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NITI Aayog

Automotive Industry:

Powering India's participation in Global Value Chains

April 2025

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Message

The global automotive component market is projected to grow from approximately USD 2 trillion in 2023 to USD 2.4 trillion by 2030. The automotive industry is a key driver of global industrial growth, ranking among the largest and fastest-growing sectors. In India, it plays a vital role in strengthening interconnected industries such as steel, rubber, glass, and electronics, making it a significant contributor to the nation's economic progress.

In recent years, the sector has undergone a major transformation, driven by technologies such as electric vehicles (EVs), advanced driver-assistance systems (ADAS), autonomous driving (AD), and hydrogen fuel cells. Concepts like mass production and lean manufacturing, pioneered by the automotive industry, have been widely adopted across sectors, enhancing efficiency and scalability. Beyond manufacturing, the industry plays a key role in economic development by generating employment, driving technological progress, and fostering the growth of related industries.

However, the sector is not immune to global challenges. The COVID-19 pandemic revealed supply chain weaknesses, while recent geopolitical uncertainties and resulting disruptions have driven manufacturers to seek more reliable and cost-effective production hubs.

In this context, India offers a unique opportunity to emerge as a trusted global manufacturing partner. With its expanding production capabilities, competitive costs, skilled workforce, and growing technological expertise, India is well-positioned to play a larger role in the global automotive supply chain.

To unlock the sector's full potential, India must adopt a range of strategic measures. This includes investing in infrastructure, promoting technological innovation, enhancing workforce skills, and introducing policy reforms to foster a competitive and resilient automotive ecosystem.

In conclusion, the report, **"Automotive Industry: Powering India's Participation in Global Value Chains"**, highlights how India can capitalise on this opportunity to achieve its vision for **Viksit Bharat 2047**. By strengthening its automotive sector, India can drive sustainable growth, boost global competitiveness, and lay the foundation for long-term economic development.

(Suman Bery)

Dated : March 28, 2025

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MESSAGE

Industrialization has long been a cornerstone of economic development, with India's industrial sector contributing roughly 27% to the nation's GDP, of which manufacturing constitutes about 17%. The manufacturing sector is not just a contributor to GDP but also serves as a key engine for economic growth by providing value-added products, stimulating innovation, and supporting supply chains across various industries. From automobiles and electronics to textiles and pharmaceuticals, India's manufacturing base spans a wide range of sectors, each contributing to economic diversification and global competitiveness.

In 2022, the global automotive industry was valued at around $2 trillion, with approximately $700 billion in global trade, underscoring the critical role of global value chains within the sector. India's automotive sector has a significant contribution in the nation's economy. The Indian auto component market, valued at an estimated $109 billion, includes an automotive consumption market of around $70 billion. This sector directly employs about 1.5 million people and maintains a nearly balanced trade ratio of 0.99, indicating that the country's exports and imports of auto components are nearly equal.

Global value chains are realigning driven by geopolitical shift, technological advancements, rise in input cost and the evolving nature of global trade, India aims to raise the manufacturing share of its GDP from 17% to 25%. In today's interconnected world, global trade plays an essential role, and India's pursuit of this goal aligns with its broader economic ambitions. To achieve the vision of doubling the economy by 2030 and becoming a "Viksit Bharat" by 2047, prioritizing the manufacturing sector is critical. Specifically, the automotive sector, which constitutes a significant share in India's industrial GVA, must remain a focal point of this strategy.

This report emphasizes the automotive sector's importance, its connections to the global economy, and its trade dynamics. It also outlines strategic and policy initiatives to boost India's share of global automotive component manufacturing and exports. I hope the recommendations highlighted in this report will pave the way for enhancing India's contribution to the global automotive component trade and support relevant ministries and departments in formulating effective policies that will benefit the industry as a whole.

(Dr. V K Saraswat)

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MESSAGE

India's economic transformation has gained unprecedented momentum in the last decade. Landmark reforms have been undertaken during this period to build a robust foundation for the growth of the economy as a whole and for the manufacturing sector in particular.

India's automobile sector is a cornerstone of its manufacturing ecosystem, playing a crucial role in the country's economic growth and industrial development. As one of the largest automotive markets in the world, India's automobile industry contributes nearly 7.1% to the national GDP. With a market size of more than USD 100 billion, India constitutes more than 3% of global auto component market. Indian auto-component production and exports are valued at USD 70 Billion and USD 20 Billion respectively in FY 22-23 with Indian auto-components constituting around 3% of global exports.

However, despite these achievements, India's integration into Global Value Chains (GVCs) remains relatively modest compared to countries like China, Germany, and South Korea. For India, the growing auto components market represents a strategic opportunity to enhance its position in the automotive value chain. As India seeks to become a dominant player in the GVC.

Recognizing this imperative, NITI Aayog, in collaboration with various stakeholders, has launched a comprehensive initiative titled 'Automotive Sector: Powering India's Participation in Global Value Chains'. The primary objective of this initiative is to identify key strategies and interventions to boost India's competitiveness in the automotive sector and facilitate its integration into global value chains.

This initiative has involved rigorous research, consultations with stakeholders, and detailed analysis of industry trends and market dynamics. Through engagement with industry bodies, think tanks, academia, state governments, and key industry players, valuable insights have been gained into the challenges and opportunities facing the automotive sector.

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A significant finding of this research underscores the critical need to enhance India's capabilities in tools and dies manufacturing to ascend the value chain. While India has made substantial progress in auto components manufactured with conventional technology, there is an urgent requirement to strengthen the ecosystem for complex and emerging technologies. Also, it is essential to scale up design innovation and high-value component production. The efforts are needed to be integrated to gradually traverse to build to spec mechanism from build to print mechanism in this sector.

