Library Progress International
Vol.44 No.3, Jul-Dec 2024: P.3580-3592

Print version ISSN 0970 1052
Online version ISSN 2320 317X

Original Article

Available online at www.bpasjournals.com

Challenges before Indian Automobile Industry: A TISM Approach

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How to cite this article: Kajal, Inamur rahaman, Abhishek kumar singh (2024 Challenges before Indian Automobile Industry: A TISM Approach. *Library Progress International*, 44(3), 3580-3592.

Abstract

The automobiles have been a part of modern culture and tradition since centuries and they have invariably become part of our lives. The automobile industry of India stands great and tall in front of all the other automobile sectors of different countries of the world. Moreover, the booming automobile sector of India is casting significant impact by fostering growth and development of nation as a whole. However, in recent years the automobile industry has faced certain hiccups due to demonetization and advent of COVID-19. Besides man induced and natural disasters there are several other challenges, which the automobile industry of India has to grapple with. In this backdrop of present paper endeavors to identify the most critical challenges confronted by the automobile industry of India and rank them through the Modified Total interpretative Structural Modeling (TISM). The study identifies nine challenges. It uses Total Interpretative Structural Model for modeling the enablers. Total Interpretive Structural Modeling (TISM), is a qualitative methodology advocated by Sushil (2017). TISM represents an evolved iteration of Interpretive Structural Modeling (ISM) and aims to elucidate intricate and vague mental models of systems by crafting a precise and well-defined model.

Keywords: TISM Modeling, Automobile Industry, India, Challenges, etc.

Introduction

There is no exaggeration in putting that automobile industry of India is the base of all the major industries of India and stimulates and achieves the factors which help in sustenance and growth and development of economy of India as a whole (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023; Qiang et al., 2008). Leading indicators of economy show that it is destined to grow in coming decades and it is set to target newer horizons of automobile sector growth such as penetration of electric vehicles by 2030 which is expected to drive the growth of electric vehicles market in India(Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023). At present it stands among the largest and fastest growing markets for automobiles. It encompasses segments such as commercial vehicles, passenger vehicles, two wheelers, three wheelers, tractors, buses and others (Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023; Ravi &Naveenchanran, 2022; Sarma & Sunder, 2022). Major players of automobile industry of India such as Maruti Suzuki, Hyundai, Tata Motors, Mahindra & Mahindra, and Honda function at the helm of market along with smaller companies which too contribute handsomely to the growth of automobile sector of India (Sarma & Sunder, 2022; Rathore & Jaiswal, 2022; Jamwal et al., 2022; Kumar et al.,). However, there are several challenges which need to be addressed at the earliest if it has to maintain the tempo of growth. In last five to seven years automobile industry

of India has witnessed several impediments to its growth which need to be understood and addressed at the earliest (Rajeev et al., 2024).

