Research Article

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Digital supply chain transformation: The role of smart technologies on operational performance in manufacturing industry

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Abstract

This study aims to investigate the impact of digital supply chains and smart technology on the operational performance of the manufacturing industry. Due to the lack of knowledge and guidance in this area, the adoption of smart technology throughout the supply chain is limited, leading to poor operational performance. Therefore, the purpose of this study is to investigate how smart technology and digital supply chain transformation can improve operational performance. To test hypotheses and accomplish study goals, the Resource-Based View (RBV) theory was combined with a quantitative research strategy. The study population of companies was obtained from a manufacturing directory, and a minimum sample size of 107 companies was determined using G*Power. Additionally, 600 online surveys were sent to the manufacturing companies, resulting in a response rate of 17.83%. Data analysis was conducted using Smart-PLS 4.0 software, and eight of the 10 hypotheses were supported. The findings showed that smart technologies completely mediate the link between digital transformation and relationship performance, emphasizing the need for manufacturing organizations to focus on incorporating smart technology into their supply chain to enhance operational performance. The study concludes by presenting theoretical and practical implications, limitations, and recommendations.

Keywords

Digital supply chain transformation, smart technology, operational performance, Malaysia manufacturing industry

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Introduction

The rise of digital technology has had a significant impact on innovation in businesses, especially in supply chain management where digitalization is now essential for leveraging additional features. Digital supply chain integrates and links supply chain activities between suppliers and customers from raw material procurement to finished product distribution.[1,2] Collaboration between companies is facilitated by digitalization, enabling collaborative manufacturing, resource pooling, and lifecycle integration.[3] Companies in the manufacturing industry need to incorporate smart technologies such as barcode scanning and location-based services into their supply chain to optimize their operations fully.[2,3] To evaluate operational success and

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plan future operations, both financial and non-financial factors, including worker performance, should be measured. Operational performance is the strategic dimension that companies employ to compete in the market and maximize profits in the short and long term while ensuring market sustainability.[4,5]

The previous studies have highlighted issues in Malaysia's manufacturing companies. These studies indicate that many companies have low productivity due to the inadequate implementation of smart technology in their industry.[3] According to Ghobakhloo and Ching,[1] Nasiri et al.,[2] Saryatmo and Sukhotu,[6] other factors that contribute to low-quality production are poor-quality raw materials, contemporary inventory management practices, and low adoption of smart technology in companies. The limited financial and human resources have made the process of adopting smart technology in the manufacturing industry challenging. The researchers claimed that the inability of manufacturers to adapt to the quick and accelerating environment of technology-driven transformation was due to their lack of understanding of smart technology implementation in the manufacturing industry.[7,8] Reza et al.[8] investigated the effect of low integration of the digital supply chain on operational performance in terms of quality, production, and cost. The study found that the absence of real-time data analysis hindered decision-making and made it difficult to determine customer demand. Companies with low supply chain integration had difficulty improving sustainable supply chain performance due to the lack of visibility in the digital supply chain network, as pointed out by Saryatmo and Sukhotu.[6] The research indicates that poor supply chain performance had a substantial negative impact on overall performance.

Besides, Hizam-Hanafiah and Soomro[9] noted that many companies struggled to understand the range of available smart technologies and determine whether they were suitable for their organization. This was due to a lack of knowledge among managers about smart technologies, which led to difficulty in identifying the risks associated with using the wrong technology. Additionally, Nasiri and Saunila[2] and Backhaus and Nadarajah[3] emphasized that the lack of guidance and knowledge on how to enhance smart technology was affecting firms' understanding of its benefits and functions. This hindered the implementation of smart technology and risked firms falling behind in the era of smart manufacturing. Nasiri et al.[2] also highlighted how low utilization of digitalization in organizational transformations was negatively affecting operational performance, making it difficult to detect which departments were underperforming and limiting access to market information.

Therefore, the objective of the study is to bridge the gaps in the literature by examining the current research on the correlation between digital supply chains, smart technologies, and operational performance. The literature review unveiled several gaps, including a lack of recognition of the significance of digital supply chain transformation in improving operational performance,[3] the inability of manufacturing industries to enhance smart technology in their digital supply chain,[1,8] the lack of investigation into the role of smart technologies in the digital supply chain,[2] and the absence of studies on how to adapt to the transformation of the digital supply chain using smart technologies.[3] To bridge these gaps, the study focused on four research objectives: (1) to examine the effect of digital supply chain transformation on operational performance; (2) to investigate the effect of digital supply chain transformation on smart technology; (3) to examine the effect of smart technology on operational performance; and (4) investigate the mediating effect of smart technologies on the relationship between digital supply chain transformation and operational performance.

Literature review

Overview of the manufacturing industry in Malaysia

The manufacturing industry in Malaysia was facing deceleration in growth. To transform and revitalize the Malaysian manufacturing industry, the government implemented five key factors: producing diverse products,[10–12] increasing productivity through automation, promoting innovation-driven growth, and strengthening and accrediting manufacturing firms[13–15] Major subsectors of the industry include petroleum, chemical, rubber, and plastic products; food, drink, and tobacco; and electrical and electronic products, with the electronics industry being the fastest-growing sector. In 2021, thanks to immunization efforts, the industry was able to meet both domestic and international market demands.[16–18]

Operational performance

Operational excellence plays a pivotal role in determining the success or failure of a company, serving as a crucial benchmark to assess whether the organization is meeting its objectives. This emphasis on operational performance extends across various scales, from small and medium-sized enterprises to major industries in both emerging and established countries. Achieving organizational objectives, goals, or targets is intricately linked to the effectiveness of operational processes.[6,19] Researchers have often focused on financial indicators to gauge a company's success, but the impact of overall operational performance on profitability remains a vital yet sometimes overlooked aspect.[6,20,21] Simultaneously, beyond the realm of financial metrics, there is a growing recognition of the broader benefits associated with operational excellence. These non-financial gains extend not only to owners and managers but also encompass positive outcomes for employees and the environment. Factors such as work-life balance, flexible work hours, and networking opportunities contribute to a holistic understanding of operational excellence that goes beyond financial considerations.[22,23] Recognizing the interconnectedness of quality, prices, productivity, adaptability, and reliability, organizations are increasingly appreciating the multifaceted nature of operational performance, where both operational and human excellence contribute to overall success.[6,24–28]

Quality. Quality management represents a holistic approach aimed at perpetually enhancing processes by engaging all stakeholders to meet and surpass consumer expectations. The significance of quality is paramount for organizations striving to excel in a fiercely competitive market, a sentiment echoed in the quality policies of many corporations, especially those in manufacturing firms.[12,20,29] Previous research underscores that fostering enduring relationships with suppliers, active involvement in product development processes, and judicious vendor selection are pivotal strategies for enhancing quality performance. In the dynamic landscape of increasing consumer expectations and global competitiveness, the alignment of business objectives, plans, and policies becomes even more critical.[29,30] Furthermore, the repercussions of poor supplier quality can be profound, potentially bringing an entire company's operations to a standstill. The fundamental role of defect-free incoming parts cannot be overstated in the context of an organization's quality performance.[31] Quality-based performance metrics concentrate on specific issues, such as minimizing the number of errors in production. These metrics, often straightforward to quantify and comprehend, highlight tangible processes, thereby aiding managers in pinpointing areas that demand corrective action.[4,32] Embracing such a comprehensive approach to quality management encompasses not only the quantitative aspects of performance but also acknowledges the intricate relationships and processes that contribute to sustained excellence.

