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Enhancing Supply Chain Resilience through Supply Chain Integration, Learning, Agility, and Digital Transformation

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Abstract

Purpose: This study intends to ascertain whether supply chain resilience in Small and Medium Enterprises (SMEs) in manufacturing firms is directly influenced by supply chain integration, supply chain learning, digital transformation, and supply chain agility. The framework for this research was developed using the dynamic capability view. The literature-based review is drawn up to link digital transformation, supply chain integration, learning, agility practices as well as resilience.

Design/methodology/approach: This research employed a random sampling technique to draw the samples from Malaysian SME manufacturing firms. A total of 180 samples were collected and analysed using partial least squares structural equation modelling (PLS-SEM).

Findings: The results confirmed that supply chain resilience is positively and directly impacted by supply chain integration, agility, and digital transformation. However, the findings revealed that supply chain learning did not demonstrate a significant relationship with supply chain resilience.

Practical implications: The research creates a baseline for the Malaysian SME manufacturing sector and offer guidelines for managers, enabling supply chain resilience understanding to meet obstacles and make better decisions, and the successful implementation of supply chain integration, agility as well as digital transformation. Developing a thorough supply chain resilience enables the implementation of decentralization, business continuity, backup plans, contact lines, and monitoring systems to support strategic goals. Companies will gain a competitive edge by using this technique, which benefits the manufacturing sector and SMEs.

Originality/value: The study underlines that supply chain resilience alone is inadequate for organizations to attain a competitive advantage, and that supply chain integration, agility and digital transformation should be included into organizational strategy design. The results are practical since the proposed structural model employs empirical data.

Keywords: Supply Chain Integration, Supply Chain Learning, Digital Transformation, Supply Chain Agility, Supply Chain Resilience, SMEs.

Classification: Research paper

Introduction

Today's supply chains are more vulnerable and complex in the unpredictable and volatile commercial climate. The ongoing disruptions caused by the coronavirus outbreak have made supply chains even more vulnerable due to multiple disruptions (Karwasra, Soni, Mangla, & Kazancoglu, 2021). Malaysian SMEs encountered supply chain disruptions that impacted their operations during the coronavirus outbreak, according to a study conducted by Hasin, Jamil, Johari, and Kasim (2021). The agitated and disordered business environment, characterized by aggressive competition, demanding customers, and complicated, integrated business operations, always causes organizations to be susceptible to a variety of risks. Organizations must react to a changing environment in this environment, which emphasizes the resilience of the organization, by being flexible, adaptable, and creative. Thus, researchers have considered resilience as a vital concept for organizational persistence in unstable, disorderly, and irregular environments.

Research on supply chain resilience in relation to digital transformation and supply chain practices is lacking, according to a search across many databases, including Emerald, ScienceDirect/Elsevier, Springer, Taylor & Francis, Sage and Wiley. In their previous studies, the majority of academics have looked into supply chain resilience as an independent variable. Researching supply chain resilience success features for SMEs in Malaysia requires an understanding of the interaction between supply chain resilience, its antecedents, and independent variables such as supply chain agility as well as dynamic capability components. The supply chain resilience implementation phase lacks a well-defined theory in current research studies. Teece's (2007) theory of dynamic capabilities was more comprehensive and acceptable. Dynamic capabilities consist of elements such as learning, transformation, and integration. A competitive edge that can rapidly adapt to changing conditions gave rise to the idea of dynamic capabilities.

Supply chain integration improves resilience by combining dynamic capabilities and a relational perspective to understand the causes, effects, and ways to reduce disruptions (Pu, Qiao, & Feng, 2023). It enhances resilience by promoting flexibility, innovation, redundancy, strong supplier relationships, information processing capability, and the adoption of disruptive technologies. This integration enables organizations to respond effectively to disruptions by investing in flexibility and innovation, which positively impact the supply chain's resilience (Ghomi, Nooraei, Shekarian, Shokoohyar, & Parast, 2023).

Supply chain learning is a crucial strategy for firms to enhance their supply chain resilience as well as innovation performance in the volatile and uncertain business environment (Qiao, Li, Xiong, &

Li, 2023). It is a process that entails cultivating a culture of collaboration, information exchange, and skill development among supply chain participants. This approach aims to stimulate innovation and build resilience to navigate uncertain circumstances within the supply chain ecosystem effectively (Liu, Tse, Wang, & Sun, 2023). As highlighted in several research studies (Nilesh, 2022), swiftly adapting and responding to changing circumstances is paramount in strengthening supply chain resilience. As such, agility is crucial for enhancing supply chain resilience by maintaining normal production, regulating capacity, and ensuring timely delivery, contributing to sustainable advantage in manufacturing companies (Abourokbah, Reem, & Mohammad, 2023).

Digital transformation improves supply chain resilience by addressing visibility, transparency, and collaboration issues, enhancing connectivity, and optimizing data distribution to create more effective and robust supply chains (Chowdhury, Scerri, Shahriar, & Skellern, 2023). Embracing these digital technologies and leveraging them strategically can empower organizations to build digital supply chain resilience without compromising profitability or increasing vulnerabilities (Al-Banna, Yaqot, & Menezes, 2023).

In light of the discussion that was previously mentioned, the research question is postulated: "Do supply chain management integration, learning, agility, and digital transformation influence supply chain resilience?" To address this question, the research seeks to ascertain whether supply chain resilience in small and medium enterprise (SME) manufacturing is directly influenced by supply chain integration, supply chain learning, supply chain agility, and digital transformation

Literature Review

Supply Chain Resilience

The ability of a business to efficiently manage its workforce and concurrently establish a robust strategy to address disruptions in the supply chain is known as organizational resilience (Liu and Lee, 2018; Ambulkar, Blackhurst, and Grawe, 2015). Resilience is an organization's ability to manage its supply chain such that regular operations may continue after an interruption (Tarigan, Siagian, & Jie, 2021). Factors such as the volume of items shipped and the average delivery distance need to be considered in a company's supply chain resilience (Li, Dong, Jin, & Kang, 2017).

Ivanov, Sokolov, and Käschel (2013) explain that recovery plans, continuous monitoring, redundancies, and visibility technologies can be used to evaluate supply chain resilience. An organization's capacity to recover from adversity and thrive, if not surpass, its previous state is measured by its supply chain resilience (Aslam, Khan, & Rashid, 2020; Karmaker & Ahmed, 2020). Supply chain resilience, according to Piprani, Mohezar, and Jaafar (2020) and Hosseini, Ivanov, and Dolgui (2019), is the capacity of a company to promptly rectify defects as well as disruptions in the supply chain and resume regular business operations following them.