Literature Review

There has been several researches conducted on the contribution of automobile industry of India and its growing trajectory towards growth of Indian economy (Noor et al., 2024; Gouda & Tiwari 2024). The study undertaken by Rajeev et al. (2024) elucidated that the automotive business was characterized by fierce competition, which was rapidly evolving. In such industries, the process of new product development was identified as a critical component for an organization's success, survival, and vitality. The study conducted by Mittal et al. (2024) emphasized that transportation systems worldwide heavily relied on fossil fuels, contributing to environmental issues, global emissions, and rising temperatures. Electric vehicles (EVs) were identified as a sustainable alternative to mitigate carbon emissions. The study conducted by Kumar et al. (2024) underscored India's transition towards a "zero or low carbon emission" transportation paradigm, aimed at combatting emissions from the transportation sector. This transition involves promoting the use of hydrogen fuel cars and electric vehicles (EVs). The study conducted by Toke and Kalpande (2024) underscored the significance of environmental auditing and accounting in balancing environmental protection with economic development. In order to assess the acceptable level of environmental degradation and development, a detailed analysis of the benefits and costs of environmental harm is essential. The study conducted by Lema et al. (2024) emphasized that the transition to electric mobility was instigating disruptive transformations in the global automotive sector. The study examined domestic preconditions, policy and enterprise responses, and initial industrial development outcomes. The study conducted by Noor et al. (2024) emphasized that Industry 4.0 had revolutionized manufacturing, presenting significant challenges for adoption, particularly in developing countries like India. The study aimed to identify and evaluate challenges specific to the implementation of Industry 4.0 in the Indian automobile industry to address this issue. Utilizing Latent Dirichlet Allocation (LDA), a machine learning-based text analysis algorithm, challenges were discerned from existing literature. The study conducted by Gouda & Tiwari (2024) explored how the COVID-19 outbreak disrupted the business environment and had a severe impact on the morale and performance of employees. Moreover, it highlighted that the Indian automobile industry experienced significant setbacks and was drastically affected by the COVID-19 pandemic. The study conducted by Singh et al. (2023) elucidated that the rapid fluctuations in the market price of crude oil were a direct consequence of the fundamental economic concept known as the "Law of Demand," which dictates that as globalization progresses, the demand for oil-based energy increases. The study conducted by Kakkar & Singh (2023) shed light on new or different factors pertaining to the disputable view that, at some point in the future, the global automobile industry could reach a maturity level and naturally shift towards key developing countries where the auto market is anticipated to grow rapidly and wages are significantly lower. The study conducted by Sharma & Sharma (2023) elucidated that the Indian automobile industry grappled with a range of challenges, both internal and external. Chief among these was the urgent need for sustainable mobility solutions in light of escalating environmental concerns. The study conducted by Ravi & Naveenchanran (2022) emphasized that the automotive industry was the world's fastest expanding sector and one of India's significant businesses, owing to its robust democracy and international partnerships. Given this context, there was a growing need in India to expand the compact vehicle industry. The study conducted by Sarma & Sunder (2022) provided insights into the central and critical role of the automotive industry in achieving India’s ambitious commitments to address climate change. The paper discussed India’s commitments along with the development challenges it faced in its green energy mission in the transportation sector, with an emphasis on Electric Vehicles (EVs). The study conducted by Ravi & Naveenchandran (2023) shed light on the fact that first-tier suppliers strove to cut costs while enhancing delivery lead times, dependability, and flexibility in the dynamic and competitive climate of the automotive sector. The study conducted by Jha et al. (2023) evaluated that the COVID-19 pandemic wreaked havoc along Global Value Systems (GVSs), and India's domestic economic crisis deepened. The study conducted by Rathore & Jaiswal (2022) provided that the world witnessed turmoil in the last two years due to the COVID pandemic. Economies worldwide faced significant downturns in growth rates, declining FDI, and underperformance of economies. The study conducted by Jamwal et al. (2022) showed that the manufacturing industries of India were facing global pressure to adopt sustainable supply chain management practices. The study conducted by Kumar et al. (2021) elucidated that the Indian automobile industry was growing rapidly; however, it was predominantly served by internal combustion engine vehicles (ICEVs). The study conducted by Sethi (2020) emphasized the significance of the Indian Automotive Car Industry, noting it as one of the major industries due to its status as the fastest-growing industry globally, supported by a robust democracy and global partnerships. The study conducted by Desai (2020) underscored the pressing need for better air quality, human health, and mitigating global greenhouse gases in a consistently rapidly growing economy, necessitating a comprehensive study on automobile fuel quality in India.

Research Gaps

- Most of the researches have been done regarding the growth of automobile sector.
- Some others have dealt with the impact of manmade and natural disasters on automobiles industry.
- There are very few studies, which have been done on concurrent challenges before the automobile industry of India.

Research Objective

- To study the major challenges before the automobile industry of India.
- To determine the interconnectedness of challenges confronted by the automobile industry of India.

Research Methodology

Present paper utilizes the Total Interpretative Structural Modelling (TISM) for categorizing and streamlining the path of connectivity followed by the factors identified for the present study. For applying this methodology firstly the factors, which posed as the major hurdles in the path of growth of automobile sector were identified. Subsequently, the tool of TISM was employed to model these factors. The selection of factors or major challengers was based on comprehensive literature review of the existing literature in the field of automobile industry. For accessing a wide range of studies, we employed reputable databases, including EBSCO, Scopus, Web of Science, Wiley online library, Inderscience Publishers, Emerald, and Springer Link, covering the period from 2002 to 2024. Our research focussed on articles or research papers which had the titles or abstracts by the keywords Indian automotive or Indian automobile industry and challenges and barriers to automobile industry of India. From an initial pool of 332 articles 235 articles were selected for present analysis. Analysis of those articles enabled us to pinpoint the critical challenges before the automobile industry of India.

After the completion of the first phase of present study, we proceeded with the second part that comprised of modelling the identified challenges. For that we employed a qualitative technique called the Total interpretive structural modelling (TISM) which has been extensively used by Sushil (2017). The technique used in present paper is the advanced version of the interpretive structural modelling (ISM) which is designed to transform complex and poorly articulated mental models of systems into a clear and well-defined model.

