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Smart Supply Chain & Smart Technologies Adoption to Improve Operational Performance in Manufacturing Industry

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ABSTRACT

In the competitive and progressive world where every company tries to maintain competitive advantage in order to adopt leadership position of the industry by implementing differentiation and cost leadership strategies. In this scenario, 4.0 Industry and adopted Smart Supply Chain as the most effective tool to decrease the overall Supply Chain expenses and increase the profit and improve company operations. Smart Supply Chain has become the essential requirement of every company which has also become an emerging strategic tool & essential facilitator for firms which pursue adaptation with the idea of resilience and sustained competitiveness that results the company to grow exponentially and meets societal and environmental requirements which helps to gain customer confidence and loyalty with the future aspect of relationship. Through content analysis, the model identifies the critical production-level and technology elements that affect a firm's capacity to develop responsive, ecologically sustainable, and digitally oriented supply chains.

Introduction

Globalization is continuously growing in supply chains to improve continuous operations and reflect their impact to reduce its impacts and leads to sustainable performance. For that purpose, we utilize Artificial Intelligence which transformed the idea of acting as a responsive catalyst as agility has become the primary issue faced by companies. In these issues, model that have been driven by AI helps to improve societal, economical issues with real time data checking to improve operational stability.

SCM operate excellently and resiliently in the long term approach; whereas, it is necessary to address them. Nonetheless, previous research shows the result that AI application of

manufacturing industry has confirmed that the advantages usually prevail over the disadvantages as AI gets used in a strategic manner to solve the key challenges, including sustainability and efficiency in the processes. (António R. Teixeira, 2025).

Artificial intelligence technologies have also proven to be incredibly promising in enhancing key supply chains including the process of choosing vendors, inventory control, and logistics modelling. The use of algorithms enables anticipating demand, preventing stockouts, and demands to take optimized decision in difficult environments (Smith GE, 2007). The adoption of the further digital technologies have developed different technologies along with AI, have also led to the overall improved organizational performance. In the current research we report technological tool that optimize various businesses in majority of the industries to enhance and add agility in their organizations. We give a holistic evaluation of agility (Gupta S, 2019)and Industry 4.0 technology in dimensions and facet.

Although it is an increasingly important topic, our thorough review of the literature only revealed a handful of articles that specifically deal with the overlap between supply chains and M2M. Hence, it is obvious that additional empirical investigations need to be conducted to explore the impact of M2M technologies on agility in both supply and value chains (Gupta S, 2019).

Literature Review

A majority of the businesses might lack the necessary potential of developing their smart technology capacity, a variable, which presents a relative net impact of it (Subramanian, 2020) Multinational corporations or otherwise referred to as transnational corporations, are simply large and mighty corporations with the big hand in the environment and society.

The modern society is undergoing critical challenges. Whereas, manufacturing industry (Chatchawanchanchanakij P, 2023)has also been evolved and defined the certain measures to improve sustainability performances though mediating role of flexibility of the SC and autonomous role of the SSC, but the results were not so good as it has become a global issue (A N. F., 2019). Several scholars in the past were able to come up with various facts which were inefficient. In the paper, SCF progressed as the mediator between fluctuations of different notions of Smart Supply Chains and Operational performance (AlMulhim, 2020). The proposed research would be conducted in Pakistan and manufacturing sector would be sampled. The sample will include those individuals who are related to the manufacturing industry, even though the manufacturing industry in Pakistan will form part of the population (MD, 2022).

This literature will contribute immensely to the work. It will surely expand the digital online content (Li G, 2019). They can receive a suggestion of how to utilize supply chain flexibility as a middleman in order to improve their growth (Guo X, A comprehensive review of blockchain technology-enabled smart manufacturing: a framework challenges and future research directions, 2022).

The governmental institutions will also find this study useful. The governmental officials were concerned in the production industry development (B, 2023). They will be able to receive diverse pieces of advice which they will be able to implement, design fresh strategies concerning the further development for production as it impacts in real life as well. Experts can provide the insights of the process to improve the industry operations and process (X, 2020). Previously, SSC was not considered the main pillar but now time has been changed and with the introduction of IT (X, 2020) has evolved the whole concept of company’s operations and organizations have started

to adopt SSC (A A. M., 2023).In early 1990s manufacturing industry was facing issue and disruption which leads to the decline of its contribution in country's economics condition. At that time, OP has been evolved and industry recognize its significance in terms of the performance improvement.

