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Case Study

COVID-19 Induced Supply Chain Disruptions and Automotive Industry: A Case Study of Maruti Suzuki India Limited and Mitigation Strategies

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Abstract: The paper analyzed the impact of the COVID-19 pandemic induced supply chain disruptions (SCDs) on the Indian automotive industry (IAI) using a case study of Maruti Suzuki India Limited (MSIL), which share about 50% of automotive market in India and offered mitigation strategies and the SCDs recovery model. The study revealed that the IAI is unlikely to achieve its target for 2021-2022 due to pandemic induced SCDs and MSIL is no exception. The study revealed that in 2019-2020, the MSIL reduced its production several times to adjust dealers' inventories in view of unprecedented economic slowdown and the prolonged domestic slump in automobile industry. In 2020-2021, MSIL is still facing severe disruption risks caused by the COVID-19 along with other OEMs in India and globally. In the first wave of the pandemic in India, MSIL production was totally halted and domestic sales were virtually zero in April 2020. During the second wave of the pandemic crisis in India, MSIL again experienced a severe fall in production and sales performance due to regional lockdown restrictions and SCDs. The rapid decline in production of MSIL has been mainly due to the pandemic induced lockdown and the SCDs in auto-components and halt in manufacturing activities. Therefore, robust mitigation strategies are needed to recover from the COVID-19 induced SCDs. The suggested model focused on the SCDs and risk management and offered the proactive and reactive responses for speedier readjustment of automotive industry from the COVID-19 pandemic induced SCDs. Ending the COVID-19 era and its impact on SCDs will not only depend on government policies, but also on proactive and reactive risk mitigation measures initiated by the firms. Robust measures should be taken to tackle the current supply chain threats in automotive sector to build the resilience of supply chain systems to safeguard them against business downturns.

***Keywords*:** automotive industry, case study, COVID-19, India, Maruti Suzuki India Limited, supply chain disruption

JEL Codes: C89, L62, R41

1. Introduction

Disruptions to business operations and global supply chains (GSCs) caused by the COVID-19 pandemic have led practitioners and researchers to focus on recovery strategies. The stricter border restrictions and lockdowns have caused a negative short-term impact on international trade and disrupted the GSCs (Kumar & Managi, 2020). The COVID-19

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pandemic hampered the supply chains resilience in both the downstream and upstream, thereby making the lean and globalised firms more vulnerable to supply chain disruptions (SCDs) by stopping production and logistics (Ivanov, 2020) due to high dependence on China for the supply of automotive components (Kumar & Managi, 2020; Sharma et al., 2020). The SCDs refer to the unexpected and unanticipated occurrences that impede the flow of products and services along the supply chain (Craighead et al., 2007; Tang, 2006).

The SCDs are versatile and classified as disruption risk and operational risk (Xu et al., 2020). Day-to-day global supply and demand unpredictability, such as lead-time and demand variations, created operational risks (Ivanov et al., 2017; Kinra et al., 2019; Hosseini et al., 2019) whereas disruption risks arose from the catastrophic events such as natural disasters or man-made disasters and have low probability and high consequences (Knemeyer et al., 2009). Other disruption risks include supply disruption, demand disruption, technology disruption and process disruption (Bogataj & Bogataj, 2007; Tang & Tomlin, 2008). It has affected both downstream and upstream capital and supply networks, including distribution and product availability (Wang & Su, 2020).

The world economy has been highly impacted due to the unprecedented impact of the pandemic (Ozili & Arun, 2020). In Eurozone, the GDP plummeted by 3.8% in the first quarter of 2020 (Eurostat, 2020), while GDP declined by 1.2% in the United States (Pwc, 2020a), and 2%, in the United Kingdom during the same period (ONS, 2020). The GDP estimates for the first quarter (April to June) of 2020 revealed a decline of 24% in India compared to 2019 (Waghmare, 2020). Governments across the globe have established regulations and recovery plans, and imposed restrictions to contain the pandemic spread. These restrictions affected the sustainable functioning of firms. For instance, a strong decline in prices of oil and a steep fall in manufacturing have resulted in a sharp fall in the global stock markets and a global recession is looming large due to severe COVID-19 induced SCDs (Bobdey & Ray, 2020). Indeed, while some supply chains are spinning incredibly hard to keep up, others such as the Volkswagen were forced to ramp down. The pandemic impact on the supply chain has been largely unpredictable due to the absence of complete risk assessment (Kumar & Managi, 2020; Ivanov & Dolgui, 2020).

The pandemics like COVID-19 are recurring health crisis like the influenza pandemic and are likely to reoccur after 10-50 years or more intervals. Besides the pandemic crisis, threats such as climate change induced disasters, man-made circumstances such as terrorism, and other potential risks have also posed immense threats to supply chain sustainability. All this requires the application of robust mitigation measures through supply chain risk management (SCRM) linking with innovative supply chain management methods to recover from business slowdown. Therefore, firms should develop efficient mitigation strategies to recover the businesses. Currently, there exists relatively little research on why existing supply chain structures have not addressed the pandemics or similar crises and how should this be accomplished? Against this background, we intended to review the existing literature on supply chains and SCDs, evaluated the recent performance of Indian automotive industry (IAI), analyzed the experiences of Maruti Suzuki India Limited (MSIL) as a case study and offered mitigation strategies and developed an SCDs recovery model using proactive and reactive strategies for prompt recovery of automotive industry from the COVID-19 pandemic induced SCDs.

2. Review of literature

The unpredicted natural disasters induced supply chain risks attributed to increased business insecurity and susceptibility (Zsidisin, 2003). SCM is more vulnerable to business risk disruption (Mitroff & Alpaslan, 2003; Craighead et al., 2007; Blackhurst et al., 2005). SCDs motivated supply chain researchers to understand such risks and their impact on supply chains (Chopra & Sodhi, 2014). The operational and financial performance of firms were greatly affected by SCD vulnerabilities (Hendricks & Singhal, 2003; Hendricks & Singhal, 2005; Bode et al., 2011). In case of high impact disruption risks, existing resources need to restructure to improve the firm's ability to adapt and respond to such risks (Eddleston et al., 2008). For instance, the ability to leverage the firm's resources was considered a key measure to recover from a massive earthquake in Japan in 2011. However, in low-impact SCDs like delays in shipment of components, the resource configurations are not essential to supply chain resilience, but earlier experiences of disruptions help better preparations to minimize the impact (Olcott & Oliver, 2014).