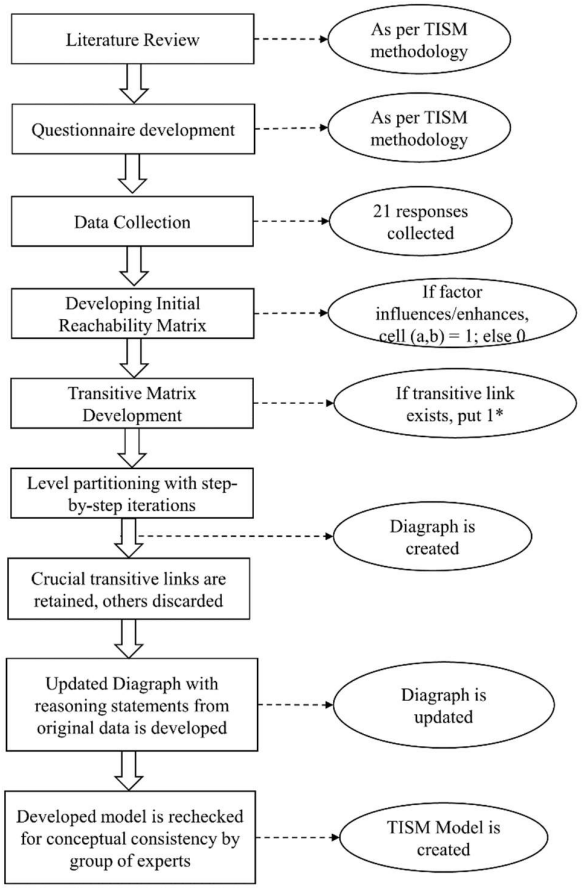


Figure: Process Flow for TISM Model Development

TISM for the Present Study

Major Challenges for Automobile Industry of India

Supply Chain Disruptions: Supply chain disruptions have significantly impacted the Indian automobile industry, particularly in recent years due to global events such as the COVID-19 pandemic, semiconductor shortages, and geopolitical tensions (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024;). These disruptions have affected the availability of essential components, leading to production delays and increased costs (Kakkar & Singh 2023). The semiconductor shortage, in particular, has hampered the production of electronic components crucial for modern vehicles, resulting in prolonged waiting periods for customers and reduced vehicle output Additionally, India's dependence on imports for certain raw materials and automotive parts has made the industry vulnerable to international trade barriers and logistical challenges. Companies have responded by diversifying suppliers, adopting digital supply chain solutions, and increasing localization efforts to mitigate future risks (Sushil (2017; Wu et al., 2016; Hu et al., 2016; García-Villalobos et al., 2016; Drohomeretski et al., 2015; Weis et al., 2014; Waraich et al., 2013; Zou et al., 2013; Zoepf (2013; Kelly et al., 2012; Bashash et al., 2011; Darabi & Ferdows 2011; Peterson et al., 2010; Srivastava et al., 2010; Hadley & Tsvetkova 2009; Bradley & Frank 2009; Hajimiragha et al., 2009; Galus & Andersson 2008; Qiang et al., 2008). However, the full recovery from these disruptions is expected to take time, with long-term implications for the industry's growth and competitiveness (Kakkar & Singh 2023).

Changing Consumer Preferences: Changing consumer preferences are reshaping the Indian automobile industry, driven by evolving lifestyles, environmental concerns, and technological advancements (Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023). Increasingly, Indian consumers are showing a growing preference for electric vehicles (EVs), hybrids, and vehicles with better fuel efficiency as awareness about climate change and sustainability raises (Ravi & Naveenchanran, 2022). Additionally, there is a shift towards compact SUVs and crossovers, reflecting the

demand for versatile, fuel-efficient, and urban-friendly vehicles (Mittal et al., 2024). The younger demographic is also prioritizing connectivity (Rajeev et al., 2024; Kumar et al., 2024) features such as smart infotainment systems, internet connectivity, and advanced driver-assistance systems (ADAS) (Sarma & Sunder, 2022; Rathore & Jaiswal, 2022; Jamwal et al., 2022; Kumar et al., 2021; Sethi, 2020; Desai, 2020; Sangwa & Sangwan, 2018; Hu et al., 2017; Sushil, 2017; Wu et al., 2016; Darabi & Ferdows 2011; Peterson et al., 2010; Srivastava et al., 2010; Hadley & Tsvetkova 2009; Bradley & Frank 2009; Hajimiragha et al., 2009; Galus & Andersson 2008; Qiang et al., 2008). The demand for shared mobility solutions, including car-sharing and ride-hailing services, is also gaining traction, particularly in urban areas, as people seek more economical and flexible transportation options (Rathore & Jaiswal, 2022). These changing preferences are pushing automakers in India to innovate, diversify product portfolios, and focus on greener technologies to cater to the evolving market dynamics (Hu et al., 2016; García-Villalobos et al., 2016; Drohomeretski et al., 2015; Weis et al., 2014; Waraich et al., 2013; Zou et al., 2013; Zoepf (2013; Kelly et al. (2012; Bashash et al., 2011;).