There are four dimensions of OP which cater to improve the performance and tends to achieve the short term and long terms goals and deliberately improve company's performance in terms of operations.

indicates that, intelligent supply chains and high-technology introduce many opportunities in operations performances. All these opportunities aid in enhancing efficiency, responsiveness and competitiveness in the industry. These dimensions will see these firms integrating their strategic investments with operations to reap maximum benefits of moving towards intelligent supply chains deployment.

This is because since the late nineties the manufacturing sector has not been making much impact to the national economy considering that this is an export oriented sector. This has contributed to reduced economic participation of the country in the globe. This industry also emerged due to the fact that the utilization rate of the capacity in the sub-sectors including petroleum, chemicals, rubber, and plastic products was high (Zhang G, 2022). This has materialized in regard to high growth of exports and IPI of most of the major trade partners. (Sukathong S, 2021). SCF refers to a multifaceted construct that has many linked variables which play positive roles towards the effectiveness of an organization to respond positively to environmental volatility and market dynamics.

Flexibility of supply chain is initially split into three major elements that include sourcing and supply flexibility, manufacturing flexibility, and distribution and delivery flexibility. Sourcing and supply flexibility means the capacity of the organization to flexibly adaptability in demand or have the capacity to switch-suppliers or flexibly vary the quantity of inputs when demand changes or when supply is interrupted. Introducing flexibility concept in manufacturing means the ability of manufacturing systems to support the change in product diversity, quantity/process specifications of the product without any substantial decrease in efficiency. Flexibility in distribution and delivery is an emphasis on the abilities of the organization to change the delivery schedules/timelines, mode of transportation, or the distribution routes with an aim of satisfying the consumer.

The articles under analysis include the article which explain the role of SCF on OP. In theoretical basis of sustainability performance management, an INSC is act like a catalyst in supply chain implementation & functioning, which is in turn effectively mediated by the supply chain flexibility, it also provides the elucidation of the role of the SCF by dividing into micro&macro flexibility processes which characterize effect on the OP. The supply chain flexibility aids in enhancing the instrumented supply chain performance and results of its sustainability. In result it shows that SCF has a critical mediating effect between instrumented supply chain and sustainability performance.

ST emphasizes transition in production system in the countries to the phase of mechanization, intelligent and interconnected technology. This evolution justifies the reason why technical inventions have remained to revolutionize the production mode, effectiveness in the process of operations, and competitiveness of the industries. The drivers of manufacturing transformation are the ST that includes the various technologies Industrial IoT, big data analytics, and cloud

computing. A large number of elements integrated into gadgets that make them smart characterize such technologies. Smart technologies gather and analyze data and help to develop the data into the information and take decision based on it. This technology should contain the ability to calculate and provides valuable information with the communication ability. The case of a service provider like that can be Amazon Echo home assistant devices.

Companies of supply chain industries have been evolving and now they have started to invest in the development of a segmented system capable of integrating the physical capacity with the digital infrastructure, which is referred to in the literature as a SC structure, and capable of supporting solutions like intelligent containers, automated warehousing, port facilities, shelving system and manufacturing plants as the supply chain is becoming a complex architecture. It has since become the urgency of dealing with them, as well as learning to deal with the reality information necessary to deal with SSCM (FDG, 2022).

Workers working in warehouses, though, have introduced their own reservations as workers have been worrying that companies will replace them with technology and the robots which is not true as the result will be more accurate with the train employees who knows how to operate technology efficiently(Sardar SK, 2021) & may result accurate data in terms of the advantage of the operations, predicting the demand, resolving the frequent issues, and creating the most suitable ones (Omar IA, 2020).

The INSC is a model which certainly increased at a very high rate to the point where the investigators will be savoring the real-time information about all the elements and in instances where such information is employed will generate a crucial competitive advantage. As it can be seen, instrumented supply-chain approach implies additional visibility, performance control, optimization and transparency of supply-chain which is mostly directed towards the efficiency of result and resources. The devices yet to be created will feature real time dashboards that will show that whats the problem and we can come out of the problem with the best use of our resouces (Chatchawanchanchanakij P, 2023).

The definition in the paper of interconnected supply chain classifies it (Bayraktar E, 2009) as an advanced form of value chain which connotes additional communication with customers, suppliers, information technology systems and products used in production process. Through such relationship, there will be increased cooperation and overall perception of the supply chain. Some researchers have determined that they are involved in horizontal company partnerships and sharing vertically sharing vertically by other international partners, which translates to lowering the cost nut results to the information breaching or whistleblowing. These environmental systems are called and define as in pose operational, reconciliation and possible fraud and security issues.