Within the supply chain system framework, supply chain resilience shapes a company's ability to minimize the risk of disruption, its effects once it happens, and the time it takes for things to return to normal (Gružauskas & Vilkas, 2017). According to this report, supply chain resilience is the

capacity of industrial firms to identify risks, mitigate their consequences, and quickly return to normal operations following the disruption. Measures of supply chain resilience include the capacity to endure disruption, adjust quickly to change, act quickly when something unexpected occurs, and continue to be highly situationally aware (Liu & Lee, 2018). The following are some of the research metrics used to evaluate supply chain resilience: (1) The company has a reserve stock in case of an epidemic; (2) Production capacity is prioritized during a pandemic; (3) The business may keep satisfying customer demands in the face of a pandemic; and (4) The company continues to evolve quickly in spite of a pandemic (Tarigan, Siagian, & Jie, 2021).

Supply Chain Integration

Integration is a collection of pragmatic procedures that entails collaboration between internal and external stakeholders and seeks to deliver tactical as well as strategic efficacy (Mellat-Parast & Spillan, 2014). Previous studies examined integration based on both width and length (Wiengarten & Longoni, 2015). Accordingly, integration can be superficial or deep and is divided into coordinative and collaborative forms depending on depth (Wiengarten & Longoni, 2015). Previous studies mainly distinguished between integration on the inside and outside, given the significance of integration width (Kim, 2013). Departments inside an organization might integrate internally (Kim, 2013; Yu, 2015; Zsidisin, Hartley, Bernardes, & Saunders, 2015), On the other hand, integration from outside the organization is referred to as external integration (partnering integration). In order to share their common goals among supply chain participants, external integration may manifest itself through cooperative planning or information exchange (Yu, 2015; Zhao, Feng, & Wang, 2015; Zsidisin, Hartley, Bernardes, & Saunders, 2015).

In the literature, Huo (2012), Flynn (2010), and Huo and Zhao (2010) have mainly divided supply chain integration into three categories: integration of the internal organization, suppliers, and customers. The coordination of numerous processes, such as purchasing, production, marketing, and finance, is referred to as internal integration. It provides a comprehensive overview of the company to the directors of each division, allowing them to collect detailed information on orders from customers, production schedules, active projects, commodities coming in and going out, as well as financial and accounting data (Piprani, Mohezar, & Jaafar, 2020).

The level of cooperation that manufacturers and their suppliers have when deciding on material flow, inventory control, demand forecasting, and capacity planning is referred to as supplier integration. Conversely, customer integration denotes the level of cooperation that producers have with their customers when making decisions about estimating demand, planning manufacture, keeping track of orders, and shipping goods (Wong, Boon-itt, & Wong, 2011). In the end, supply chain integration is meant to facilitate seamless business operations across the network of supply chains while serving as a competitive advantage (Huo, Ye, Zhao, & Shou, 2016).

The importance of cooperation and integration with supply chain partners has been stressed by Frohlich and Westbrook (2001), Shou, Li, Park, and Kang (2018), and other supply chain practitioners and academics. Nevertheless, other studies, such as those conducted by Danese and Romano (2011) and Jajja, Chatha, and Farooq (2018), presented some contradicting empirical findings. These differences may result from the various conceptualizations of supply chain integration that were applied in those research. When academics are examining supply chain

integration, the majority of studies to date appear to divide it up into discrete constructs (such as internal, supplier, and customer integration) (Jajja, Chatha, & Farooq, 2018). From internal, supplier, and customer integration, supply chain integration is conceptualized in this study.

Supply Chain Learning

According to Norman (2004), in order to develop operational resilience, organizations should engage in a continuous learning process". The ability to adapt swiftly to changes is a critical component of organizational learning, as it fosters more proactive production planning in supply chains and improves their overall performance (Bell, Mengüç, & Widing, 2010). According to Santana-Vijande, López-Sánchez, and Trespalacios (2012), organizational learning enables businesses to more accurately predict shifts in consumer demand and therefore gain sustainability. Hamad and Yozgat (2017) claim that the abundance of knowledge derived from organizational learning enhances supply networks' adaptation and flexibility.

It has been discovered that businesses with a focus on the market outperform others, both in terms of profitability and market performance. Companies accomplish this by embracing a mentality and creating protocols with the goal of collecting data about their clients and rivals, disseminating their findings inside the organization, and taking appropriate action based on that data (Jaworski & Kohli, 1993; Slater & Narver, 2020). This market information interchange is crucial for collaboration, innovation, and organizational learning (Hurley & Hult, 1998; Maltz & Kohli, 1996).

Organizational learning is often listed as one of the most important issues to grasp because of its significance for performance (Bessant, 2004; Teece & Pisano, 1994; Flint, Larsson, 2005). The concept is expanded to include inter-organizational supply chain interactions, which occur when two or more businesses collaborate to address supply chain and logistical problems in organizational learning. The emphasis on supply chain learning has improved this concept of interorganizational learning (Flint, Larsson, & Gammelgaard, 2008). In this instance, Flint, Larsson, and Gammelgaard (2008) seek to focus attention on organizational learning management and influence between an individual's own company and the companies of supplier chain partners, including significant vendors and important client organizations. They also seek to highlight innovations related to flow concerns, such as those involving knowledge and supplies.

Inter-organizational learning can be limited to two related organizations, but it is quite diversified. This is why Flint, Larsson, and Gammelgaard (2008) make a distinction between the two. According to Flint, Larsson, and Gammelgaard (2008), the degree of learning in supply chain management is thus determined by how thoroughly companies analyze their supply chains in order to oversee and plan internal as well as external learning initiatives.

Nonetheless, it is imperative to remember that the requirement for cooperative learning processes as a problem with the supply chain's relationships basically means that the parties must, in essence, have mutual trust, be committed to ongoing collaboration, and be open to integrating essential business operations (Mentzer, Flint, & Hult, 2001). This is further supported by Bessant's (2004) proposal for a methodical framework for supply chain education that encourages creativity. In the setup phase, he suggests that supply chain players should have direction and a shared goal. During

an operational stage, consensus on shared goals and objectives becomes new operational processes and modes of operation. An ongoing phase will include management techniques that stress the necessity of on-going learning, for example benchmarking and measurement, to keep the process moving forward. Structures inside the supply chain, such as supplier associations, may become important now. This paradigm and our research clearly show that customer insights, not benchmarking and measuring, are what will eventually drive future development (Flint, Larsson, & Gammelgaard, 2008).