Productivity. In the complex landscape of manufacturing, a notable variability in goods and production techniques is often observed, where the presence of a significant number of defective items can significantly impact organizational performance. The manufacturing industry, particularly in sectors characterized by poor productivity, faces challenges linked to high-defect products resulting from a lack of defect measurement equipment and inadequate defect forecasting. While the occurrence of a single flaw in an item might be anticipated, the emergence of multiple defects warrants thorough investigation and should not be casually dismissed as routine or "expected" instances.[33] Previous research has underscored the transformative impact of integrating smart technology into manufacturing processes, offering a pathway to enhance the overall efficiency of manufacturing organizations.[34]

An avenue for progress in developing nations lies in the innovation of equipment used within organizations, acting as a catalyst for increased productivity and growth. Illustrating this point, Malaysia experienced a notable industrial productivity growth of 3.4 percent in 2020, a testament to the positive outcomes when senior management actively encourages heightened efforts and productivity from the workforce.[35] Insights gleaned from research on productivity performance highlight the substantial influence of smart technology on key facets such as overall productivity, maintenance performance, and operational flexibility.[36] The holistic integration of such technological advancements emerges as a promising solution not only to address immediate productivity concerns but also to lay the groundwork for sustained growth and adaptability in the ever-evolving landscape of manufacturing.

Operational costs. The cost of the organization's overall performance is paramount, playing a decisive role in determining the company's viability and longevity. Companies, with an eye on long-term survival, engage in strategic cost-cutting measures within the realm of supply chain management. These measures aim to pinpoint the most cost-effective and environmentally friendly approaches to procure, transport, and deliver products, all while ensuring customer satisfaction remains a top priority. Within the manufacturing system, the performance of equipment holds a critical position in shaping both product quality and cost, underscoring its profound impact on the organization's financial landscape. One avenue to bolster the fixed-asset turnover ratio involves upgrading or replacing outdated equipment and assets, a strategy aimed at optimizing operational efficiency.[2,6,37] However, an alternative perspective underscores the importance of routine maintenance as a proactive measure to forestall expensive repairs, albeit resulting in a lower fixed-asset turnover ratio.

The intricate dynamics of cost reduction strategies come to the fore in previous research, which highlights that the initial investment costs associated with novel technologies might indeed be substantial. Yet, these costs are expected to decrease over time as the technology matures and becomes more ingrained in the organization's processes. However, the success of such cost-reduction endeavors is contingent upon effective top management control and seamless coordination across different facets of the organization. In instances where top management control falters or lacks synchronization, the potential for failure looms large, necessitating additional efforts to realign various components with the overarching organizational objectives.[20,37] The intricate interplay between cost reduction strategies, technological integration, and organizational coordination underscores the multifaceted nature of navigating financial challenges within the contemporary business landscape. In navigating the complex landscape of cost considerations, organizations are confronted with the need for not only financial acumen but also strategic alignment and adaptability. This dual challenge requires a nuanced approach, balancing immediate financial considerations with a forward-looking perspective that accommodates technological advancements, maintenance strategies, and organizational cohesion to ensure sustained success in the long run.

Smart technology

Smart technology refers to digital technologies that enhance physical equipment or processes, resulting in improved organizational connectivity and intelligence. Memorability, communicability, associability, responsiveness, programmability, and addressability are fundamental features of smart technologies that facilitate effective digital transformation in supply chain management.[2,8,9] Previous research indicates that advanced artificial intelligence frameworks have enhanced customer satisfaction with smart technology. The adoption of smart technology is on the rise as it enables organizations to keep up with changing market systems and consumer preferences, improve transparency and interconnectedness of processes, and enhance performance, adaptability, productivity, and sustainability.[38–41] However, implementing smart technology in manufacturing processes can be challenging due to human adaptability issues, and technology may need to be corrected to address the various functions of the processes, which can slow down the implementation process.[8,19,42]

Digital supply chain

The digital supply chain is a highly advanced technological system that employs digital hardware, software, and networks to facilitate communication and collaboration between suppliers and customers, resulting in enhanced interactions and extensive data processing capabilities.[2,6] According to Büyüközkan and Göçer,[43] companies consider collaborative ties as an opportunity to ensure that their supply chain is responsive and sensitive to market changes. By providing additional information, digital supply chains can also influence product development, allowing for better integration with customers' needs and enabling efficiency upstream and downstream. Digital supply chains offer numerous benefits, but many businesses have yet to take advantage of them. In the future, traditional supply chains will have to transition to digital supply chains to support transportation modes, new production models, customer experiences, and linkages, all of which depend on real-time data exchange. By adopting digital supply chains, large enterprises can gain a competitive advantage and reduce transaction costs while establishing strong long-term relationships with their partners. This shift to digitalization in supply chains is necessary for the future.[43] According to Caltabian,[44] a long-term planned, optimization planned, and transformation management plan was required for the digital supply chain. These plans would assist businesses in identifying what needs had be upgraded in the future, as well as short-term goals and an overview of the procedure used to achieve the transformation. However, organizations would face certain obstacles when integrating digital supply chains,[45–47] such as difficulty keeping up with new digital trends and the threat of cyber-attacks.

Hypotheses development

The focus of several studies was on the impact of digital supply chains on quality performance.[2,6,48] These studies suggested that information technology could improve the supply chain's performance by enhancing market competitiveness and data quality management. Digital supply chain facilitates the planning of future quality innovations by providing accurate information on customer demand,[1,49] increases a company's capacity to handle product flow and thus affects quality performance.[31] Studies by Lundgren et al.,[36] Vafaei-Zadeh et al.[50] and Dudukalov et al.[51] highlighted the digital supply chain's innovation, which allows firms to source data before the selection process and positively impacts quality performance by strengthening supply chain activity through the Internet of Things infrastructure. Hence, the above statements lead to the below hypothesis:

H1. Digital supply chain has a positive effect on quality performance.

Saryatmo and Sukhotu[6] and Yoo[48] emphasized that the integration of smart technology into a manufacturing organization improved production efficiency by enabling accurate information exchange and customer integration. Barraco[52] demonstrated that the digital supply chain has reduced processing time, leading to faster output. Additionally, the researchers highlighted that a digital supply chain increases collaboration and communication by automating some production processes.[6,53] Liu et al.[54] stressed that better data resulting from digital procurement creates opportunities for strategic decision-making, such as accessing supplier innovation, collaborative platforms, innovation laboratories, advanced analytics, increased computing capacity, and improved visualization tools. Hence, this study recommended the hypothesis below:

H2. Digital supply chain has a positive effect on productivity performance.