INSC contains numerous limitations and alternatives to resolve the executives in deciding on trade-offs and simulation of alternate strategies without the interference of human. It is also able to tap into the physical assets like the industrial locations, fulfillment centres and transportation fleets on commission whenever it sees the need to utilise virtual transactions. It will also be put into use in real-time decision making and future events prediction (MS., 2009).

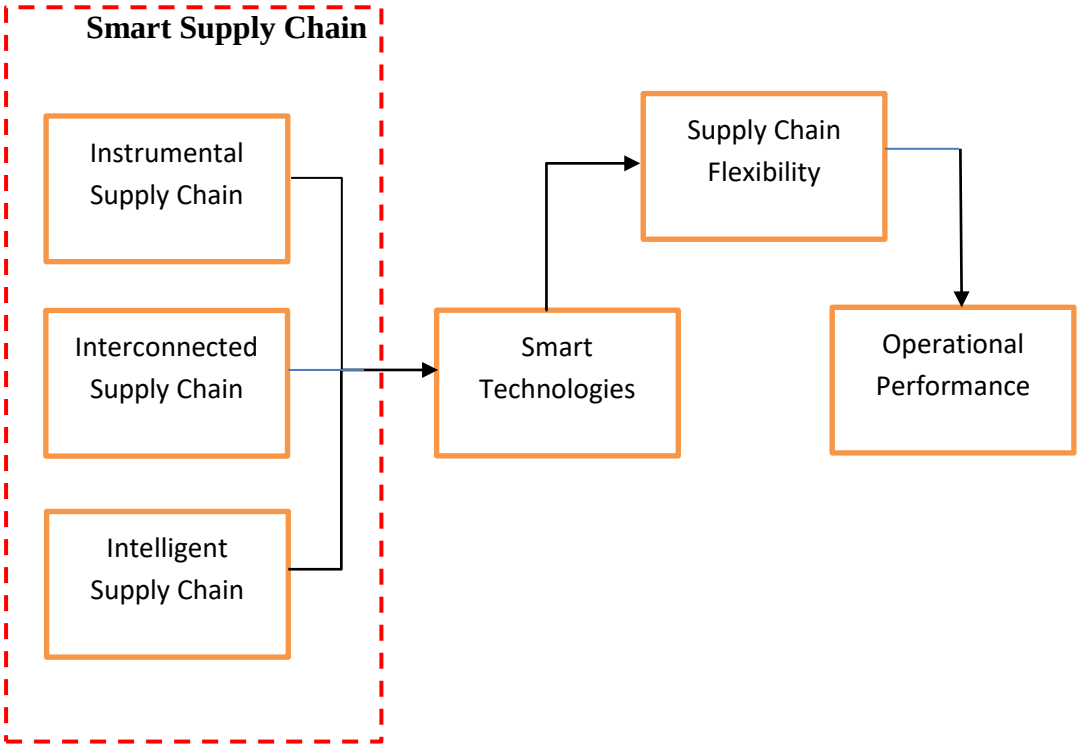


Figure 1 Conceptual Framework

Hypotheses development

Instrumented Supply Chain is the continuation of the concept of Smart Supply Chain that has already demonstrated itself as tractional in terms of business and operational performance (Hair JF, 2019). The concept of Instrumented Supply Chain is expanded into Smart Supply Chain paradigm that has gained popularity in the business and operational performance (Guo X, 2022). Most of these businesses have not succeeded in implementing industry technologies that may improve the overall performance and productivity of the business despite their heavy resources. To enable the instrumented supply chain, systematic gathering, management, and evaluation of the information require sensor technologies, hardware, and software, which enable the gradual intensification of the power of the practices connected with the adoption of sensor-related innovations (Manufacturers, 2022), therefore, the tendency towards adopting sensor-related innovations has been gaining momentum as the technologies become more accessible (Chau KY, 2021). It is indicated that the supply chain integration has also shown increasing interest in some of the businesses particularly by their gains and opportunities (D, 2022).

The success and operational performance of the organizations are positively related to the integration of suppliers or the involvement of the supply chain. It is based on the above statements that the following hypothesis will be formulated:

H1: The instrumented supply chain influences the operational performance positively.