According to Hult, Nichols, and Ketchen (2003), organizational learning is regarded as an essential intangible resource that is firmly embedded in a company's supply chain structure. Flint, Larsson, and Gammelgaard (2008) define learning as the interaction between many supply chain players, with education being carried out with supply chain problems and solutions as the major focus. Supply chain learning, according to Bessant, Kaplinsky, and Lamming (2003), is a way for a company to aggregate information and create strategic resources by cultivating both internal and external partnerships.

Supply chain learning has been classified into three phases: setup, operation, and maintenance (Bessant, Kaplinsky, & Lamming, 2003). The setup stage is establishing policies and procedures to promote learning throughout the supply chain. It is now up to an organization to determine what will act as a spur to create a learning environment. The process of operating involves converting organizational norms, practices, and ideals into protocols that will be utilized for control within and between organizations. The act of examining and evaluating protocols, such as benchmarking, to guarantee earning continuity is referred to as the sustaining stage.

Now, a business needs to figure out how to maintain and stabilize the learning process. Two primary learning tools that are essential for enterprises are the focus of additional studies (Hult, Nichols, & Ketchen, 2003; Song, van der Bij, & Weggem, 2005; Wang, Schoenherr, Zhao, & Zhang, 2019). These include gaining knowledge from both clients and vendors. Supplier learning is the term used to describe the technological know-how and innovations that a business may obtain, both formally and informally, from its vendors. Corresponding to this, customer learning describes the knowledge about specific merchandise that companies can get from their customers. The expertise with the technological knowledge that an organization is able to obtain from its suppliers as well as customers by way of an official setup is described as supply chain learning. The knowledge as well as expertise developed can help businesses increase the resilience of their supply chains (Mubarik, Bontis, Mubarik, & Mahmood, 2022).

Digital Transformation

According to Vial (2019), a digital transformation is a process or technique that aims to improve anything by bringing about significant changes to its attributes through the combination of different information sources, computing, information sharing, and network hardware. Enterprises undergoing a digital revolution are integrating modern technologies into every aspect of their operations, changing the way they do business (Westerman & McAfee, 2012). Businesses can leverage machine learning techniques and the Internet of Things to better understand their customers and the market, enabling them to provide personalized and seamless consumer experiences (Breidbach et al., 2018).

According to Breitenbach et al. (2018), there is a worldwide trend toward digital transformation in all businesses. Based on the IDC Worldwide Semiannual Digital Transformation Guide, By 2023, approximately $2.1 trillion was expected to be spent globally on digital transformation. Based on a 2020 Dell survey of about 4,000 global company leaders, 80% of companies increased their digital transformation efforts. According to He, Huang, Choi, and Bilgihan (2022), the COVID-19 pandemic has also significantly accelerated the pace of digital transformation. In 2020, He, Huang, Choi, and Bilgihan (2022) found that almost all CEOs surveyed, both globally and in their own companies, stated that digital technology usage has been accelerated in businesses since the COVID-19 outbreak started. By implementing digital technology, a company can change its client experiences, operational processes, and corporate structures (Henriette, Feki, & Boughzala, 2015). Digital transformation, however, encompasses more than just incorporating new technologies. Rather, to get the necessary degree of digital transformation, the organization's corporate structures, workforce, culture, and technological infrastructure are all modified continuously through a dynamic process (He, Huang, Choi, & Bilgihan, 2022).

Digital transformation includes multi-dimensional notions, according to Henriette, Feki, and Boughzala (2015), with the ability to impact a company's organizational structure and overall performance. How successfully firms implement digital transformation depends on numerous elements, such as the degree of external rivalry and technological maturity (He, Huang, Choi, & Bilgihan, 2022). The digital revolution may have an influence on supply chain resilience under complex causal symmetry. When examining the usage of flexible supply chains and digital transformation, for instance, digital technology would seem to be a required but not sufficient condition for creating networks of flexible suppliers (Shashi, Centobelli, Cerchione, & Ertz, 2020). When studying supply chain resiliency as well as transformation, the essential characteristics of digital supply chains are those that have embraced digital tools and are digitally mature. Supply chain resilience will be impacted by the use of digital technologies and the level of digital development (Zouari, Ruel, & Viale, 2021).

Previous research has connected supply networks' ability to withstand unforeseen turbulence to both supply chain resilience and digitalization, which is an important concept for managers who advance their expertise in this field. Supply chain digitization is characterized by digital maturity and the application of digital technology in supply chains; these two aspects positively impact supply chain resilience (Zouari, Ruel, & Viale, 2021). Digital supply chain solutions are required, as evidenced by developing market situations, particularly in the automotive industry. According to Faruquee, Paulraj, and Irawan (2021), using digital transformation can improve supply chain resilience. Being resilient means having the flexibility to adapt and develop in addition to being able to recover from a jarring event. Adopting digital transformation can, therefore, help firms become more adept at spotting potential threats. In this study, digital transformation is the process by which an organization has adopted digital tools and reached a level of digital maturity (Zouari, Ruel, & Viale, 2021).

Supply Chain Agility

Lockdowns caused COVID-19 to have a bullwhip effect on manufacturing companies' supply chains, which resulted in a shortfall of finished goods (Handfield, Graham, & Burns, 2020; Kraus,

et al., 2020). Supply chain agility was developed by a company as a tactical skill to react swiftly to environmental changes (Fayezi, Zutshi, & O'Loughlin, 2015; Wamba & Akter, 2019). According to Fayezi and Zomorrodi (2015), supply chain agility is an indicator of an organization's capability to quickly adjust to changing situations by integrating information, rapid processes, and a mindset shared by all supply chain firms. The capability of an organization to change both swiftly and skillfully is known as supply chain agility. It is essential to have a supply chain agility strategy (Tarigan, Siagian, & Jie, 2021). The agility methods employed by the organization include dexterity, sensitivity, responsiveness, and group ability (Mavengere, 2013).