AlMulhim[19] and Jwo et al.[55] found that the digital supply chain had a significant impact on overall financial performance by reducing costs associated with collaborative work. Barraco[52], DeStefano[56] and Emily[57] noted that the digital supply chain could lower transportation and delivery costs, as well as costs incurred during production. Zubair et al.[34] and Özkanlısoy and Akkartal[58] emphasized the need for a digital supply chain in a company's financial and production departments due to the high cost of materials used in the production process. Alabdali and Salam[59] underscored the importance of a digital supply chain in ensuring that traceable logistical assistance and support benefit relevant individuals promptly. Finally, Teng et al.[60] stated that the digital supply chain's connectivity, sharing, and openness qualities optimize the transaction process and decrease external transaction costs. The above statements lead to below hypotheses:

H3. Digital supply chain has a positive effect on cost performance.

Researchers emphasized that the digital supply chain was essential for the implementation of smart technology to enhance supply chain management, offering various benefits.[2,6,12,36] Lee et al.[12] and Jwo et al.[55] noted that effective digital supply chain performance provides valuable potential for competitive advantage and organizational improvement. The complexity of modern supply chains and reliance on external intermediaries necessitates smart technology for efficient data exchange. Superior supply chain performance results in increased market share and organizational performance,[61] requiring smart technology implementation. The use of digital technology to improve the supply network has been studied, demonstrating its potential to improve decision-making.[60] Therefore, the research proposed the following hypothesis:

H4. Digital supply chain has a positive effect on smart technology.

Introducing smart technology into the firm's supply chain has increased its quality performance by assisting firms in optimizing the quality of manufacturing operations and developing goods. According to the findings of,[29] the researcher proves that smart technology improves the process of information sharing and knowledge management among businesses, suppliers, customers, and information systems. Nasiri et al.,[2] Jwo et al.,[55] Vella[62] and Kersten and Blecker[63] believed that smart technology improved not only in the aspects of communications of sharing information by showing the difference between their product with the competitors in every aspect. Meanwhile, some researchers claimed that smart technology would improve a company's ability to sustain quality performance by offering guidance on how managers could manage and develop the manufacturing process without lowering quality.[64] According to Schmidt et al.,[65] an adaptable alliance of networked equipment and systems enhances manufacturing processes and product quality. Hence, this research recommends the below hypothesis:

H5. Smart technology has a positive effect on quality performance.

Reference[2] mentioned that smart technology could dramatically boost output and efficiency because the researcher believed that smart technology could improve corporate productivity by allowing the firm to make better judgments in its collaboration with suppliers. Smart technology also provides an element that would support the process of a product because it can ensure the productivity of the operation process by giving a signal when there is a faulty product or process.[17,62,66] The findings of le Thi Kim et al.,[22] Nürk[64] and Lefophane and Kalaba[67] found that smart technology would decrease not only the stages of production but also the time taken to produce the same amount of product. Schmidt et al.[65] mentioned that network equipment and systems boost supply chain capabilities and operational flexibility, enabling innovative solutions and enhanced performance while adding value. Therefore, the research proposed the following hypothesis:

H6. Smart technology has a positive effect on productivity performance.

Smart technology enhances production capacity while decreasing the organization's likelihood of paying for product delay costs such as faulty items and delivery.[6,31] According to the findings of Nguyen et al.,[29] the researcher proves that smart technology can assist supply chain organizations in cutting costs associated with the knowledge acquisition process. Nasiri et al.[2] and Mahyuni et al.[68] highlighted that smart technology could minimize the external surcharge where it was not needed for the business, leading to better operational costed performance. Schmidt et al.[65] highlighted that the use of the smart supply chain could minimize demand uncertainty and inaccuracy, as well as demand risk linked to supply visibility by better interacting, coordinating, and cooperating to transmit real-time data on customer demand, transportation costs, location, and inventory level utilizing information technologies and systems. Hence, the research recommends below hypotheses:

H7. Smart technology has a positive effect on cost performance.

Smart technology was one of the most important keys to supply chain process innovation to improve quality performance. The researchers expected that the integration of software and its components, along with the mixing of content across platforms, infrastructures, and production systems, would enhance a company's operational performance through the use of smart technology.[2,48] According to Lundgren et al.[36] and Sam,[69] smart technology could maintain product quality while simultaneously improving the efficiency of the digital supply chain. As a result, smart technology improved product quality performance and firm-quality communication. During the supply chain communication process, researchers felt that the human language's difficulty would require smart technology to assist company employees in learning the language input and providing replies and actions. According to Zhou et al.,[70] an excellent traceability activity in a supply chain will need to be supported by excellent coordination and control of smart technology, which can improve quality performance. As a result, the following was the research's proposed hypothesis:

H8. Smart technology mediates the relationship between the digital supply chain and quality performance.

According to researchers, smart technology could support a variety of supply chain service tasks, which would increase the performance of the company, where smart technology would incorporate computers, communication, control, and sensing.[2,6,19,71] Smart technology not only increases the productivity of the logistics service providers sector but also increases client satisfaction in quality. Tarigan et al.[72] prove that using smart technology in the digital supply chain to solve operational problems and clarifying the data to maintain product performance would support the digital supply chain. According to Queiroz et al.,[61] smart technology also could increase the influence of the digital supply chain on productivity performance because smart technology allows companies' personnel to receive additional training in adapting and interacting successfully with technology. Researchers demonstrated that smart technology would enable production systems in the digital supply chain to become more responsive, meaning real-time decisions based on demanded patterns.[2,43,61] The above statements lead to the below hypothesis:

H9. Smart technology mediates the relationship between the digital supply chain and productivity performance.

The assistance provided by smart technology in the interaction of organizations used in their digital supply chain network resulted in a shift of physical activities to digital, which was utilized in both physical and digital activities to reduce resource consumption, where the costed consumption of a corporation in the manufacturing process had been reduced.[43] Meanwhile, researchers thought that to reduce resource consumption costs, firm managers must understand which form of smart technology suits the company's operations.[6,69] According to Lu and Weng,[73] smart technology would offer firms a digital supply chain roadmap, allowing them to prepare for the future.[1,6,55,74] The experts also predicted that smart technology would allow businesses to minimize process delays in the digital supply chain. Using smart technology in a supply chain will minimize cost consumption, including internal management expenses, unit product manufacturing, and labor costs.[70] The above statements lead to below hypotheses:

H10. Smart technology mediates the relationship between the digital supply chain and cost performance.

Based on the discussion of the relationship between variables in the hypothesis development, the conceptual framework has been developed as shown in Figure 1.