Rising Input Costs: Rising input costs have become a significant challenge for the Indian automobile industry (Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024;), putting pressure on profit margins and leading to increased vehicle prices. The costs of essential raw materials such as steel, aluminum, and plastics have surged due to global supply chain disruptions, inflation, and geopolitical tensions. Additionally, the semiconductor shortage (Kakkar & Singh 2023; Hu et al., 2017; Sushil, 2017; Wu et al., 2016; Hu et al., 2016) has escalated the prices of electronic components, which are critical for modern vehicles, especially with the rise of electric and connected cars (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Gouda & Tiwari 2024; Desai, 2020; Sangwa & Sangwan, 2018). The rising cost of fuel, energy, and logistics has further compounded the problem, as manufacturers struggle to manage operational expenses (Automakers are being forced to pass on some of these costs to consumers, leading to higher vehicle prices, which in turn dampens demand in price-sensitive markets like India (Lema et al., 2024; Zoepf, 2013; Kelly et al., 2012; Bashash et al., 2011; Darabi & Ferdows 2011; Peterson et al., 2010; Srivastava et al., 2010). To mitigate the impact, many companies are exploring localization of supply chains, improving operational efficiencies, and negotiating long-term contracts with suppliers (Lema et al., 2024; Noor et al., 2024), but the overall challenge of rising input costs continues to affect the industry's growth and profitability (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Gouda & Tiwari 2024; Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023).

Economic Slowdown: The economic slowdown has had a profound impact on the Indian automobile industry, leading to a significant decline in sales and production (Ravi &Naveenchanran, 2022; Sarma & Sunder, 2022; Rathore & Jaiswal, 2022). Factors such as reduced consumer spending, liquidity crunch, rising fuel prices, and higher vehicle ownership costs (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024;), including insurance premiums and taxes, have contributed to weakened demand across segments, from passenger cars to commercial vehicles(Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023; Ravi &Naveenchanran, 2022; Weis et al., 2014; Waraich et al., 2013; Zou et al., 2013; Zoepf (2013; Kelly et al., 2012). The slowdown has forced automakers to scale back production, implement cost-cutting measures, and offer substantial discounts to attract buyers. Additionally, the lack of access to affordable financing options has further dampened consumer sentiment, particularly in rural areas where demand for two-wheelers and entry-level cars is typically robust (Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023; Ravi &Naveenchanran, 2022; Sarma & Sunder, 2022; Rathore & Jaiswal, 2022; Jamwal et al., 2022; Kumar et al., 2021;). The ripple effects have also hit the ancillary industries, including auto components and logistics, leading to job losses and slowing investments in new technologies. Although the government has introduced reforms like reducing GST on vehicles and promoting electric mobility, the industry's full recovery from the economic downturn remains uncertain and is closely tied to broader macroeconomic improvements (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024).

Environmental Management and Safety: In 2019, automotive Original Equipment Manufacturers (OEMs) found themselves racing to adhere to additional safety equipment mandates, including anti-lock brakes, integrated driver bags, speed warning alerts, rear brake sensors, front seat belt warnings, and collision mitigation systems. These requirements augmented investment costs, consequently raising the overall cost for each vehicle model, thus impacting consumer prices (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023). Furthermore, regulations introduced in 2018 (Sarma & Sunder, 2022), such as the mandate for early collection of five-year third-party premiums for two-wheelers, exerted a significant influence on overall car and

especially two-wheeler sales throughout the year, with lingering effects (; Ravi &Naveenchanran, 2022; Rathore & Jaiswal, 2022; Jamwal et al., 2022; Kumar et al., 2021; Sethi, 2020; Desai, 2020; Sangwa & Sangwan, 2018; Hu et al., 2017). Moving forward, by April 2020, all vehicle categories, spanning two- and three-wheelers, cars, and commercial vehicles, must comply with stringent BS-VI emission standards, leading to an anticipated price hike of 5-10%. Already, Original Equipment Manufacturers (OEMs) initiated a 2-3% price increase in January 2020 to offset rising financing costs, thus grappling with the challenge of balancing sales costs amidst potential fluctuations(Ravi & Naveenchandran, 2023;Jha et al., 2023; Ravi & Naveenchanran, 2022; Sarma & Sunder, 2022; Rathore & Jaiswal, 2022).

