility to finish orders and advertising objectives to achieve organizational goals. Supply Chain Agility refers to the smooth glide of deliver chain sports with minimum price and is particularly important for supply chain sports. Supply chain agility is flexibility in manufacturing and distribution methods to achieve organizational targets. The supply chain agility supports advertising activities to attain advertising and marketing goals, advantage organizational competence, and gain lengthy phrases desires (Bokhari, 2017). Today, the producing industries depend on technological development, and groups need to gain a competitive advantage with references to era and innovation. The idea of 3PL is technological advancement, and don't forget innovation. In order for business enterprises to be aware of their middle talents, they need to outsource the activities that can be required and maintain connections with providers and dealers (Zailani et al., 2017).

The Supply Chain Agility and Flexibility is working on further developing the production network execution and the board. The methodology adjusts to deal with recent fads, volatility, and changes in inventory network rehearsals. Dealing with the production network execution, in light of administrative execution, the executives of time with assets are alluded to as store network the board (Khan, Ayub, Khan, & Khan, 2023). The Supply Chain Agility and Flexibility is working on further developing inventory network execution and the executives. The system adjusts to chip away at recent fads, volatilities, and changes in inventory network rehearsals (Kalubanga, Tumwebaze, & Kakwezi, 2016). The resource-based administration; see Expounds on how the store network works on being handled through the populace, productivity, effectiveness, and relativity of association (Banker, Mashurwala, & Tirpathy, 2014). The supply chain rehearses; they follow the acquisition coordination, creation and assembly, limit control, and development of items for end purchasers.

The distribution networks influence the by and large authoritative exhibition and deals, and solid conveyance organization, item accessibility, and forceful selling influence the hierarchical presentation (Filipe, Easingwood, & Coelho, 2013). Supply chain flexibility was one of the key factors that was analyzed in the research. Inventory network management can be a complex and simultaneously unstable measure. The eccentrics of both the inner and outside production network factors can fundamentally affect the results of a whole industry, or in this situation, Pakistan's drug industry. The supposition was that the more adaptable an inventory network structure for the drug business is, the stronger it would be when confronting outside and inner shocks. Asset and output

performance are factors that influence the interior administration of an industry's inventory network organization (Raees, Khan, & Zaheer, 2023). The dependability of on-time conveyances, quality control measures, and the general accomplishment of the progression of merchandise and administrations from one end of the inventory network organization to another were instances of the measures engaged with resource and output performance (Putra, 2018). By and large, a store network structure that had a steadier resource and output performance was a more significant one. Furthermore, resource and output performance shortfalls could add to the volatility and vulnerabilities in the administration of an industry's inventory network organization. In an optimal situation, both the degrees of supply chain flexibility and resource and output execution ought to float reliably at an ideal exhibition level to guarantee the fruitful conveyance of labor and products from the underlying to the furthest limit of the network (Kalubanga, Tumwebaze, & Kakwezi, 2016).

Pakistan's public drug industry shows a ton of guarantee; however, there are a great deal of steps that should be taken with the end goal, for it's anything but a really serious local industry pioneer, and one of those means is the progression and upgrade of its inventory network and the executives execution (Khan, Rashid, Rasheed, & Amirah, 2023). There are in excess of 600 organizations that work in Pakistan. The specific number is difficult to decide in light of the fact that it will in general vary with a vertical inclination every now and then. It is qualified to take note that the greater part of the drug firms that have been set up in the nation are working units (Usman, Rauf, Ahmad, & Sparks, 2019). Globally, the market players in the garment industry are working hard to penetrate the market by increasing their global share to survive and thrive by increasing their productivity and reducing their lead times. Simultaneously, they should also have to defend their local market from international players. The major challenge faced by such market players at the time of competition is how they can distribute their goods to customers both locally and internationally with minimum delivery time and defect-free deliveries. Supply chain performance is critical for organizational growth and output (Ahmed and Sattar, 2019).

In various industries, supply chain performance plays an effective role in development and innovation. Due to changes in technology and innovation, the supply chain has become an integral part of every organization, and its impact is evident in its output. The supply chain activities include procurement, production and manufacturing, warehousing and inventory management, distribution of goods and services, and logistics performance (Zaman et al., 2023). The research evaluates distribution network strategies and their effectiveness on organizational performance and change in output organization (Stadtler, 2015). The supply chain is a group of three or more units that are directly involved in the upstream and downstream flow of finances, services, information, and products from source to client (Mentzer et al., 2001). The long-term competition in small and medium enterprises focused on the clients and development of customers with good quality services, better prices for customers, and additional value-added services to increase customer focus (Arsawan et al., 2020). Generally, the supply chain contains customer services, inventory management, production planning, operations of information systems management, purchasing and sourcing, production planning, warehousing, order processing, and disposal of materials and packaging aftermarket (Haque et al., 2023). Therefore, the combination of these actions through better relations guarantees a prolonged competitive advantage. An appropriate combination of these