Businesses using supply chain agility as a strategy may manage operations and respond quickly and affordably to market changes (Hosseini, Ivanov, & Dolgui, 2019). Five indicators, as follows, are used to gauge supply chain agility: my company can: (1) continue with regular production procedures to fulfill orders; (2) maintain manufacturing capacity; (3) immediately modify the production strategy; (4) quickly adapt the production methods to meet needs; and (5) quickly adjust the work system to comply with government regulations.

Underlying Theory: Dynamic Capabilities

Dynamic Capabilities Theory by Teece (2007) serves as the foundation for the primary underlying theories used in this investigation. Examining the effects of supply chain integration, learning, agility, and digital transformation on supply chain resilience has highlighted the significance of dynamic capabilities theory as one of the key underpinning theories. Below is a section that goes into further detail about this theory.

Dynamic capabilities are concentrated on strategic transformation and making sure the business is in tune with its environment. According to Zahra, Sapienza, and Davidsson (2006), three types of dynamic capabilities exist: 1) identifying and forming opportunities, 2) acting upon them, and 3) reorganizing and reconfiguring (generating, expanding, and altering) a company's resource base (Teece, 2007). A variety of techniques are needed to identify and form opportunities and dangers, including scans, lookups, studying different marketplaces, and using technology (Teece, 2007). Adherence to industry best practices and close communication with clients, vendors, and workers are vital. Seizing opportunities involves assessing current and developing capabilities as well as potential investments in pertinent designs and technologies that are most likely to be adopted by the market (O'Reilly III & Tushman, 2008; Teece, 2007). Reconfiguring a company's resource base is recombining its operational capabilities and resources as it expands and as markets and technologies evolve (Teece, 2007).

According to Chmielewski and Paladino (2007) and Hitt Bierman, Shimizu, and Kochhar (2001), organizations that possess dynamic skills are able to respond to turbulence more effectively, quickly, and also efficiently, which results in improved performance. According to Drnevich and Kriauciunas (2011), dynamic capabilities enable "the organization to capitalize on revenue-generating opportunities while also modifying its procedures to reduce costs." By identifying and rearranging opportunities, dynamic capabilities provide the company with new options that may enhance business success (Eisenhardt & Martin, 2000; Teece, 2007).

According to Heilfat et al. (2007), the evolutionary fitness concept can be used to quantify the impact of dynamic skills on performance. Evolutionary fitness describes a dynamic capacity's ability to assist a business by growing, adapting, or enhancing its resources. According to Walden, Gudergan, Nielse, and Lings (2013), businesses that possess dynamic characteristics that foster high evolutionary fitness are able to adapt to change in the external environment, for example, modifications in customer demands and company strategy priorities, and go on to thrive. According to Drnevich and Kriauciunas (2011), one of the main ways that dynamic capabilities operate is by how fast, effectively, and efficiently the business runs. Organizations can become more competitive by taking advantage of strategies for market capitalization and operational cost reduction that can be achieved with enhanced responsiveness, efficacy, and efficiency in response to environmental changes.

Hypotheses Development and Proposed Research Framework

Supply chain integration and supply chain resilience

According to Schoenherr and Swink (2012), integration improves the functional areas' capacity for coordination, which in turn improves cross-departmental communication, business performance, and organizational goals. Businesses that want to be proactive in addressing supply chain disruptions consider supply chain integration to be crucial. Therefore, a smooth and well-organized information flow between the departments will be internally integrated, strengthening and fortifying the supply chain.

Supply chain resilience is greatly impacted by integration, according to past studies (Christopher & Peck, 2004; Jüttner & Maklan, 2011). Effective departmental integration provides two benefits that are critical for supply chain resilience: it reduces uncertainty and increases visibility (Christopher & Peck, 2004). Internal integration ensures an adequate risk information flow across departments. It is possible to manage the effects of interruptions while simultaneously reducing their likelihood by coordinating efforts across departments.

Hohenstein, Feisel, and Hartmann (2015) assert that quicker response times to disruptions are the outcome of a more cooperative supply chain. Through information sharing, planning preparation, and coordinated operations, external integration improves the flow of threat details across supply chain players, allowing them to detect changes in their surroundings and act quickly when something goes wrong (Christopher & Peck, 2004).

In order to improve the sustainability of supply chain operations, businesses need to synchronize and coordinate corporate activities with participating supply chain companies (Mandal, Sarathy, & Korasiga, 2016). Companies are unable to effectively adapt to unanticipated changes in highly volatile settings in the absence of any cooperative agreements between the partnering enterprises (Juttner & Maklan, 2011; Manyena, 2006). Transparency in the system can also be improved by the cooperative agreements between suppliers and consumers that integrative capabilities enable. Businesses can use it to increase their visibility throughout the supply chain. As a result, companies are more equipped to handle any unanticipated events early on, which aids in boosting supply chain resilience. Consequently, the initial hypothesis is stated as follows:

H1: Supply chain integration relates positively to supply chain resilience.

Supply chain learning and supply chain resilience

Organizational learning necessitates integrating the collection, analysis, and application of knowledge to be prepared to identify, respond to, and adapt to changes in the organization's environment (Berthoin Antal & Friedman, 2004). Employee resilience is increased, and critical skills are developed through information and knowledge sharing throughout the entire organization (Purushothaman, 2015). Thus, it is possible to view organizational learning as promoting information sharing within the business. To achieve this modification, businesses must be knowledgeable about their internal operations and surroundings (Liao, Chuang, & To, 2010). By exchanging knowledge through organizational learning, organizations can foresee disruptions and maintain resilience (Barratt & Oke, 2007). Supply networks require timely information to develop strategic responses to disturbances (Sarkis, Cohen, Dewick, & Schröder, 2020). Organizational learning facilitates more effective change management and improves information processing inside organizations (Eryarsoy, Torgaloz, Acar, & Zaim, 2022). Ali, Arslan, Chowdhury, Khan, and Tarba (2022) state that frequent employee training as well as personnel growth are viewed as ready, which results in supply chain resilience. Thus, information that is shared along the supply chain has an opportunity to be an asset for companies.

Norman (2004) asserts that incorporating learning boosts an organization's ability to endure, which fosters resilience. Businesses can gain knowledge from near-misses to anticipate for and guard against the consequences of bigger-scale interruptions (Azadegan, Srinivasan, Blome, & Tajeddini, 2019). In addition, learning acts as a stimulant for bringing attention to the necessity of alteration, as well as consciousness strengthens the determination to increase resilience (Eryarsoy, Torgaloz, Acar, & Zaim, 2022). Ali, Golgeci, and Arslan (2021) highlighted how crucial knowledge management is to supply chain resilience when it comes to acquiring, applying, and assimilating knowledge.