The up-stream and down-stream stakeholders can be manipulated with supply chain linkages and also in the process improving functional performance. The high-level of the international supply chain integration and coordination is linked with the high performance and profitable investment

into connectivity (MD, 2022). The networked supply chain success is directly related to the operation management models that incorporate the asset management business system, the operational business systems and the logistics. One of the modern trends in the manufacturing industry, the search of smart supply chains must contribute to enhancing the core competitiveness in terms of quality of products and services, efficiency, and innovativeness, green practices, and coordination (Guo X, A Comprehensive review of blockchain technology-enabled smart manufacturing: a framework challenges and future research directions, 2022). Business manufacturers can be involved in healthcare supply chain, and this is a cross-industrial peculiarity of the study; it is defined as an enmeshed supply chain, which can ensure products and services provision to the society and markets (S, 2014). The collective handling of all the necessary information items is still scarcely studied, and the separate ones, including the lot size and the lead time are investigated (He L, 2020). The various views regarding management of comprehensive information in the interconnected supply chains should take into account the economic value and availability of various information (Ivanov D, 2018). The priorities and the attention levels of KPIs are also determined based on the extent of influence of disruptions to the supply chain network and its effects and connection between them and strategic position of the company.

It requires the quantitative analysis of reconfigurations to inject resiliency and viability with regards to the state of minor and major disruptions, which are predictable and unpredictable. Based on the above-stated, the hypothesis below is obtained:

H2:. The positive scope of interconnected supply chains is on the operational performance.

An integrated supply chain is able to learn, make decisions as well as reorganize its networks on its own when disruptions occur (A, 2023). Programs of next generation optimization and analytical solutions enable organizations and enterprises to enhance supply chain performance and decisions (Lee KL R. P., 2022). The intelligent supply chain has been recognized as among the most significant innovations in the sustainability performance and effective method of accomplishing optimum efficiency. The new supply chain will emphasize evolving an advanced intelligent infrastructure, which is composed of data, information, physical items, products, and business processes due to the development of semiconductors, computer science, and various engineering technologies (X, 2020). The orders may also be applied at the value chain with the help of smart supply chain manufactures, global teams, advanced analytics, and flexible technology (Lee KL R. P., 2022). The intelligent supply chain can be used to help capital investment management, emergency management and evaluation of the flexibility factors (customer demand, pricing, timing, and quality) with the help of the simulation analysis (A N. F., 2019). In turn, when it comes to the factors of research that hold the utmost significance in the field of supply management, one should bring up the way organisations prevent disruptions and develop contingency plans that can be applied to them (RA, 2022). The hypothesis is developed as a result of the above-mentioned statement:

H3: The effect of the intelligent supply chain on the operation performance is positive.

Instrumented supply chains (ICSC) use sensor technologies, RFID, and IoT devices to continuously capture data across logistics and operations. Even so, simply having raw data from instrumentation does not by itself ensure flexibility; the data should be utilized and converted into practical knowledge. Smart technologies (ST) like big data analytics, artificial intelligence, and blockchain are therefore intervening mechanisms which enable firms to reconfigure supply chain processes dynamically, hence increasing supply chain flexibility (SCFS).

H4: Smart technologies acts as a mediator between Instrumental Supply Chain & Supply Chain Flexibility.

The SEM results have confirmed the hypotheses that, while INSC did not have a direct positive effect on operational performance, it had a strong impact on SCFS. This impact was manifested in the use of smart technologies that changed the way the information produced by interconnected networks was transformed into actionable knowledge. Such a result is consistent with Gupta et al. (2019) and Lee et al. (2023) who state that integration alone is not a sufficient condition for agility and must be complemented by advanced technologies. The SEM results indicated that without smart technologies the interconnected supply chains component would not directly lead to operational performance improvements. Nonetheless, smart technologies serve as the enabler that allows interconnected supply chains to influence supply chain flexibility significantly.

Zara is an example that we can use to illustrate. The global fashion retail chain has an interconnected supply chain worldwide that links its suppliers, manufacturers, and stores. On its own, this network produces tons of data (inventory levels, customer demand, supplier lead times). This data without smart technologies remains isolated. Through AI analytics and blockchain platforms, Zara can convert this raw data into predictive customer behaviors, for example, and plan its deliveries accordingly. This flexibility enables Zara to respond to fashion trends and new competitive situations quickly and thus take advantage of opportunities in the market. This is a case where smart technologies have allowed INSC to influence SCFS. Consequently, the hypothesis follows:

H5: Smart technologies acts as a mediator between Interconnected Supply Chain & Supply Chain Flexibility.

