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Digitalization of supply chain and its impact on cost, firm performance, and resilience: Technology turbulence and top management commitment as moderator

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Abstract— **This study determines the impact of supply chain digitalization on firm performance and resilience. We also investigate the moderating role of technology turbulence and top management commitment. A theoretical model is developed from the inputs from literature review and resource-based view (RBV), dynamic capability view (DCV), and absorptive capacity theories. The theoretical model is then validated using structural equation modelling with consideration of 712 usable responses from different service and manufacturing firms. Multigroup analysis (MGA) was also conducted to investigate the moderating role of technology turbulence and top management commitment. The study finds that supply chain digitalization has a significant impact on the cost performance of the firms, which in turn impacts significantly and positively on firm performance, mediated through operational performance of the firms. The study also highlights that there is a considerable moderating impact of technology turbulence and top management commitment on the digitalization of the supply chain management process.**

Index Terms— **Digitalization, SCM, Resilience, SRM, Technology turbulence, Management commitment, Agility, Cost, CRM**

I. Introduction

The classical meaning of supply chain management (SCM) is concerned with the movement of goods from the end of production to the final customers [1]. SCM is deemed to encompass all the necessary information processed through such movement of goods [2]. Unphysicalization (or digitalization) of SCM can include the sharing of information, negotiating of costs, and listing of goods in the supply chain movement in a virtual environment [3,4]. Here, unphysicalization of supply chain management means digitalization of the supply chain management in the sense that, when functions of supply chain like sharing of information or negotiation of costs and so on are done physically, it is considered as physicalizing of supply chain management and when all the functions of supply chain are conducted through virtual environment, it is called unphysicalization of supply chain management. More explicitly, the digitalization process includes various stages where in some stages there are necessities for use of physical assets and in some other stages there are necessities for using digital assets. Thus, the entire process of digitalization may involve use of physical assets as well as digital assets. Such facilities of digitalization of SCM have ignited firms to develop their intelligence infrastructure and dynamic systems which are built on supply chain relationships [5]. The digitalization of SCM has improved the capacity of the firms to recover quickly from different crises or turbulent situations like COVID-19 pandemic. Such resilience of the firms can provide them with better competitiveness. Digital transformation is considered as an enabler of transformation of business practices. This has brought in a massive change in business operation by providing a better business model with new methods of more engagement in the supply chain management system. Applications of digital technology have made it easier to monitor every point in the perspective of supply chain flow and as such, any interruption of supply chain flow can be removed. Again, with the help of artificial intelligence (AI), it has become easier to predict the possible nodes where interruptions in the supply chain flow may occur. The firms can arrange well ahead to keep options for quickly managing such situations [6]. By integrating digital technologies like bigdata analytics, internet of things, artificial intelligence, and so on into their supply chain operational activities, many large organizations like Amazon, DHL, Uber, Walmart, P&G, and so on have been able to achieve beneficial results [7,8]. It is pertinent to mention here that digitization is conceptualized as the process of converting physical information into digital format. But digitalization refers to the use of applications of different digital technologies for improving business processes and operations which could be helpful to create value for potential customers [9]. Thus, conversion of analog information into the digital format is known as digitization whereas use of digital technologies in business activities is known as digitalization.

Wu et al. [10] argued that SCM can be transformed “from isolated, local, and single-company applications to supply chain wide systematic smart implementations” (p.396). They also considered that intelligent supply chain management considerably impacts visibility, relationships with suppliers, customer relationship management, exploration, and exploitation of supply chain (agility), and responsiveness to supply chain changes. Hence, digitalization of SCM offers many facilities, as opined by Wu et al. [10]. The basic steps of the SCM process consist of planning, procurement, production, inventory management, warehousing, and logistics. Each of these stages requires applications of different technologies for ensuring digitization. Industry 4.0 consists of a bucket of different technologies. They include technologies like artificial intelligence, internet of things, big data analytics, block chain technology, and so on. For each of these stages of SCM process, applications of these industry 4.0 technologies play a critical role for the digitization of SCM of the firms.

Digitalization of SCM uses digital devices which include but are not limited to Internet of Things (IoT) and robots [11,12]. Practitioners believe that most of the organizations will eventually be using different emerging technologies to improve the efficiency of their supply chain management process [13], especially due to the pervasive digitalization of multifarious functions of intelligent SCM. Digitalization of SCM includes using sensor data to reduce downtime, using blockchain technology to avoid unwanted asymmetric information, using robots to optimize warehouse space, and using drones to deliver products [7,14].

Firms are expected to derive benefits from SCM digitalization in the context of financial convenience, impacting their cost performance, and better resilience [8], more options for strategic choices [15], and better transparency [16]. Digitalization of SCM ensures responsive supply chains for innovative products [17]. It has been observed that digitalization of SCM systems impacts firms' financial effectiveness [8]. Studies have highlighted that use of advanced SCM system impacts firm performance [18,19]. Again, the rate of technological change in the market environment is known as technology turbulence [20]. It may influence supply chain management thereby impacting firm performance and resilience [21]. In digitalizing SCM, the part played by firm top management is critical, because they must motivate their employees to use the digital technologies in the supply chain system without being reluctant to adopt modern technologies in the embryonic phase [22].

For digitalization of the supply chain system, applications of digital technologies are essential. To apply the digital technologies in the supply chain system, adequate expertise and skills of the employees are needed. The employees must enrich themselves by developing the ability to recognize, assimilate, and apply new knowledge to successfully digitalize the supply chain system. Thus, the concerned employees need to have possessed adequate absorptive capacity [23,24]. The competencies of the employees to appropriately use digital technologies in the supply chain system are considered valuable in-house resources which supplements the concept of RBV [25]. Firms also need to sense, seize, and integrate external resources with their existing internal resources to address the dynamic market. This corroborates the concept of dynamic capability view (DCV), which was envisaged by Teece et al. [26].

Schneiderjans et al. [27] recently demonstrated that, from the knowledge management perspective, digital SCM can lead to a diversified research arena. However, given that the topic of unphysicalization (or digitalization) of SCM is relevant for practitioners and academic researchers, and that it has distinct implications for the economy and society, it is surprising that studies on its applications and implications have remained underexplored. Against this background, the present study aims at addressing the following research questions (RQs).

RQ1: What are the different factors required to be improved to ensure better supply chain digitization process?

RQ2: Is there any moderating impact of technological turbulence and top management commitment on the relationship between supply chain digitalization and cost performance of firms?

The abovementioned research questions have been duly addressed by analyzing the input of the 712 respondents. A theoretical model has been developed which has been tested by the factor-based PLS-SEM technique. For theoretically substantiating the empirical findings, RBV and DCV have duly been integrated since neither perspective can, on its own can explain the direct implications of supply chain digitalization on the firm performance.

Several studies have been found to have investigated how supply chain systems can be improved by using risk mitigation inventories, enhancing visibility, and developing informational substantiality [26]. But the present study has investigated and extensively analyzed how digitalization of the supply chain system can influence the cost, performance, and resilience of the firms duly moderated by technological turbulence as well as support of top management commitment. Extant literature has not extensively investigated these issues. In such perspective, the present study has contributed to the overall body of knowledge.