Supply chain learning is necessary for a business to build, preserve, and broaden its supply chain expertise. A corporation that uses supply chain learning to create and use expertise will be able to recognize and react to problems in the supply chain rapidly. Businesses can use supplier insights to learn from and take advantage of upcoming adjustments to their upstream activities and then develop the best plans to handle them, according to Wang, Schoenherr, Zhao, and Zhang (2019).

Supply chain resilience can only be maintained by an organization using its network to enhance its ability to effectively handle disruptions. Supplier and customer learning are two learning dimensions that can enhance all resilience-related traits, according to researchers (Schoenherr & Swink, 2015; Zhang, Qi, Wang, Pawar, & Zhao, 2018). Zhang, Qi, Wang, Pawar, and Zhao (2018) state that supply chain learning also helps the company formulate and implement backup plans. A business can effectively reduce any unanticipated losses by taking this action. With the background mentioned above, it is hypothesized that:

H2: Supply chain learning positively relates to supply chain resilience.

Digital transformation and supply chain resilience

Supply chain resilience may be enhanced by accelerating digital transformation, according to He, Huang, Choi, and Bilgihan (2022), by promoting methodical control over activities throughout the crisis. Increasing investment in digital technology allows organizations to more easily and flexibly organize internal resources (labor, information, expertise, etc.) to control main vulnerabilities and continue operating against adversity (He, Huang, Choi, & Bilgihan, 2022). COVID-19 was a prime example of this. Regulating quarantine-related issues prompted many service organizations to close, but companies that have made digital technology investments were able to continue by reaching out to customers in new and creative ways.

By making smart investments in digitization, organizations can use external resources and make new opportunities to support corporate operations. Past research indicates that digital technologies help companies build networks to engage with other companies (supply chain partners), offering useful data and resources to continue operations and boost resilience in disruptive circumstances (Chowdhury & Quaddus, 2016).

Increasing supply chain resilience is crucial for firms to improve their ability at responding to challenges of supply chain. With the use of digital transformation, a business may enhance supply chain visibility and risk prediction (Hanelt, Bohnsack, Marz, & Marante, 2021). This can strengthen supply chain resilience and assist businesses in better planning their risk management strategies. According to Sharma, Pathak, Borah, and Adhikary (2019), the growth of complex and interconnected supply chain networks makes traditional linear thinking an inadequate approach for solving problems.

Digital transformation can improve resource integration and sharing while also strengthening supply chain resilience (Faruquee, Paulraj, & Irawan, 2021). It involves more than simply being able to move on from a conflictual event; it also entails being adaptable enough to develop and change (Faruquee, Paulraj, & Irawan, 2021). Consequently, the third hypothesis is stated as follows:

H3: Digital transformation relates positively to supply chain resilience.

Supply chain agility and supply chain resilience

Rapid response to external events may improve a company's resilience and ability to recover (Fayezi & Zomorrodi, 2015). According to Hohenstein, Feisel, and Hartmann (2015), an organization's supply chain agility, a notion of supply chain resilience, is determined by its ability to adjust swiftly to shift. Manufacturing businesses can boost their organizational resilience by building supply chain agility, which enables them to respond quickly to both volatile environmental changes and dynamic market developments (Aslam, Khan, Rashid, & Rehman, 2020). Supply chain agility, which the model measures as a company's ability to dispatch items with short lead times, favorably affect supply chain resilience (Karmaker & Ahmed, 2020).

Supply chain agility is crucial in times of disruption because it fosters cooperation and knowledge sharing across supply chain participants. Teece (2007) asserts that supply chains with greater agility are more capable to identify potential disruptions or environmental hazards and take

appropriate action by utilizing their cooperative supplier network, redundant resources, and cooperative risk response infrastructure. These steps contribute to the resilience of enterprises.

Flexible supply networks, as argued by Sheffi and Rice (2005), can anticipate interruptions and make plans for contingencies. Consequently, it is the capacity to face, address, and, when appropriate, make use of unforeseen catastrophes (Juttner & Maklan, 2011). Therefore, it makes sense that the supply chain's enhanced agility will make it more resilient to disturbances.

Resilience and agility go hand in hand, according to Christopher and Peck (2004), who provide a resilience paradigm. As it allows for a quicker response to changing circumstances, agility promotes resilience. Furthermore, in order to counter vulnerabilities, Pettit, Fiksel, and Croxton (2010) point out that supply networks might develop traits like adaptability that guarantee sustainable existence. Agility is a crucial element of resilience, according to Ponomarov and Holcomb (2009). Consequently, the following is the fourth hypothesis:

H4: Supply chain agility relates positively to supply chain resilience.

Figure 1 illustrates the conceptual framework that is developed to examine the relationships among supply chain integration, supply chain learning, digital transformation, supply chain agility and supply chain resilience based on dynamic capabilities theory.

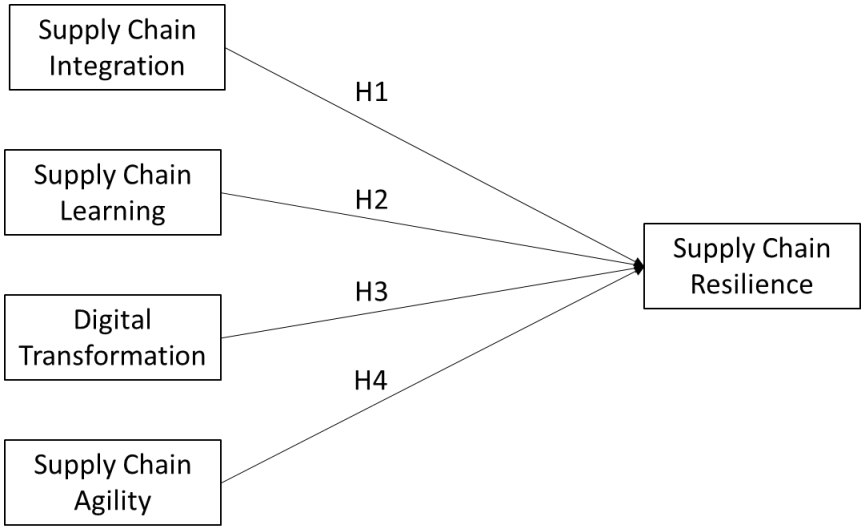

Figure 1: Conceptual Framework

Method

To investigate how the variables in the conceptual framework relate to one another, quantitative research was selected. Data were gathered using the questionnaire method in order to test the hypotheses outlined in the conceptual framework.