Various mitigation strategies have been implemented to overcome SCDs including SCD orientation (SCDO) and supply chain resilience (SCR) (Sodhi et al., 2012). These are aimed to improve a firm's capability to absorb disruptions

and rapidly recover to a stable environment (Blackhurst et al., 2011; Sheffi & Rice, 2005). SCR refers to a dynamic capability of the firm to effectively acclimate, respond, and recover from SCDs (Chowdhury & Quaddus, 2016; Yu et al., 2019). It is used to recuperate from unplanned disturbances of the supply chain (Christopher & Peck, 2004; Sheffi & Rice, 2005). Therefore, resilient firms are more capable of managing disruption risks (Sheffi & Rice, 2005). Resilience proficiency allows the firms to lessen the brunt of disruption and to retrieve to their original position (Blackhurst et al., 2011).

Several researchers analyzed the epidemic impact on the business operations (Mamani et al., 2013; Büyüktahtakın et al., 2018; Ivanov, 2020). Manufacturing firms experienced a negative financial impact and were deeply concerned about disastrous impact of the pandemic (PwC, 2020b). The Chinese's GVCs and production centers were gravely affected (Nakamura & Managi, 2020). China's deeper integration into GSCs has increased the economic spillovers to other countries with a substantial impact on global growth.

The COVID-19 pandemic has impacted the automotive industry supply chains on a large scale (Accenture, 2020). The transmission of disruptions across automotive supply chain network (SCN) is severe (PwC, 2020a) when the disruption risks impact the firms' performance strongly (Dolgui et al., 2020, Li & Zobel, 2020; Ivanov, 2020). This resulted in significant domino effects (Ivanov, 2020) and calls for robust SCRM (Chen et al., 2019; Pournader et al., 2020) with comprehensive data and digital SCs (Choi et al., 2020; WEF, 2020a, 2020b) to raise the effectiveness of response (Ivanov et al., 2019). The COVID-19 also created fear psychosis among the firms resulting from the longer lockdown of modern times. The psychological effects of the crisis can be equated to the biological and other terrorism threats that caused a high level of stress with longer-term consequences. The COVID-19 drastically undermined the entire global production network (GPN) and increased the SCD (Araz et al., 2020). For instance, in April 2020, MSIL production was totally halted and domestic sales were virtually zero, while export was marginal at 632 units, which is attributed to disruptions in operations caused by the closure of the manufacturing plants and dealers' showrooms (MSIL Annual Report, 2020). Thus manufacturing and transportation disruptions have generated immense economic impacts in India (ETAuto, 2020).

Abundant strategic choices have been provided to the automotive supply chains by many research groups. For Instance, Boston Consulting Group (BCG) provided a plethora of strategic choices adopted globally by major original equipment manufacturers (OEMs) in the automotive industry which included restructuring the supply chains, designing customer-oriented supply chains and diverse operational strategies (Collie et al., 2020). Virtual vehicle certification, improvements to the supplier integration process and supply chain sustainability have been offered in Indian context (Singh, 2020). But Indian automotive firms have adopted varied strategies depending upon the individual OEM's nature, philosophy, supply networks and management system. Several auto-component supplier firms, automotive dealers, and automotive service centers in small and medium-sized enterprises (SMEs) sector also participated in automotive supply chains. The COVID-19 pandemic induced SCDs adversely impacted their smooth functioning due to national and global lockdowns, and severe trade disruptions with China, the major auto components manufacturer in the world, which in turn affected the OEMs functioning adversely.

Consequently, the strategies adopted by auto-component supplier firms during the pre-pandemic and pandemic period can remarkably impact the strategies adopted by the OEMs. The easing of the lockdown restrictions has led many OEMs to gain stability, resiliency and infused strength to the channel members by launching new products and shifting sentiments. This may be expected to achieve a positive growth rate in the automotive industry in 2021-2022 and following years as real growth and market expansion in an automotive sector still requires improvement and agile and resilient strategies (BT, 2021). At the same time, various automotive channel members failed to achieve positive outcomes and struggled hard to recover to their pre-pandemic strength (Chibber & Gupta, 2021). For instance, in 2020-2021, passenger vehicles (PVs) production, domestic sales, and export stood at 3434013, 2773575, and 677311 units respectively in India (SIAM, 2020). In December 2020, PVs' sales stood at 271249 units, compared to 218775 units in December 2019, registering a 23.99% growth. One of the reasons for failure or slow recovery of the automotive industry can be a blind implementation of the old strategies or replication of previously successful strategies during the pandemic (Bhatt & Varghese, 2020).

India's auto sector might face a long-term impact on demand, procurement, manufacturing, and distribution due to mobility restrictions and the nation-wide second-wave of the COVID-19 induced SCDs. The procurement and shortage of semi-conductors, delayed distribution network along with the rising second-wave of the COVID-19 restrictions have

the strong potential to re-dampen the automobile supply's operational recovery and resilience and posed hurdles to meet the increase in demand. The automobile sector has already started to experience the impact of the second-wave of the COVID-19 on the key auto-components suppliers' firms in the second half of March 2021, which will have severe negative impacts on the sales of PVs in India (Balachandar, 2021). For instance, despite sales improvement in 2020, Nifty Auto Index had experienced a stock tumble by 255.85 points with Ashok Leyland, Hero MotoCorp, MSIL, Tata Motors, Eicher Motors observed 4.3%, 2.4%, 2.1%, 1% and 4% dipped respectively in the stock market (IINS, 2021).