Underpinning theories

In this study, the Resource-Based View (RBV) theory was utilized to provide a theoretical framework to examine the role of smart technology in enhancing the performance of organizations through the digital supply chain. The RBV theory emphasizes that a company's resources and capabilities are valuable, rare, and difficult to imitate and are the key sources of sustainable competitive advantage. The study explored the evolution of the digital supply chain from its manual form to its current digitalization state, incorporating technologies such as IoT, big data,[2,8] and blockchain.[75] The study examined how smart technology could act as a bridge between the digital supply chain and operational performance, with a focus on quality, productivity, and cost reduction as crucial variables. The study aimed to demonstrate the value of the digital supply chain's characteristics, such as being valuable, rare, and difficult to imitate, for organizational competitiveness. This approach was consistent with previous studies that applied the RBV theory to explain the factors that contribute to a company's.[76–79] Overall, the study employed the RBV theory to provide a framework to explain the role of smart technology in enhancing organizational performance through the digital supply chain, taking into account the valuable, rare, and difficult-to-imitate characteristics of digital supply chain resources.[2,6,80,81]

Research methodology

The study employed quantitative methodologies, which involved collecting and analyzing numerical data through the distribution of close-ended questionnaires. The questions were adapted from past research,[6,82] and respondents can answer the questionnaire using a five-point Likert scale. The questionnaire consisted of two sections (A and B), with

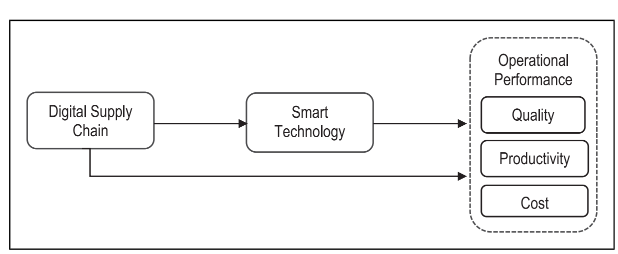

Figure 1. Conceptual framework.

section A gathering personal information such as gender, age, education level, designation, and work experience. Section B required respondents to indicate their level of agreement with each survey item on a Likert scale ranging from 1 (strongly disagreed) to 5 (strongly agreed). The purpose of Section A was to gather general information about the participants, while Section B covered the respondents' opinion on operational performance metrics such as quality, productivity, and operational expenses (dependent variable), the role of smart technology (mediating variable), as well as digital supply chain (independent variable).

According to the FMM Directory,[83] the manufacturing sector had a population of 3400 manufacturing companies included in this research. The researchers employed G*Power statistical analysis software to determine the smallest feasible sample size for this investigation. The software suggests the minimum sample size was 107. Because this study focused on Malaysian manufacturing industries, the organizational unit of analysis, an organization, or a company, was employed in this study. For a variety of reasons, a sample was taken from the population using the basic random sample approach as a sample strategy to categorize the manufacturing industries into a population. Compared to other techniques, simple random sampling eliminated any trace of bias and was the easiest for the researcher to employ.

An online questionnaire was used to collect data for this investigation. Data collection was an important and regulated part of the research since it influenced the investigation's findings and effects. The questionnaire was produced in Google Forms, translated into a link, and delivered online and via email to respondents. This survey would ask respondents to answer the survey questions within 7 days to save time. The researcher would collect data for up to 3 months, beginning 13 June, 2022, and ending 13 September, 2022. When the researcher had 107 replies, respondents proceeded to the next stage, data analysis. Microsoft Excel was used to collect data on respondent demographics and conduct descriptive analysis for this study. Because this study had a sample size of 107, partial least squares structural equation modeling (PLS-SEM) with SmartPLS 4.0 was used to examine the reliability, validity, convergent validity, composite reliability (CR), discriminant validity, Heterotrait-Monotrait ratio (HTMT), and hypotheses testing.

Results

Demographic analysis

The study involved 107 manufacturing companies in Malaysia, which fulfilled the needs of the minimum sample size of this study. The demographic profile of the respondents was analyzed, including gender, age group, designation, religion, academic qualification, current company size, and years in the current company. The majority of the respondents were female (50.47%) and aged between 36 and 40 years old (21.50%). The most common designation was general manager (18.69%), and the most common religion was Buddhism (54.21%). Degree holders comprised the highest percentage of respondents (70.09%). The majority of respondents worked in medium-sized companies (44.86%), and over half had more than 5 years of experience in their current positions (53.27%). Table 1 shows a descriptive analysis of demographic data.

Descriptive analysis

Table 2 presents the descriptive statistics of each variable's sample size, mean, and standard deviation. These statistics are essential for assessing the state of Malaysia's manufacturing companies in terms of implementing digital supply chains and operational performances (quality, productivity, and cost) with smart technology as the mediator. The mean values are utilized to assess the level of the digital supply chain and operational performance, while the standard deviation values indicate the consistency of the digital supply chain and operational performance. It shows the mean values and standard deviations for the dependent variables, namely quality performance, productivity performance, and cost performance. The quality performance has a mean value ranging from 4.112 to 4.757 with standard deviation values between 0.509 and 0.674. The productivity performance has a mean value ranging from 4.206 to 4.374 with a standard deviation ranging from 0.677 to 0.792. Lastly, Cost Performance has a mean value between 3.822 and 4.383, with a standard deviation ranging from 0.741 to 0.850. It also indicates that quality performance has the highest mean value of 4.757, while Cost Performance has the lowest mean value of 3.822 among the dependent variables. Table 2 shows that the mean value of the digital supply chain is between 4.308 and 4.224, with a standard deviation range of 0.612 and 1.022. Furthermore, the mediator of this study, smart technology, has a mean value range of 4.131 to 4.439 with a standard deviation ranging from 0.677 to 0.978.

Normality test

Based on previous researchers, they had mentioned that the normality test is an evaluation that will decide whether the data is set off the normal distribution. The normality can be tested through two other shape measures: skewness and excess kurtosis.[84,85] They also mentioned that the normality test is essential because it clearly measures features from normality. Skewness is a statistical measure that describes the extent of

Table 1. Demographic profile.

Demographic item	Information	Count	Percentage(%)
Gender	Female	54	50.47
	Male	53	49.53
Age	21–25 years old	14	13.08
	21–35 years old	4	3.74
	26–30 years old	14	13.08
	31–35 years old	20	18.69
	36–40 years old	23	21.50
	41–45 years old	9	8.41
	46–50 years old	10	9.35
	51–55 years old	7	6.54
	56–60 years old	4	3.74
	>60 years old	2	1.87
Designation	President	1	0.93
	Vice president	2	1.87
	Chief executive officer (CEO)	6	5.61
	Executive director	9	8.41
	Managing director	11	10.28
	Chief of financial officer (CFO)	1	0.93
	Chief of operations officer (COO)	5	4.67
	Director	5	4.67
	General manager	20	18.69
	Plant manager	9	8.41
	Area manager	3	2.80
	Branch manager	6	5.61
	Senior manager	7	6.54
	Manager	8	7.48
	Assistant manager	1	0.93
	Section head	1	0.93
	Supervisor	4	3.73
	Executive	8	7.48
Religion	Buddha	58	54.21
	Christian	15	14.02
	Hindu	9	8.41
	Islam	25	23.36
Ethnic groups	Chinese	74	69.16
	Indian	9	8.41
	Malay	24	22.43
Academic qualification	Degree	75	70.09
	Diploma	1	0.93
	Master	25	23.36
	MCE/STPM/SPM	1	0.93
Size of company	Large company	35	32.71
	Medium company	48	44.86
	Small company	24	22.43
Count of number of years in the company	<3 years	11	10.28
	3–5 years	39	36.45
	>5 years	57	53.27
Count of numbers of years in current position	<3 years	11	10.28
	3–5 years	39	36.45
	>5 years	57	53.27
	Grand total	**107**	**100.00**

Table 2. Descriptive statistics.