Instrument and participants

SME manufacturing companies in Malaysia were the target group for this study. The Federation of Malaysian Manufacturers (FMM) (2022) provided the sampling frame. SMEs account for 75% of the 3,000 manufacturing businesses listed in the FMM database. Nevertheless, since the FMM list only includes businesses who willingly provide FMM access to their data, this figure is lower than the actual number of businesses. In order to examine the sample and comprehend its population attributes or features, sampling was the process of choosing an adequate number of accurate population components (Sekaran & Bougie, 2010). The whole population of SME manufacturing companies is the target audience for the research. Using a questionnaire survey, the sampling approach is applied.

A total of 2,250 SMEs were taken out of the FMM directory and put on a different list. Out of 2,250 enterprises, 300 were the focus of this research. Basic random sampling was the method employed for the sample process. Emails containing questionnaires were sent to the relevant organization, and a resent email was made to gather the completed forms. The manufacturing company, or organizational level, serves as the analytical unit in this study. The respondents with managerial positions in manufacturing organizations were the most relevant.

In order to record and gather the respondents' responses, this study used the survey approach to create questionnaires. The cover letter on the questionnaire's first page outlined the goal of the study and a request for respondents' support. Additionally, the responders were reassured in this letter that their answers would remain anonymous. There were 35 items in all, broken down into 4 sections of the questionnaire. The SME's broad profile is shown in Section A. The variable measures are in Sections B and C. The personal information is located in Section D.

Measurements of the Variables

The study variable, supply chain resilience and all the items adapted in this research were evaluated utilizing the scale developed by Tarigan, Siagian, and Jie (2021). It was measured accordingly to respondents' opinions to a Likert 5-point scale ranging from 1 to 5 which are such as "not strongly disagree" for 1, "neutral" for 3, "strongly agree" for 5, indicates how well their organization has done at putting the following practices into practice. All the items and measures of supply chain integration were adapted from Piprani, Mohezar and Jaafar (2020) utilizing a Likert 5-point scale. All measures and items of supply chain learning were adapted from Mubarik, Bontis, Mubarik, and Mahmood (2022) utilizing a Likert 5-point scale also. The items and measures of digital transformation were adapted from He, Huang, Choi, and Bilgihan (2022) utilizing the Likert 5-point scale. All the items were adapted from Tarigan, Siagian, and Jie (2021) for the supply chain agility constructs as well with the measures of a Likert 5-point scale. Table 1 provides a summary of the research's measurement items.

Table 1: Items for supply chain resilience, supply chain integration, supply chain learning, digital transformation and supply chain agility

Variable	Lower Order Constructs	Items
Supply chain resilience		Our organization has a reserve stock.
		Maintaining manufacturing capacity is crucial in our organization

		Our organization's business can meet client needs.
		Our organization's business keeps evolving swiftly.
Supply chain integration	Internal Integration	Intersect-departmental teams are used to solve problems.
		Objectives and priorities are frequently discussed by internal management.
		Our organization values collaboration and transparency.
		Between several departments, official meetings are frequently planned.
	Customer Integration	Customers provide input on whether the company is meeting their expectations.
		Our organization frequently ask our important clients for information on demand.
		The process of creating new products involves active customer participation.
		Our organization's main customers are informed of our inventory levels.
		Our organization's main clients are informed of our production schedules.
	Supplier Integration	Our organization work closely together strategically with our main suppliers.
		Our organization share our manufacturing schedules with our major vendors.
		Our organization discusses the status of our inventory with our primary suppliers.
		Our organization regularly communicates with essential suppliers at the corporate level on crucial topics.
		With important suppliers, our organization have seamlessly connected our information systems.
Supply chain learning	Supplier Learning	We may learn a great deal of technical information from our suppliers.
		Using the information we have learned from our suppliers, we quickly adapt to technical changes in the market.
		We seek to apply any expertise we learn from suppliers as quickly as possible in our business.
	Customer Learning	Our customers' vast product expertise is something we can benefit much from.
		By putting what we've learned from our clients to use, we can react quickly to technical changes in the market.
		As soon as we learn something from clients, we look for ways to use it in our business.
Digital transformation		We use digital technologies, including analytics, social media, mobile and embedded devices to better understand our customers.
		Our essential operations are automated.

		Our organization's system is integrated to support important operational and customer information.
		To make better operational decisions, we employ analytics.
		A similar vision of digital transformation is shared by senior executives and middle managers.
		Our organization is pushing the cultural changes required for digital transformation.
Supply chain agility		Our organization's usual standard production procedures can be continued to fulfil orders
		Our organization's production capacity can be changed to reflect the circumstances.
		Our organization's production strategy can be immediately modified.
		Our organization's production methods can be adapted quickly to meet needs.
		Our organization's work system can be quickly adjusted in accordance with government regulations.

Sampling

To select the appropriate sample size for this study, the smallest sample should be at least ten times the number of variables (Roscoe, 1975). The required total sample size, as determined by the G*Power computation, is 129. Out of the 300 questionnaires distributed, 180 responses were obtained, meeting the necessary sample size criteria.

Data preparation and modelling

The data were tested using response validity, normality, and common method bias/variance. The data gathered show no evidence of common method bias because the total variation recovered is less than the suggested threshold of 50% by a single factor. There is no substantial issue with the Common Method Bias data sets when one variable only accounts for less than half of the variance (Podsakoff & Organ, 1986). For extra item clarity validation, industry professionals administered a cognitive perception questionnaire test item-by-item prior to the survey's implementation.

The responses were modeled using the software-based SEM technique Smart PLS 4.0 (Hair, Hult, Ringle, & Sarstedt, 2016; Sarstedt, Ringle, & Hair, 2017). The path model, which is constructed with the elements connected in accordance with the hypothesis, is used to compute multiple partial regressions. Evaluations are also conducted on the path weights, discriminant validity results, and construct validity as well as reliability. Measurement models are satisfied by means of discriminant validity, internal consistency (composite reliability), and convergent validity (loading and average variance retrieved) (Hair, Hollingsworth, Randol, & Chong, 2017). Lastly, a bootstrap was employed to determine whether the component correlations have statistically significant values in direct and indirect associations using the known PLS approach (Hair, Hult, Ringle, & Sarstedt, 2016; Sarstedt, Ringle, & Hair, 2017).