The imposition of regional lockdowns will jeopardize the progress achieved over the past few months. The automotive industry has played an influential role and provided lessons to manufacturing industries due to its wider experience in managing SCDs (Childerhouse et al., 2003). Therefore, the study of automotive industry supply chains response in managing the COVID-19 induced SCDs will offer an example to build resilience in the manufacturing supply chains at large. Hence, the research on the mitigation strategies for the automotive industry during the COVID-19 pandemic is therefore very important for constructing SCR. However, the existing knowledge on complex and dynamic automotive industry supply chains involving many automotive SMEs is inadequate specifically in the context of the impact of the COVID-19 pandemic. The automotive industry's SCDs created a threat to a significant portion of the GSCs due to low flexibility (Martin et al., 2020). Hence, designing SCR in the automotive industry and associated SMEs is highly significant and will furnish valuable insights to the other automobile manufacturing and service SCs to robustly manage the COVID-19 induced SCDs. Recent developments have paid substantial attention to the automobile sector and related SME supply networks. The existing literature lacks empirical evidence in building resilient automotive industry and associated SMEs SCR and has not adequately addressed the impact on GSCs (Rose et al., 2017). Therefore, the current study is highly contemporary, which intends to develop an SCR model to bolster and resilient the automotive industry and associated SMEs' supply chains under COVID-19 induced SCDs.

Recent SCR research emphasized resilience measurements before building response and recovery mechanisms (Hosseini et al., 2019; Graveline & Grémont, 2017; Ivanov et al., 2017; Chowdhury & Quaddus, 2016). The existing SCR literature has focused on theoretical and modeling approaches (Hosseini et al., 2019; Ojha et al., 2018; Torabi et al., 2015; Schmitt & Singh, 2012; Ivanov et al., 2016; Simchi-Levi et al., 2015) and also quantification approaches (Yagi et al., 2020; Jabbarzadeh et al., 2018; Hosseini et al., 2020) to offer mitigation strategies. However, most studies have emphasized the need for more empirical research on SCR evaluation during disruptions.

The SCR literature has concentrated mostly on assessing firms to construct SCR without proposing mitigation measures to deal with disturbances, their enablers, procedures, antecedents, capacities and skills (Tukamuhabwa et al., 2017). However, these factors also involve mitigation strategies to build SCR indirectly by focusing on enhancing SC agility, visibility, flexibility, redundancy, and linkages with the collaborating firms. Thus, the literature review enabled us to identify diverse SCR approaches, grouped into proactive and reactive sources (Hendry et al., 2019; Tukamuhabwa et al., 2017). The proactive sources refer to technology involving digital connectivity and automation to prevent future interruptions (Ralston & Blackhurst, 2020; Tan et al., 2019; Hofmann et al., 2019), localization and regionalization of sourcing (Iakovou et al., 2014), integrated SC risk management (Zhu et al., 2017), and development of human capabilities (Blackhurst et al., 2005). The reactive sources refer to in-house information systems and decision making based on data (Kamble & Gunasekaran, 2020; Belhadi et al., 2019; Belhadi et al., 2018), virtual marketplaces (Sharifi et al., 2006) and SC simulation (Hofmann et al., 2019). Besides proactive and reactive strategies, the existing literature also offered concurrent strategies including transport management (Graveline & Grémont, 2017; Ivanov et al., 2016; Haraguchi & Lall, 2015), inventory development and creation of reserve capacity (Lücker et al., 2019; Simchi-Levi et al., 2015), and contingency and continuity plans and decision-making (Zsidisin et al., 2005).

The literature review enables us to develop a conceptual framework to evaluate the SCR strategies based on the impact of COVID-19 induced SCDs on MSIL and to analyze both the proactive and reactive SCR and mitigation strategies adopted by the automotive industry players to manage the disruption risks. The application of the existing SCR theory with proactive and reactive sources will assist us to understand when and why a strategy should be applied at which stage in the automobile industry. The impact of the COVID-19 pandemic is likely to last for a long time and warrants a new SCM model. Therefore, both the proactive and reactive SCR and mitigation strategies are vital for the automotive industry and associated SMEs to recover and become agile and resilient during the pandemic and post-pandemic scenarios. Kumar and Managi (2020) and Ivanov and Dolgui (2020) have suggested to build SCR among the firm to address the COVID-19 impact, while Jacobsen (2020) advocated for an improved SCM to deal with the

COVID-19 pandemic induced SCDs.

The automotive industry's GSCs have been substantially impacted due to higher dependence on China to meet auto component supplies. Many auto component suppliers in Wuhan have shown their inability to supply auto components**.** The ripple effect of SCDs in the automotive industry has spread globally and affected the OEMs adversely. There is minimal evidence-based research to help the supply chains develop resistance to the COVID-19-induced SCDs (Yoo & Managi, 2020). Therefore, it is highly significant to clearly understand both the short-term and long-term impacts of the COVID-19 pandemic and its risk assessments on the automotive industry (Nakamura & Managi, 2020) and to offer the suitable mitigation strategies to build SCR (Kochan & Nowicki, 2019). Complexity and variability in the effects of SCDs caused by COVID-19 make it difficult to properly understand supply chains risk and establish long-term effective SCR solutions (Kumar & Managi, 2020; Ivanov & Dolgui, 2020). Thus, the analysis of SCR in automotive industry supply chains is very timely in this uncertain situation.

3. Objectives and methodology

The earlier used strategies might not be useful in addressing the COVID-19 induced SCDs without integrating novel and advanced strategies (Paul & Chowdhury, 2020). There is a missing link between the current pool of knowledge on the role of the SCR strategies implemented to overcome large-scale SCDs and its impact on OEMs performance, which reflects a gap between understanding of SCDs in theory and practice. Thus, there is a need for a more holistic and integrated research on the COVID-19 induced SCDs and SCR focusing on automotive industry players and how to address the COVID-19 induced SCDs on a proactive and reactive basis for the sustainability of the automotive industry (Scholten et al., 2020). Therefore, the paper is a maiden attempt to examine the impact of COVID-19 induced SCDs on MSIL and how to mitigate the SCDs in Indian automotive industry using more holistic and integrated advanced agile SC and SCR practices to overcome the COVID-19 induced SCDs and similar outbreaks in the future. The paper has used the secondary data from the recent reports of the Society of Indian Automobile Manufacturers (SIAM), the Automotive Component Manufacturers Association of India (ACMA), Government of India (GoI), the Centre for Monitoring Indian Economy (CMIE) and annual reports of MSIL. The data has been analyzed using descriptive statistics and graphics.