Slowing Economic Growth: The Indian automobile market, akin to Europe and China, faced the repercussions of the global economic downturn (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024;). India's GDP growth decelerated to 4.5% in the third quarter of 2019, a drop from 5% in the previous quarter and 7.1% a year prior, attributable to diminished consumer spending and investment levels (Sarma & Sunder, 2022; Rathore & Jaiswal, 2022; Jamwal et al., 2022; Kumar et al., 2021). Particularly, rural areas with scant annual rainfall experienced a notable decline in two-wheeler demand. Concurrently, escalating unemployment and a sluggish economy prompted individuals to defer their car purchase decisions(Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023). Data from India's Center for Monitoring Indian Economy (CMIE) revealed an unemployment rate of 8.5% in October 2019, marking the highest since August 2016 (Toke & Kalpande 2024). Moreover, inflation surged from 3.18% in June to 3.99% in September 2019. The International Monetary Fund also downscaled its 2020 growth projection for India from 7% to 6.1%, indicative of the challenging economic landscape (Rajeev et al., 2024; Mittal et al., 2024).

The rise of ridesharing; The proliferation of carpooling services continues to bolster the demand for ride-hailing in urban areas, attracting individuals keen on shared transportation options(Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023). According to a preliminary survey conducted in the country in 2019, Counterpoint Research approximates that two-thirds of frequent ride-sharing users perceive driving as a more cost-effective alternative to car ownership(Wu et al., 2016; Hu et al., 2016; García-Villalobos et al., 2016; Drohomeretski et al., 2015; Weis et al., 2014; Waraich et al., 2013; Zou et al., 2013; Zoepf). Major players such as Ola and Uber are strategizing to extend their services to tier 2 and 3 cities in the coming years, aiming to broaden their reach and cater to a larger demographic (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Bradley & Frank 2009; Hajimiragha et al., 2009; Galus & Andersson 2008; Qiang et al., 2008).

NBFCs wary of loans: In India, non-banking financial institutions (NBFCs) play a crucial role in financing the majority of cars, particularly through dealer channels. Dealers often depend on these NBFCs to fund bulk purchases of vehicles from Original Equipment Manufacturers (OEMs) (Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023; Ravi &Naveenchanran, 2022; Sarma & Sunder, 2022; Rathore & Jaiswal, 2022; Jamwal et al., 2022; Kumar et al., 2021; Sethi, 2020; Desai, 2020; Sangwa & Sangwan, 2018; Hu et al., 2017; Sushil (2017; Wu et al., 2016; Hu et al., 2016; García-Villalobos et al., 2016; Drohomeretski et al., 2015; Weis et al., 2014; Waraich et al., 2013; Zou et al., 2013; Zoepf (2013; Kelly et al. (2012; Bashash et al., 2011; Darabi & Ferdows 2011; Peterson et al., 2010; Srivastava et al., 2010; Hadley & Tsvetkova 2009; Bradley & Frank 2009; Hajimiragha et al., 2009; Galus & Andersson 2008; Qiang et al., 2008). However, recent challenges pertaining to the resolution of issues within India's NBFC sector have resulted in a climate of cautious lending, thereby adversely impacting auto sales throughout 2019, with no discernible signs of recovery. In response, companies and stakeholders have petitioned the Financial Services Authority of India, advocating for government intervention to enhance the overall health of these financial institutions(Rajeev et al., 2024; Mittal et al., 2024; Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023).

Increasing competition: Even amidst the economic downturn, significant investments in India have been made by MG Motor (a subsidiary of SAIC Motor), BYD, and other prominent Chinese Original Equipment Manufacturers (OEMs) like Changan Automobile and Great Wall Motors, as announced during this year's Delhi Auto Show (Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023; Ravi &Naveenchanran, 2022; Sarma & Sunder, 2022; Rathore & Jaiswal, 2022; Jamwal et al., 2022; Kumar et al., 2021; Sethi, 2020; Desai, 2020; Sangwa & Sangwan, 2018; Hu et al., 2017; Sushil (2017; Wu et al., 2016; Hu et al., 2016; García-Villalobos et al., 2016; Drohomeretski et al., 2015). In contrast, MG Motor and South Korean automaker Kia Motors have unveiled new SUV models, garnering substantial orders several months

prior. As the competition in the passenger car segment escalates in 2020, Counterpoint forecasts that these fresh offerings will encroach upon the market share of Maruti Suzuki and Tata Motors (Kumar et al., 2024; Toke & Kalpande 2024; Lema et al., 2024; Noor et al., 2024; Gouda & Tiwari 2024; Singh et al., 2023; Kakkar & Singh 2023; Sharma & Sharma, 2023; Ravi & Naveenchandran, 2023;Jha et al., 2023; Darabi & Ferdows 2011; Peterson et al., 2010; Srivastava et al., 2010; Hadley & Tsvetkova 2009; Bradley & Frank 2009; Hajimiragha et al., 2009; Galus & Andersson 2008; Qiang et al., 2008)