II. Literature Review

Studies have documented that to overcome the upcoming challenges, firms need to optimize their business procedures as well as practices. Therefore, they are required to develop their SCM system to ensure better operational performance as well as resilience [28] to overcome any unpredictable and unprecedented crisis. Studies have also identified the specific actions firms should focus on to survive in the coming years, emphasizing the use of industry 4.0 technologies [29,30,31] to keep pace with the other competitors for ensuring better competitive advantage. Moreover, Wu et al. [30] pointed to the use of smart SCM for reducing overall business costs and increasing business efficiency, resilience, and sustainability [6,32,33]. It has been argued that supply chain agility and supply chain adaptability are considered as two principal distinctive capabilities of the firms which could lead to the competitive advantage [8,19].

According to Ross [34], smart SCM comprises instrumented, interconnected, and intelligent characteristics. Instrumented SCM includes automated transaction processes driven by AI and big data that enhance visibility, reduce costs and risks, and overcome complexity [35,36,37]. Interconnected processes use the internet to analyze customer feedback from social media activities. This virtual interconnectivity in the supply chain design process is impacted by integrative technologies such as IoT and big data [38]. Interconnectivity in the supply chain provides opportunities for firms to create synergy by combining normal as well as customer-specific production [39]. Intelligent SCM can simulate supply chain events to evaluate and eliminate risks before they occur [40,41,42]. These three technology-oriented drivers of supply chains can transform SCM from traditional to digitalized by integrating ecosystems that possess transparent interfaces.

It has been observed that through a digitalized SCM system, firms can improve their customer and supplier management systems along with their supply chain agility and responsiveness [43] helpful to corelate demand and supply. Studies demonstrate that supply chain agility will help firms to have a flexible and effective supply chain system for their products [44,45]. Lee [46] applied RBV [25] to argue that firms need to embrace an effective supply chain system so that they can rapidly respond and react to the short-term changes in demand with the help of their existing valuable resources. In applying DCV [26], it can be argued that firms need to appropriately restructure their supply chain system with emerging technologies to survive the long-term market changes. They can accomplish this by sensing, seizing, and integrating external opportunities with the existing internal resources.

To cope with the changing environments, digitalized SCM can improve the intra-firm and inter-firm operations with a focus on impacting the firms' cost performance and eventually their overall performance and resilience [47,48]. However, in the paradigm shift, from traditional SCM to digitalized SCM, firms experience technological turbulence, because technology changes so quickly in the business practices of the firms [49]. And since the shift from legacy SCM to digitalized SCM is a new idea, employees of the firms will be reluctant to make the change. In such situations, leaders of the firms need to assist the employees to make the transformational journey by removing the initial adoption blocker [22]. For this to happen, it is important for firms' leaders to have the capability to recognize the value of digital

SCM, assimilate it and then to translate that into action, which is in accordance with the concept of absorptive capacity theory [23]. Thus, it appears that the recent studies have investigated regarding risk mitigation inventories, informational substitutability, or visibility in supply chain flow [50], but there is a lack of understanding how supply chain digitalization could impact firm performance and resilience mediated through the improvement of some contextual factors like cost and operational performance under the moderating influence of technology turbulence as well as top management commitment. So, there is a significant research gap which needs to be addressed. Moreover, digitalized supply chain management has the scope to develop intra-firm and inter-firm operations helpful to improve the performance of the firms. Studies have also demonstrated that due to such paradigm shift from traditional supply chain management to digitalized supply chain management, the firms could face technological turbulence. But the extant literature has not extensively investigated how digitalization of supply chain management was duly impacted by the moderating effects of technology turbulence and top management commitments could eventually impact the performance of the firms.

III. Theoretical foundation and hypotheses formulation

A. Theoretical foundation

In the context of study, resource-based view (RBV) [25] is considered by Crook et al. [51] as an important theory that provides a guided inquiry towards determining firm performance. In terms of RBV [25], offered formalized details by identifying its two central roles, which are the availability of multiple resources, which are valuable, rare, inimitable, and non-substitutable (VRIN), and the abilities of firms to use those resources to improve firm performance. Thus, from this perspective, digital SCM is a VRIN resource of a firm which can help it to improve its financial health and operational excellence, and eventually to improve its performance and resilience, with leaders' active support to overcome any technological turbulence. More explicitly, in the static market condition, supply chain digitalization capability is the internal ability of the firms, and this ability has the VRIN characteristics and as such in the static market condition, the in-house capability of the firms could eventually improve the firm's performance and resilience.
However, since the external market is changing continuously, and to address the changing marketing scenario, the firm must possess the abilities to sense and seize the external resources, and then to integrate them into their existing VRIN resources so that it is able to extract the best potential of a digital SCM system to ensure better performance through improved financial health and operational excellence. The sensing, seizing, and integrating abilities of the firm are considered dynamic abilities [52]. In this context, SCM digitalization ability is also construed as a dynamic ability, and this is in consonance with dynamic capability view (DCV) [26].
We should note that not all firms which have adopted a digital SCM system will be able to perform at the same rate. That is because the relative position of the firm's intangible resources matters. It is argued that knowledge resources need to be successfully and efficiently utilized to extract the best potential from a digital SCM system. This argument conforms with the concept of absorptive capacity theory [23]. Absorptive capacity is the ability of a firm to appropriately recognize, assimilate, and then apply such knowledge-oriented assets in the commercial settings [24].
With the RBV and DCV and absorptive capacity theory, it is possible for us to argue that supply chain digitalization can impact on the several diversified dimensions for the supply chain of firms. A digital SCM system can also impact the financial health, as well as the operational excellence, of the firms, which eventually lead the firms to exhibit better performance and resilience, provided the firms can address technological turbulence with the active support of top management. Technology turbulence, being the rate of technological change in the industry, is a factor in the external environment of a firm. Technology turbulence causes uncertainty in the dynamic environment. To cope with the dynamic situation, the firms must develop dynamic capabilities to appropriately sense which technology will help the firms to perform better [53] and to face any unpredictable challenges with the help of support of top management. This idea supplements the concept of DCV.

B. Conceptual model and hypotheses development

Drawing from the supply chain management literature as well as the inputs from RBV, DCV, and absorptive capacity theory, a theoretical model is proposed to explain how digitalizing the supply chain could eventually impact firm performance when mediated through some conceptual factors under the boundary conditions of technology turbulence and top management support. The inputs from the literature, along with the underpinning theories, have segmented three clusters of factors to articulate the proposed conceptual model. These are subdimensions of supply chain digitalization, effects of supply chain digitalization, firm performance and resilience impacted by cost and operational performance of the firms under the moderating influence of technological turbulence and top management support. Also, to examine the effects for digitalized SCM on firm performance, three control variables (firm type, firm size, and firm age) have been considered and the conceptual model is provided in Figure 1.