Findings

Companies and Respondents Profile

Out of 300 Malaysian-owned businesses, 180 participate in the questionnaire in total, yielding a 60% reply rate. 21.11% of small businesses have fewer than 75 employees, while 78.89% are medium-sized businesses with between 75 and 200 employees, according to the criteria of SME Corporation. According to the samples taken, the bulk of businesses are located in the central region (40.56%), which includes Kuala Lumpur and Selangor. The northern region (36.11%), which includes Kedah and Pulau Pinang, and the southern region (23.33%), which includes Johor. Every SMEs has operated for a minimum of five years. The majority of respondents to this survey, 85.56%, are men; 52.22% of them are between the ages of 35 and 44; 63.89% have bachelor's degrees; and 90.56% having been in their present position for a minimum of three years; all of them are section managers or above.

Out of the 180 participated companies examined, 62.78% have been in operation for more than ten years, making them a more important category in this research. The results also show that the organizations situated in industrial hubs are more significant. Malaysia's industrial centers, the north and central regions, are home to 76.67% of the country's businesses.

Measurement Model Evaluation

Higher Order Constructs (HOCs), which are reflective-reflective, make up the structural model for supply chain integration and supply chain learning. The discontinuous two-stage reporting approach proposed by Sarstedt, Hair Jr., Cheah, Becker, and Ringle (2019) was used to analyze the measurement model. The Lower Order constructs (LOCs) and measurement data for each indicator are included in the first-stage report.

Factor loadings, composite reliability (CR), and average variance extracted (AVE) were used to evaluate the reflective constructs' convergent and discriminant validity in order to establish their reliability and validity (Hair, Ringle, & Sarstedt, 2011). For every reflective LOCs (from 0.714 to 0.951) exceeded the suggested factor loadings threshold of 0.7 (Hair, Ringle, & Sarstedt, 2011). The composite reliability exceeded the suggested value of 0.7 for all reflective LOCs (range from 0.768 to 0.943) (Hair, Ringle, & Sarstedt, 2011). The AVE is greater than 0.5 for all reflective LOCs (0.585 to 0.872) (Hair, Ringle, & Sarstedt, 2011). Consequently, it was discovered that each reflective LOCs had adequate convergent validity. Table 2 displays the outcomes.

Table 2: Measurement Model of First-stage Reflective Lower Order Constructs (LOCs)

Constructs	Items	Loadings	CR	AVE
Internal Integration	SCI_II1	0.903	0.904	0.774
	SCI_II2	0.869		
	SCI_II3	0.888		
	SCI_II4	0.859		
Customer Integration	SCI_CI1	0.893	0.943	0.803
	SCI_CI2	0.909		

	SCI_CI3	0.897		
	SCI_C4	0.890		
	SCI_C5	0.892		
Supplier Integration	SCI_SI1	0.838	0.916	0.739
	SCI_SI2	0.840		
	SCI_SI3	0.881		
	SCI_SI4	0.842		
	SCI_SI5	0.896		
Supplier Learning	SCL_SL1	0.926	0.927	0.872
	SCL_SL2	0.951		
	SCL_SL3	0.924		
Customer Learning	SCL_CL1	0.930	0.922	0.864
	SCL_CL2	0.941		
	SCL_CL3	0.917		
Digital Transformation	DT1	0.819	0.883	0.632
	DT2	0.836		
	DT3	0.774		
	DT4	0.769		
	DT5	0.779		
	DT6	0.788		
Supply Chain Agility	SCA1	0.812	0.881	0.659
	SCA2	0.822		
	SCA3	0.804		
	SCA4	0.741		
	SCA5	0.873		
Supply Chain Resilience	SCR1	0.832	0.768	0.585
	SCR2	0.714		
	SCR3	0.718		
	SCR4	0.790		

In the context of Sekaran and Bougie (2010), discriminant validity describes a situation where two or more separate concepts are unrelated to each other. Measures' discriminant validity was established using the HTMT criterion. Afterwards, Henseler, Ringle, and Sarstedt (2015) looked into the heterotrait-monotrait (HTMT) discriminant validity. HTMT 0.90 was utilized in this investigation because there is no consensus on the appropriate range of HTMT values, which is less than 0.85 or 0.90 (Henseler, Ringle, & Sarstedt, 2015). Comparing the HTMT (see Table 3) to a preset threshold serves as the basis for the criterion. Thus discriminant validity is appropriate.

Table 3: Discriminant Validity of First-stage Reflective Lower Order Constructs

	DT	SCA	SCI_CI	SCI_II	SCI_SI	SCL_CL	SCL_SL	SCR
DT								
SCA	0.810							
SCI_CI	0.845	0.776						
SCI_II	0.888	0.795	0.898					
SCI_SI	0.785	0.696	0.880	0.881				
SCL_CL	0.770	0.699	0.795	0.780	0.768			
SCL_SL	0.762	0.606	0.735	0.724	0.664	0.848		
SCR	0.835	0.766	0.795	0.885	0.770	0.722	0.691	

SCI=Supply Chain Integration, SCL=Supply Chain Learning, DT=Digital Transformation, SCA=Supply Chain Agility, SCR= Supply Chain Resilience, II=Internal Integration, CI=Customer Integration, SI=Supplier Integration, SL=Supplier Learning, CL=Customer Learning

Reflective HOCs comprise the evaluation outcomes in the second stage model, which will use LOCs as the indicators for HOCs. The factor loadings for every reflective HOCs (from 0.710 to 0.947) exceeded the suggested threshold of 0.7 (Hair, Ringle, & Sarstedt, 2011). The composite reliability exceeded the suggested value of 0.7 for all reflective HOCs (range from 0.768 to 0.935) (Hair, Ringle, & Sarstedt, 2011). The AVE is greater than 0.5 for all reflective HOCs (0.585 to 0.892) (Hair, Ringle, & Sarstedt, 2011). Consequently, it was discovered that each reflective HOCs had adequate convergent validity. The outcomes are displayed in Table 4.