Variable	Item	Min	Max	Mean	Standard deviation
Quality performance	QP1	3	5	4.757	0.509
	QP2	3	5	4.402	0.594
	QP3	2	5	4.280	0.638
	QP4	2	5	4.112	0.674
Productivity performance	PP1	3	5	4.374	0.677
	PP2	1	5	4.206	0.851
	PP3	3	5	4.308	0.716
	PP4	1	5	4.374	0.792
Cost performance	CRP1	1	5	4.383	0.850
	CRP2	2	5	3.822	0.830
	CRP3	1	5	4.308	0.741
Smart technology	ST1	1	5	4.439	0.978
	ST2	1	5	4.280	0.955
	ST3	2	5	4.243	0.807
	ST4	3	5	4.374	0.677
	ST5	1	5	4.327	0.795
	ST6	2	5	4.131	0.810
	ST7	1	5	4.206	0.904
Digital supply chain	DSC1	1	5	4.243	1.022
	DSC2	3	5	4.308	0.662
	DSC3	3	5	4.290	0.612
	DSC4	1	5	4.224	0.900

asymmetry in a normal distribution, whereas kurtosis is a measure of the distribution's peak or flatness. The kurtosis value is often referred to as proper kurtosis.[86] The acceptance range of skewness is from −2 to 2, while kurtosis ranges from −7 to 7. Referring Table 3 shows the skewness, and kurtosis value for the operational performance indicators (i.e., quality performance, product performance, cost performance) is between −2.038 and −0.325 and −0.904 to 3.565. Next, for Smart Technology, the value of skewness and kurtosis is between −2.198 and −0.629 and −0.628 to 4.855. Then, the value of skewness and kurtosis for Digital Smart Technology is between −0.625 and −1.555 and −0.601 to 3.085.

Measurement model

This study uses Partial Least Square Equation Modelling (PLS-SEM) to analyze and generate results. The SmartPLS Version analyzes the measurement models' convergent and discriminant validity. Figure 2 shows the initial research model that contains the independent variable, the digital supply chain (DSC), with four items. At the same time, the operational performance has three constructs which are quality performance (QP), Productivity performance (PP), and cost performance (CRP), with a total of 11 items in this study. The mediating dependent Smart Technology (ST) has seven items. Besides, Figure 3 illustrates the modified research model of the second-order construct, which will help the researcher to simplify the path model.

According to Hair et al.,[84] the convergent validity, average variance extracted (AVE), must be equal to or greater than 0.500. Other than that, based on the study, the researcher also mentioned that the value of the outer loading for each construct must be greater than 0.500, and the composite reliability (CR) must be greater than 0.700. Based on Table 4, the composite reliability and AVE of Quality Performance are 0.776 and 0.627, in which the composite reliability is greater than 0.700 and AVE is greater than 0.500. To fulfill CR and AVE, items QP2 and QP1 are excluded. Next is the Productivity Performance, in which the CR and AVE are also greater than or equal to 0.700 and 0.500 (0.789 and 0.564), where the items PP2 and PP3 are also eliminated. Followed by the CR and AVE of Cost Performance are 0.729 and 0.590, where the items CRP 1 and CRP4 are factored out. Then, the smart technology's CR and AVE are 0.756 and 0.630, where passes the threshold of 0.700 and 0.500, respectively. To fulfill the lowest requirement of the study of CR and AVE, the ST2, ST4, and ST5 were removed to fulfill the convergent validity threshold. For the Digital Supply Chain, the CR and AVE were 0.814 and 0.524, and both CR and AVE were greater than 0.7 and 0.5.

According to Sani et al.,[87] discriminant validity demonstrates that one notion in the structural model differs empirically from the others. As a result, it employs Fornell and Lacker to be used as a measurement to compare the square root of each construct's AVE with its correlations with all other constructs in the model, where

Table 3. Normality assessment.

Variable	Item code	Item	Kurtosis	Skewness
Quality performance	QP1	Implementing DSC increases a company's ability to provide high-quality products with a minimum defect rate consistently.	3.402	−2.038
	QP2	Implementing DSC enhances the company's capacity to keep customer complaints about product quality to a minimum.	−0.658	−0.427
	QP3	Implementing DSC improves the company's regular customer satisfaction surveys, which we use to monitor the quality of the company's products.	2.645	−0.985
	QP4	Implementing DSC enhances the company's ability to keep customer complaints about product quality to a minimum.	−0.100	−0.325
Productivity performance	PP1	The implementation of DSC improves the organization's capacity to optimize manufacturing faults to acceptable levels.	−0.682	−0.629
	PP2	Implementing DSC increases the company's ability to supply clients with quick delivery times.	2.231	−1.242
	PP3	The implementation of DSC increases production capacity to meet consumer requests.	−0.904	−0.539
	PP4	Implementing DSC improves the company's labor and machine productivity in its intended purpose.	3.288	−1.582
Cost performance	CRP1	The incorporation of DSC employing smart technology into the company's process results in the production of products at competitive pricing while retaining profitable operational performance.	2.974	−1.573
	CRP2	DSC implementation allows companies to make products with a limited inventory of raw materials, lowering production costs.	−0.357	−0.352
	CRP3	Implementing DSC through the company's supply chain management reduces logistics costs such as distribution, transportation, and handling.	3.565	−1.408
Smart technology	ST1	The ability of smart technology tends to access trustworthy and exact information.	4.855	−2.198
	ST2	Implementing smart technology of cloud computing improves the process capability of the company.	1.764	−1.441
	ST3	Storage technologies improve the local storage of the company.	0.741	−1.016
	ST4	Implementing smart technology increases the company's product traceability in the supply chain.	−0.682	−0.629
	ST5	Implementing smart technology such as the internet of things (IoT) can connect all smart technology related to manufacturing workflow to the internet.	3.970	−1.569
	ST6	Implementing smart technology, such as robotics, has enhanced industrial capacity.	0.623	−0.889
	ST7	Implementing smart technology, specifically big data, tends to improve the company's data quality.	2.261	−1.422
Digital supply chain	DSC1	DSC can support the company's goal to collect massive amounts of data from many sources.	0.950	−1.306
	DSC2	DSC can build stronger networking between different corporate operations.	−0.737	−0.441
	DSC3	DSC enables the company to achieve better knowledge management.	−0.601	−0.265
	DSC4	Through real-time DSC data processing, companies tend to be able to monitor consumer contact.	3.085	−1.555

the square root of AVE must be greater than the correlation coefficients of that construct with other constructs. Meanwhile, the Heterotrait-Monotrait (HTMT) ratio is the ratio of between-trait to within-trait correlations. If the HTMT correlation ratio surpasses 0.900, the researcher will use Fornell and Lacker to investigate discriminant validity. HTMT would not be suggested in this study since the connection between CRP, PP, and ST is more than 0.900. The correlation between PP, QP, and ST is also larger than 0.900. As a result, the Fornell and Lacker criterion will be used in place of the HTMT ratio in this investigation. CRP diagonal value was 0.792, DSC was 0.751, PP was 0.768, QP was 0.793, and ST was 0.724, according to Table 5.