Fig. 1. Conceptual model (adopted from Cohen and Levinthal [21]; Barney [23]; and Teece et al. [24])

C. Supply chain digitalization (SCD) and its different subdimensions

The supply chain digitalization ensures that different supply chain related tools can work together seamlessly for optimization of the process integration. Such process integration involves better supplier relationship management (SRM), customer relationship management (CRM), supply chain visibility (SCV), supply chain responsiveness (SCR), and supply chain agility (SCA). Such digitalization process helps the firms to enhance their efficiency, cost optimization, and helps to retain their competitiveness [15,25].
The SRM is conceptualized as a systematic approach for evaluating the vendors of goods and services to a firm and assessing contributions of each supplier's success. It also includes developing strategies for improving firm performance and resilience [54]. SRM will be successful by

integrating the appropriate resources, processes, technologies, and tools that are needed to align the firm with the relevant suppliers to create stronger, more loyal relationships. These success factors of SRM are perceived to be impacted by SCD [9].

The supply chain visibility (SCV) is conceptualized as the ability to track the transit of different goods or products in supply chain process and to provide a transparent view of the activities and the inventory. It improves customer service to help shoppers as well as controls costs by managing the inventory in motion. Digitalized SCM will improve supply chain visibility because it will be possible to select an appropriate platform for connectivity purposes to manage and to standardize the data, to focus on real-time transparency, and to drive efficient as well as effective decision-making processes [55].

Again, customer relationship management (CRM) is conceptualized as the effective combination of strategies, practices, and technologies that firms use to effectively manage, as well as analyze, the huge volume of diverse customer data throughout the customer life cycle [9,56,57]. The process is perceived to be impacted by applications of digitalized supply chain management.

Also, supply chain responsiveness (SCR) is conceptualized as how the supply chain process could be quicker and the extent to which it could effectively address the changing needs of the customers in terms of the customer demands. SCR also includes how the system can effectively respond to the changes in the hypermarket [58,59,60]. Short production lead time, small batch sizes, and low set-up costs are considered effective advantageous conditions to be fulfilled by a responsive supply chain management system [9].

Moreover, supply chain agility (SCA) enables the firms to better synchronize both the supply as well as demand, which could decrease inventory costs and transportation costs [61]. SCA helps to reduce supply chain costs [62]. According to Hendricks and Singhal [63], SCA is the ability of firms to adjust their procurement strategy and how they manage inventory and delivery to address the dynamic supply chain requirements.

Information technology (IT) has thoroughly changed business practices. IT-enabled services have a considerable impact in manufacturing and service sectors regardless of whether they are in a developing or a developed country [64]. Stemmler [65] demonstrated that digitalization has a significant impact on SCM by improving the flexibility of transactions throughout the entire supply chain cycle using different digital technologies, which supports the firms to fulfill their financial and operational needs. Gautam et al. [66] observed *inter alia* that the ongoing process of digitalization logistics operations in warehousing, as well as in manufacturing, has revitalized the digital transformation in supply chain management. Kindstrom and Kowalkowski [67] demonstrated that digitalization of SCM always supports the development of cost-effective business operations. Haddud and Khare [68] emphasized improving operational practices of the firms by digitalizing the supply chain system. Chatterjee et al. [6] highlighted the need to use modern technologies for sharing knowledge in the context of supply chain management. The digitalization of SCM could benefit firms' businesses by providing them with choices of suppliers [15], improving cost performance and resilience [8], and ensuring more transparency [16]. Digitalization of SCM includes using sensor data to reduce downtime in the supply chain system, using robots to optimize warehouse spaces in the warehouses, using drones to deliver goods, and using blockchain technology to prevent asymmetric information [7]. All these benefits from using digitalized SCM are perceived to impact the cost performance of firms. Accordingly, the following hypothesis is proposed.

H1: Supply chain digitalization (SCD) positively impacts cost performance (COP) of the firms.

D. Cost performance (COP)

Cost performance (COP) is considered to measure the financial efficiency of a firm's performance. It is represented by the amount of completed work in respect of every unit of cost which has been spent. Cost performance can also be assessed by computing the ratio of the targeted cost of work of a project's earned value and the actual cost of work that has been performed [69]. By knowing the cost performance of a project, a firm's project manager could have an idea of how far behind or ahead the relevant project is at the time of analysis [70]. Moreover, Eckstein et al. [61] argued that advanced SCM has a significant impact on the cost performance and resilience of a firm. Several studies have demonstrated that an efficient supply chain system enables a firm to effectively handle supply chain disruptions, which are considered a major cost-involved factor in the global supply chain [63,71,72]. Inventory and transportation costs could be reduced by applying an efficient SCM system to help synchronize supply and demand [61,73]. In support of these observations, there exists a rich body of literature which could identify the positive relationship between efficient and smart SCM and cost reduction [50,62,74]. Thus, cost reduction is perceived to impact firms' operational efficiency. All these arguments lead us to formulate the following hypotheses.

H2a: Cost performance (COP) positively impacts operational performance (OPP) of a firm.
H2b: Cost performance (COP) positively impacts firm performance and resilience (FPR).

E. Operational performance (OPP) and firm performance and resilience (FPR)

The operational performance (OPP) of a firm can be best interpreted as the synergy among different units of a firm and the capacity of the firm to be able to produce better results by synergizing all its units. Operational performance can be conceptualized as the level where all the business units of the firm collaborate with each other with a target to successfully accomplish the business goal in a cost-effective manner [39,75]. A firm's principal objectives for operational performance are to ensure speed, cost, quality, dependability, resilience, and flexibility that often translates also in higher levels of competitiveness [76]. The operational performance of a firm can be improved by improving the existing operations. That means regularly training for the employees, streamlining the communication activities, reviewing, and refining the processes in the supply chain system, articulating effective financial strategies to reduce the cost of supply chain activities, assessing the overall performance and resilience, adopting emerging technologies for digitalization, and so on [8,9]. It is argued that if a firm can improve its operational efficiency, it is perceived that the firm can develop the ability in appropriately utilizing its human resources and material resources for achieving the target. The operational efficiency of a firm is concerned with the optimized way of using different resources like people, equipment, time, inventory, as well as money. Such an optimized way of using the resources serves the businesses to ensure their profit. Thus, if the operational performance of a firm is improved, it can help the firms to optimize the use of the equipment, can help to improve the skillsets of the employees, can help to reduce time consumption, also can reduce the inventory, and can help to support saving cost [9,39]. Thus, it is argued that if all these aspects are improved, the performance and resilience of the firms will also be improved. Accordingly, it is hypothesized as follows.

H3: Operational performance (OPP) of a firm positively impacts firm performance and resilience (FPR).

F. Moderating role of technology turbulence (TT) and top management commitment (MC)

Often technological innovation triggers environmental turbulence by increasing the rate of change of technologies in both the marketplace and the scientific communities [77]. Relying on the extent of turbulence, firms learn to continue with their supply chain activities by integrating technological knowledge, as well as market knowledge, in order to be motivated to digitalize their SCM system [9,49,77]. Technological turbulence is interpreted as "the rate of technological change in an industry" [78, p.57]. Technological turbulence is considered an additional factor that influences modern supply chain management, which could ultimately impact on the overall performance of the firm [28,79]. Technological turbulence is considered as an aspect concerned with firms' external environment apart from market turbulence and intensity of the competitors [49]. Here, due to the emergence of the industry 4.0 technologies, the SCM process has undergone through a rapid change. Such rapid change in SCM process creates turbulence in the marketplace. Firms which can adopt such emerging technologies at a rapid pace have tremendous competitive advantages [15,25]. Thus, there is an aspect of technological turbulence in the performance of the firms as well as their competitiveness. Other factors are market turbulence and rivalry among the competitors [49,80]. Technological turbulence could create challenges to firms in processing their business activities, including supply chain activities [79,81]. The rate of change and the unpredictability of technology in the firm can be considered as technological turbulence [20]. This can be managed with the firm's technology-based knowledge resources, if the firm adopts such technologies [9,77]. Accordingly, the following hypothesis is prescribed.