actions will also provide a higher value to end services and products than the actions' total cost (Stadtler, 2015). All around the world, the market players in the clothing industry are striving to enter the market by expanding their worldwide offer to endure and flourish by expanding their efficiency and lessening their lead times. At the same time, they ought to likewise need to safeguard their neighborhood market from worldwide players (Jamil et al., 2023). The significant test looked at by such market players at the hour of rivalry is how they can appropriate their merchandise to clients both locally and globally with the least conveyance time and defect-free conveyances. Key positioning of the stock is fundamental to making the item accessible to the client at the hour of interest (Aziz, Memon, & Ali, 2020). The supply chain is coordinated with different divisions for operations and assembling; the supply chain is associated with showcasing, requests, and procurement; flexibly, chains are associated with the deals office to give prepared, finished great stock on schedule for deals in the interest of clients to satisfy their orders.

Supply chain execution is essential for affiliation advancement and yield. In various ventures creation and network execution, expect an incredible part being created and progression. Due to the advance of development and improvement, stock organization has become a basic piece of every affiliation, and its impact is clear on affiliation yield. The store network practices consolidate securing, creation and amassing, warehousing and stock organization, apportionment of work and items, and collaboration execution. The assessment surveys the distribution network procedures and their practicality for progressive execution and change in yield affiliation (Banker, Mashurwala, & Tirpathy, 2014). The supply chain information medium provides firms with activities to share information about distribution facilities through an IT network. The supply chain information is the chain of activities provided by the firm to attain a competitive environment. Firms prefer methods of outsourcing to develop supply chain activities (Kalkan and Ayden, 2020).

Firms use production network procedures to fulfill their clients more than their rivals. The choices engaged with this guarantee the accomplishment of the promotion focuses of firms. A regular store network technique tries to accomplish a smooth stream with the base expense. Then again, these days, customization is particularly significant in items and administrations. In an internationally serious climate, firms incline toward techniques, for example, moving to foster inventory network methodologies that are predictable with incentives (Souten et al., 2012). The capacity to rapidly adjust individuals, organizations, and activities as per clients' dynamic and tempestuous prerequisites is the deftness of the production network. Market affectability, measure coordination, organization, and virtual-based construction are needed for store network deftness. This can be accomplished through synergistic connections, measure mix, data incorporation, and client affectability in accomplishing client-arranged objectives (Usman, Raouf, Ahmad, & Sparks, 2019). The output, which is overall productivity, elaborates the performance and productivity organization based on inputs and manufacturing and supply chain activities and looks to inspect how multi-channel activities influence a company's performance. The pharmaceutical industry is a critical industry that is growing worldwide, and the same is true in Pakistan. Due to the advent of technology, many diseases, vaccines, and medicines have been discovered, produced, and tasted worldwide.

Supply chain execution is basic for association development and yield. In different enterprises, production network execution assumes a powerful role in development and

advancement. Because of the progress of innovation and development, the inventory network has become an indispensable piece of each association, and its effect is apparent on association yield. The store network exercises incorporate acquisition, creation and assembly, warehousing and stock administration, appropriation of labor and products, and coordination execution. The examination assesses distribution network techniques and their viability for hierarchical execution and change in yield association (Putra, 2018). The supply chain practices they follow include procurement logistics, production and manufacturing, capacity control, and the movement of products to end consumers. The distribution networks affect the overall organizational performance and sales, and a strong distribution network, product availability, and aggressive selling affect the organizational performance (Putra, 2018). At long last, there is a need to examine whether carrying out estimation frameworks to assess inventory network execution is savvy, particularly for small businesses (Filipe, Easingwood, & Coelho, 2013). Since the term production network was presented to the executives, there has been a lot of disarray about what it really includes. It is broadly recognized that there has been a moderately low premium in creating estimation frameworks and measurements for assessing store network execution. While a few administrators and specialists keep on utilizing it conversely with coordination, there is an expanding understanding that production networks are considerably more than coordination (Kalubanga, Tumwebaze, & Kakwezi, 2016).

Supply chain management is described as a phenomenon that targets organizing and managing operational duties at the strategic level of a firm confined within a chain. In this scenario, SCM covers aspects from operations to strategy, and consequently, the requirement for different managerial stages is also essential (Estampe et al. 2013). As per SCM, it takes in the management and planning of all the activities related to purchasing, sourcing, logistics management, and conversion. This field is also responsible for collaboration and coordination with frequent suppliers, channel partners, intermediaries, service providers through outsourcing, and customers. In short, SCM incorporates demand and supply management inside and outside of organizations.