List of challenges identified in present study

Sl. No.	**Challenges**
i.	**Supply Chain Disruptions**
ii.	**Changing Consumer Preferences**
iii.	**Rising Input Costs**
iv.	**Economic Slowdown**
v.	**Environmental Management and Safety**
vi.	**Slowing Economic Growth**
vii.	**The rise of ridesharing**
viii.	**NBFCs wary of loans**
ix.	**Increasing competition**

Exhibit 2 Reachability matrix

	T1	T2	T3	T4	T5	T6	T7	T8	T9
T1	1	1	0	0	0	0	0	0	1
T2	1	1	0	0	1	0	0	0	0
T3	0	0	1	0	0	0	0	1	1
T4	0	0	1	1	1	0	0	0	0
T5	0	0	1	1	1	0	0	0	0
T6	0	0	0	0	0	1	0	0	0
T7	0	0	0	0	0	1	1	0	0
T8	0	0	0	0	0	1	0	1	0
T9	0	0	0	0	0	1	1	0	1

	T1	T2	T3	T4	T5	T6	T7	T8	T9
T1	1	1	1[a]	1[a]	1[a]	1[a]	1[a]	1[a]	1
T2	1	1	1[a]	1[a]	1	1[a]	1[a]	1[a]	1[a]
T3	0	0	1	0	0	1[a]	1[a]	1	1
T4	0	0	1	1	1	1[a]	1[a]	1[a]	1[a]
T5	0	0	1	1	1	1[a]	1[a]	1[a]	1[a]
T6	0	0	0	0	0	1	0	0	0
T7	0	0	0	0	0	1	1	0	0
T8	0	0	0	0	0	1	0	1	0
T9	0	0	0	0	0	1	1	0	1

Exhibit 3 partitioning the reachability matrix into different levels

Variables	Reachability set	Antecedent set	Intersection set	Level
(a): Iteration -1				
T1	1,2,3,4,5,6,7,8,9	1,2	1,2	
T2	1,2,3,4,5,6,7,8,9	1,2	1,2	

T3	3,6,7,8,9	1,2,3,4,5	3	
T4	3,4,5,6,7,8,9	1,2,4,5	4,5	
T5	3,4,5,6,7,8,9	1,2,4,5	4,5	
T6	6	1,2,3,4,5,6,7,8,9	6	I
T7	6,7	1, 2, 3, 4, 5, 7, 9	7	
T8	6, 8	1, 2, 3, 4, 5, 8	8	
T9	6, 7, 9	1, 2, 3, 4, 5, 9	9	
(b): Iteration -2				
T1	1,2,3,4,5,6,7,8,9	1,2	1,2	
T2	1,2,3,4,5,6,7,8,9	1,2	1,2	
T3	3,7,8,9	1,2,3,4,5	3	
T4	3,4,5,7,8,9	1,2,4,5,	4,5	
T5	3,4,5,7,8,9	1,2,4,5,	4,5	
T7	7	1,2,3,4,5,7,9	7	II
T8	8	1,2,3,4,5,8	8	II
T9	7,9	1,2,3,4,5,9	9	
T1	123459	12	12	
T2	123459	12	12	
T3	39	12345	3	
T4	3459	1245	45	
T5	3459	1245	45	
T9	9	123459	9	III
(c) : Iteration -3				
T1	1,2,3,4,5	1,2	1,2	
T2	1,2,3,4,5	1,2	1,2	
T3	3	12345	3	IV
T4	3,4,5	1245	45	
T5	345	1245	45	
(c) : Iteration -4				
T1	1245	1, 2	1, 2	
T2	1245	1, 2	1, 2	
T5	45	1245	45	V
T4	45	1245	45	V
(c) : Iteration -3				
T1	1, 2	1, 2	1, 2	VI
T2	1, 2	1, 2	1, 2	VI