H4a: Technology turbulence (TT) moderates the relationship between supply chain digitalization (SCD) and cost performance (COP) of a firm.

Studies have demonstrated that top management commitment (MC) of firms plays a decisive role in sustaining SCM [82]. To digitalize their SCM, firms' employees are required to exhibit several competencies [83]. Employees must exchange their knowledge with each other to solve any issue during the SCM digitalization process, they must be trained appropriately, also they are to be motivated by their managers [84]. It is crucial that top management allocates an appropriate budget to digitalize the SCM [85]. Top management commitment is deemed to help enhance employees' trust in the effectiveness and success of digitalization of SCM [9,77]. If top management supports employees to be engaged with the digitalization process, they could reduce the financial burden and improve the operational efficiency of it [86]. Top management commitment is necessary for successful digitalization of SCM process [9]. Top management of the firms should ensure adequate fund allocation towards adopting appropriate emerging technologies like internet of things, artificial intelligence, big data analytics, and so on in the different SCM stages such as procurement, warehousing, inventory management, logistics, and so on. Besides, the leadership of the firms needs to ensure adequate training budget to be allocated to improve the skillsets and expertise of the employees engaged in different SCM processes. It is also argued that digitalization of SCM process can reduce the overall expenses of the firms which could eventually improve and optimize cost performance of the firms [8]. Accordingly, the following hypothesis is derived.

H4b: Top management commitment (MC) moderates the relationship between supply chain digitalization (SCD) and cost performance (COP) of a firm.

The control variables considered in this study are firm age, firm size, and firm type. A control variable could be any variable that remains constant throughout the research study. Such control variables may not be a variable of interest in a research study. But such control variables sometimes become important as they could influence the research outcomes. Thus, a control variable can be regarded as an experimental element which remains constant throughout the research study. Although, in this study three control variables have been considered to assess if these control variables could play a vital role by influencing the research outcomes. These three control variables (firm age, firm size, and firm type) have been considered in this research study as per the available data provided in table 1.

IV. Research Methodology

A. Research instrument

Through the extant literature and theories, we prepared items to make them relevant to measure the constructs from the perspective of this study. We first asked some people who are experts in the domain of the present study for their opinions of the prepared items. Some of these experts were academicians and others were industry experts. Their opinions helped us to modify the wordings and formats of some of the items so the respondents would not be constrained to understand them properly.

After that, we conducted a pilot test on 35 respondents from different firms that were likely to introduce a digitalized SCM process. Those respondents did not participate in the main survey, although the selection criterion was the same. The analysis of the feedback from the pilot test enabled us to revise and refine the items. Some of the items, which did not explain the corresponding constructs appropriately, were dropped. After this rectification process, we ended up with 27 items. Details of the items in the questionnaire, including the sources, are provided in the Appendix.

B. Strategy for data collection

Here the data was collected from firms based out of India as India is the fifth largest economy in the world. In India, many firms are located having their established supply chain operations. Besides, India is considered as a technology hub for information technology industry and as such many firms located in India have already digitalized their SCM processes. Thus, as a part of purposive sampling technique, India has been chosen to get the feedback from the respondents. Moreover, some of the researchers are based out of India and have some links with key officials of some of the business associations in India, like the Federation of Indian Chambers of Commerce and Industry (FICCI) and PHD Chamber of Commerce and Industry. Hence, to collect data, both purposive and convenience sampling techniques have been used to target employees of the firms of India as the potential respondents for the survey [87]. To obtain responses in the specified format, incurring minimum cost, we created an online questionnaire using Google Forms and then shared the questionnaire link with the key officials of those business associations. With their extensive network of manufacturing and service firms, it was easy to send the questionnaire to some respondents of the specific firms that have either adopted a digitalized supply chain management system or had been contemplating to adopt.
As managerial employees principally take the decisions for their businesses, we planned to select them from both manufacturing and service firms. Hence, a purposive sampling technique was also adopted [88]. Several attempts were made to enhance the response rate. The questions were prepared in such a manner so we could assess what the respondents understood in the context of using digital technologies in a supply chain management system [89]. All the prospective respondents were provided with the link which contained the questions. Each question had five options, and each respondent was to put one tick mark in one option for each question. This was done because we used a 5-point Likert scale to quantify the responses, anchoring Strongly Disagree (SD) with 1 and Strongly Agree (SA) with 5. With the response link, a guideline was also provided describing how to answer the questions. Finally, the prospective respondents were assured that their identities would not be disclosed so that they could respond without being biased. They were requested to respond within two months (January and February 2022). Within the scheduled time window, we received 726 responses, although the questionnaire was initially sent to 1609 potential respondents. The response rate was 45.12%. In this context, a non-response bias test has been conducted. For this, the chi square test and independent t-test have been performed with the consideration of the inputs of first and last 100 responses. No deviation of results was noted in these two cases. Hence, non-response bias did not pose a major concern in this study. On evaluation of these responses, 14 responses were found incomplete, and these were not considered for analysis. These 14 responses were not considered because all the respondents concerned put tick marks in more than one option against each question. The demographic information of the 712 respondents is provided in Table I.

TABLE I
DEMOGRAPHIC RESPONSES

V. ANALYSIS OF DATA AND RESULTS

To estimate the research model, we adopted the partial least squares (PLS) – structural equation modeling (SEM) technique, since the approach is considered to provide robust results by thoroughly analyzing a hierarchical complex model [90,91]. It is also thought to be appropriate for analyzing the results [92,93]. PLS-SEM technique has the advantage, but it does not impose any sample restriction and it does not need the data to be normally distributed which is the initial essential condition of analysis of data by the help of covariance-based (CB) – structural equation modelling (SEM) technique. We used SmartPLS 3.2.3 software [94] to perform a non-parametric bootstrap procedure taking 5000 resamples to estimate the path coefficients for all the linkages, along with other parameters and levels of significance, to test the proposed hypotheses.

A. Analysis of data

The measurement properties of all the first order constructs are provided in Table II. From the measurement model, we observed that the convergent validity of all the items of the constructs have been estimated. To do this, the loading factor (LF) of each first order construct was assessed, and the values were all found to be greater than 0.70 [95]. To assess the reliability as well as validity of the constructs, composite reliability (CR) and average variance extracted (AVE) were estimated. The estimated values of CRs and AVEs are greater than 0.80 and 0.50, respectively [96]. Then, to estimate the consistency of the constructs, it was necessary to estimate the constructs' Cronbach's alpha (α). Again, multicollinearity may exist whenever an independent variable is highly corelated with the other independent variables because in that case, it undermines the statistical significance of an independent variable. For this, variance inflation factor (VIF) has been assessed for all the constructs. It is provided in Table II. The values of VIF highlight that correlation is not enough for warranting any corrective measure.