In addition, these authors emphasize the need for a structured framework for the design, implementation, and improvement of the approaches mentioned above. SCM is responsible for implementing and developing purchasing arrangements that will boost the viable status of the company. As a result, supply chain management takes into account both the inputs purchased and the management and transition of production outputs (goods and services). SCM is able to guarantee the competitiveness of the company in different ways, for example by reducing the material cost, the time of cycles, and the time required for the products to enter the marketplace. Supply chain execution is basic for association development and yield. In different enterprises, production network execution assumes a powerful role in development and advancement. Because of the progress of innovation and development, the inventory network has become an indispensable piece of each association, and its effect is apparent on association yield (Prajogo and Olharger, 2012). The store network exercises incorporate acquisition, creation and assembly, warehousing and stock administration, appropriation of labor and products, and coordination execution. The examination assesses distribution network techniques and their viability for hierarchical execution and change in yield association (Putra, 2018).

This research emphasizes the strategic significance of supply chain management strategies for SMEs in Pakistan's garment sector. The Pakistan Trade Development Authority (PTDA) elaborates on the figures: SMEs contribute 40% of GDP output and enhance the growth of the manufacturing sector in Pakistan in 2019–2020 (Chang, Lu, Lai, 2021). SCM is responsible for implementing and developing purchasing arrangements that will boost the strategic position of the company. In addition, supply chain management facilitates an organization's potential for innovation. Previous research discussed in Section 2.4 evidently shows the significance of supply chain management approaches for a firm. That subject is similarly general for SMEs. Hence, recognizing the significance of SCM strategies in the development of SMEs is of paramount importance to economics. SMEs create jobs and stimulate the growth of the economy, particularly in developing countries. SMEs provide good job opportunities and increase employment in the economy. Thus, this increase has had a positive impact on the economy and growth (Wang, Huo, and Zhao, 2020).

In addition, SMEs confront other definite challenges related to less expensive products that flood the market from countries like India and China. SMEs must, therefore, prepare to confront the challenges posed by intense competition and rapid globalization (Abrar, Bashir, Safeer, Shabbir, and Baig, 2018). Supply chain performance is based on the manager's performance and also on lead time, operational efficiency, and the strategic goals of the organization. Managing supply chain performance based on managerial performance and management of time and resources is referred to as supply chain management. Like in the past, the examination was conveyed in financial areas, while the current one utilized assembly areas. With the end goal of ensuring the dependability and worthiness of the discoveries, the examination focused on one firm inside the assembly business as opposed to testing a few firms inside the Kenya Association of Manufacturers. Moreover, the investigation utilized meetings with top administration to enhance the survey for inside and out data on how the firm used direct separation to acquire upper hand (Sreenivas & Srinivas, 2018).

The supply chain in which they create value and deliver value to the customer can connect resources, a number of organizations, and knowledge streams in innovation (Handfield and Nichols, 2002). Supply chains can be viewed as an effective organization which creates value-adding paths (Simchi-Leive et. al., 2003). Porter (1985) explained the general value-adding actions of the organization; basic activities: organization, internal logistics, outbound logistics, maintenance, marketing, sales, and service; supporting activities: R&D, purchasing, firm infrastructure, and human resource management. The value addition in products and services is the change of inputs to outputs (Hines, 2014). The supply chain focuses on the tangible value addition of products and services and on developing quality products and services. Building intellectual capital is also important as organizations focus on retaining employees for longer periods of time and develop the resources for the supply chain. Being flexible in terms of products and services and producing the products based on orders and enhancing supply chain activity (Banker, Mashurwala, & Tirpathy 2014). Supply chain management takes into consideration both the inputs purchased and the control and transition of production outputs (goods and offerings). SCM is able to assure the competitiveness of the corporation through extraordinary approaches, such as decreasing the cloth value, the time of cycles, and the time required for the goods to enter the market. The supply chain

execution is basic for affiliation improvement and yield. In different companies, production community execution expects an effective part to be advanced and developed. Because of the development of innovation and improvement, the inventory network will become an integral piece of every association, and its impact will be obvious on affiliation yield (Prajogo and Olharger, 2012). The shop community incorporates acquisition, introduction and assembly, warehousing and stock administration, appropriation of labor and products, and coordination and execution. The examination assesses distribution community techniques and their viability for hierarchical execution and trade in yield affiliation (Putra, 2018). The waste can be eliminated through lean manufacturing, as it also improves value addition (Rose et al., 2011). In Table 2 (see Section 2.2.3), there are best lean manufacturing practices that minimize the cost of production while improving the value addition of the manufactured items. Shop floor scheduling is a major factor in textile industries as it minimizes wastage of resources, generally in small enterprises (Bruce et al., 2004).

JIT is an element of lean manufacturing; it also plays a vital role in maintaining a minimum level of inventory, mitigating waste, and improving cash flow, resulting in higher value addition. Higher value-added is possible through the JIT system by improving the quality of small inventories (Lyu and Gunasekaran, 1997). Flexibility can also be measured as JIT (Sohal and Perry, 2000; Gunasekaran et al., 2004). Shop floor control scheduling can be done by reducing tool/machine set-up time and implementing effective cell layout in the manufacturing process; therefore, the improved quality levels and shorter time required for product development can be achievable and realistic (Chang, Lu, and Lai, 2021). The output is overall productivity, which elaborates on the performance and productiveness of an enterprise based totally on inputs and manufacturing and delivery chain sports and appears to look into how multi-channel activities impact a company's overall performance. The pharmaceutical enterprise is an essential industry that is growing globally and is identical in Pakistan. Due to the advent of technology, many diseases, vaccines, and remedies have been discovered, produced, and tasted internationally.