To address these challenges, the recommendations encompass a comprehensive range of fiscal and non-fiscal interventions designed to create an enabling environment for sustainable growth. These include fiscal incentives to streamline manufacturing processes, as well as non-fiscal support for skill development and technology transfer, aimed at unlocking the full potential of India's automotive sector.

This report is presenting the findings and recommendations, thereby providing a comprehensive overview of the strategic roadmap for enhancing India's participation in the global automotive value chain. By implementing these recommendations cohesively, India can realize its vision of achieving USD145 billion in automotive production and USD 60 billion in exports by 2030, thereby generating millions of employment opportunities.

I acknowledge the efforts made by Shri Ishtiyaque Ahmed, Programme Director (Industry) and his team in NITI Aayog for developing such as insightful report on one of the most crucial sectors of the economy. The team have undertaken numerous stakeholder consultations and visits to firm up the contents of this report. I would also like to thank for the contributions and inputs provided by Industry Associations, Knowledge Partners, Central Ministries & Departments including Ministry of Heavy Industry, Industry representatives and most importantly States.

As we embark on this transformative journey, we recognize the pivotal role to be played by the concerned Ministries/Departments of the Central and State governments in acting on these recommendations and making the vision of India becoming a manufacturing hub a reality.

Dated: 28th March, 2025

[B.V.R. Subrahmanyam]

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MESSAGE

India's economic progress over the last decade has been exceptional, making it the fastest-growing major economy globally. Realizing the $10 trillion economy vision by 2035 relies heavily on the manufacturing sector, a key contributor to GDP. However, technological advancements in other Asian economies have outpaced India's manufacturing capabilities. With more than 60 million workers employed, robust industry support is essential to meet these growth aspirations.

India's manufacturing contribution to GDP has hovered between 13-18% in recent past. India's automotive industry contributes nearly 7.1% to the national GDP and accounts for nearly 49% of the country's manufacturing GDP, making this sector a key driver for manufacturing sector growth. The Indian government has been instrumental in shaping the growth trajectory of the automotive sector through several policy initiatives such as Make in India, Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME), Atmanirbhar Bharat, PLI Scheme, PLI (Advanced Chemistry Cell) ACC Battery, The Electric Mobility Promotion Scheme 2024 (EMPS 2024), PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE)' Scheme, aimed at enhancing the country's manufacturing capabilities and positioning it as a global automotive hub.

The global auto component market was estimated to be around $ 2 trillion in 2022. Over the past five years, the global auto component market has grown steadily at 4–6% annually, highlighting sustained demand and emphasizes the sector's pivotal role in the global automotive value chain.

Engine and engine components represent the largest segment of the global automotive trade, accounting for 23% of total traded value, followed by drive transmission and steering components at 17%. Notably, 70% of components are domestically produced for local markets, while the remaining 30% ($700 billion) serves the global export market.

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For India, expanding auto components market offers a strategic opportunity to strengthen its automotive value chain position. Currently, India constitutes almost 3% of global auto component exports. To become a dominant player in the global value chain (GVC), India must address key challenges, including cost competitiveness, inadequate R&D infrastructure, limited engagement with global OEMs, restricted access to global markets, and the absence of advanced testing and validation centres to scale up production and meet global demands. Furthermore, Industry-academia disconnect hinders collaboration driving automotive technology innovation.

To boost India's presence in the global automotive value chain investments in infrastructure, R&D, and workforce skills are vital. Strengthening capabilities in design innovation, high-value components manufacturing will help India gaining a higher share in the global value chain. Additionally, Collaborative efforts between industry and academia for indigenous technology development will enhance competitiveness and make India an attractive hub for global manufacturers diversifying supply chains.

This report is the culmination of findings from numerous stakeholder consultations with industry, academia, industry associations, Ministries and Departments of Union Government and States. I would like to express my sincere appreciation to SIAM and ACMA for their invaluable support in facilitating these consultations and organizing visits to various industries. Additionally, the Ministry of Heavy Industries (MHI) has provided critical insights and played an integral role in providing the actionable inputs and finalization of this report. I also acknowledge the association of our knowledge partners, including CRISIL, in this study.

I would like to extend my heartfelt gratitude to Hon'ble Vice Chairman, NITI Aayog and Dr. V.K. Saraswat, Hon'ble Member, NITI Aayog for their insightful suggestions and recommendations from time to time. I am also grateful to CEO, NITI Aayog for his continuous guidance and support throughout this initiative.

Additionally, I would like to extend my sincere appreciation to Shri Upendra Kumar Gupta, Deputy Advisor, NITI Aayog; Shri Abhishek Mukherjee, Research Officer, NITI Aayog; Shri Bhadraksh Bhargav, Young Professional, NITI Aayog and all other members for their insightful contributions and support. Their dedication has significantly enriched the depth and practical relevance of this report.

I sincerely hope that the recommendations presented in this report will benefit the industry in adopting suitable business strategies, and also help concerned Ministries/Departments and State governments in developing favorable policies for the advancement of automotive sector.

Date: 28th March, 2025

(Ishtiyaque Ahmed)

PREFACE

The Indian automotive industry stands at a pivotal juncture, poised to redefine its role in the global manufacturing landscape. As the world transitions toward electric mobility, autonomous driving, and sustainable production, the automotive sector offers India a unique opportunity to emerge as a key player in the global value chain (GVC). This report, the second in the series of Global Value Chains, titled **"Automotive Industry: Powering India's participation in Global Value Chains"**, explores the transformative potential of India's auto component industry, outlining a strategic roadmap to elevate its global salience and drive economic prosperity. Historically, the automotive sector has been a cornerstone of industrial growth, fostering innovation, employment, and cross-sectoral linkages. In India, the industry has made significant strides, positioning the country as the world's fourth-largest automobile producer. Yet, despite this achievement, India's share in the global traded auto component market remains modest at just 3%, reflecting untapped potential and underlying challenges. With a near-neutral trade balance and a cumulative cost disability of nearly 10% compared to competitors like China, India's auto component sector faces structural hurdles that impede its competitiveness. These include supply chain inefficiencies, high material and equipment costs, and limited penetration in high-precision segments like engine and transmission systems.