4. Recent performance of Indian automotive industry

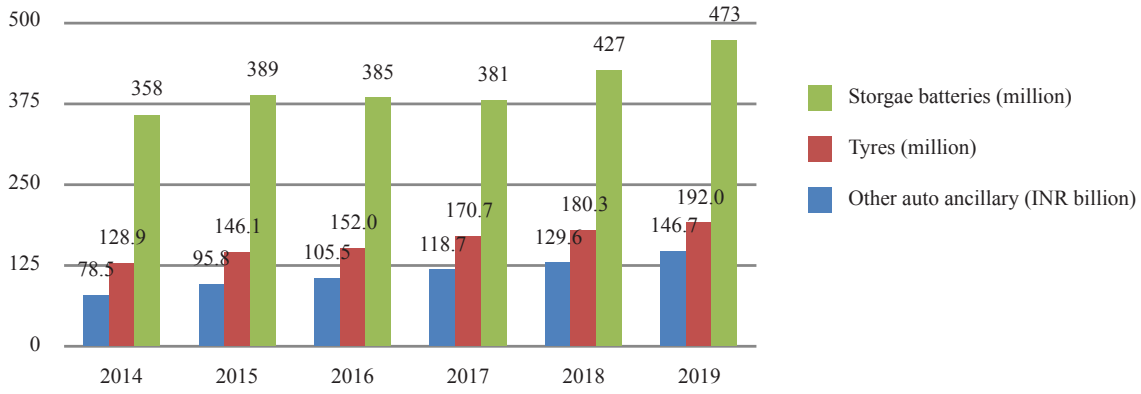

Figure 1. Production of ACs in India

Source: Authors' creation

The performance of the Indian automotive industry (IAI) was slow before the 1980s due to limited competition.

In the early 1980s, the Japanese firms entered the IAI followed by the entry of foreign automotive firms up to the mid-1990s (SIAM, 2017). The IAI showed significant performance after the introduction of the Auto Policy (GoI, 2002) and the Automotive Mission Plan (AMP) (2006-2016) (GoI, 2006).

Table 1 shows the recent performance of the IAI. Domestic sales of passenger and commercial vehicles surged at 2.7% and 17.55% respectively, while automobile exports increased at 14.5%, but exports of passenger vehicles declined by 9.64% in early 2019 compared to early 2018 (SIAM, 2019). The COVID-19 pandemic induced SCDs severely impacted the IAI. Table 2 reveals a declining trend of investments in auto-component industry (ACI) in India. The cumulative FDI in the automotive sector stood at US$20.85 billion from 2000-2001 to 2018-2019. Despite the decline in investment in ACS, production of ACI has increased steadily from 2014-2015 to 2019-2020, which is reflected in Figure 1. India was projected to become the world's third-largest passenger vehicle market by 2021 (SIAM, 2015).

Table 1. Production, Domestic Sale and Export of Passenger and Commercial Vehicles (million units)

Year	Passenger vehicles			Commercial vehicles		
	Production	Domestic Sale	Export	Production	Domestic Sale	Export
2000-2001	0.63	0.60	0.027	0.15	0.15	0.014
2001-2002	0.67	0.67	0.050	0.16	0.14	0.012
2002-2003	0.72	0.70	0.070	0.20	0.19	0.012
2003-2004	0.98	0.90	0.11	0.25	0.26	0.082
2004-2005	1.21	1.06	0.16	0.35	0.32	0.030
2005-2006	1.31	1.14	0.17	0.39	0.35	0.041
2006-2007	1.54	1.38	0.19	0.52	0.46	0.049
2007-2008	1.78	1.55	0.21	0.55	0.49	0.059
2008-2009	1.84	1.55	0.33	0.41	0.38	0.043
2009-2010	2.36	1.95	0.44	0.56	0.53	0.045
2010-2011	2.98	2.50	0.44	0.76	0.68	0.074
2011-2012	3.12	2.61	0.50	0.91	0.81	0.093
2012-2013	3.23	3.22	0.55	0.83	0.79	0.080
2013-2014	3.09	3.09	0.59	0.69	0.63	0.077
2014-2015	3.22	2.60	0.62	0.69	0.61	0.087
2015-2016	3.46	2.78	0.65	0.78	0.68	0.10
2016-2017	3.80	3.04	0.75	0.81	0.71	0.11
2017-2018	4.02	3.29	0.74	0.90	0.85	0.097
2018-2019	4.03	3.37	0.67	1.11	1.01	0.099
2019-2020	3.43	2.77	0.67	0.75	0.72	0.60
2020-2021	-	2.71	0.40	-	0.57	-

Source: Authors' compilation based on data provided in Society of Indian Automobile Manufacturers (SIAM) (2015, 2016, 2017, 2019, 2020) and data extracted from Centre for Monitoring Indian Economy (CMIE) and SIAM.