TABLE II
MEASUREMENT PROPERTIES

In the present study, the construct supply chain digitalization (SCD) has been developed as a second order construct that could help to interpret five subdivisions, which are supplier relationship management (SRM), customer relationship management (CRM), supply chain visibility (SCV), supply chain responsiveness (SCR), and supply chain agility (SCA). The number of items of each of these subdivisions is three and as such, the total number of items of supply chain digitalization (SCD) is 15. All the estimated values are shown in Table III. Here significance is $p<0.001$ (***) and $p<0.01$(**).

TABLE III
SECOND ORDER RELATIONSHIP

All the estimations relating to the dimensions are found to be within the permissible range. Path coefficients between SCD and its five subdimensions with significance levels have been estimated and are shown in Figure 2.

Fig. 2. Construct (SCD) along with its five subdimensions

B. Discriminant validity test

Discriminant validity, relating to all the first order constructs, has been estimated. In terms of the Fornell and Larcker criterion [97], the results demonstrate that square roots of all the AVEs are greater than the bifactor correlation coefficients, thus confirming discriminant validity of all the first order constructs. The results are provided in Table IV.

TABLE IV
DISCRIMINANT VALIDITY TEST

C. Common method bias (CMB)

Since the results of this study depend on survey data, the chance of CMB in the respondents' answers cannot be eliminated. To minimize the chance of CMB, some procedural remedies were adopted. During the survey, the questionnaire was simplified by the inputs from some experts and by the outcomes of pilot tests. Also, the respondents were assured that their identities would not be disclosed so that they could respond in an unbiased way. However, to check the severity of CMB, Harman's Single Factor Test (SFT) was conducted, and it revealed that the first factor emerged as 21.62% of the variance, which is far less than the highest threshold value of 50%, as recommended by Podsakoff et al. [98]. However, Harman's SFT is not a robust test for CMB, as opined by Ketokivi and Schroeder [99], so we also performed non-response bias analysis [100] and marker variable analysis [101]. Here, the 'firm commitment' has been considered as the marker variable [102]. The results of these tests did not provide any evidence of bias. Hence, CMB did not pose a major challenge to this study.

D. Structural model

PLS-SEM provided a distinct idea as to how the latent variables are interconnected. The approach helps to accurately ascertain whether the model is in order or not. To conduct PLS-SEM, the root mean square error (RMSE), along with some specific fit indices and other parameters, were estimated to predict if the data were appropriately represented by the structure. Therefore, chi square with degrees of freedom, CFI (comparative fit index), NFI (normed fit index), TLI (Tucker-Lewis's index), and RMSE were assessed, and the respective values came out as 2.011, 0.96, 0.98, 0.99, and 0.02. Since all the values are in the allowable range, it can be inferred that the model is in order and the structure could be represented correctly by the available data. This helped to compute the β-values of different linkages along with the respective levels of significance and coefficients of determination of all the endogenous variables. The results also reflect that the control variables have insignificant impacts on firm performance. The entire results are provided in Table V.

TABLE V
STRUCTURAL MODEL

The validated model, after statistical analysis, is provided in Figure 3.

Fig. 3. Validated model

The study formulated six hypotheses, out of which two are concerned with the moderating effects of technology turbulence (TT) and top management commitment (MC) on the linkage H1 (SCD→COP). This study subdivided SCD into five dimensions, which are labeled SRM, CRM, SCV, SCR, and SCA. We found that SCD could impact COP significantly and positively, as the path coefficient concerned is 0.27 with level of significance as $p<0.01$(**) (H1). Also, COP could impact OPP and FPR (H2a and H2b) significantly and positively since the path coefficients concerned are 0.32 and 0.17 with level of significance as $p<0.001$(***). The study has shown that OPP could impact FPR significantly and positively, as the concerned path coefficient is 0.35 with level of significance $p<0.01$(**) (H3). The moderator TT impacts H1 (SCD→COP) significantly and positively, with a path coefficient of 0.11 and level of significance is $p<0.05$(*) (H4a). The moderator MC moderates the same relationship H1 (SCD→COP) significantly and positively since the concerned path coefficient is 0.16 and level of significance is $p<0.01$(**) (H4b). In terms of the coefficient of determination, SCD could explain COD to the tune of 37% ($R^2=0.37$). The COP could explain OPP 51% ($R^2=0.51$) of the time, whereas COP and OPP could simultaneously explain FPR to the extent of 65% ($R^2=0.65$), which is the predictive power of the model. Further, it appears from the results that the three control variables of firm type, firm size, and firm age could not impact FPR significantly, as the path coefficients are too low at 0.02, 0.01, and 0.01, respectively, with each having a level of non-significance at $p>0.05$(ns).

E. Moderator analysis (MGA)

To verify the effects of the moderators TT and MC on the linkage SCD→COP (H1), multigroup analysis (MGA) was conducted with the help of SmartPLS. The bootstrapping procedure was used with consideration of 5000 resamples to assess the p-value difference for the two categories of each of the moderators on the linkage H1. Each moderator was categorized into two groups – Strong TT and Weak TT as well as Strong MC and Weak MC. In terms of how each moderator's two categories affect a linkage, if the p-value difference is either greater than 0.95 or less than 0.05, we can say that the effects of that moderator on that linkage are significant [92]. The results provided in Table VI highlight that the effects of the two moderators on the linkage H1 (SCD→COP) are significant.

TABLE VI
MODERATOR ANALYSIS (MGA)

F. Mediation analysis

Here in this section, the mediation effects of operational performance (OPP) on the relationship between cost performance (COP) → operational performance (OPP) → firm performance and resilience (FPR) are discussed. Using a method laid down in other studies [103,104], the bootstrap procedure was performed on a sampling distribution of the indirect effects by using a 95% CI (confidence interval). The mediating path emerging from COP via OPP to FPR is the product of β-values from COP→OPP and OPP→FPR, which came out as 0.32 × 0.35 = 0.112, significant at $p<0.001$(***). Additionally, the direct impacts of COP→OPP and OPP→FPR were also significant at $p<0.001$(***). This highlights that OPP acts as an effective partial mediator connecting COP and FPR [96]. The results of mediation are shown in Table VII.

TABLE VII

MEDIATION TESTING

VI. DISCUSSION

The present study highlights that digitalized supply chain management is a process, during which information is shared, costs are diligently negotiated, and the goods involved in supply chain are listed in an efficient virtual environment. We have also discussed that, in such a scenario, firms strive to develop their smart and intelligent infrastructures and dynamic systems, which are built on adaptive supply chain connectedness. This study also highlights how, by adopting a digitalized SCM system, a firm can improve the relationship with its suppliers and customers, and it can improve supply chain visibility to make the process more efficient, transparent, responsive, and agile. This study has highlighted that dynamic capability allows the firms to shape the market in such a way which can facilitate the value creation as well as realization. In this context, it is argued that firm's ability for sensing threats and seizing the business opportunities and then quickly reconfiguring their resource-base to appropriately capture business value from these opportunities could explain heterogeneity in the firm's performance. These arguments help to understand the BDA, AI, or IoT enabled dynamic capabilities and such abilities also help to understand their impacts in supply chain capability by conceptualizing that these technologies also possess three sub capabilities like sensing, seizing, and reconfiguring. It is also argued that strong BDA, AI, or IoT enabled dynamic capability could be involved in both agile and adaptable supply chain system to eventually improve firm performance. To realize smart SCM, firms need to address many new challenges that are at the primary stage, since many processes of supply chain activities are still carried out manually. The study has demonstrated that supply chain digitalization will impact firms' cost and operational performance, which eventually impacts their overall performance and resilience, as supported by Wamba et al. [8]. The rapid change in technology, or technology turbulence, affects digitalized SCM and finally firm performance, which was also seen in Lee et al.'s study [105]. Our study has also demonstrated that the potential of digital SCM in a firm can be better executed if top management supports the employees, which has also been supported by another study [106]. This study used MGA to analyze the effects of the two moderators (TT and MC) on the linkage SCD→COP, and the analysis found them to be significant. In Figure 4 and Figure 5, we present graphs that illustrate the effects of these two moderators on the same linkage (H1), which we will further discuss below.