This report envisions a bold future where India's automotive component production reaches $145 billion by 2030, with auto component exports tripling to $60 billion, yielding a trade surplus of $25 billion. Such growth promises to create 2-2.5 million additional direct jobs, bolster ancillary industries, and elevate India's GVC share to 8%. Achieving this ambition, however, demands a concerted effort to address cost disadvantages, enhance infrastructure, and integrate advanced technologies such as Industry 4.0. The shift toward electric vehicles (EVs) and next-generation features like Advanced Driver Assistance Systems (ADAS) further underscores the urgency of aligning India's capabilities with global trends.

To realize this vision, we propose a comprehensive set of fiscal and non-fiscal interventions. These include targeted operational support for identified components and capital expenditure support for tools and dies, cluster development to strengthen supply chains, Measures for improving R&D and skill-building initiatives to nurture talent. Equally critical are measures to foster international collaboration through joint ventures and free trade agreements, alongside efforts to elevate quality standards and build a globally competitive brand for Indian auto components. This holistic approach aims not only to enhance export potential but also to position India as a hub for high-quality, technology-driven manufacturing. As we present this summary and the detailed findings that follow, our goal is to catalyze dialogue and action among policymakers, industry leaders, and stakeholders. The timely implementation of these recommendations offers a powerful pathway to unlock India's potential, driving economic growth, job creation, and technological advancement. We invite you to join us in this journey to transform India's auto component sector into a global powerhouse, contributing to a sustainable and prosperous future.

EXECUTIVE SUMMARY

The global landscape of automobile manufacturing has undergone a remarkable transformation over the past few centuries, driven by profound technological advancements and shifts in economic and social patterns. From the advent of mass production to the emergence of modern manufacturing methodologies such as Industry 4.0 and Lean manufacturing, the automotive sector has played a pivotal role in shaping the broader manufacturing ecosystem.

As a prime driver of innovation, the automotive industry not only pioneers new manufacturing practices and technologies but also encourages their adoption across other sectors. Furthermore, it has been instrumental in advancing sustainable manufacturing, promoting energy-efficient processes, and leading the transition toward a circular economy.

One of the most significant transformations in the global manufacturing landscape is the increasing interdependence between the automotive industry and advanced sectors such as electronics, semiconductors, and artificial intelligence. The global automotive industry is also deeply connected to broader sectors, including steel, textiles, leather, rubber, plastics, glass, electronics, and IT, making it one of the largest consumers of these industrial products.

Currently, the automotive sector is undergoing a major transformation, shifting from conventional automobiles to electric vehicles (EVs) equipped with next-generation technological features such as Advanced Driver Assistance Systems (ADAS), the Internet of Things (IoT), and Autonomous Driving (AD). With the integration of these cutting-edge technologies, the cost of semiconductor chips per vehicle is projected to double, rising from $600 to $1,200 by 2030.

The global automotive component market was valued at approximately $2 trillion in 2022, underscoring its critical role within the global automotive industry. Of this, around 30%—or $700 billion—constitutes the traded automotive component market. Over the past five years, the automotive sector has maintained steady growth of 4–6%, driven by rising consumer demand and growing interest in automobile ownership.

Despite being the world's fourth-largest automobile producer—following China, the U.S., and Japan—India holds only a minimal 3% (~$20 billion) share in the global automotive component traded market. This highlights India's limited participation in global auto component trade.

Breaking down the global traded market, engine and engine components, along with drive transmission and steering systems, account for 60% of total trade in auto components. India's share in these critical, high-precision segments remains relatively low at 2–4%. Given the stringent quality and precision requirements for these components, India's limited presence indicates a gap in competitiveness.

India currently exports auto components worth approximately $20 billion while importing a similar value, resulting in a near-neutral trade ratio of 0.99. This balance suggests that India's automotive component trade remains largely self-contained, with exports and imports nearly offsetting each other.

India's automotive component manufacturing sector faces a cumulative cost disability of nearly 10% compared to China, making it less competitive in the global market. Additionally, there is an extra cost disadvantage of approximately 20% on equipment (capital goods)

required for component manufacturing. One of the key factors contributing to this cost gap is material cost disability. China benefits from a well-integrated supply chain, spanning from raw minerals to high-value-added products, whereas India lacks such depth in its supply ecosystem. Furthermore, depreciation policies add to India's cost disadvantage. India has a 100% depreciation rate compared to China's 50%, leading to an additional ~3.4% cost burden. Additional cost disabilities also arise from higher tax and financing costs, further reducing India's competitiveness.

Despite advantages in areas like labor, fuel, and power costs, these structural inefficiencies make India a less attractive investment destination for automotive component manufacturing, limiting its ability to compete globally. Complete details of fiscal disability for Automotive manufacturing are given in the report.

This report envisions India advancing to approximately $145 billion in automotive component production by 2030, with auto component exports expected to triple from $20 billion to $60 billion during this period. This growth would position India as a formidable player in global markets, achieving a trade surplus of ~$25 billion and increasing its share in the global value chain (GVC) of auto components from 3% to 8%. Such progress is projected to generate 2–2.5 million additional large-scale employment opportunities, bringing the total direct employment in the sector to 3–4 million people. However, realizing this ambitious vision will require strategic and focused policy initiatives to enhance competitiveness, improve infrastructure, and attract investment in high-value automotive manufacturing.