Supply chain execution is primary for affiliation development and yield. In distinctive establishments, manufacturing community execution expects an effective part to be advanced and developed. Because of the progress of innovation and development, the stock network has become a quintessential piece of every affiliation, and its impact is obvious on affiliation yield. The keep community sporting events include acquisition, advent and assembling, warehousing and stock administration, appropriation of exertions and merchandise, and coordination execution. The examination assesses distribution community techniques and their viability for hierarchical execution and alternate yield associations (Putra, 2018). In the logistics and manufacturing processes, international, aggressive gain emerges from the creation of supplier abilities to create purchaser value and reap cost and/or differentiation blessings, resulting in market proportion and corporation profitability. To obtain competitive gain by way of agility and responsiveness, deliver chain tasks based on collaboration, inclusive of the usage of incorporated systems and inspiring provider upgrading, can be hired. The researcher suggested that value and fine are part of the competitive benefit measurement. The study also recommended fee, pleasantness, dependability, pace of shipping, fee-to-

consumer pleasure, and product innovation as some of the vital aggressive priorities for manufacturing (Bruce and Daly, 2011).

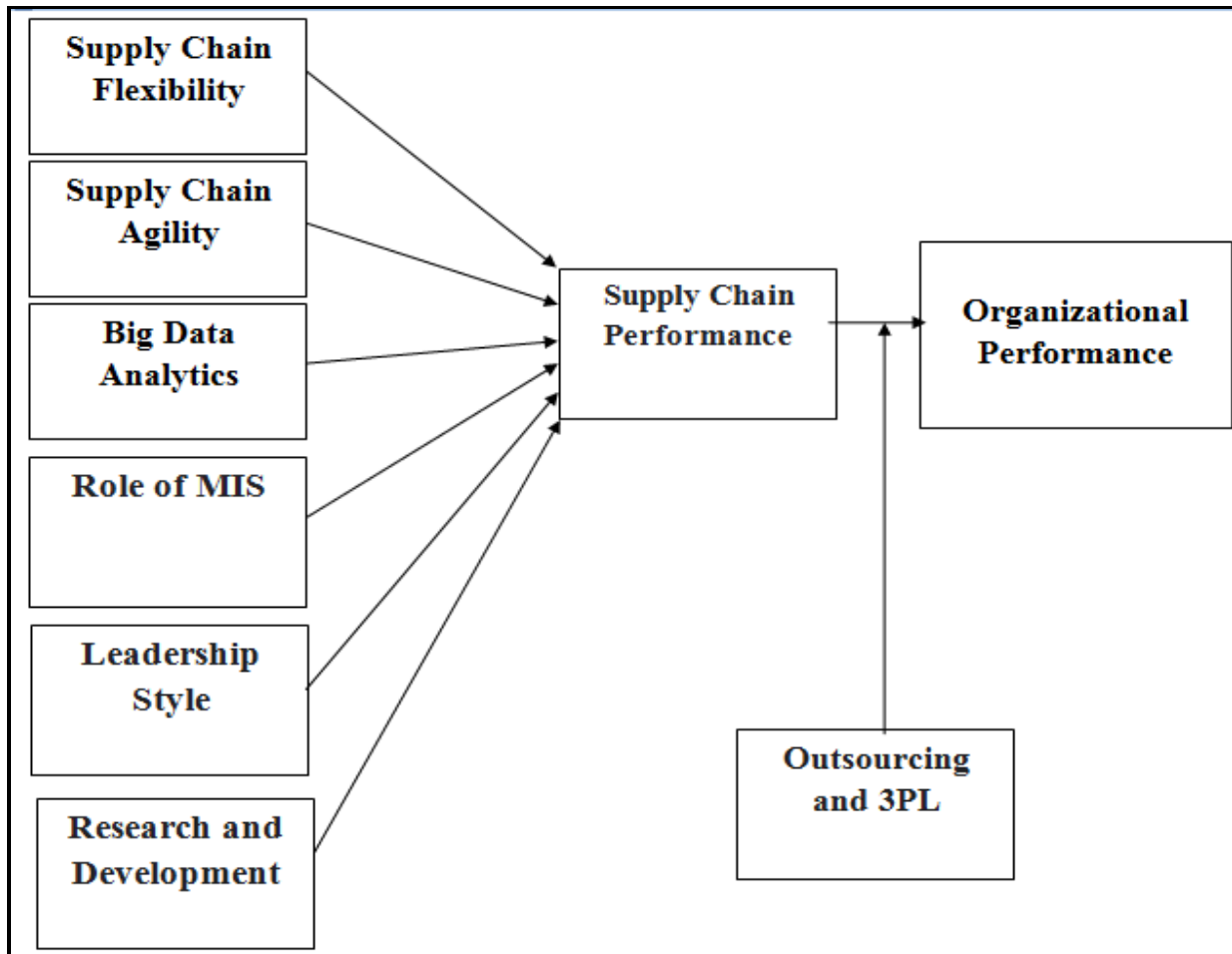


Figure 1.
Conceptual Framework

Source:

H1. There is significant impact of Supply Chain Flexibility on Supply Chain Performance.