Fig. 4. Effects of TT and H1

Fig. 5. Effects of MC and H1

In Figure 4, Strong TT and Weak TT are represented by continuous and dotted lines, respectively. With the increase of SCD, the rate of decrease of COP is more from the effects of Strong TT compared to the effects of Weak TT, since the continuous line is more inclined with the SCD axis than the dotted line is.

Similarly, in Figure 5, Strong MC and Weak MC are indicated by continuous and dotted lines. We can see that with the increase of SCD, Strong MC affects the rate of increase of COP more compared to Weak MC, since the gradient of continuous line is more than the gradient of the dotted line. It is to note that the gradient of a straight line is the trigonometrical tangent of the angle which the straight line makes with the positive direction of the horizontal axis.

Moreover, our study demonstrated that, in the context of impact of SCM on firm performance and resilience, the contributions of the three control variables, which are firm type, firm size, and firm age, are insignificant, since the concerned path coefficients are too low, and each have a level of non-significance as $p>0.05$(ns).

A. Theoretical contributions

The primary and effective contributions of the present study are associated with the empirical development of the nexus between supply chain digitalization and firm performance with resilience, mediated through some critical contextual factors under the moderating influence of the technology turbulence and top management commitment. Our study expands the insights of the researchers into how digitalized SCM could impact supplier and customer relationship management, supply chain visibility, responsiveness, as well as agility. Until now, no other studies were known to have simultaneously assessed the extent of the impact of these salient factors on firm performance and resilience.

The present study mainly discussed adoption of supply chain digitalization by the firms. As such, a standard adoption model or theory could have been used, but we opted not to. Instead, we identified some better suited contextual determinants through which we were able to develop a successful theoretical model with high explanative power. We have also successfully extended the concepts of RBV and DCV [25,26] by considering that, among the internal competencies of a firm, supply chain digitalization capability possesses valuable, rare, inimitable, and non-substitutable (VRIN) abilities, which help the firm to improve its performance through improved cost performance as well as operational excellence. Organizational ability needs to be improved to appropriately extract the best potential from the digitalized SCM system. The organizational capability is the intangible, strategic asset which the firms draw to get their work done, execute their business strategies, and eventually satisfy the customers [22]. In such context, the ability of the digitalized SCM system of the firms is construed to have had the VRIN abilities that corroborate RBV [25]. Thus, by considering that the supply chain digitalization capability of the firms possesses VRIN characteristics, this study has been able to extend the applicability of RBV. Besides, in the dynamic market, to address customer demands, firms need to sense, seize, and integrate the internal VRIN abilities with the seized external opportunities to meet the objectives of the firms. It has been argued that digitalized SCM could fulfill such requirements, therefore, by expanding the concept of DCV, the present study has interpreted how supply chain digitalization could eventually improve firm performance and its resilience.

Moreover, by expanding the amplitude of applications of absorptive capacity [23], it has been argued that a firm with better knowledge resources can recognize the full potential of supply chain digitalization, assimilate that potential, and eventually utilize that potential for better commercial success than other firms that have also adopted digitalized SCM. Another study [21] analyzed technology turbulence on the adoption of supply chain technology. This concept has been extended in the present study to interpret how the effects of technology turbulence could impact the relationship between supply chain digitalization and the cost performance of a firm. This has enriched the body of supply chain management literature. Another study [107] investigated how top management support could help a firm to adopt ubiquitous CRM successfully. The concept of that study has been extended here to investigate how top management commitment could impact adopting digitalization in a firm's supply chain management. This has added value to the extant literature.

B. Implications to practice

Our results can provide several implications for practitioners. We have documented that supply chain digitalization impacts supplier and customer relationship management, which are the two main subdimensions of supply chain digitalization. This implies that firm managers and especially supply chain managers should strive to strengthen the relationships with their suppliers and customers. They may achieve this by sharing knowledge and information with them, which could improve cordiality.

Firm managers should have proper and executable strategies to deal with potential conflicts when they arise, which could weaken the relationships with suppliers and customers. They need to focus on developing a digital supply chain by improving employees' competencies to extract the best from the digitalized supply chain system. To accomplish this, employees need appropriate training to improve their skills. With training, employees will be able to handle the modern technologies used in SCM by enacting smarter transactions through facilitated communication and collaboration with the supply chain stakeholders, which include but are not limited to suppliers, manufacturers, customers, and distributers.

The firm managers should build resilience in the digitalized supply chain activities by regularly ensuring that the employees who are involved in supply chain activities use digital technologies to their best potential. The top management of the firm should also ensure that supply chain management is responsive, transparent, and agile. For this, supply chain managers should be required to have contingencies in place so that the supply chain system can remain viable throughout, which could help the firms to properly check all the upstream and downstream digitalized supply chain management activities in real time. Supply chain managers should also always update the employees regarding modern technology usage, so that technology turbulence may not impede their smooth functioning.

The study has enumerated the influence of top management commitment in promoting digitalized supply chain activities. Top management must strive to establish a collaborative as well as conducive environment so that the employees will not encounter any obstacle to using modern technology, thus sustaining the supply chain resilience.

C. Conclusion, limitations, and future scope

The present study has been able to establish a close nexus between the supply chain digitalization with the firm performance by analyzing how digitalization of supply chain could improve the relationships between the suppliers and the customers as well could enhance supply chain ambidexterity. The present study has successfully used some theories to interpret this study through the theoretical lens and has provided a pragmatic and implementable framework helping the firms to improve the relationship between the potential customers and the suppliers. This study has provided a prescription to understand how it is possible to extract the best potential of the supply chain digitalization process. The study has advocated that this can be achieved by enriching the competencies of the employees of the firms who are the key resources of the firms. This research has suggested that unless the top management of the firms actively supports the digitalization process and incentivizes the employees appropriately, the outcomes of the digitalized supply chain system will not perceive the color of success.