This report outlines a comprehensive set of interventions across multiple domains to achieve the envisioned growth in India's automotive component industry. Components have been prioritized based on their maturity and complexity in manufacturing and development, ensuring a targeted approach to expansion across both the Conventional and Complex segment and the Emerging and Complex segment. The recommended fiscal interventions include operational expenditure (Opex) support to scale up manufacturing, with a special focus on capital expenditure (Capex) assistance for the development of tools and dies, IP transfer and Branding support which are crucial for automotive component manufacturing. Cluster development is also emphasized to strengthen supply chains, reduce logistics costs, and establish common R&D and testing facilities, thereby accelerating product development. Additionally, skill development initiatives are highlighted to ensure a steady pipeline of talent, which is essential for driving sectoral growth. On the non-fiscal front, the report suggests interventions such as business improvement support to enhance global competitiveness, encouragement of joint ventures (JVs) and free trade agreements (FTAs) to foster international collaboration and market access, adoption of Industry 4.0 and enhanced quality standards to improve manufacturing efficiency initiatives to position India as a key global player in the automotive component sector. These policy measures, if effectively implemented, will be crucial in enabling India to scale up its automotive component production, increase exports, and strengthen its standing in global markets.

Timely and effective implementation of the recommended reforms and initiatives presents a promising and powerful pathway for India to enhance its global value chain (GVC) salience in the automotive sector. This, in turn, will drive accelerated economic growth, income generation, and job creation, while strengthening the supply chain ecosystem and ancillary industries. Additionally, it will create opportunities for skill and knowledge advancement, positioning India as a globally recognized supplier of high-quality, technologically advanced products.

1 Chapter

INTRODUCTION

1.1 GLOBAL MANUFACTURING LANDSCAPE

The global landscape of automobile manufacturing has undergone a remarkable transformation over the past two centuries, shaped by profound technological advances and shifts in economic and social patterns.

In the 19th century, the birth of the automobile industry was marked by the invention of the Benz Patent-Motorwagen, constructed in 1885 by the German innovator Karl Benz. This three-wheeled, two-seater vehicle, powered by a four-stroke, single-cylinder engine, was patented in 1886 and stands as the world's first automobile powered by an internal combustion engine. The advent of this machine not only signalled a new era of personal transport but laid the foundational stone for an industry that would come to revolutionize global manufacturing, trade, and mobility.

As the 20th century dawned, the early automobiles were handmade, luxurious commodities, available only to the wealthiest few. It was the visionary approach of Henry Ford, and his introduction of the assembly line in 1913, that democratized the automobile. Ford's Model-T became emblematic of this shift, as the assembly line reduced production time from over 12 hours to merely 90 minutes, reducing costs and making cars affordable to the burgeoning middle class. This method of mass production soon became a template for industrial manufacturing across the globe. The rise of industry giants like General Motors and Chrysler in the United States, Rolls-Royce and Fiat in Europe, and Nissan and Toyota in Japan diversified and expanded the automobile industry to different corners of the world.

In the post-World War II period, the focus shifted toward operational efficiency and quality, with pioneering practices like Total Quality Management (TQM), Toyota Production System (TPS), Lean Manufacturing, and Six Sigma becoming central tenets of production. These innovations led to enhanced process flows, minimized lead times, and significant cost savings, as they were widely adopted across the global manufacturing sector. These transformative approaches to production not only improved operational efficiency but also played a crucial role in evolving the concept of Tier 1, Tier 2, and Tier 3 suppliers.

The 21st century heralds a new frontier for the automotive industry, defined by the advent of Electric Vehicles (EVs) and the increasing integration of Artificial Intelligence (AI) and digital technologies. In response to shifting market demands and the rising global emphasis on sustainability, traditional automakers and component manufacturers have begun transitioning from internal combustion engine vehicles to electric-powered alternatives. Investment strategies have evolved, with significant resources redirected toward advanced technologies, ensuring the industry remains at the forefront of innovation.

This evolution is part of a broader global shift in automobile manufacturing. Historically dominated by mature economies such as the United States, Germany, and Japan, the sector has witnessed a notable shift towards emerging markets, driven by evolving global economic patterns, labour costs, and growing consumer markets.

In 2023, global automobile production of cars and commercial vehicles, reached around 94 million units, rebounding from the disruptions caused by the COVID-19 pandemic. The industry's resilience is evident in its recovery, driven by pent-up demand, changing consumer preferences, and the rapid adoption of EVs.

China is the world's largest automobile producer, manufacturing over 30 million units of car and commercial vehicles in 2023, accounting for approximately 30% of global production. Its strategy encompasses both domestic consumption and an expansive global footprint. Leading domestic companies like BYD and Geely have aggressively pursued the EV market, supported by strong governmental incentives, infrastructure growth, and technological advancements. China also dominates the global EV market, with sales exceeding 8 million units in 2023.

The United States, producing over 10 million automobiles (Cars and Commercial vehicles), remains the second largest player, blending the legacy of giants like General Motors and Ford with the rise of new entrants such as Tesla. Detroit, once synonymous with U.S. automobile production, remains a manufacturing hub, although production has shifted toward southern states and Mexico, driven by lower labour costs and favourable trade agreements.

Japan, the third-largest automobile producer, manufactured nearly 9 million car and commercial vehicles in 2023. Known for its innovation in fuel-efficient and hybrid technologies, Japanese automakers like Toyota and Honda emphasize kaizen (continuous improvement) and lean manufacturing, hallmarks of the Toyota Production System. Despite a mature domestic market, Japan's export-driven automobile industry remains vital, with over 4 million vehicles exported annually, particularly to North America and Europe.