H2. There is significant impact of Supply Chain Agility on Supply Chain Performance.

H3. There is significant impact of Big Data Analytics on Supply Chain Performance.

H4. There is significant impact of Role of MIS on Supply Chain Performance.

H5. There is significant impact of Leadership Styles on Supply Chain Performance.

H6. There is significant impact of Research and Development (R&D) on Supply Chain Performance.

H7. There is significant impact of Supply Chain performance on Organizational Performance

H8. There is significant mediating impact of Supply Chain Indicators and Organizational Performance.

H9. There is significant moderating impact of Outsourcing and 3PL in relationship of Supply Chain performance and organizational performance.

METHODOLOGY

Research Design

The research design elaborates on the methods and choices researchers select to conduct the research (Sunders, 2011). This research was conducted based on epistemology and the post-positivist research paradigm to test the hypothesis and expand the limits of knowledge. The research is conducted based on a quantitative approach, and the research is explanatory in nature. The research conducted in the automobile sector of Karachi, Pakistan, is limited to the supply chain performance of organizations. The type of research is quantitative; the research will be conducted based on theory and hypothesis, and data will be collected through a questionnaire. The research is quantitative in nature because there is already available theory and knowledge on this topic, and researchers will abstract further into the same area in different industries.

Population of the Study

The research population is the supply chain departments of automobile sector companies. The automobile sector industry includes Toyota Motors, Honda Motors, and Suzuki Motors. These 3 companies were selected for the collection of data from supply chain departments. The research was conducted in the field of supply chain management and worked on outsourcing third-party logistics in the automotive industry of Pakistan. The companies are selected from Karachi, Pakistan, those companies that have factories and operations here in the vicinity of Karachi.

Sampling Technique and Sample Size

The sampling strategy Convenience sampling. The data will be collected from supply chain experts in the automobile sector in Pakistan. Based on a 95% confidence interval and a 5% margin of error (Saunders, 2011), the sample size will be 100. The target population of the research is about 10,000 employees, considering employees of the automobile sector in Pakistan. The data collected from supply chain experts of selected companies to achieve the research purpose.

Research Instrument

The Research was conducted based on a questionnaire and will be developed based on the adopted model and scale. The research questionnaire will be adopted from the articles Ozoglu & Buyukkelik (2017) and Ashok & Rajesh (2019). The Likert scale was adopted to develop the questionnaire. The research is quantitative, and only a questionnaire will be used to collect the data for the research.

DATA COLLECTION ANALYSIS TECHNIQUES

The data was collected from supply chain management employees and managers of selected automobile sector industries. The data will be collected from the automobile sector industry, which includes Toyota Motors, Honda Motors, KIA Motors, Ford Motors, and Suzuki Motors. The collected data was processed through Smart PLS software, and analysis performed to analyze the results based on primary data includes Reliability and validity analysis, structural equational modeling regression, path coefficient analysis, and hypothesis testing.

DATA ANALYSIS

The research was conducted to analyze the impact of Industry 4.0 indicators on the supply chain performance of manufacturing firms in Pakistan. Industry 4.0 places emphasis on technological innovation, supply chain flexibility and agility, big data analytics, adaptation of technology, use of artificial intelligence, robotics, fintech, and the internet of things so that organization production and manufacturing remain up-to-date and industry reaps the benefits. The data collected from manufacturing organizations and research is focused on the automobile sector in Pakistan. The supply chain activities change with changes in technology, and manufacturing organizations adopt new techniques and usage. The supply members who are involved and have worked in the supply chain industry for years have a greater scope of knowledge, and they can elaborate on their industry and organization, how they develop changes in the supply chain, and what practices have been changed with references to Industry 4.0 practices in relevant organizations. The research was conducted through a questionnaire and primary data collection. The research elaborates on the relationship and impact of 3PL drivers and outsourcing of logistics on the business performance and outcome of the organization. The firms are taking action by going for 3PL when they have observed they can gain better outcomes and benefit in terms of profitability. The research data collected from 100 employees of automobile organizations includes Honda Motors, Suzuki Motors, and Toyota Motors, and all are top- and middle-level managers.

Table 1.
Demographics - Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	67	67	67	67.0
	Female	33	33	33	100.0
	Total	100	100.0	100.0	

The data collected from employee of manufacturing sector and data has been collected from 100 managers of automobile sector, among them 67 are males and 33 are females.