The research findings reveal that ITSC had a slightly significant direct impact on operational performance, however, its indirect influence through ST and SCFS was quite strong and significantly supported. Thus, it can be said that intelligent infrastructures need smart technologies to convert complex data into adaptive strategies, which allows for flexibility and resilience.

As per SEM findings, intelligent supply chains had borderline direct effects on operational performance, but their pathway mediated by smart technologies and SCFS was strongly supported. Example: In the automotive industry, Tesla runs an intelligent supply chain with the help of advanced optimization programs and adaptive infrastructures. Tesla gathers data from vehicles, suppliers, and production plants. The direct effect of such intelligence on flexibility is, however, very limited unless it is facilitated through smart technologies. These claims have generated the hypothesis mentioned above:

H6: Smart technologies acts as a mediator between Intelligent Supply Chain & Supply Chain Flexibility.

The SEM analysis clearly indicates that smart technologies (ST) on their own provided only limited direct benefits to operational performance (OP), but when their impact was channeled through supply chain flexibility (SCFS), the connection turned out to be strong and significant. The central message behind the findings is that smart technologies by themselves cannot bring great performance results, but that they can make the supply chain more flexible, and thereby more effective, responsive, and competitive. Similarly, the work of Iriqat et al. (2025) revealed that smart technologies influence firm sustainability and performance outcomes via the mediating roles of flexibility and agility.

H7 Supply chain flexibility is a significant mediator variable between the relationship of Smart Technologies and Operational performance.

Research Methodology

Our study follows the established five-step process of conducting research by Denyer and Tranfield (2009) and illustrated in below figure.

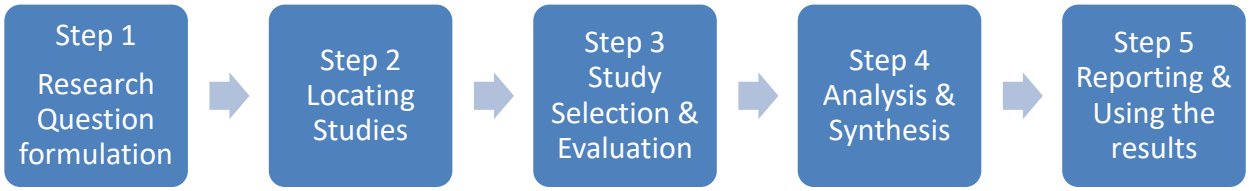


Figure 2 Research Methodology

The research methods used were quantitative methods that comprised the systematic amassing and statistical analysis of discrete information obtained by means of administration of structured, close ended questionnaires. The questions in the tool were based on available literature and the respondents were directed to fill the questionnaire using five-point Likert scale. The questionnaire was divided into two parts (Section A and Section B). Section A was aimed at measuring demographic variables, such as gender, age, education, occupational title, and tenure. Section B asked the respondents to agree with the thematic statements based on a Likert scale between 1 (strongly disagree) and 5 (strongly agree). Although Section 1 was meant to gather general features of the participants, Section 2 was devoted to the operational performance, functional role of smart technology, and the dimension of intelligent supply chain.

Sampling

The primary concern of sampling that is considered by the researchers is the size of the sample that must be paired with the method of analysis applied. More than 100 responders have respond through online surveying. will be achieved during the time of data collection that spans four months. The Descriptive analysis is done in Microsoft Excel and the Partial Least Squares Structural Equation Modelling (PLS-SEM) is done in Smart-PLS 4.0 software which entails testing reliability, validity, discriminant validity and testing hypotheses.