Table 2. Auto Component Industry (ACI) in India

Year	Auto component[1] sector (US$ billion)				FDI in automotive[2] sector
	Investment	Aggregate turnover	Exports	Imports	
2000-2001	-	3.97	0.63	-	-
2001-2002	2.30	4.47	0.58	0.26	-
2002-2003	2.64	5.43	0.76	0.26	-
2003-2004	3.10	6.73	1.27	0.26	-
2004-2005	3.75	8.70	1.69	0.61	-
2005-2006	0.7	12.00	2.47	0.78	-
2006-2007	1.0	15.00	2.90	0.82	-
2007-2008	1.8	26.44	3.62	4.9	-
2008-2009	0.1	24.09	5.10	6.8	-
2009-2010	1.7	29.23	3.99	8.16	-
2010-2011	2.3	41.31	6.65	7.70	5.93[3]
2011-2012	1.8	42.68	8.91	10.30	0.83
2012-2013	1.5	39.69	9.68	11.50	1.54
2013-2014	0.7	35.10	10.16	12.80	1.52
2014-2015	0.4	38.41	11.21	13.50	2.57
2015-2016	0.5	39.05	10.83	13.80	2.68
2016-2017	0.37	43.55	10.90	13.5	1.61
2017-2018	1.74	51.20	13.50	15.9	2.09
2018-2019	-	56.52	15.17	17.6	2.62
2019-2020	-	49.30	14.50	15.4	24.21[4]
2020-2021E	-	15.90	5.20	-	-

Note: Aggregate turnover includes the domestic supplies to OEMs, aftermarket sales and exports for the period. [1]Include components for passenger, commercial, two-wheelers and three-wheelers, [2]include automobiles and auto-components, [3]2000-2001 to 2010-2011 and [4]2000-2001 to 2019-2020 (up to December 2018). Source: Author's compilation based on data provided in Automotive Component Manufacturers Association of India (ACMA) (2016 and 2019), GoI (2006), India Brand Equity Foundation (2019) and data extracted from Centre for Monitoring Indian Economy (CMIE) and ACMA

Figure 2 shows domestic and exports markets of ACI in India 2020. ACI was projected to increase at about 15% in 2020 due to the robust demand for passenger and commercial vehicles in domestic and export markets. In India, the exports and imports of ACs are likely to be US$80 billion and US$ 23-28 billion respectively by 2026 (ACMA, 2019). However, the pandemic induced SCDs are likely to impact the achievement of these targets.

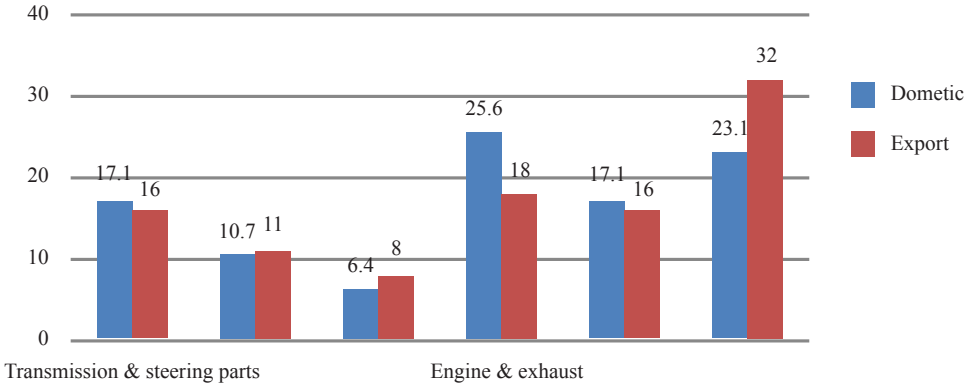

Figure 2. Domestic and Export Markets of ACI in 2020E (%)
Source: Authors' creation

5. Case study of MSIL

In 1982, the GoI established the Maruti Udyog Limited (MUL) through a joint venture (JV) with the Suzuki Motor Corporation (SMC) of Japan. Later the MUL was renamed as MSIL. The company has three manufacturing plants in Manesar and Gurugram (Haryana) and Gujarat in India. In 2019-2020, the automotive market share of MSIL stood at about 50% with total sales of over 10 million since inception (MSIL, 2019). Table 3 shows the growth performance of MSIL since 1999-2000.

In India, the outbreak of COVID-19 and lockdown measures to contain the pandemic spread had led to SCDs via decline in automotive manufacturing and severely affected ACS, which posed various challenges to OEMs for the revival of their activities and sustaining SCs. In this context, the main challenges faced by OEMs include the inability to procure auto-components, supply of counterfeit products, and disruptions in out-sourcing, transportation and coordination in SCs. Many OEMs faced the SCDs in critical auto-components from China and other countries.

For instance, the automotive industry imports most auto-components and suffered severely due to SCDs and temporarily suspended production, which strongly impacts their performance. In the process, the bargaining power has been shifted from OEMs to auto-components suppliers. Disruptions in automotive manufacturing and supply including lack of inventory at distribution outlets have reduced automotive supplies to consumers. With relaxation in lockdown and consequently revised guidelines by the government, the automotive assembly has been restored in a phase manner to address SCDs though partially.

In 2019-2020, MSIL reduced its production several times to adjust dealers' inventories in view of the unprecedented economic slowdown and a prolonged domestic slump in the automobile industry. In 2020-2021, MSIL is facing severe disruption risks caused by COVID-19 along with the other OEMs in India and globally. For instance, COVID-19 induced SCDs have impacted the automotive sector severely from March 2020 due to lockdown and manufacturing restrictions. Figure 3 shows the monthly performance of MSIL from January 2017 to April 2021. MSIL experienced a significant decline in production due to the impact of the COVID-19 induced SCDs. In the first wave of the COVID-19 pandemic in India, MSIL production was totally halted and domestic sales were virtually zero in April 2020, while export was marginal at 632 units, due to severe disruptions in operations caused by the closure of the manufacturing plants and dealers' showrooms during the lockdown. With the relaxations in lockdown, MSIL resumed its operations from 12th May at the Manesar plant, while Gurugram and Gujarat plants opened up slightly later. In May 2020, MSIL experienced a decline in production and domestic sales respectively by 97.5% and 89% compared to May 2019, while production and domestic sales dropped by 54.66% and 53.73% respectively in June 2020 compared to June 2019. During the second wave of the pandemic in India, MSIL again experienced a severe fall in production and sales performance due to regional lockdown restrictions and SCDs. The rapid decline in production of MSIL has been mainly due to the pandemic induced lockdown and the SCDs in auto-components and halt in manufacturing activities. Besides SCDs, the impact of demand disruptions, labour shortage, social distancing measures, change in working hours and labour management

practices have been severe on MSIL production and sales.