Table 2.
Demographics - Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-25	30	30	30.0	30.0
	26-35	21	21	21.0	51.0
	36-45	19	19	19.0	70.0
	Above 45	30	30	30.0	100.0
	Total	100	100.0	100.0	

The respondents are varying in age, the respondents are the 18 to 25 years are 30, 26 to 35 years are 21, 36-45 years are 19 and above 45 years are 30 respondents.

Table 3.**Demographics – Education**

	Frequency	Percent	Valid Percent	Cumulative Percent
Graduate	41	41	41.0	41.0
Masters	59	59	59.0	100.0
Total	100	100.0	100.0	

The respondents with different level education and working experience are the part of research, respondents with 41 are Graduate and 59 are Post Graduate and having Masters Level of education.

Table 4.**Demographics – Income**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Rs. 40,000 - 60,000	10	10	10.0	10.0
Rs. 60,001 - 80,000	72	72	72.0	82.0
80,001 - 100,000	18	18	18.0	100.0
Total	100	100.0	100.0	

The respondents have different levels of income based on their profession and business; 10 respondents have an income of Rs. 40,000 to 60,000; 72 respondents have an income range of Rs. 60,000 to 80,000, which is a major chunk; and 18 respondents have an income range of Rs. 80,000 to 100,000.

MEASUREMENT MODEL

The measurement model in the PLS-SEM was analyzed to confirm the relationship of the items with their respective constructs (Hair Jr. et al., 2016). It also validates the health of the collected data. In the measurement model, the reliability and validity of each model construct have been assessed. As this study is based on the three primary constructs, all of them are of second order. Therefore, at first, we run the measurement model of each second-order construct with its first-order sub-constructs to validate the measurement model of each second-order with their first-order separately. After the validation, we used the latent scores of the second-order construct to run the study's structural model or primary model. The model explains the relationship between variables moderation and mediation and the values of each factor loading with t statistics and model analysis to determine which variables are significant and which are insignificant.

The model elaborates the relationship between variables based on the highest correlation, beta coefficient, and t statistics, while the researcher performs the SEM regression model. First, researchers check the reliability of the data based on Cronbach's alpha and composite reliability, and then analysis is performed based on SEM regression. The reliability and validating tests performed in Smart PLS are based on structural equation modeling (SEM). The values of factor loading show the consistency of response over the scale on each statement, and the values of Cronbach's alpha show the consistency of responses over each variable. The variables greater than 0.7 show better consistency.

Table 5.
Reliability and Validity

Variables	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Big Data Analytics	0.805	0.812	0.884	0.718
Leadership Style	0.744	0.757	0.856	0.666
Organizational Performance	0.770	0.774	0.867	0.685
Outsourcing and 3PL	0.779	0.790	0.871	0.693
R&D	0.770	0.777	0.867	0.687
Role of MIS	0.860	0.864	0.914	0.781
Supply Chain Agility	0.765	0.774	0.864	0.680
Supply Chain Performance	0.730	0.731	0.849	0.653
Supply Chain Flexibility	0.781	0.787	0.872	0.694

All the variables, including supply chain flexibility, supply chain agility, research and development, role of MIS, leadership style, and big data analytics, are independent variables; supply chain performance is taken as a mediator; outsourcing; and 3PL is moderation between supply chain performance and organizational performance. The data collection and values of Cronbach's alpha and composite reliability are greater than 0.7, which is required, and research results can be used for further analysis.