Though the present study has provided several theoretical and practical implications, it is not free from all limitations. First, the results depended on cross-sectional data, which create defects of causality in the relationships between the constructs. In particular, it gives rise to the problem of endogeneity. To remove these errors, future researchers could consider conducting a longitudinal study. Second, the data were collected in a survey from respondents in India, which has the issue of external validity. The results also cannot be deemed to be generalizable. It is suggested that to rectify these limitations, future researchers should collect data for analysis from respondents who are uniformly spread across the globe. Analysis of their responses could then provide more generalizable results. Third, the study analyzed the data of 712 respondents. That sample does not represent the total population. Future researchers should think of analyzing data from more respondents to avoid this limitation, as well as focusing on the customers along the supply chain [108]. Fourth, the present study has used DCV [26], which Ling-Yee [109] opined is context insensitive. DCV fails to identify the specific conditions under which firm performance will be most valuable [50]. Future studies may further explore the optimum condition in which supply chain digitalization may yield best firm performance. Fifth, the explanative power of the proposed theoretical model is 65%. Future researchers may consider including other boundary conditions and constructs to verify if they could strengthen the explanative power of the proposed theoretical model. Sixth, the study has mostly focused on the impacts of 'top management commitment' towards the digitization process of the supply chain management system of the firms. It could be an interesting study to examine if the young generation also impacts on the digitization process as they are more supposed to be savvy with digital technologies. The present study did not explicitly nurture this issue. Future researchers could examine if the young generation of employees also impact the digitization process in their firms.

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Authors' Biography

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Appendix

Appendix: Summary of Questionnaire

Items	Source	Statements	Response [SD][D][N][A][SA]
SRM1	[77]	I believe that digitization of supplier relationship management is important for the successful digitalization of supply chain management system.	[1][2][3][4][5]
SRM2	[8], [49]	Adoption of modern digital technologies is essential in developing an efficient supplier relationship management system.	[1][2][3][4][5]
SRM3	[9]	I think that the top management needs to allocate sufficient budget for digitization of supplier relationship management system.	[1][2][3][4][5]
CRM1	[55], [107]	Digitization of customer relationship management process plays a significant role towards overall digitalization of supply chain management process.	[1][2][3][4][5]
CRM2	[6]	Adoption of artificial intelligence in customer relationship management system could help to automate several regular tasks thereby improving efficiency.	[1][2][3][4][5]
CRM3	[9], [56]	I believe that there could be several technological challenges while adopting digital customer relationship management practices.	[1][2][3][4][5]
SCV1	[56]	Efficient supply chain visibility can track different goods in real time scenario.	[1][2][3][4][5]
SCV2	[9], [77]	I believe that through digitalized supply chain management system, there will be improvement of supply chain visibility.	[1][2][3][4][5]
SCV3	[55]	I believe that an effective and transparent supply chain visibility can improve decision making process.	[1][2][3][4][5]
SCR1	[8], [41]	I believe that a digital supply chain responsiveness process can help to meet the changing needs of the customers.	[1][2][3][4][5]
SCR2	[58]	I think an efficient supply chain responsiveness process can effectively respond to the changes in the hyper market.	[1][2][3][4][5]
SCR3	[9]	I believe that a responsive supply chain management system can reduce the overall cost of a supply chain management system.	[1][2][3][4][5]
SCA1	[63], [65]	I believe that supply chain agility enables the firms to better synchronize with both the supply as well as demand side.	[1][2][3][4][5]
SCA2	[61]	Improvement in supply chain agility will decrease the inventory cost as well as transportation cost.	[1][2][3][4][5]
SCA3	[62], [66]	I believe that an agile supply chain system can significantly reduce the overall supply chain cost for the firm.	[1][2][3][4][5]
COP1	[69]	Cost performance is a measure of financial efficiency of a firm's performance.	[1][2][3][4][5]
COP2	[61], [72]	Advanced supply chain management system has a significant impact on the cost performance of a firm.	[1][2][3][4][5]

COP3	[63], [71]	I believe an efficient supply chain system which can effectively handle supply chain disruptions is very expensive.	[1][2][3][4][5]
COP4	[61], [73]	Inventory and transportation costs could be reduced by the application of an efficient supply chain management system.	[1][2][3][4][5]
OPP1	[75]	Synergy amongst different units of a firm can improve the operational performance of a firm.	[1][2][3][4][5]
OPP2	[39]	Collaboration among different units of a firm is an important aspect of improving the operational performance of a firm.	[1][2][3][4][5]
OPP3	[8], [76]	To make the operations of a firm more efficient, imparting regular training to the employees is important.	[1][2][3][4][5]
OPP4	[9]	I believe that operational efficiency can improve the overall efficiency of a firm.	[1][2][3][4][5]
FPR1	[49], [78]	I believe that digitalized supply chain management system can improve the overall performance of a firm.	[1][2][3][4][5]
FPR2	[9[	Adoption of modern technology is important to improve firm performance.	[1][2][3][4][5]
FPR3	[8]	Digitization of the supply chain management system can improve the competitiveness of the firm.	[1][2][3][4][5]
FPR4	[39], [75]	The overall performance of the firm can be improved by streamlining all the processes.	[1][2][3][4][5]

Note: SD = Strongly Disagree; D = Disagree; N = Neither disagree nor agree; A = Agree; SA = Strongly Agree

Figures and Tables

Fig. 1. Conceptual model (adopted from Cohen and Levinthal [21]; Barney [23]; and Teece et al.[24])