Results and Discussion

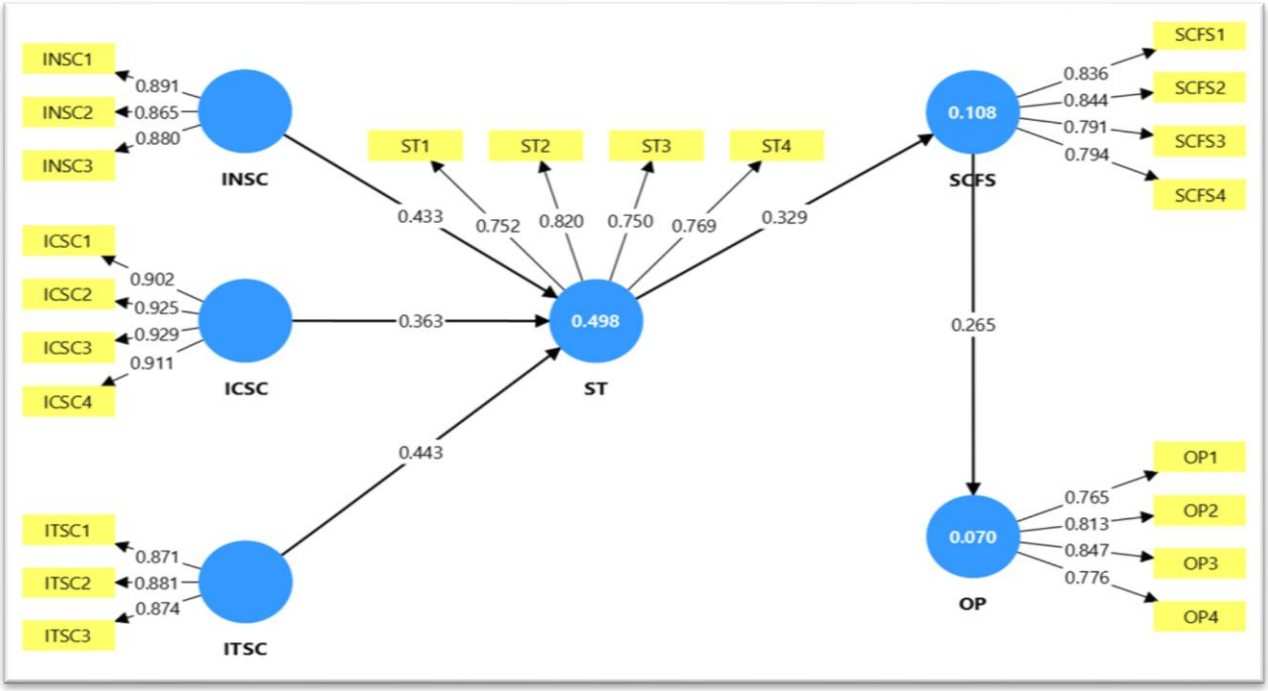
The table 1 depicts the means and the standard deviations of the major pointers i.e. INSC, ICSC, ITSC, ST, SCF and OP of the manufacturing sector of Pakistan manufacturing sector. These statistics will be crucial in defining what the industry is doing to ensure it leverages three SSC indicators, as well as what ST is doing to enhance the performances of the operations.

There are means and standard deviation of each indicator. Based on the case example, the standard deviation of mean value of INSC indicator is between 0.53 and 0.58 with standard deviation of between 3.93 and 4.01. The value of 0.26 to 0.29 with an average of 3.97 to 4.05 is seen in the ST indicator. The value of the means of the Standard deviation values of the OP indicator are 2.17 with a standard deviation of 0.31-0.37.

Mean and Standard Deviation

Constructs	Item code	Item	Mean	Std. Deviation
INSC	INSC1	We have integrated technology into our supply chain	4.01	0.538423625
	INSC2	We use rapid technological changes that are taken care of by updating software and systems regularly	3.93	0.587452126
	INSC3	We use RFID for factory automation to enhance efficiency	3.97	0.555967625
ICSC	ICSC1	We have real-time enterprise monitoring capabilities	3.91	0.649538298
	ICSC2	We use standardized communication protocols	4.01	0.741552426
	ICSC3	We emphasize coordination, integration, and management of key business processes across our supply chain	3.99	0.655667599
	ICSC4	We use inventory levels that are visible throughout the supply chain	3.98	0.632139225
ITSC	ITSC1	We have adopted smart processes for planning, sourcing, and delivering goods	4	0.583095189
	ITSC2	We use devices to monitor the proper handling conditions of goods actively	4.01	0.591523457
	ITSC3	We use systems to provide more accurate information for effective decision-making	4.01	0.519519008
ST	ST1	We use all the programmable devices	4.05	0.295803989
	ST2	We use all the devices that can be uniquely identified	3.97	0.298496231
	ST3	We use all the devices aware of and respond to environmental changes	3.99	0.264386081
	ST4	We use all the devices that can send and receive messages	4	0.346410162
SCF	SCF1	Our supply chain can quickly adjust production or procurement levels in response to sudden changes in customer demand.	4.14	0.529528092
	SCF2	We are able to shorten or extend delivery lead times to meet customer requirements without major disruptions.	4.14	0.510294033
	SCF3	Our supply chain can handle unexpected changes while keeping costs under control.	4.17	0.548725797
	SCF4	We can modify products or services to meet specific customer needs without significant delays	4.18	0.536283507
OP	OP1	We use smart technology and a smart supply chain to reduce lead time in production	4	0.346987031
	OP2	We use smart technology and smart supply chains have better resource planning	2.14	0.312889757
	OP3	We use smart technology and smart supply chains have better operational efficiency	2.11	0.375632799
	OP4	We use smart technology and smart supply chain to costs saving	2.17	0.346987031