South Korea, well known for technological advancements and R&D in automotive industry, has a presence of major players like Hyundai and Kia. The country produced over 4 million automobiles (Cars and Commercial) in 2023, witnessing a 13% growth in production as compared to previous year.

Germany, renowned for luxury brands such as BMW, Mercedes-Benz, and Audi, produces over 4 million automobiles annually. The German automotive sector, contributing 5% to the nation's GDP, is deeply integrated with advanced technologies like automation and robotics. Germany's focus on luxury and innovation, especially in electric and autonomous driving technologies, ensures its continued relevance in the global market, bolstered by its role as a central hub in the European automotive supply chain, with components sourced from neighbouring countries in Eastern Europe.

Meanwhile, India has emerged as a prominent player, ranking fourth globally with an annual production of nearly 6 million automobile units. Indian companies such as Maruti, Tata Motors, and Mahindra & Mahindra have established significant domestic and export markets, especially in the small car and utility vehicle segments. Supported by government initiatives like 'Make in India' and a cost-competitive workforce, India is positioning itself as a global automotive manufacturing and export hub.

1.1.1 REGIONAL SHIFTS AND THE RISE OF EMERGING MARKETS

Over the last two decades, a significant shift has occurred in global automotive production from established industrialized economies to emerging markets. Several factors have contributed to this rebalancing.

Cost dynamics have been a major driver, as labour costs in traditional automotive hubs such as Western Europe and North America are significantly higher than in emerging economies like China, India, and Mexico. This cost differential has led to the relocation of many manufacturing facilities to lower-cost regions. For instance, Mexico has become a critical player in North American automotive manufacturing due to its proximity to the U.S. market, competitive labour costs, and favourable trade policies under the United States-Mexico-Canada (USMCA) agreement. In 2023, Mexico produced approximately 4 million vehicles, with most of its output destined for export.

Additionally, the proximity to growing markets in emerging economies not only provides lower-cost labour but also represent rapidly expanding consumer markets. The middle-class population in countries such as China and India have surged, leading to greater demand for automobiles. By establishing production facilities in these regions, global automakers can cater to local demand while also avail the advantage of low-cost manufacturing.

Complementing these economic and market dynamics are government policies and incentives that actively support the automotive sector in many emerging markets. In China, for example, the government has played a pivotal role in shaping the domestic EV market by offering substantial subsidies for EV purchases and investing heavily in charging infrastructure. Similarly, India's Production-Linked Incentive (PLI) and Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme aim to attract significant investment in automotive manufacturing, particularly in electric vehicle and Plug-in Hybrid Electric Vehicles (PHEV) segments.

1.1.2 ELECTRIC VEHICLE (EV) REVOLUTION AND ITS IMPACT ON MANUFACTURING

The rise of electric vehicles is one of the most significant trends reshaping the global automobile manufacturing landscape. EV sales have grown exponentially, driven by consumer demand for sustainable mobility, regulatory pressure to reduce carbon emissions, and technological advancements in battery technology.

China leads the world in EV production, accounting for over 50% of global EV sales in 2022. Chinese companies such as BYD, Nio, and Xpeng have become global leaders in the EV space, challenging established players in Europe and North America. China's dominance in the EV market is also supported by its control over the global supply chain for lithium-ion batteries, with Chinese firms like CATL being the largest battery manufacturers globally.

Europe has also made significant strides in EV adoption. The European Union's stringent carbon emission targets and regulatory frameworks have pushed traditional automakers such as Volkswagen, BMW, and Renault to accelerate their transition to EV production. In 2022, EVs made up nearly 25% of all vehicle sales in Europe, with countries like Norway and the Netherlands leading the charge.

The U.S., led by Tesla, is also witnessing rapid growth in EV production. Tesla's gigafactories in Nevada and Texas serve as models of high-tech, scalable EV production. Moreover, the U.S. government's Inflation Reduction Act (2022) and the Chips Act (2022) has introduced significant incentives for EV production and purchases, aimed at reducing dependence on fossil fuels and encouraging domestic manufacturing of EV components such as batteries and semiconductors.

The rise of EVs has also led to the creation of new manufacturing hubs, particularly for battery production. Gigafactories for battery manufacturing are being established in regions such as China, Europe, and the U.S., driving investments in related industries like mining for lithium and cobalt, which are critical for EV battery production. These developments are altering traditional automotive supply chains and creating new opportunities for collaboration and competition globally.

1.1.3 THE SHIFT TO ADVANCED MANUFACTURING

The automotive industry is at the forefront of the Industry 4.0 revolution, which integrates advanced technologies like Artificial Intelligence (AI), Machine Learning (ML), Additive Manufacturing, the Internet of Things (IoT), and robotics into manufacturing processes. This shift is enhancing productivity, reducing costs, and increasing the flexibility of production lines to cater to the growing diversity of vehicle models, particularly with the rise of EVs and autonomous vehicles. South Korea is a leader in adoption of automation and robotics and has deployed 1012 robots per 10,000 employees in 2022. Following are Singapore and Germany with 730 and 415 robots per 10,000 employees[1]. German manufacturers employ high levels of automation and robotics in their production processes. Germany is a leader in adopting Industry 4.0 practices in automotive manufacturing. Japanese automotive plants are renowned for their use of just-in-time production and lean manufacturing techniques, which have been further enhanced by the integration of AI and predictive analytics. Toyota, for instance, uses advanced AI systems to optimize its supply chain and manufacturing efficiency.

This digital transformation is not only limited to manufacturing processes but also extends to smart factories and connected vehicles, creating new business models and ecosystems within the global automotive sector.