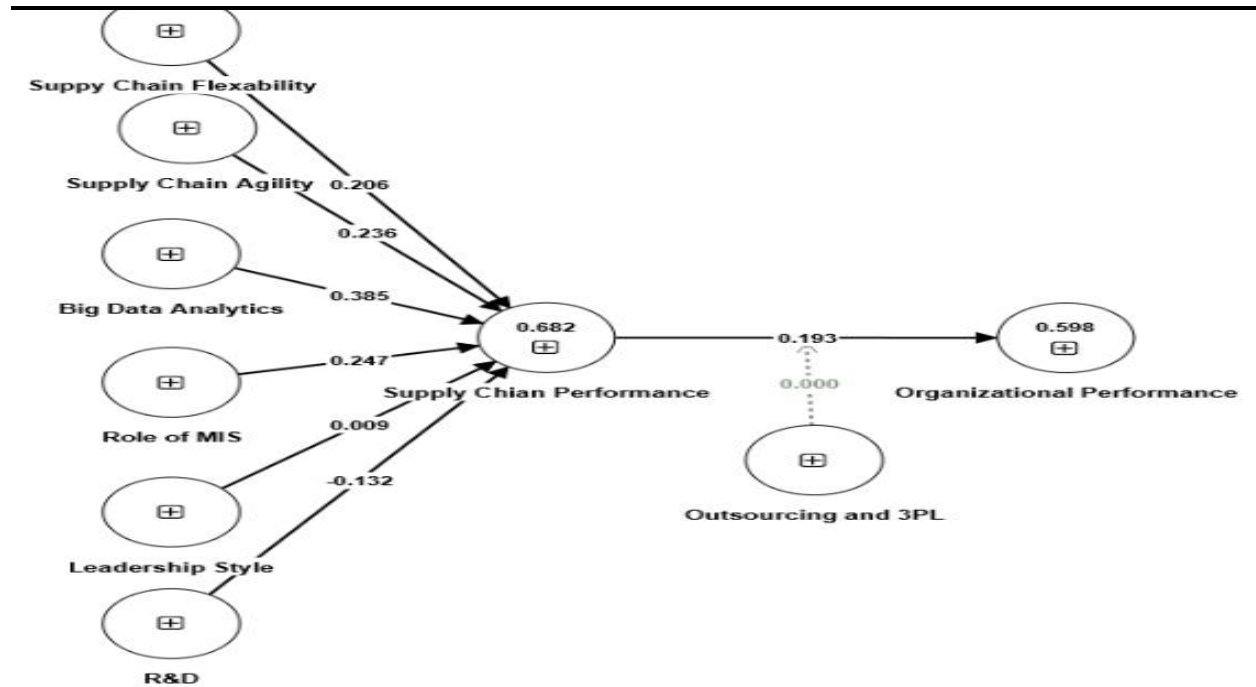


Figure 2.
Structural Model of SEM

Table 6.
Path Co-efficient

Paths	T statistics	P values
Big Data Analytics -> Supply Chain Performance	7.920	0.000
Leadership Style -> Supply Chain Performance	0.198	0.843
Outsourcing and 3PL -> Organizational Performance	14.418	0.000
R&D -> Supply Chain Performance	2.195	0.028

Strategic Impact of Industry 4.0 and Big Data		Arif, M, et al. (2023)
Role of MIS -> Supply Chain Performance	5.922	0.000
Supply Chain Agility -> Supply Chain Performance	6.734	0.000
Supply Chain Performance -> Organizational Performance	3.892	0.000
Supply Chain Flexibility -> Supply Chain Performance	4.259	0.000
Outsourcing and 3PL x Supply Chain Performance -> Organizational Performance	0.004	0.996

Table 6 and Figure 2 show the analysis of each independent and dependent variable. The results show that the variables are significant and that there is a significant moderating and mediating impact of the variables. The research considers the relationship of variables based on Supply Chain Flexibility, Supply Chain Agility, Research and Development, Role of MIS, Leadership Style, and Big Data Analytics as independent variables. Supply chain performance is taken as a mediator, outsourcing, and 3PL is moderation between supply chain performance and organizational performance. All relationships are significant except one direct relationship between leadership style and supply chain performance, which is insignificant, and moderating impact between supply chain performance and organizational performance is also insignificant. The hypothesis testing table shows the relationship between variables based on a 95% confidence interval and a 5% margin of error. The research results show that all the variables, including supply chain flexibility, supply chain agility, research and development, role of MIS, leadership style, and big data analytics, are independent variables that impact supply chain performance. Only one relationship is insignificant between leadership style and supply chain performance. The research also proves that the mediating impact of supply chain performance indicators and organizational performance is also significant.

CONCLUSION

The research explored the factors of Industry 4.0 and how they shaped manufacturing organizations to change their supply chain practices. Supply chain practices affect organizational performance and enhance organizational activity to increase performance and efficiency. The quantitative research conducted based on variables includes supply chain flexibility, supply chain agility, research and development, role of MIS, leadership style, and big data analytics, which are independent variables; supply chain performance is taken as a mediator; outsourcing; and 3PL is moderation between supply chain performance and organizational performance. The research results show that all the variables, including supply chain flexibility, supply chain agility, research and development, role of MIS, leadership style, and big data analytics, are independent variables that impact supply chain performance. Only one relationship is insignificant between leadership style and supply chain performance. The research also proves the mediating impact of supply chain performance indicators and organizational performance is also significant. The research is useful for managers and manufacturing organizations to analyze the process of Industry 4.0 and how it changes supply chain performance and activity with change. enhanced management performance and control, reducing costs, and increasing sales. Supply chain agility and flexibility are gained through effective production and time management. Supply chain practices are improved in the context of better production, better control, better manufacturing facilities, and location. Due to the adaptation of technology, more control over

production and quality has been gained. The industry dynamics focus on competition and a better approach to the level of production. Firm performance is affected by organizational supply chain services, and supply chain activities play a pivotal role in the development of organizational competence. Various business demands demand a higher degree of individualization to the requirements, focusing on end users and a more competitive edge over others. Industry 4.0 is the idea for the enterprise revolution and focuses on innovation and improvement. Supply chain flexibility was one of the key factors that was analyzed in the research.