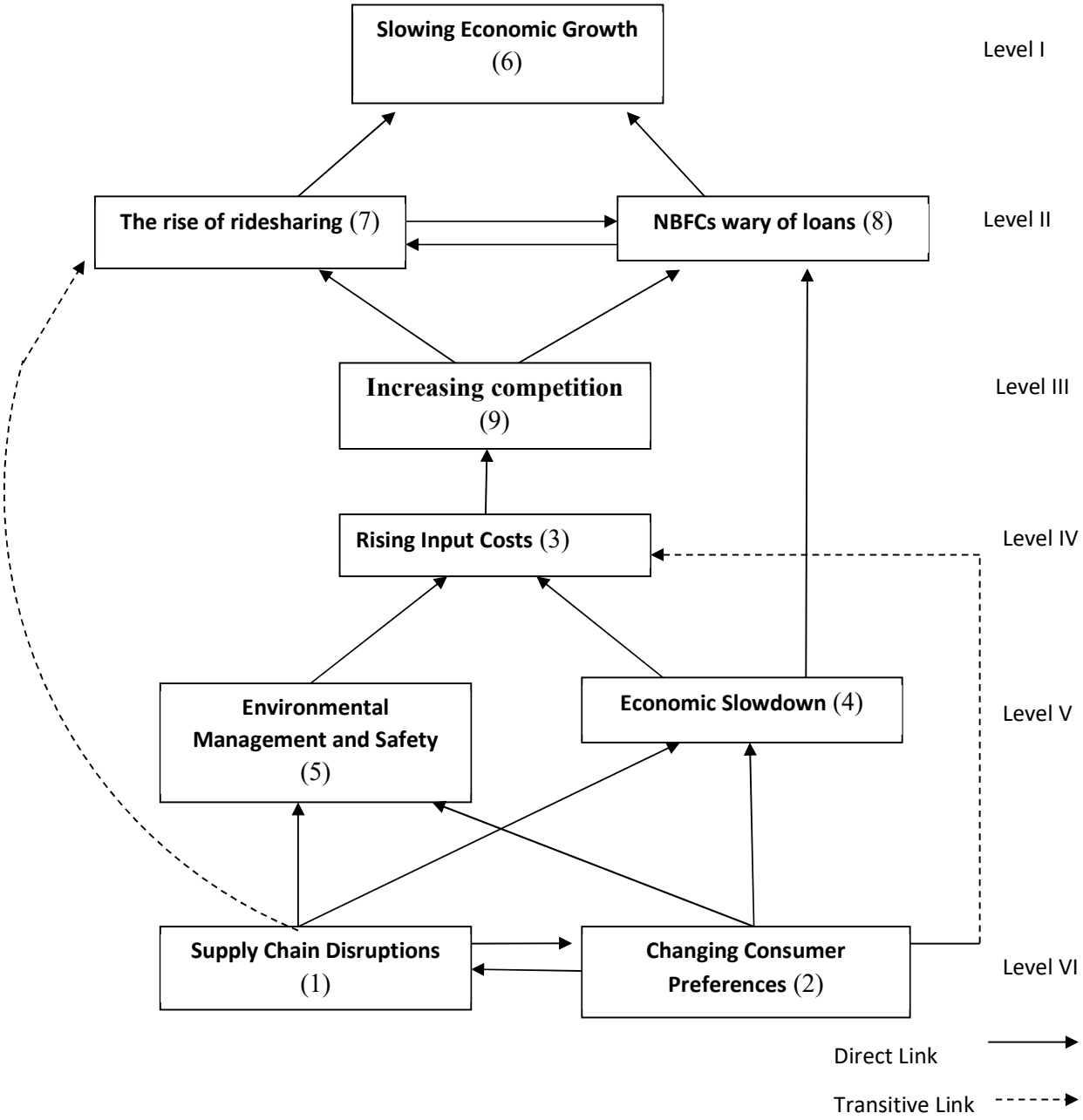
List of Enablers and Levels

Sl. No.	Factors	Level
i.	**Slowing Economic Growth** (6)	Level I
ii.	**The rise of ridesharing** (7)	Level II
iii.	**NBFCs wary of loans** (8)	Level II
iv.	**Increasing competition** (9)	Level III

v.	**Rising Input Costs** (3)	Level IV
vi.	**Environmental Management and Safety** (5)	Level V
vii.	**Economic Slowdown** (4)	Level V
viii.	**Supply Chain Disruptions** (1)	Level VI
ix.	**Changing Consumer Preferences** (2)	Level VI

It can be witnessed from the Figure 2 given below the different challenges before the automobile industry of India and their interrelationship is casting impact on the growth and development of this sector along with advancement of the Indian economy as a whole. To determine the type of relationship between different challenges we need to discuss different levels of TISM model along the figure, which is given below:

Figure 2: Diagraph for Challenges for Automobile Industry of India



Level VI

Figure 2 shows that Supply Chain Disruptions (1) Level VI impacts Changing Consumer Preferences (2) Level VI and Changing Consumer Preferences Level VI effects Supply Chain Disruptions (1) Level VI and manufacturing of automobiles. It can also be seen that Supply Chain Disruptions (1) Level VI impacts Environmental Management and Safety (5) Level V and Economic Slowdown (4) Level V of automobiles. Similarly, Changing Consumer Preferences (2) Level VI also impacts Environmental Management and Safety (5) Level V and Economic Slowdown (4) Level V of automobiles in India.