1.2 ROLE OF THE AUTOMOTIVE SECTOR IN TRANSFORMING GLOBAL MANUFACTURING

The automotive sector has long been a catalyst for industrial transformation and innovation, driving advancements in manufacturing technologies that are now integral to various other industries. Over the last few decades, the sector has pioneered

1 *https://www.therobotreport.com/ifr-world-sets-record-for-operational-robots-in-2022/*

the adoption of cutting-edge practices, such as robotics, automation, artificial intelligence, and digitalization. This transformation has been pivotal in enhancing production efficiency, reducing costs, and enabling the mass customization of products. The integration of Industry 4.0 technologies has positioned the automotive industry at the heart of a new era of global manufacturing, reshaping supply chains and fostering cross-sectoral linkages.

1.2.1 TECHNOLOGY ADOPTION IN THE AUTOMOTIVE INDUSTRY

The automotive sector has led the way in adopting automation and robotics, driven by the need for precision, speed, and cost-efficiency in mass production. The sector's complex production processes and high volumes of output have necessitated significant investment in automation technologies to ensure consistency and minimize errors.

- **Robot Density:** According to the data published by International Federation of Robotics (IFR), South Korea, Singapore and Germany, which are pioneer in manufacturing, robot density in these countries are highest in the world. In automotive manufacturing, robot density is significantly higher than in other industries. It is one of the highly automated sectors globally. Particularly in automotive industry, South Korea leads with a robot density of 2,867 robots per 10,000 employees. Germany, the United States, Japan, and China follow with densities of 1,500, 1,457, 1,422, and 772 robots per 10,000 employees, respectively.[2] The extensive use of robotics helps manufacturers achieve high-quality standards and scale production, especially for premium and high-tech vehicles like electric cars.

- **Automation and AI:** Artificial intelligence and machine learning are transforming automotive manufacturing by optimizing production lines, reducing downtime, and predicting potential equipment failures. AI-driven predictive maintenance systems are increasingly common in modern automotive factories, helping to avoid costly disruptions. For example, BMW employs AI to monitor production machinery, ensuring smooth operations and improving the overall efficiency of its plants.

- **Digital Twins and IoT:** Another transformative innovation in automotive manufacturing is the use of digital twins—virtual models of physical assets that allow manufacturers to simulate, monitor, and optimize production processes in real-time. Coupled with the Internet of Things, digital twins enhance flexibility and reduce lead times. Toyota has employed digital twins to create highly efficient production processes, integrating IoT sensors to provide real-time data on machine performance and inventory management.

1.2.2 INDUSTRY 4.0 AND THE FUTURE OF AUTOMOTIVE MANUFACTURING

The ongoing transformation of the automotive sector is closely linked to the Industry 4.0 revolution, which integrates cyber-physical systems, big data,

2 *https://ifr.org/news/one-million-robots-work-in-car-industry-worldwide-new-record*

cloud computing, and automation into manufacturing processes. Automotive manufacturing is now at the forefront of smart manufacturing, with companies leveraging these technologies to enhance operational efficiency, improve product quality, and reduce production costs.

- **Smart Factories:** Many global automakers are investing heavily in creating smart factories, where AI, IoT, and robotics are integrated into every aspect of the production process. Audi's factory in Ingolstadt, Germany, serves as an exemplar of a smart factory, where vehicles are produced with minimal human intervention, and production lines are highly flexible, capable of producing different models simultaneously based on real-time demand.

- **Additive Manufacturing:** Also known as 3D printing, additive manufacturing is revolutionizing automotive production by enabling the creation of complex components with reduced material waste. Ford and BMW are leading users of 3D printing technology, using it to produce everything from prototype parts to components for final assembly. The ability to quickly and cost-effectively produce bespoke parts is reducing development times and enabling greater customization.

- **Big Data and Analytics:** Automakers are utilizing big data analytics to optimize their supply chains, improve production efficiency, and enhance product quality. By analysing vast amounts of data from sensors, connected vehicles, and production lines, companies can identify patterns and make data-driven decisions. For example, Toyota uses big data to predict maintenance needs and optimize its just-in-time production processes.

1.2.3 SUSTAINABILITY AND CIRCULAR ECONOMY PRACTICES

The automotive industry has also been a key player in driving the shift toward more sustainable manufacturing practices. The sector's environmental impact, including emissions from production and end-of-life vehicle disposal, has prompted significant efforts to reduce carbon footprints and embrace circular economy models.

- **Energy Efficiency:** Automakers are increasingly integrating renewable energy sources into their production processes. For instance, by 2030, Volkswagen has aimed 100% of the external electricity purchases by all sites is to come from carbon neutral sources, aligning its operations with global efforts to mitigate climate change.

- **Circular Economy:** The sector is at the forefront of the circular economy, focusing on minimizing waste, promoting the reuse and recycling of materials, and developing closed-loop systems. For example, BMW has implemented a comprehensive recycling program for its electric vehicle (EV) batteries, ensuring that valuable raw materials such as lithium, cobalt, and nickel are recovered and reused in new battery production. This not only reduces environmental impact but also addresses the growing concern over raw material shortages for EV production.

- **Sustainable Manufacturing:** Automakers are increasingly employing green manufacturing practices, such as using lightweight materials (e.g., aluminium, high-strength steel, and carbon fibre) to reduce vehicle weight and improve fuel efficiency. These materials are produced using less energy-intensive processes, thus reducing overall emissions. For example, Ford has committed to reducing the carbon footprint (Scope 1 & Scope 2 Carbon emissions) from its operations by 76% by 2035.

1.2.4 LINKAGES WITH OTHER SECTORS: ELECTRONICS, AI, AND SEMICONDUCTORS

One of the most significant transformations in the global manufacturing landscape is the growing interdependence between the automotive industry and other advanced sectors, particularly electronics, semiconductors, and artificial intelligence.