Table 1: Mean and Standard Deviation



PLS SEM

Figure 3: PLS SEM

Internal Consistency Reliability and Convergent Validity

Constructs	Item code	Outer loadings	Composite reliability	AVE
INSC	INSC1	0.89	0.85	0.77
	INSC2	0.86		
	INSC3	0.88		
ICSC	ICSC1	0.90	0.95	0.84
	ICSC2	0.93		
	ICSC3	0.93		
	ICSC4	0.91		
ITSC	ITSC1	0.87	0.85	0.77
	ITSC2	0.88		
	ITSC3	0.87		
ST	ST1	0.75	0.78	0.60
	ST2	0.82		
	ST3	0.75		
	ST4	0.77		
SCF	SCF1	0.84	0.84	0.67
	SCF2	0.84		
	SCF3	0.79		
	SCF4	0.79		
OP	OP1	0.77	0.91	0.64
	OP2	0.81		

OP3	0.85
OP4	0.78

Table 2: Internal consistency reliability and convergent validity

Discriminant validity aims to evaluate the substantial correlation among dimensions within a model and alleviate multicollinearity issues in latent variable research. It ensures that non-overlapping components of the investigation remain distinct. The Heterotrait-Monotrait (HTMT) correlation ratio must not exceed 0.90; if it does, the Fornell and Larcker criterion is violated. The criterion should be employed instead. 28 Given that the HTMT results do not meet the minimum standards, the Fornell and Larcker criterion will be utilized and displayed in Table 3 of this study. The results demonstrate that the connection between different constructs is weaker than the correlation among items evaluating the same construct. Thus, this signifies that the results are reliable and accurately evaluate the constructs of interest.

Structural model assessment

Direct hypotheses were tested using SmartPLS 4 and evaluated through the bootstrapping method, which employs a resampling strategy to generate hypothetical samples for assessing the statistical accuracy of estimated path coefficients (Soumyaa Rawat, 2021). Hypothesis acceptance is determined by a p-value less than 0.05 (<0.05) and a t-value greater than 1.645 (>1.645).

	ICSC	**INSC**	**ITSC**	**OP**	**SCFS**	**ST**
ICSC	0.92					
INSC	0.00	0.88				
ITSC	-0.09	0.03	0.88			
OP	0.22	0.36	0.27	0.80		
SCFS	0.16	0.62	0.11	0.27	0.82	
ST	0.32	0.45	0.42	0.44	0.33	0.77

Table 3: Discriminant validity: Fornell and larcker criterion.

Table 4 presents the results of directional hypotheses. The findings reveal that ICSC exerts a significant positive impact on ST (t = 6.918, p = 0.000), confirming H1. Similarly, INSC demonstrates a significant positive influence on ST (t = 6.657, p = 0.000), and ITSC also shows a significant positive relationship with ST (t = 5.852, p = 0.000). These results indicate that H1, H2, and H3 are all supported.

					Confidence Interval		
Relationships	**β**	**SD**	**T Value**	**P values**	**LL**	**UL**	**Decision**
ICSC -> OP	0.03	0.02	1.63	0.10	-0.01	0.08	Not Supported
ICSC -> SCFS	0.12	0.05	2.65	0.01	0.04	0.22	Supported
INSC -> OP	0.04	0.02	1.52	0.13	-0.02	0.11	Not Supported
INSC -> SCFS	0.14	0.06	2.33	0.02	0.05	0.28	Supported
ITSC -> OP	0.04	0.02	1.74	0.08	-0.12	0.09	Supported
ITSC -> SCFS	0.15	0.05	2.96	0.00	0.06	0.25	Supported
ST -> OP	0.09	0.05	1.76	0.08	0.03	0.22	Supported