Table 3. Production and Sales of MSIL (Units)

Year	Production Volume	Domestic Sales	Exports
1999-2000	407589	384892	21450
2000-2001	350374	335461	15300
2001-2002	358108	340182	12233
2002-2003	359960	330175	32240
2003-2004	472908	420947	51175
2004-2005	540415	487402	48899
2005-2006	572127	527038	34781
2006-2007	667048	635629	39295
2007-2008	777017	711818	53024
2008-2009	774623	722144	70023
2009-2010	1025466	870790	147575
2010-2011	1273361	1132739	138266
2011-2012	1134607	1006316	127379
2012-2013	1168917	1051046	120388
2013-2014	1155041	1053689	101352
2014-2015	1292415	1170702	121713
2015-2016	1424330	1305351	123897
2016-2017	1573414	1444541	124062
2017-2018	1624487	1653500	126074
2018-2019	1562938	1753700	108749
2019-2020	1580244	1461126	102171
2020-2021	1327923	1361722	96139

Source: Authors' compilation

The likely production and sales outlook of MSIL seems negative due to slow demand recovery, subdued aftermarket demand and muted export demand in view of the pandemic induced global trade tensions. Even with small inventories for next few months, the automotive sector will not revive, if SCDs remain unresolved and MSIL is no exception. Therefore, robust mitigation strategies are needed to recover from COVID-19 induced SCDs.

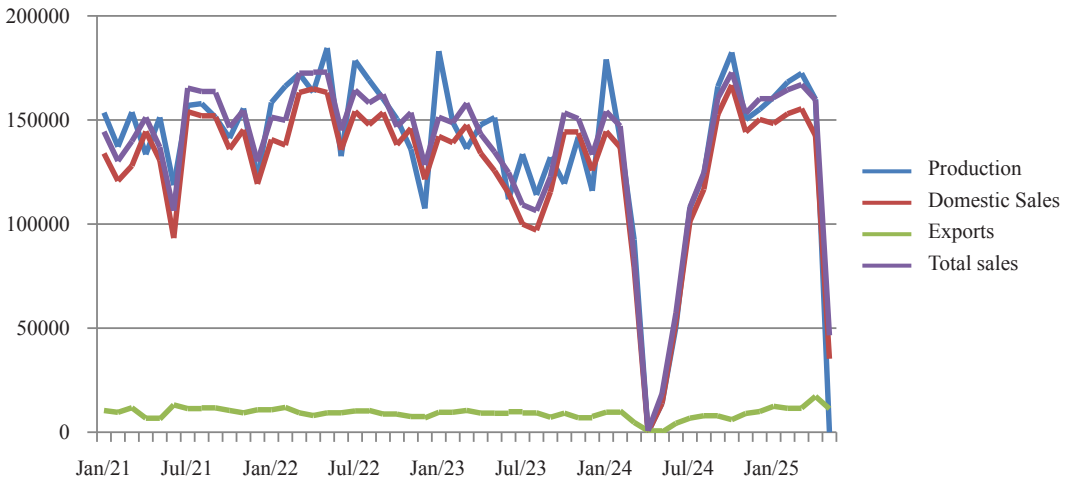

Figure 3. Monthly Production, Sales and Exports of MSIL (units)
Source: Authors' creation

6. Proposed model

The proposed model is shown in figure 4. Risk is the disruption in the allocation of practicable consequences, and their subjective values. Risks are the outcome of uncertain events like earthquakes, hazards, or COVID-19 pandemic. The model concentrates on SCDs and risk management for automotive firms to revive and recover. Risk disruption management begins by identifying risk and susceptibility sources, risk assessment and control mitigation strategies. This work consistently fuses current empirical and conceptual knowledge to allow progress in the field. Therefore, supply chain disruptions management (SCDM) play a major role in the supply chain and logistics sector in order to redefine and promote the productive capabilities of firms to meet their long-term strategic objective. Various antecedents and mediating variable has been discovered to provide the outcomes that emphasize superior firm performance, SCR, recovery and risk mitigation orientation. The type of disruptions itself depends on the source of risks, vulnerability, probability and impact of disruptions, risk perception and disruption location. In the proposed model, the source of risk comprises hazards and vulnerability. Hazards like COVID-19, operational risks or disruptive risks are the occurrences that destabilize the entire supply chain. Vulnerability is a systemic susceptibility in which mitigation measures are impaired and weakened. A firm's perception of the total potential loss associated with the disruption is related to the impact and the probability of disruption risks, including factors that are subjective and correlate to overall disruption risk and varies from firms to firms and between different market such as developed and developing countries. Even, disruption location plays a critical role in understanding the disruption recovery challenges and strategies related to the information to the supply chain partners which further affect the development and adaptation of the robust mitigation strategies. Therefore, a firm's mitigation strategizes depend on its source of risk, vulnerability, perception of risk and the probability and magnitude of disruptions.

Disruptions of the supply chain are better addressed when supply chain partners are informed of the nature and implications of the disruptions. These antecedents further led to several risks such as demand risk, process risk, control risk, product risk, operational risk, supply risk, environmental and density risk, transportation risk and outsourcing risks which combine to form supply chain disruption risks. Supply chain disruptions risks that arise from the catastrophic events such as natural disasters (COVID-19 outbreak) are infrequent and difficult to mitigate and have low probability and high consequences (Knemeyer et al., 2009). Mitigating supply chain disruption risks like COVID-19 crisis in the future from supply chain structure and multi-echelon assembly supply chain networks involve the implementation of both proactive and reactive responses.

The closed-loop procedure is essential for the efficacy of proactive risk management. Risk identification is accompanied by risk assessment that yields an implementation plan culminating in the implementation of the control and monitoring system. These new and enhanced processes drive continuous improvement. Therefore, proactive

responses consist of collaborative planning, forecasting and replenishment (CPFR), robust inventory policies, supply chain collaboration, proactive contract renegotiation, big data capabilities, supply chain visibility, recovery demand and supply portfolio.