- **Semiconductors and Electronics:** The shift towards electric and autonomous vehicles has vastly increased the reliance of the automotive industry on semiconductor chips. Advanced vehicles today are equipped with complex electronic systems that control everything from engine performance and safety features to infotainment and connectivity. The global semiconductor shortage that began in 2020 underscored the critical role of semiconductors in automotive manufacturing, with many automakers forced to halt production due to the scarcity of chips. To address these vulnerabilities, companies like Tesla and Ford have begun to secure direct partnerships with semiconductor manufacturers, while others, like Toyota, have opted for a "just-in-case" supply chain strategy, stockpiling key components.

- **Artificial Intelligence and Autonomous Vehicles:** AI is also reshaping the sector by enabling the development of autonomous driving technologies. Companies like Waymo, Tesla, and NVIDIA are pioneering advancements in AI-based systems that allow vehicles to operate with minimal human intervention. The implications for manufacturing are profound, as AI-driven vehicle production will require increasingly sophisticated electronic components and software, driving further collaboration between the automotive, electronics, and AI sectors.

- **Battery Technology:** The rise of electric vehicles has also led to significant innovations in battery technology. The automotive sector has emerged as a key driver of advancements in lithium-ion batteries, which are now widely used not only in vehicles but also in other industries such as consumer electronics and energy storage. Countries like China have positioned themselves as global leaders in battery production, with companies like CATL (Contemporary Amperex Technology Co. Ltd.) supplying batteries to automakers across the globe.

1.3 ROLE OF THE AUTOMOTIVE INDUSTRY IN INDIAN MANUFACTURING SECTOR

India's automobile sector is a cornerstone of its manufacturing ecosystem, playing a crucial role in the country's economic growth and industrial development. As one of the largest automotive markets in the world, India's automobile industry contributes nearly 7.1% to the national GDP and accounts for nearly 49% of the country's manufacturing GDP[3]. This contribution underscores the sector's importance as a driver of industrial output, employment, and technological advancement in India.

1.3.1 AUTOMOTIVE PRODUCTION AND MARKET OVERVIEW

The Indian Auto industry produced over 28 million vehicles including Passenger Vehicles, Commercial Vehicles, Three Wheelers, Two Wheelers, and Quadricycles in April 2023 to March 2024, making it the fourth-largest automobile producer globally, following China, the United States and Japan. The sector encompasses a broad spectrum of vehicles, including passenger cars, commercial vehicles, two-wheelers, and three-wheelers, catering to both domestic consumption and exports. The industry is dominated by a few key players which together control a significant portion of the domestic passenger vehicle market.

- **Car and Commercial Vehicles segment:** In 2023-24, the Indian Automobile market saw the production of nearly 6 million units, driven by rising demand from the middle-class and improved affordability of vehicles. Leading companies such as Maruti Suzuki, Tata Motors and Mahindra & Mahindra remain prominent in this segment and have made significant inroads with their strong portfolios of electric vehicles (EVs), and utility vehicles. On the commercial vehicle front, companies like Ashok Leyland and Tata Motors dominate the market. Commercial vehicles are critical to India's infrastructure and logistics sectors, playing a key role in freight transportation across the country's vast road network.

- **Two-Wheeler and other Segments:** India is the world's largest producer of two-wheelers, with over 21 million units produced annually in 2023- 24. Three-wheelers and quadricycles have also experienced production growth, with nearly 1 million units being produced. This rise reflects the growing demand for compact, efficient transportation solutions, particularly in emerging markets where these vehicles are popular for urban mobility.

1.3.2 GOVERNMENT INITIATIVES SUPPORTING THE AUTOMOTIVE SECTOR

The Indian government has been instrumental in shaping the growth trajectory of the automobile sector through several policy initiatives aimed at enhancing the country's manufacturing capabilities and positioning it as a global automotive hub.

Make in India	Launched in 2014, the Make in India initiative has provided a significant boost to the country's manufacturing sector, particularly in automobiles. This policy promotes domestic manufacturing, reduces reliance on imports, and encourages foreign direct investment.
Atmanirbhar Bharat:	The Atmanirbhar Bharat initiative aims to foster self-sufficiency in manufacturing and reduce the country's dependence on foreign components. In the automotive sector, this has resulted in increased domestic production of critical components such as engines, transmissions, and EV batteries. The government has also extended support to start-ups and small and medium enterprises (SMEs) in the automotive space, helping them integrate into global supply chains.
FAME India Scheme phase-I	The Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) India scheme was launched in 2015 to promote adoption of electric/ hybrid vehicles (HEVs) in India. The Phase-1 of the scheme was available up to 31st March, 2019 with budget outlay of Rs 895 Cr. This phase had four focus areas i.e., technological development, demand generation, pilot project and charging infrastructure components.
FAME-India Scheme phase-II	The scheme implemented on pan India basis for a period of five years commencing from 1st April, 2019 with an outlay of INR 10,000 Crore which was further enhanced to INR 11,500 Crore. This scheme mainly focuses on supporting electrification of public & shared transportation, and aims to support the industry through demand incentive e-vehicles including e-buses. In addition, creation of charging infrastructure is also supported under the Scheme.
PM E-DRIVE Scheme	The PM Electric Drive Revolution in Innovative Vehicle Enhancement scheme has a financial outlay of INR 10,900 crore. Effective from October 1, 2024 until March 31, 2026. Its primary aim is to accelerate the adoption of electric vehicles (EVs), establish charging infrastructure, and build a robust EV manufacturing ecosystem in the country. The PM E-DRIVE scheme aims to incentivize approximately 24.79 lakh electric two-wheelers (e-2Ws) and around 3.2 lakh electric three-wheelers. A budget of INR 500 crore each has been allocated for deploying e-ambulances and to incentivize the use of e-trucks. A total of INR 4,391 crore is allocated for the procurement of 14,028 electric buses by State Transport Undertakings (STUs)/public transport agencies. The total outlay for charging infrastructure under the scheme is INR 2,000 crores.