Structural model

Hypotheses testing. In this study, there is a total of 10 hypotheses conducted. There are seven direct hypotheses and three indirect hypotheses. The bootstrapping method of SmartPLS 4 has been used to test the hypotheses' results. According to Hair et al.[84] and Luis and Moncayo,[88] SmartPLS will be required to collect the data for a summary of hypothesis testing. When the confidence interval

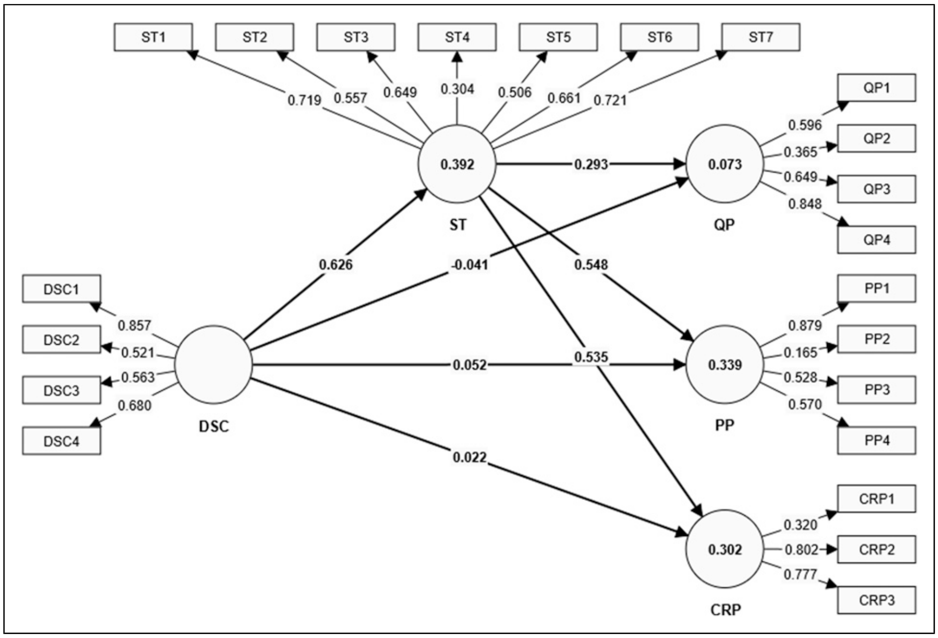

Figure 2. Initial PLS-path model. Notes. Dsc: digital supply chain; ST: smart technology; QP: quality performance; PP: productivity performance; CRP: cost performance.

does not contain zero, the t-value is more than 1.645, and the *p*-value is less than or equal to .05, the outcome of the hypotheses will be accepted. It is suggested that if the loading is low yet substantial, the researcher disregards it if it is less than 0.50. The route coefficient in the redundancy analysis had to be equal to or more than 0.70. It had to include global item and indicator collinearity where the variance inflation factors outer were less than 5, and outer weight was larger than 0.50.

According to Table 6, the result for the directional hypotheses, Digital Supply Chain (DSC) has a negative impact on the operational performance, which is Quality Performance (QP) at (t-value = 0.955 and *p*-value = .170) as well as H2 is giving negative impact on Productivity Performance (PP) shown statistically significant impact at (t-value = 0.250 and *p*-value = .401). This leads to both hypotheses being rejected since they do not satisfy the structural model's requirements, in which the t-value is less than 1.645 and the *p*-value is more than .05. Meanwhile, H3 positively impacts the Cost Production Performance (CRP) at (t-value = 2.557 and *p*-value = .005). As shown in Table 6, Digital Supply Chain (DSC) has a positive relationship with Smart technology (ST) because Digital Supply Chain (DSC) has a significant t-value which is 5.974 while the (*p*-value = 0) respectively, to Smart technology (ST), which leads H4 being supported. Other than that, Smart Technology (ST) has a positive impact on Quality Performance (QP) at (t-value = 2.158 and *p*-value = .015). The Smart Technology (ST) also has significant t-values, which are 7.694 and 4.851, while both (*p*-value = 0), respectively, to Productivity Performance (PP) and Cost Performance (CRP). This has caused H6 and H7 to be supported. Therefore, Smart Technology (ST) has a positive relationship with Cost Performance (CRP) and Productivity Performance (PP), respectively.

Mediating effects. In this study, there are three mediating effects have been tested. This test aims to determine whether a mediating effect exists between the independent and dependent variables. The result of the test for mediating variables of indirect relationship is shown in Table 7. H8 is being supported that Smart Technology (ST) has a positive relationship between Digital Supply Chain (DSC) and Cost Performance (CRP) AT (t-value = 2.029 and *p*-value = 0). Next, H9 gives Smart Technology (ST) a positive effect on the interaction between Digital Supply Chain (DSC) and Productivity Performance (PP). The result proved that the relationship between these two variables is significant at (t-value = 4.399 and *p*-value = 0). Lastly, H10 predicts a significant positive connection between Digital Supply Chain (DSC) and Quality Performance (QP) with Smart Technology (ST) as the mediation achieved an absolutely significant test result at (t-value = 3.199 and *p*-value = .001). Generally, the mediating variables support all the relationships between Digital Supply Chain (DSC) and the operational Performances (i.e., Quality Performance (QP), Productivity Performance (PP), and Cost Performance (CRP)).

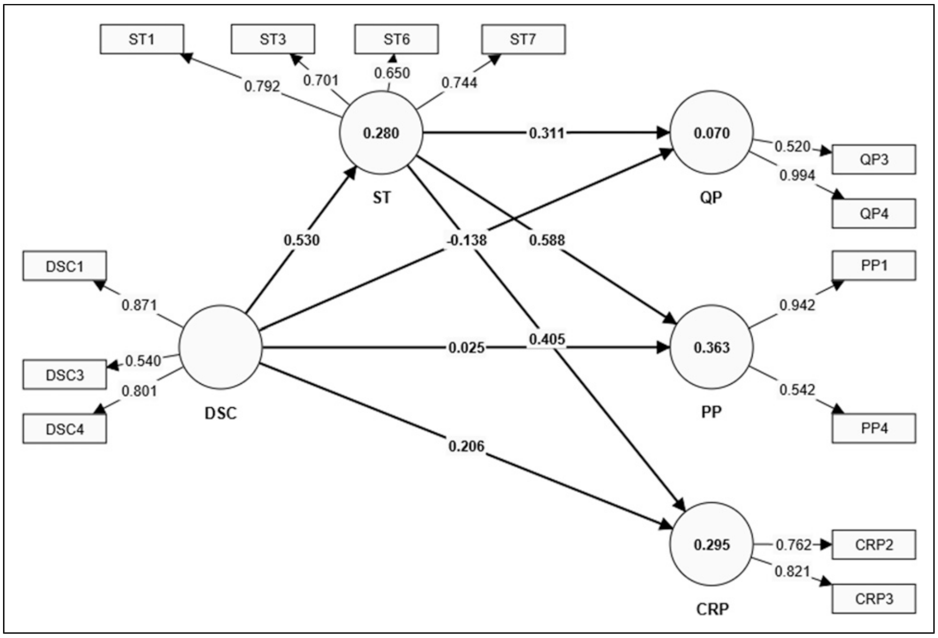

Figure 3. Modified PLS-path model. Notes. DSC: digital supply chain; ST: smart technology; QP: quality performance; PP: productivity performance; CRP: cost performance. Deleted QP2, QP1, PP2, PP3, CRP 1, CRP4, ST2, ST4, and ST5 to increase the value of CR and AVE.