6.1 *Proactive strategies*

6.1.1 *Collaborative planning, forecasting and replenishment (CPFR)*

CPFR will help in building supply chain visibility by integrating multiple firms together to share intelligence on the supply chain disruption risks. It will help the firms in synchronizing production planning, scheduling, and purchasing and delivery activities among all the firms in the supply chain during supply chain disruptions. CPFR can be used as replenishment programs for distribution centres which will enhance visibility, stock out reduction, over reduction and aid in aligning capacity to demand to mitigate the impact of the COVID-19 crisis.

6.1.2 *Robust inventory policy*

Efficient inventory policies such as safety stock or buffer stock, strategic stock and pre-positioning of inventory have the capabilities to mitigate the disruption impact in the short-term. Safety stock prevents disruption when there is an unexpected delay from suppliers. It is an effective insurance policy against stock out during COVID-19 induced pandemics to prevent from unanticipated shortages. Safety stock is also known as inventory buffer. Emergency preparedness is the pre-condition of inventory management, which requires long-term plans to achieve highly efficient risk mitigation orientation. Firms can also follow the classification of inventory on the basis of emergent use at the time of risk

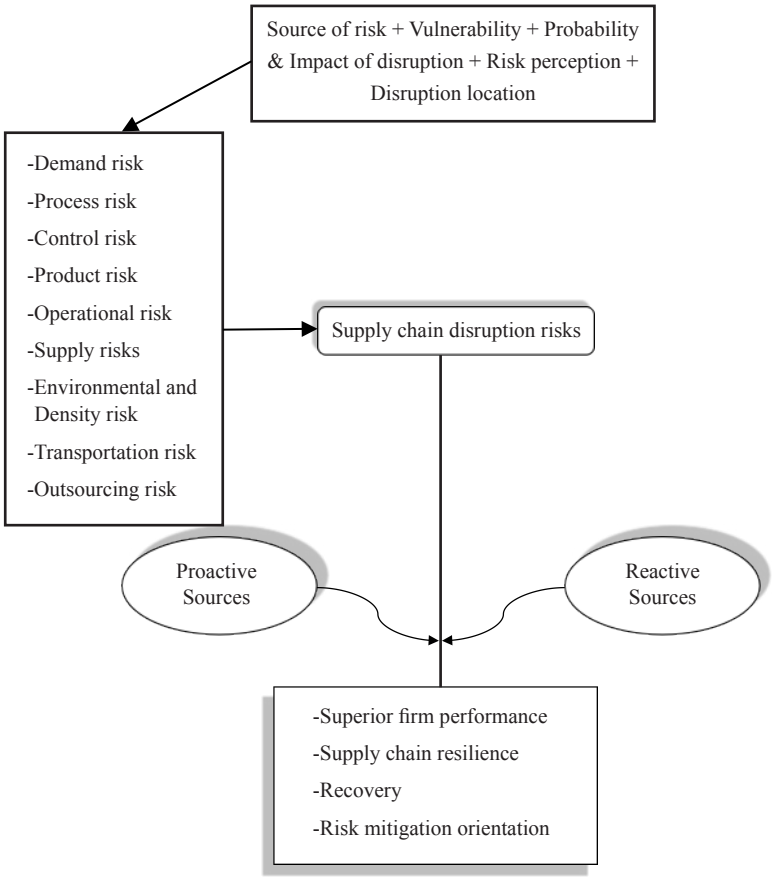

Figure 4. Supply Chain Disruption Model
Source: Authors' creation

For instance, firms can use ABC analysis for classifying inventory items with little modification. Instead of focusing on items' consumption value, firms should identify the level of risk associated with the particular item and its capability to disturb production, manufacturing or distribution during SCDs.

6.1.3 *Supply chain collaboration*

Supply chain collaboration is acknowledged as a major resilience strategy during SCDs. Collaboration is the capabilities of the firms to plan, design, develop, execute and monitor supply chain operations towards intended objectives. One of the objectives of the firms is to mitigate SCDs. This can be accomplished through multiple data and resources sharing, networking, common knowledge pool, collective decision-making and congruence of objectives, which will enhance the resilience and build risk mitigation orientation against any type of disruptions. Thus, supply chain collaboration is essential to achieve resilience in the supply chain via data exchange, accessibility and agility to recover from the unpredicted disruptions in the supply chain. In brief, supply chain collaboration will be the future-proofing of supply chains against disruptions.

6.1.4 *Proactive contract renegotiation*

Complexity and disruptions in the supply chain create risk which further impacts the profits. Written contracts help businesses to manage costs and minimize exposure to price fluctuations during the crisis. Even when agreements are in place, the wording can be interpreted differently or simply not adhered to. Firms assume that having a contract with a supplier means that they will automatically receive all negotiated benefits. But errors, misunderstandings, and oversight of agreed terms imply that suppliers don't always deliver everything outlined in the contract. Hidden inefficiencies and unrealized advantages are very much the norms. Resources procurement teams should strengthen their sources and negotiate programs with the vendors and integrate more reliable suppliers for enhanced flexibility and agility in components supply for risk mitigation. Therefore, proactive contract renegotiation is a systematic and efficient procedure to protect the firms from surprises, minimize the risk and maximize the operational and financial performance during the SCDs.

6.1.5 *Big Data capabilities*

During the COVID-19 crisis, the main objective of the firms is to enhance supply chain visibility to cope with complexities and to aid decision-making when dealing with the risks and delays in supply chains. Big Data capabilities help to increase visibility and deliver deeper insights by rapidly modeling enormous organized and unorganized data from supply chain partners and enhancing their response times to disruptions. The data derived from supplier relationships help to optimize supplier visibility, agility, and decision-making during SCDs. Supply chain agility can be a by-product of information technology integration and supply chain visibility. Big data capabilities and supplier relationships can help the firm to improve supply chain visibility and supply chain agility.

6.1.6 *Supply and demand portfolio*

Supply chain disruptions have the potential to damage or disrupt both prime suppliers and demand portfolio. Therefore, firms must identify and select the recovery suppliers and alternate production facilities to integrate transshipment of components from disrupted primary plants to recovery plants. The distribution of unsatisfied component demand among the recovery manufacturing facilities will determine a portfolio of recovery, demand or capacity during the SCDs. In addition, in-house production of components at a recovery manufacturing facility should potentially contemplate a backup portfolio of robust supplies.