Table 4: Significance of Hypothesis Relationships

Indirect Effects

					Confidence Interval		
Relationships	**β**	**SD**	**T Value**	**P values**	**LL**	**UL**	**F2**
ITSC -> ST -> SCFS	0.15	0.05	2.96	0.00	0.06	0.25	Supported
ST -> SCFS -> OP	0.09	0.05	1.76	0.08	0.03	0.22	Supported
INSC -> ST -> SCFS -> OP	0.04	0.02	1.52	0.13	-0.02	0.11	Not Supported
ICSC -> ST -> SCFS -> OP	0.03	0.02	1.63	0.10	-0.11	0.08	Not Supported
ITSC -> ST -> SCFS -> OP	0.04	0.02	1.74	0.08	0.14	0.09	Supported
ICSC -> ST -> SCFS	0.12	0.05	2.65	0.01	0.04	0.22	Supported
INSC -> ST -> SCFS	0.14	0.06	2.33	0.02	0.05	0.28	Supported

Table 5: Significance of Hypothesis Relationships (Mediating)

Discussions

The paper analyses the correlations between the attributes of smart supply chain- Interconnected Supply chain (ICSC), Instrumented Supply chain (INSC) and Intelligent supply chain (ITSC) and smart technologies (ST), supply chain flexibility system (SCFS) and performance in operations (OP). Based on the results of the structural model, the following ITSC (b = 0.443), INSC (b = 0.433), and ICSC (b = 0.363) have a positive influence on smart technologies. They involve ITSC that influences ST the most and thus states that to increase the technological capabilities of the realm of the supply chain management, it is crucially important to have intelligent decision-support systems, data-based planning, and advanced analytics. This means that the three supply chain variables may be used to explain the adoption of smart technology by over 50 percent, which suggests that the three supply chain variables have high power to impact the digital transformation of companies.

The present analysis compared to the innovative research findings that have proven mixed impact of SSC factors, shows that the three elements of supply-chain have positive influence on smart technologies. This implies that the reliance on the manufacturing firms in the interconnecting systems and control- as well as smart platforms to complement the technological preparedness is gradual. The positive effect of ICSC on ST may be attributed to the fact that the process results in the better integration and the disclosed information of the supply-chain partners, and the predominant role of ITSC proves the increased importance of automated decision-making, predictive analytics, and digital optimization in the new supply-chain networks. These findings of the analysis prove that the flexibility of supply-chain is positively influenced by smart technologies (0.329). This fact results in the argument that new technologies such as the Internet of Things, the real-time systems of monitoring, and intelligent planning tools can make organizations more adaptable since they would become more responsive, flexible, and capable of organizing the supply-chain operations more efficiently. The value of R 2, SCFS is not very high (0.108) and this implies that the introduction of the smart technologies adds flexibility at the supply-chain, much flexibility is added by the other determinants, i.e. organizational structure, supplier relationships and external environmental circumstances. Its observation helps in proving the hypothesis of the study that was conducted in order to conclude that the integration of technology is not enough and needs structural and managerial capacity.

The correlation between the supply chain flexibility systems/operational performance is seen to be having positive but low percentage of correlation (b = 0.265). Although SCFS can increase

operation efficiency, reliability of service and responsiveness, its overall impact is not very high. The low value of R2 of the operational performance (0.070) means that it is greatly affected by other problems besides the smart technology and the supply chain flexibility such as the level of cost managements to prove the first hypothesis of research that the situational factors and the organizational preparedness are the determinants of the operational success, especially in the developing or the transitioning countries where the digital adoption process may be disproportionate.

The supply chain financial systems (SCFS) are positively correlated with the performance of the operations (OP), which are put under the impact of smart technologies. Therefore, one can consider smart technologies as a useful tool based on which the dimensions of the smart supply chain indirectly influence the improvement of the operational performance.

Conclusion

The paper has discussed how the presence of intelligent supply chains and modern technologies has affected the output of manufacturing sector in Pakistan. The relationships between the dimensions of smart supply chain and adoption of smart technology and operational performance were tested on the basis of 7 hypotheses. The finding showed that 4 of the hypotheses were statistically significant, and 4 of them were not proved. These findings have indicated that the smart supply chains and technologies can produce positive impacts on the performance of operations, but their impacts will be determined by the level and extent of implementation.

Among the main problems that made the need of such a study, one can distinguish the building of awareness and advocacy of adopting smart supply chain methods among the representatives of the manufacturing industry. The intelligibility of the smart supply chain metrics will assist the companies in taking appropriate strategic investment choices and apply the technologies to streamline their operations. In case of smart supply chains, businesses will make more visibility, timeliness, and coordination’s in their operations. The study would provide a level of deep information and would help in the successful transition of the manufacturing processes using the smart supply chains successfully.

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