Table 4. Internal consistency reliability and convergent validity results.

Construct	Item code	Outer loading	Composite reliability (CR)	Average variance extracted (AVE)
Quality performance	QP3	0.520	0.776	0.627
	QP4	0.994		
Productivity performance	PP1	0.942	0.789	0.564
	PP4	0.542		
Cost performance	CRP2	0.762	0.729	0.590
	CRP3	0.821		
Smart technology	ST1	0.792	0.756	0.630
	ST3	0.701		
	ST6	0.650		
	ST7	0.744		
Digital supply chain	DSC1	0.871	0.814	0.524
	DSC3	0.540		
	DSC4	0.801		

The Effect Size (F^2) and coefficient of determination (R^2) from the PLS algorithm will be gathered in SmartPLS 4.0, while the Predictive Relevance (Q^2) will be acquired from SmartPLS 4.0 bootstrapping. According to Hair et al.,[84] the constructs of coefficient of determination (R^2), Effect Size (f^2), and Predictive Relevance (Q^2) must be included in structural models.

Assessment of coefficient of determination (R^2). Coefficient of Determination, R^2 is the measurement for the model's predictive accuracy. R^2 will represent the amount of variance in endogenous variables (DV) explained by all the exogenous variables (IV) linked to it. If the prediction of R^2 is high, the prediction in the PLS path model will be better to achieved. According to Hair et al.,[84] there are three rules of thumb to indicate the R^2 value contributing to the independent variables towards the dependent variables, which is 0.19 is weak, 0.33 indicates moderate, and 0.67 is substantial. According to Table 8, the R^2 of item QP is in the weak level, where the R^2 is 0.070, which is lower than 0.19. The items CRP, PP, and ST are at a moderate level where the R^2 is 0.295, 0.363, and 0.280, which is above 0.33.

Table 5. Discriminant validity: Fornell and Larcker criterion.

	CRP	DSC	PP	QP	ST
Cost performance (CRP)	**0.792**				
Digital supply chain (DSC)	0.421	**0.751**			
Productivity performance (PP)	0.335	0.337	**0.768**		
Quality performance (QP)	0.149	0.026	0.387	**0.793**	
Smart technology (ST)	0.514	0.53	0.602	0.238	**0.724**

Note: Diagonal values (bolded) are the square root of AVE, off-diagonal values are correlation coefficients.
Square root of AVE > correlation coefficients of that construct with other constructs.

Table 6. Hypothesis testing (direct).

Path	Original sample (O)	Sample mean (M)	Stan. deviation	t-values	*p*-value	F^2	Bias	Confidence intervals 5.00%	95.00%	Decision
H1: DSC -> QP	−0.138	−0.117	0.145	0.955	.170	0.015	0.022	−0.329	0.147	Not supported
H2: DSC -> PP	0.025	0.029	0.101	0.250	.401	0.001	0.003	−0.151	0.178	Not supported
H3: DSC -> CRP	0.206	0.213	0.081	2.557	.005	0.043	0.007	0.057	0.322	Supported
H4: DSC -> ST	0.530	0.528	0.089	5.974	.000	0.390	−0.002	0.352	0.645	Supported
H5: ST -> QP	0.311	0.303	0.144	2.158	.015	0.075	−0.008	−0.093	0.464	Supported
H6: ST -> PP	0.588	0.594	0.076	7.694	.000	0.391	0.006	0.455	0.707	Supported
H7: ST -> CRP	0.405	0.404	0.083	4.851	.000	0.167	−0.001	0.260	0.530	Supported

*Notes: Confidence intervals do not contain zero, t-value >1.645, and *p*-value <.05.

Table 7. Hypothesis testing (indirect).

Path	Original sample (O)	Sample mean (M)	Stan. deviation	t-values	*p*-value	Bias	Confidence intervals 5.00%	95.00%	Decision
H8: DSC -> ST -> QP	0.165	0.160	0.081	2.029	.021	−0.005	−0.003	0.270	Supported
H9: DSC -> ST -> PP	0.312	0.315	0.071	4.399	.000	0.003	0.194	0.422	Supported
H10: DSC -> ST -> CRP	0.214	0.216	0.067	3.199	.001	0.002	0.109	0.329	Supported

*Notes: Confidence intervals do not contain zero, t-value >1.645, and *p*-value <.05.

Effect size (F^2). In this study, F^2 can be determined in three levels, in which 0.02 indicates a small, 0.15 indicates a medium effect, and above 0.35 indicates a large effect (Hair et al.,[84]). Based on Table 6, the f2 of hypotheses 2 and 3 is less than 0.02 (0.001 and 0.043), which is clarified as a small effect. Hypothesis 1 (0.015), 5 (0.075), and 7 (0.167) indicate a medium effect, where the F^2 of these hypotheses is above 0.02. Next, hypotheses 4 and 6 indicate a large effect where the f2 is above 0.35 (0.390 and 0.391).

Blindfolding (Q^2). Blindfolding, also known as Q^2 values, is essential in predicting the accuracy of the R^2 value. To prove the predictive path model is acceptable, the values of Q^2 for the endogenous variable must be greater than 0.[84] Table 8 shows that the Q^2 value of the CRP, PP, and ST is acceptable because the value is above 0 (0.147, 0.089, and 0.253). While for the QP is not acceptable because the Q^2 value is −0.015, which is lower than 0.

Discussion

This study examines the role of smart technologies (ST) as a mediator between digital supply chain (DSC) and operational performance, including quality performance (QP), productivity performance (PP), and cost performance (CRP) in the Malaysian manufacturing industry. It expands on

Table 8. Assessment of R^2 and Q^2.