Table 4: Measurement Model of Second-stage Reflective Higher Order Constructs (HOCs)

Constructs	**Items**	**Loadings**	**CR**	**AVE**
Supply Chain Integration	II	0.942	0.935	0.878
	CI	0.942		
	SI	0.927		
Supply Chain Learning	SL	0.941	0.880	0.892
	CL	0.947		
Digital Transformation	DT1	0.819	0.883	0.632
	DT2	0.836		
	DT3	0.774		
	DT4	0.769		
	DT5	0.779		
	DT6	0.788		
Supply Chain Agility	SCA1	0.812	0.881	0.659
	SCA2	0.822		
	SCA3	0.804		
	SCA4	0.741		
	SCA5	0.873		
Supply Chain Resilience	SCR1	0.834	0.768	0.585
	SCR2	0.710		

SCR3	0.718
SCR4	0.792

Comparing the HTMT (see Table 5) to a preset threshold serves as the basis for the criterion of HTMT 0.90. The discriminant validity of second-stage reflective HOCs passed the study of the measurement model assessment.

Table 5: Discriminant Validity of Second-stage Reflective Higher Order Constructs

	DT	SCA	SCI	SCL	SCR
DT					
SCA	0.810				
SCI	0.891	0.803			
SCL	0.832	0.710	0.858		
SCR	0.835	0.766	0.869	0.768	

SCI=Supply Chain Integration, SCL=Supply Chain Learning, DT=Digital Transformation, SCA=Supply Chain Agility, SCR= Supply Chain Resilience

Path Coefficient Assessment

To produce the path coefficient as well as the associated t-values, for this analysis, the bootstrapping process was performed with 5000 subsamples. Table 6 shows how the independent and dependent variables are directly correlated. H1 (t=3.716), H3 (t=2.211) and H4 (t=1.889) were three direct relationships that demonstrated a substantial positive relationship ($t>1.645$, $p<0.05$). H2 (t=0.787) was a direct relationship that showed a significant negative relationship ($t\leq1.645$, $p\geq0.05$). As a result, three hypotheses were found to be correct.

Table 6: Results of the Hypothesis Testing

Effects	Hypothesis	Path	Standard Error	t-value	p-value	Decision
Direct	H1	SCI -> SCR	0.112	3.716	0.000	**Supported**
	H2	SCL -> SCR	0.083	0.787	0.216	Not supported
	H3	DT -> SCR	0.091	2.211	0.014	**Supported**
	H4	SCA -> SCR	0.079	1.889	0.029	**Supported**

SCI=Supply Chain Integration, SCL=Supply Chain Learning, DT=Digital Transformation, SCA=Supply Chain Agility, SCR= Supply Chain Resilience

Discussion

It appears from the first finding that supply chain resilience and integration are positively correlated. In a comparable setting, this outcome is in line with earlier research. Integration has a significant impact on supply chain resilience, according to earlier research (Christopher & Peck, 2004; Jüttner & Maklan, 2011). Two benefits of effective departmental integration are reduced uncertainty and increased visibility, both of which are crucial for supply chain resilience

(Christopher & Peck, 2004). The results of this study indicate that supply chain resilience is unaffected by supply chain learning. Based on a particular interpretation of the data, small and medium-sized enterprises (SMEs) in Malaysia are still in the process of recovering from the pandemic and are not yet able to maintain their resilience (SAMENTA, 2021). Malaysian SMEs aim to recover quickly rather than strengthening their resilience.

Supply chain resilience and digital transformation are positively correlated. This outcome aligns with the findings of earlier research. According to Faruquee, Paulraj, and Irawan (2021), digital transformation has the potential to enhance resource integration and sharing, as well as bolster supply chain resilience. It requires being flexible enough to grow and evolve, in addition to being able to go past a difficult situation (Faruquee, Paulraj, & Irawan, 2021). The findings of earlier research in a comparable setting support the notion that supply chain agility and resilience have a positive relationship. Regarding agility and resilience, Christopher and Peck (2004), who present a resilience paradigm, also advise that agility contributes to resilience development since it allows for a quicker response to changing circumstances.

The results of this study indicate that supply chain integration, supply chain agility and digital transformation have a positive relationship with supply chain resilience, whereas supply chain learning was not supported in the relationship with resilience. Integration, agility and digital transformation must work together to improve supply chain resilience. The study underlines that organizational strategies should be designed for integration, agility and digital transformation with resilience for organizations to attain a competitive advantage in the supply chain.

From a theoretical standpoint, the research aims to enhance supply chain resilience by studying supply chain integration, learning, agility, and digital transformation. It also uses the current theories of dynamic capabilities to study the phenomenon and test the hypotheses derived from the theories and research questions. It makes a substantial theoretical contribution by extending dynamic capabilities theories. By incorporating current ideas into a new theoretical framework, this study is expected to advance our understanding of the body of literature already in existence. Theoretically, this research demonstrates the significance of integration, agility, as well as digital transformation in promoting resilience in organizations. Since resilience is insufficient for firms to achieve competitive advantage, the study emphasizes the need for integration, agility as well as digital transformation in the context of supply chain.

The results are practically applicable because empirical data are used in the suggested structural model. Because of practicing supply chain resilience along with supply chain integration and agility, the results showed that an organization might optimize its benefits. In addition to supply chain integration and agility, the results showed that implementing digital transformation in addition to resilience could maximize the organization's capability. From a managerial standpoint, an organization's capacity to obtain a competitive edge depends on supply chain integration, agility and digital transformation, and the study's positive findings emphasize the necessity of incorporating resilience into organizational plans.

Gaining a competitive edge requires an understanding of the positive effects that supply chain activities have on resilience. Managers should give priority to certain supply chain practices to

improve resilience, as integration, agility and digital transformation have a direct impact on it. The performance of the supply chain will increase immediately after.

Conclusion

Other variables that are also directly related to supply chain practices should be considered, even though the current independent factors in this study can be further studied in relation to supply chain practices and their impact on dependent variables. The analysis of a single sector in many situations for other sectors can also be extended by this study. Malaysian SMEs that produce goods for a variety of industries would profit from the valuable results.

This research provides guidelines for managers and creates a baseline for the Malaysian SME manufacturing sector, allowing for the successful implementation of integration, digital transformation as well as agility along with resilience understanding to meet obstacles and make better decisions in the supply chain. Developing a thorough supply chain resilience enables the implementation of decentralization, business continuity, backup plans, contact lines, and monitoring systems to support strategic goals. Companies will gain a competitive edge by using this technique, which benefits the manufacturing sector and SMEs.

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