Table 7: Hypothesis Testing

Hypothesis	T va values	Sig. Value	Decision of Hypothesis
H1: There is significant impact of Supply Chain Flexibility on Supply Chain Performance.	4.4	0.00	Accepted
H2: There is significant impact of Supply Chain Agility on Supply Chain Performance.	6.734	0.000	Accepted
H3: There is significant impact of Big Data Analytics on Supply Chain Performance.	7.920	0.000	Accepted
H4: There is significant impact of Role of MIS on Supply Chain Performance.	5.5	0.00	Accepted
H5: There is significant impact of Leadership Styles on Supply Chain Performance.	0.198	0.843	Rejected
H6: There is significant impact of Research and Development (R&D) on Supply Chain Performance.	2.195	0.028	Accepted
H7: There is significant impact of Supply Chain performance on Organizational Performance	3.8	0.00	Accepted
H8: There is significant mediating impact of Supply Chain Indicators and Organizational Performance.	0.004	0.996	Rejected
H9: There is significant moderating impact of Outsourcing and 3PL in relationship of Supply Chain performance and organizational performance.	14.4	0.00	Accepted

IMPLICATIONS OF RESEARCH

Research and development are the core parts of organizational innovation, and research and development returns are important for organizations. The research is useful for manufacturing organizations and the supply chain industry to analyze innovation and technological change in organizations and how supply chain processes shift and paradigm changes happen in organizations. Industry 4.0 brings supply chain innovation, supply chain agility, and flexibility, helps organizations achieve sustainable development goals, and increases performance and productivity by reducing costs and increasing efficiency. The research is useful for managers and manufacturing organizations to analyze the process of Industry 4.0 and how it changes supply chain performance and activity with change.

AREAS OF FURTHER RESEARCH

The research is useful for organizations to analyze supply chain activities and enhance organizational performance. Further research can be conducted to analyze the impact of big data analytics on supply chain performance. Research also needs to be conducted to evaluate the impact of the Internet of Things on the supply chain industry and other factors of technological innovation.

DECLARATIONS

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Availability of data and material: In the approach, the data sources for the variables are stated.

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Conflicts of Interests: The authors declare no conflict of interest.

Consent to Participate: Yes

Consent for publication and Ethical approval: Because this study does not include human or animal data, ethical approval is not required for publication. All authors have given their consent.

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Appendices

Appendices 1: Questionnaire

Questionnaire

I am an MBA in Supply Chain Management from Greenwich University, Karachi, Pakistan. I am conducting research on "The Impact of Industry 4.0 Indicators and Big Data Analytics on Supply Chain Performance". You are invited to participate in this research. Survey responses assure you that they will be strictly confidential, and data from this survey will be reported only in aggregate. You're understanding and cooperation in this academic exercise will be highly appreciated.

Name of Respondent: _____

<u>Gender</u>	<u>Age (years)</u>	<u>Education</u>	<u>Monthly Income</u>
<input type="checkbox"/> Male	<input type="checkbox"/> 18-25	<input type="checkbox"/> Intermediate	<input type="checkbox"/> Rs. 25,000 to 50,000
<input type="checkbox"/> Female	<input type="checkbox"/> 26-33	<input type="checkbox"/> Graduate	<input type="checkbox"/> Rs. 50,001 to 75,000
	<input type="checkbox"/> 33-40	<input type="checkbox"/> Post graduate	<input type="checkbox"/> Rs. 75,001 to 100,000
	<input type="checkbox"/> Above 40		<input type="checkbox"/> Above 100,000

Please tick the most appropriate items that best describe you (1=Strongly Disagree, 2= Disagree, 3= Neutral, 4=Agree, 5= Strongly Agree

Constructs and References	1	2	3	4	5
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Innovation

- Realization of cost reduction
- Organization has consultative/knowledge-based skills
- Organization has flexibility in operations and delivery
- Organization follow continuous improvements

Big Data Analytics

- Improve Employee Morale
- Logistics Cost reduction
- Enhance Customer Satisfaction
- Enhance Internal Logistics System Performance

Supply Chain Agility

- Delivery time
- Flexibility

Attitude towards customer/relationship

Strategic commitment to customers

Reliability of the 3PL provider

Supply Chain Flexibility

Reputation

Ability to meet customer needs

Storage facilities

Quality of services

Internet of Things (IoT)

Reduce Cost and Increase focus

Good communication

Financial stability

Documents accuracy

Technical competence

External Environment and Competition

External Forces enhance competition

Enhance Average order cycle length

Diverting capital investment and use of Commerce application

Affect on business performance and sales

Supply Chain Performance

Focus on core competencies

Logistics cost reduction and Improved customer service

Improve conformance quality

Improve process capability and cycle time

Organizational Performance

To develop supply chain flexibility

Improve process lead time

Access to emerging technologies

Improve return assets and increase inventory turn

Thank you for your time and cooperation**Sources adapted from;**

Ozoglu, B. BUYukkeliç, A. (2017). An Analysis of Third Party Logistics' Performance and Customer Loyalty. *International Journal of Marketing Studies*, 9(6).

Ashok & Rajesh (2019), Business Performance Measures in Third party logistics, *International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, 8(4), 121-134.*



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