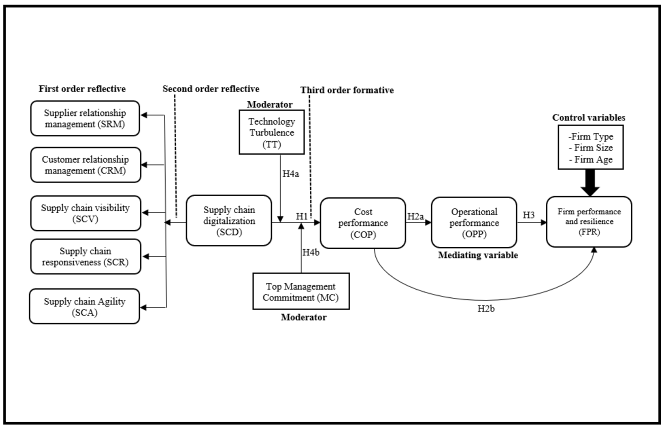

Fig. 2. Construct (SCD) along with its five subdimensions

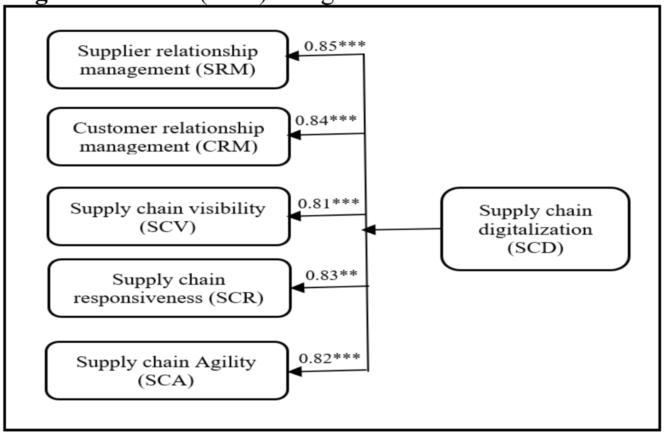

Fig. 3. Validated model

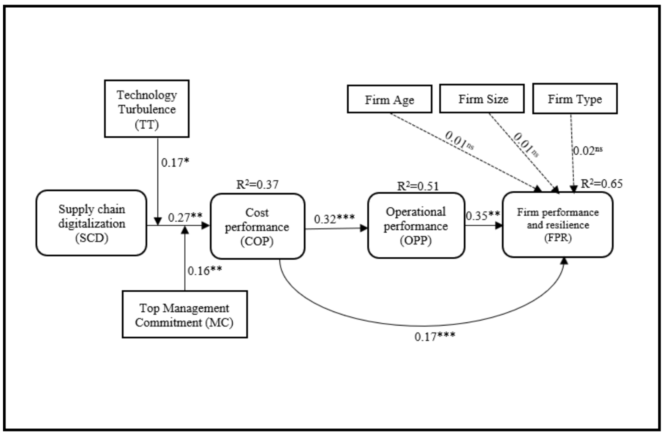

Figure 4, 5: Effects of moderator

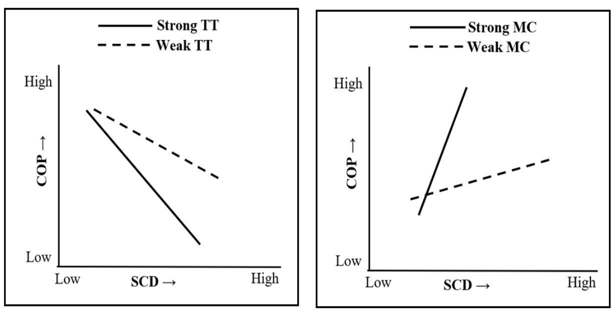

Figure 4: Effects of TT and H1 **Figure 5:** Effects of MC and H1

Table I: Demographic responses

Particulars	Category	Frequency	Percentage
Managerial Rank	Top Management (Leadership) [CXOs e.g., CEO, CFO, CIO, CMO etc.]	88	12.3
	Senior Manager [Director, General Manager, Vice President, Sr. Advisors and so on]	114	16.0
	Midlevel Manager [Team Leaders, Project Managers, Solution Managers, Consultants, and so on]	194	27.2
	Junior Manager [Associates, Programmers, Inventory/Warehouse Managers, Junior Consultants, and so on]	316	44.5
Firm age	Older firms (>25 years)	232	32.6
	Established firms (10-25 years)	301	42.3
	New-age firms / Startups (<10 years)	179	25.1
Firm size	Large firms (Revenue: > USD 1 billion /Year)	286	40.2
	Midsize firms (Revenue: 100 million – 1 billion /Year)	230	32.3
	Small and startup firms (Revenue: <100 million USD/Year)	196	27.5
Firm type	Service firms	509	71.4
	Manufacturing firms	203	28.6

Table II: Measurement properties

Constructs / Items	Mean	SD	LF	AVE	CR	α	VIF	t-values
SRM				0.83	0.87	0.91	3.1	
SRM1	4.1	1.2	0.87					21.24
SRM2	2.3	1.4	0.95					26.11
SRM3	3.7	1.6	0.91					29.54
CRM				0.85	0.89	0.92	2.8	
CRM1	4.3	1.4	0.92					25.52
CRM2	2.7	1.3	0.95					29.11
CRM3	2.9	1.5	0.90					21.32
SCV				0.87	0.90	0.94	2.5	
SCV1	3.1	1.6	0.85					25.52
SCV2	4.5	1.9	0.90					26.47
SCV3	4.7	1.4	0.95					25.11
SCR				0.89	0.92	0.96	3.3	
SCR1	3.3	1.7	0.91					26.47
SCR2	2.4	1.7	0.85					20.29
SCR3	2.8	1.5	0.97					31.04
SCA				0.86	0.91	0.96	2.9	
SCA1	3.4	1.4	0.95					25.72
SCA2	4.9	1.9	0.94					29.11
SCA3	3.5	1.6	0.90					31.74
COP				0.88	0.93	0.97	2.6	
COP1	4.6	1.7	0.92					40.02
COP2	4.1	1.6	0.90					41.11
COP3	3.2	1.8	0.96					26.17
COP4	2.9	1.1	0.97					29.91
OPP				0.83	0.88	0.91	2.5	
OPP1	3.6	1.2	0.96					24.08
OPP2	3.4	1.6	0.93					26.77
OPP3	2.8	1.5	0.89					29.12
OPP4	3.7	1.7	0.95					32.76
FPR				0.80	0.84	0.89	3.1	
FPR1	3.1	1.4	0.96					25.27
FPR2	3.6	1.5	0.89					29.11
FPR3	4.1	1.6	0.85					26.77
FPR4	4.8	1.5	0.93					24.09

Table III: Second order relationship

Construct	LF	CR	AVE	p-values	Linkage	β-value	t-value
SCD	0.87	0.87	0.83	p<0.001(***)	SCD→SRM	0.85	28.47
	0.95						
	0.91						
	0.92	0.89	0.85	p<0.001(***)	SCD→CRM	0.84	29.51
	0.95						
	0.90						
	0.85	0.90	0.87	p<0.001(***)	SCD→SCV	0.81	30.07
	0.90						
	0.95						
	0.91	0.92	0.89	p<0.01(**)	SCD→SCR	0.83	32.44
	0.85						
	0.97						
	0.95	0.91	0.86	p<0.001(***)	SCD→SCA	0.82	35.62
	0.90						
	0.94						

Table IV: Discriminant validity test

Construct	SRM	CRM	SCV	SCR	SCA	COP	OPP	FPR	AVE
SRM	0.91								0.83
CRM	0.26	0.92							0.85
SCV	0.29	0.27	0.93						0.87
SCR	0.17	0.32	0.23	0.94					0.89
SCA	0.32	0.29	0.17	0.26	0.93				0.86
COP	0.34	0.19	0.29	0.25	0.32	0.94			0.88
OPP	0.24	0.26	0.28	0.29	0.35	0.39	0.91		0.82
FPR	0.23	0.24	0.37	0.37	0.31	0.33	0.29	0.89	0.80

Table V: Structural model

Linkages	Hypotheses	R^2 / β-values	p-values	Remarks
Effects on COP		R^2=0.37		
By SCD	H1	0.27	p<0.01(**)	Supported
Effects on OPP		R^2=0.51		
By COP	H2a	0.32	p<0.001(***)	Supported
Effects on FPR		R^2=0.65		
By COP	H2b	0.17	p<0.001(***)	Supported
Effects on FPR		R^2=0.65		
By OPP	H3	0.35	p<0.01(**)	Supported
(SCD→COP) × TT	H4a	0.17	p<0.05(*)	Supported
(SCD→COP) × MC	H4b	0.16	p<0.01(**)	Supported
Effects of control variables				
Firm type → FPR		0.02	p>0.05(ns)	Insignificant
Firm size → FPR		0.01	p>0.05(ns)	Insignificant
Firm age → FPR		0.01	p>0.05(ns)	Insignificant

Table VI: Moderator analysis (MGA)

Linkages	Moderators	Hypotheses	p-value differences	Remarks
(SCD→COP) × TT	TT	H4a	0.03	Significant
(SCD→COP) × MC	MC	H4b	0.01	Significant

Table VII: Mediation testing

Effects	Linkages	β-values	Standard errors	T-statistics	p-values
Direct effects	COP→FPR	0.17	0.035	15.709	0.00
Indirect effects	COP→OPP →FPR	0.112	0.026	5.642	0.00