6.1.7 *Multi-tier supply chain visibility*

In one supply chain, there are various suppliers to buyers, which are termed multiple single level partnerships. A multi-tier supply chain is an essential strategy to reduce costs and deliver the products to the marketplace more effectively and efficiently. Most firms have tools which provide visibility and insights related to their tier-1. But

exploring beyond the tier-1 is immensely demanding. Creating visibility may provide multiple benefits such as lesser planning cycles, fast product changes, better clarity to the supply chain for less risk, improved negotiation and better supplier performance. It begins with the determination of critical parts of the operations and identifying critical components which are supplied from the affected areas and lacks substitutes. When they have been identified, the firms can then evaluate the disruption from N-tiers called n-tier visibility. For disruptions, that could halt production and operations, businesses can explore substitute suppliers that are not in the affected areas. If the substitute suppliers are unprocurable, the risk is being addressed by the affected tier-1 organizations. In the proposed model, firms will have to understand the impact of restrictions such as travel restrictions and social distancing guidance, which can have a significant influence on the accessibility of other suppliers. Understanding the impact of the disruption across the multitier supply chain will help in quick recovery after the COVID-19 crisis.

6.2 *Reactive strategies*

Reactive strategies help to address recognizable challenges to minimize or erase the risk associated with SCDs. The reactive responses include flexible route strategy, emergency sourcing, supply chain risk analytics, supply chain reconfiguration, crisis response team and contingency planning, and supplier specialization.

6.2.1 *Flexible route strategy*

Transport network requires adaptability for changing routing protocols, modes, carriers and inventories of storage when mitigating risks. An adequate risk management plan supports resilience and agility through existing infrastructure and collaborations to smooth transport via flexible routes. An alternative route should be utilized until the disruption ended for better recovery. Firms should also evaluate how they organize contracts for transportation.

6.2.2 *Emergency sourcing*

A strategic approach to combat supplier disturbance during SCDs is to establish emergency backups which involves an alternative supply source. The industrial sector that has a contingency for supplier integration and backup supplier have a high probability of revival from the disruption risks. A backup supplier is used when the primary suppliers are not able to supply. The backup supplier can protect the firms during the disruption risks if the flow of material is not continuous and also act as a mitigation strategy.

6.2.3 *Supply chain risk analytics*

Supply chain risk analytics can assist, detect and mitigate risks in the supply chain. Supply chain risk analytics presently use technological innovations to enhance the precision and speed of disruption forecasts, allowing firms to make more resilient data-driven policies. Supply chain risk analytics can provide intelligence on what might happen under specific scenarios by examining the probability and potential consequences. By creating robust supply chain risk analytics, firms can improve their supply chain risk management in the face of disruptive events. Furthermore, any delays in information have serious consequences for supply chain networks. Implementing information strategies effectively has the potential to address a multitude of barriers in the supply chain, including a lack of visibility, slow response times, conflicting priorities and a risk management model that is insufficient during a disruption. Planning and a balance of information and human interaction are required for effective supply chain risk management. Although sharing information can reduce the optimum recovery time, it does not always serve as a motivation.

6.2.4 *Supply chain re-configuration*

Supply chain reconfigurability helps the firms in generating competitive advantage in a dynamic environment. Reconfigurability is the capability to scan the environment and reset and realign the resources efficiently for the shifted market opportunities. Firms must adopt new supply chain practices to mitigate disruption risks, such as postponement strategies, vendor-managed inventory, and CPFR programs. These measures help to reconfigure the supply chain by building the supply chain structure of physical and informational flows of collective firms. Supply chain

reconfigurability helps the firms with the competitive advantages to create favorable innovations for market needs and prevent SC configurations from being too rigid.

6.2.5 *Crisis response team and contingency planning*

A crisis response team should assist the firms to uncover the loopholes and the need for a better response within and outside resources. Analysis of reactive capacity and vulnerability assessment should help to comprehend the detrimental effect of the crises and respond quickly to the danger of disruption. In addition, contingency planning must emphasize on the economic impact of the supply chain deficiency of components and parts. Contingency actions like temporarily using alternate suppliers are also known as contingent rerouting or backup supply. Backup supply has increasingly favored as disruption risks become less frequent but longer. When firms are facing the disruption risks, they may mitigate the threats by realigning or reviving risk management infrastructure to build a strong SCD orientation. SCD orientation proactively builds competence to manage disruption risks.

6.2.6 *Risk mitigation infrastructure and supplier specialization*

Risk management infrastructure refers to resource structure to mitigate the disruption risks in the SCN. There are many advantages of risk management infrastructure such as increased task specialization, reduced work fatigue, and the capability to reflect learning. Increased task specialization guides the firms to take quick actions for faster recovery. Supplier specialization should reduce the supply delivery risk. Firms should emphasize on quality training to their suppliers on s total quality management, quality improvement techniques and integrating quality to reduce variability to achieve competitive advantage after the crisis. Specialized suppliers respond quickly to the disruption risk and production schedule attainment.

7. Conclusion

COVID-19 has immense potential to disrupt SCs and severely affected the SCR in the automotive sector. Currently, there seems to be a substantial amount of uncertainty, lack of data and clarity about the near future attributed to the prevailing crisis of multiple-wave of COVID-19 pandemic. However, one thing is evident that expected impact of COVID-19 pandemic induced SCDs is severe in the automotive industry in the short-term as well as long-term. The future is uncertain and business forecasts are adjusted frequently, but SCDs have the potential to persist for longer, if robust policy actions are not initiated on priority. Therefore, ending the COVID-19 era and its impact on SCDs will not only depend on government policies, but also on proactive and reactive risk mitigation measures initiated by the firms. Robust measures should be taken to tackle the current supply chain threats in the automotive sector to build the resilience of supply chain systems to safeguard them against business downturns.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absense of any commerical or financial relationships that could be construed as a potential conflict of interest.

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