Level V

Level V comprises of Environmental Management and Safety (5) Level V and Economic Slowdown (4) Level V of automobiles. Environmental Management and Safety (5) Level V impacts the Rising Input Costs (3) Level IV of HFCVS and Economic Slowdown (4) Level V of automobiles also impacts Rising Input Costs (3) Level IV of automobiles given at level IV.

Level IV

Level IV comprises of Rising Input Costs (3) Level IV and it impacts the magnitude of Increasing competition (9) Level III for the automobiles.

Level III

Level III consists of R&D. And, Increasing competition (9) Level III for automobiles impacts the rise of ridesharing (7) Level II and it also impacts NBFCs wary of loans (8) Level II for automobiles in market.

Level II

Level II has two main enablers of automobiles and that is NBFCs wary of loans (8) Level II for automobiles and the rise of ridesharing (7) Level II to work for manufacturing of automobiles.

Level I

Level I has Slowing Economic Growth (6) as its main component, which is very important for determining the market, manufacturing, availability and scaling of automobiles.

Growth Implications

The **growth implications for the challenges facing the Indian automobile industry**, as analyzed through the Total Interpretive Structural Modeling (TISM) approach, highlight the interconnected and complex nature of these issues. Key challenges such as supply chain disruptions, rising input costs, regulatory pressures for emissions reduction, technological shifts towards electric vehicles (EVs), and changing consumer preferences all interact in ways that affect the industry's growth trajectory. TISM helps in identifying the most critical factors that influence others, revealing that supply chain issues and regulatory compliance often act as root causes that, in turn, exacerbate challenges like cost pressures and delays in technological adaptation.

The TISM approach illustrates that addressing these foundational challenges can create a ripple effect, unlocking potential for long-term growth. For instance, improving supply chain resilience and increasing localization can reduce dependency on global markets, stabilizing production and costs. Similarly, proactively adapting to government policies on emissions and electric mobility will not only help meet regulatory requirements but also position companies to tap into the growing demand for greener vehicles. Technological advancements in automation, digitalization, and smart mobility are critical to sustaining competitive advantages, and TISM underscores the importance of innovation in overcoming both immediate and future challenges.

Ultimately, the TISM approach reveals that the ability to effectively manage these challenges will determine the industry's potential for sustainable growth, innovation, and global competitiveness in an increasingly dynamic automotive landscape.

Future Research Implications

The future research implications for this research are vast and critical for guiding the industry toward sustainable growth. First, deeper exploration of specific challenges like supply chain vulnerabilities, the shift toward electric vehicles (EVs), and rising input costs can provide actionable insights for policymakers and industry stakeholders. Future studies could apply advanced versions of TISM or integrate other Multi-Criteria Decision-Making (MCDM) methods, such as Analytical Hierarchy Process (AHP) or Decision-Making Trial and Evaluation Laboratory (DEMATEL), to validate or expand upon the structural model developed in this research. Additionally, empirical studies could be conducted to assess the real-world effectiveness of strategies derived from the TISM analysis, focusing on how various interventions influence long-term resilience and profitability.

Moreover, examining the role of emerging technologies like autonomous driving, smart manufacturing, and artificial intelligence in addressing key challenges would enrich the discussion. Future research can also investigate the evolving policy landscape in India, including electric vehicle incentives and carbon regulations, to assess their impact on the industry's growth dynamics. Comparative studies involving other emerging markets could provide global insights and cross-industry learning. In essence, this paper lays the groundwork for a comprehensive research agenda focused on navigating the Indian automobile industry's evolving challenges and opportunities.

Conclusion

Foregoing discussion based on TISM analysis provides that the Indian automobile industry has been a pivotal driver of the nation's economic growth, contributing significantly to the GDP, employment, and exports. Its traditional strengths in manufacturing, along with cost-effective skilled labor, have allowed it to become a major player in the global automotive sector (Miglani, 2019). Furthermore, India's status as a developing nation positions it favorably to meet the increasing demand for vehicles and their growth in terms of manufacturing (Hoffman, 2019). The study identified that the challengers identified in the study have decisive role to play in the development of automobile indusry of India (Harichandan & Kar, 2023). India's proactive steps toward achieving growth of automobile indursty while facign newer challenges pertaining to the changing dimensions of novel technologies being adopted is noteworthy.

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