	Constructs			
	CRP	PP	QP	ST
R-square	0.295	0.363	0.070	0.280
Q^2 predict	0.147	0.089	−0.015	0.253

previous research on digitalization in supply chains. However, the findings indicate that the hypothesis (H1) of a direct positive relationship between digital supply chain and quality performance is not supported, which is inconsistent with prior literature.[12,29] The author suggests that this could be due to a lack of understanding among Malaysian manufacturing companies about the benefits of adopting a digital supply chain and how it affects organizational and supply chain performance. Additionally, the low integration of supply chain processes may hinder companies' ability to make quick decisions and respond to customer demands. Hypothesis 2, which proposes a positive relationship between the digitalization of the supply chain and productivity performance, is not supported by the statistical data analysis conducted in this study. This finding contradicts the previous literature,[67,89,90] which suggested that digitalizing the supply chain could improve productivity. Previous studies highlighted that technology is constantly evolving, and its obsolescence can result in financial losses for businesses. However, the current study suggests that the unsupported relationship is due to the lack of guidance and training in enhancing smart technology. Consequently, the visibility of inventory levels across the supply chain is poor, making it difficult for the industry to estimate the number of outdated products, non-functional items, or stock that may arrive at the focal firm's warehouse at any point in time.

Hypothesis 3, which states that the adoption of digital supply chain positively affects a firm's cost performance, is supported by this study, consistent with previous research by Nasiri et al.[2] and Liu et al.[4] The implementation of smart technology in the supply chain operations can help control cost consumption, particularly in terms of resources used for production. According to Liu et al.,[54] the adoption of digital supply chain can improve inventory turnover, reduce manufacturing costs, and ensure timely billing and payment. This may reduce the occurrence of breakdowns in the manufacturing process. Furthermore, incorporating digital supply chain can lead to more transparent and traceable procurement transactions, thus improving the organization's relationship with its buyers and suppliers, and enhancing their trust in the organization, as observed by Alabdali and Salam.[59] Besides, hypothesis (H4) was supported in this study, which indicates that the digital supply chain has no significant impact on smart technology. This finding is consistent with recent literature[2,3,9] which emphasizes the need for digitalization in supply chains to facilitate the adoption of smart technologies. Wang et al.[91] also highlighted that the digital supply chain plays a vital role in the adoption of smart technologies, which are essential for tracking and managing product processes in real-time using advanced technologies. In addition, this study's hypothesis (H5) was supported, indicating that there is a positive relationship between smart technology and quality performance. This finding is consistent with previous studies by Nasiri et al.,[2] Nguyen et al.,[29] Jwo et al.[55] and Nürk[64] which have shown that the implementation of smart technology in the industry leads to improved product quality. Smart technology provides an efficient option for firms to control and improve customer satisfaction by detecting every quality fault of the product. Schmidt et al.[65] emphasize that the quality of information in an organization is improving due to smart technology. To remain competitive, firms must embrace digital transformation by building flexibility and innovative technology in their business processes, as emphasized by Yasin et al.[92]

Furthermore, hypothesis (H6) was supported by this study, indicating that there is a positive relationship between smart technology and PP. This finding is consistent with Lundgren et al.,[36] Merkas[93] and Tambare et al.[94] According to these researchers, smart technology improves productivity performance by enabling businesses to create an optimal work environment for their employees. Firms can also develop specialized systems and training programs that are tailored to employee needs and can monitor and measure productivity. Chege et al.[95] emphasized that using information technology to improve business processes and decentralize decision-making can enhance organizational productivity. Additionally, this study has supported hypothesis 7, which suggests that the implementation of smart technology has a positive impact on a firm's cost performance. This finding is consistent with the research conducted by Nasiri et al.[2] and Pramanik et al.[81] The researchers stated that it is crucial to integrate technologies used in the production line and transportation system, which can affect a firm's cost consumption. Smart technologies can significantly enhance a firm's performance by providing novel strategies based on advanced techniques in production and marketing procedures.[92] Additionally, utilizing automated and digitalized energy-efficient smart technologies and resource-saving technologies and procedures can reduce costs. The economic returns of smart technology can be increased by self-organizing manufacturing, predictive and cooperative maintenance, efficient transportation planning, and precise categorization of retirement and disposal decisions.[96]

This research suggests that smart technology serves as a mediator between the digital supply chain and OP in the manufacturing industry. The integration of smart technology is crucial in transforming the supply chain into a digitalized one and improving the operational performance of the industry.

The literature by[2,36,48,69] further supports H8. According to researchers, smart technology can improve communication between internal departments and suppliers in a digital supply chain and provide timely updates on the quality of information. The study suggests that Malaysia's adoption of smart technology in their digital supply chain needs improvement to increase efficiency through transaction automation and transparency, as seen in western countries. Literatures[6,19,43,71,72,82] further supported H9, which suggests the importance of smart technology as a mediator between the digital supply chain and collaboration in the manufacturing industry's operational performance. The researcher in this study emphasized the need for a collaborative work environment that facilitates interactions, and previous studies have emphasized the importance of communication technology in the productivity process, particularly in the delivery of resources. A well-interacted production process can reduce product defects and minimize production time. The supporting literature[1,43,55,69,73,74] further supports H10. Previous studies have suggested that smart technology can assist companies in preparing budgets for the future of the supply chain. Consequently, the use of smart technology in the digital supply chain can minimize the consumption of resources, production costs, and the number of staff required in the financial department, resulting in increased cost performance of the industry.

Conclusion and implications

This study aimed to investigate the impact of smart technology and digital supply chains on the operational performance of the manufacturing industry in Malaysia. Out of the 10 hypotheses tested, eight were found to be significant, while two were not. The results suggest that the integration of smart technology is crucial in enhancing the effectiveness of digital supply chains, which alone may not be sufficient in improving operational performance. This study shows that smart technology acts as a mediator in the relationship between digital transformation and operational performance. Therefore, manufacturing organizations should prioritize the implementation of smart technology in their supply chain processes in enhancing operational performance. Future studies can build upon these findings to explore the effectiveness of different smart technologies and their impact on manufacturing operations.

The study has both theoretical and practical implications. Theoretical implications include the development of new theories and instruments to understand the impact of digital supply chain transformation and smart technology on operational performance. The study shows that integrating smart technology into the digital supply chain can enhance operational efficiency in the Malaysian manufacturing industry, and it also proposes a conceptual framework for measuring operational performance in the context of the digital supply chain revolution. Educators can also benefit from this study by learning how to apply smart technology in the digital supply chain under uncertain environmental conditions. In terms of practical implications, this study emphasizes the advantages of using smart technology in the supply chain to improve operational performance in the manufacturing industry. It raises awareness of the importance of smart technology in the digital supply chain and operational performance, and businesses can use these findings to assess their resources and procedures to enhance supply chain operational performance. Furthermore, this study can help managers understand how to apply smart technology to the supply chain to achieve operational success, and it can motivate employees to embrace smart technology, leading to improved operational performance and economic growth.

Limitation and recommendations

The limitation of this study is that some respondents did not complete the survey form, and the response rate in this study is low. Furthermore, during the COVID-19 epidemic, numerous significant industrial enterprises abandoned their plants or risked bankruptcy. However, many emails will not be delivered or responded to because of this. As a recommendation for future research, to make it simpler for the public, the research proposes that FMM get the most recent information or remind the company to update the contact information. Researchers should also consider screening the list of organizations before sending out questionnaires to avoid sending them to companies that are no longer in operation. Finally, the FMM should collect the most up-to-date contact information from each Malaysian firm and encourage them to update their details annually to ensure the accuracy and reliability of the directory.

Declaration of conflicting interests

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