PLI scheme	The Production-Linked Incentive (PLI) scheme for the automotive sector, introduced in 2021, aims to boost domestic manufacturing of advanced automotive technologies. The scheme has a budget of INR 25,938 crore ($ 3.5 Bn) and is focused on encouraging the production of EV components, hydrogen fuel cells, and other advanced automotive technologies in India. This initiative is expected to generate significant investments and foster technological innovations in the sector.
PLI scheme for (Advanced Chemistry Cell) ACC Battery Storage	With a budget outlay of INR 18,100 crores, introduced in 2021, this scheme envisages to enhance India's manufacturing capabilities of Advanced Chemistry Cell (ACC) by setting up of Giga scale ACC and battery manufacturing facilities in India with emphasis on maximum domestic value addition. Beneficiary firm must ensure at least 25% domestic value addition and raise it to 60% within 5 years.

1.3.3 EMERGING TRENDS IN INDIAN AUTOMOTIVE MANUFACTURING

India's automotive sector is undergoing a transformation, shaped by evolving consumer preferences, technological advancements, and sustainability goals. The rise of electric vehicles (EVs), coupled with innovations in autonomous driving and connected vehicles, is pushing Indian manufacturers to rethink their strategies and invest heavily in research and development (R&D).

- **Electric Vehicles:** With the government's emphasis on electric mobility, the Indian automotive industry is increasingly shifting toward the production of EVs. Companies are also investing in the development of battery technologies and charging infrastructure. The EV market is expected to grow at a compound annual growth rate (CAGR) of over 23%[4] in the coming decade, with significant contributions from start-ups and global partnerships.
- **Autonomous and Connected Vehicles:** India is also making strides in the development of autonomous and connected vehicles, with significant investments from both domestic and global companies. Some Indian software companies are collaborating with global automakers to develop software solutions for autonomous driving and connected vehicles, further positioning India as a hub for automotive software development.

1.4 INTERCONNECTEDNESS OF INDIAN AUTOMOTIVE SECTOR WITH OTHER INDUSTRIES

The Indian automotive sector is deeply interconnected with various parts of the broader economy, creating strong backward and forward linkages that drive demand for raw materials, components, and services across multiple industries. These linkages extend to key sectors such as steel, rubber, glass, electronics, information technology etc. making the automotive industry a critical component

4 *https://economictimes.indiatimes.com/industry/renewables/with-23-cagr-global-ev-market-to-soar-to-usd-2108-billion-by-2033-report/articleshow/113763420.cms?from=mdr*

of India's industrial value chain. Some of the industries or sectors that highlight this interdependence are:

1. **Steel:** The automotive sector is a major consumer of steel in India, accounting for approximately 15% of the country's total steel production. Automakers rely heavily on high-strength steel for vehicle body structures, engines, and other components. Leading Indian steel companies such as Tata Steel and JSW Steel have established long-term partnerships with automakers, ensuring the steady supply of advanced steel products required for vehicle manufacturing. As the demand for lightweight vehicles grows, steel manufacturers are also focusing on developing new grades of high-strength steel that are both durable and lightweight.
2. **Rubber and Plastics:** The Indian automotive sector drives significant demand for rubber and plastics, particularly for the production of tires, hoses, seals, and other components. India is one of the world's largest producers of natural rubber, with the automotive industry consuming nearly 50% of the country's rubber production. Companies like MRF, Apollo Tyres, and JK Tyre are major suppliers of tires to both domestic and global markets. In the plastics sector, automakers are increasingly using lightweight polymer materials to improve vehicle fuel efficiency and reduce manufacturing costs.
3. **Glass:** The automotive sector is a key consumer of automotive glass for windshields, windows, and mirrors. Companies such as Asahi India Glass and Saint-Gobain supply the Indian automobile industry with high-performance glass that meets stringent safety and quality standards. The growing demand for advanced driver-assistance systems and smart glass technologies is further boosting innovation in this sector.
4. **Electronics:** The increasing integration of electronics into vehicles, particularly in EVs and autonomous cars, has strengthened the linkage between the automotive and electronics industries. Semiconductors, sensors, and microcontrollers are critical components for modern vehicles, enabling everything from engine control units to advanced infotainment systems. India's burgeoning electronics manufacturing industry is playing an essential role in supplying these components to automakers. As part of the PLI scheme for electronics, the government is encouraging the domestic production of automotive electronics, reducing dependence on imports.
5. **IT Sector:** India's thriving information technology sector plays a pivotal role in the design and development of software for autonomous driving, connected vehicles, and in-car infotainment systems. Companies like Tata Consultancy Services, Infosys, and Wipro are global leaders in providing IT solutions to automotive giants. These companies are collaborating with automakers to develop systems for vehicle-to-vehicle and vehicle-to-infrastructure communication, as well as cyber security solutions for connected cars. The IT sector's contribution to the automotive industry has positioned India as a hub for automotive software development and engineering services.
6. **Textiles and leather Sector:** Textile and leather are extensively used in automotive industry. Its application ranges from airbag cushion for safety purpose to seat covers, steering wheel, floor mats for enhancing the visual appearance of the interior. Textiles and leather are predominantly used for interior applications such as floor covering, seat covers, interior trims, seatbelts, airbag and filters.

1.5 AUTO SYSTEM OVERVIEW

The below diagram illustrates the distinct components in automobile manufacturing.

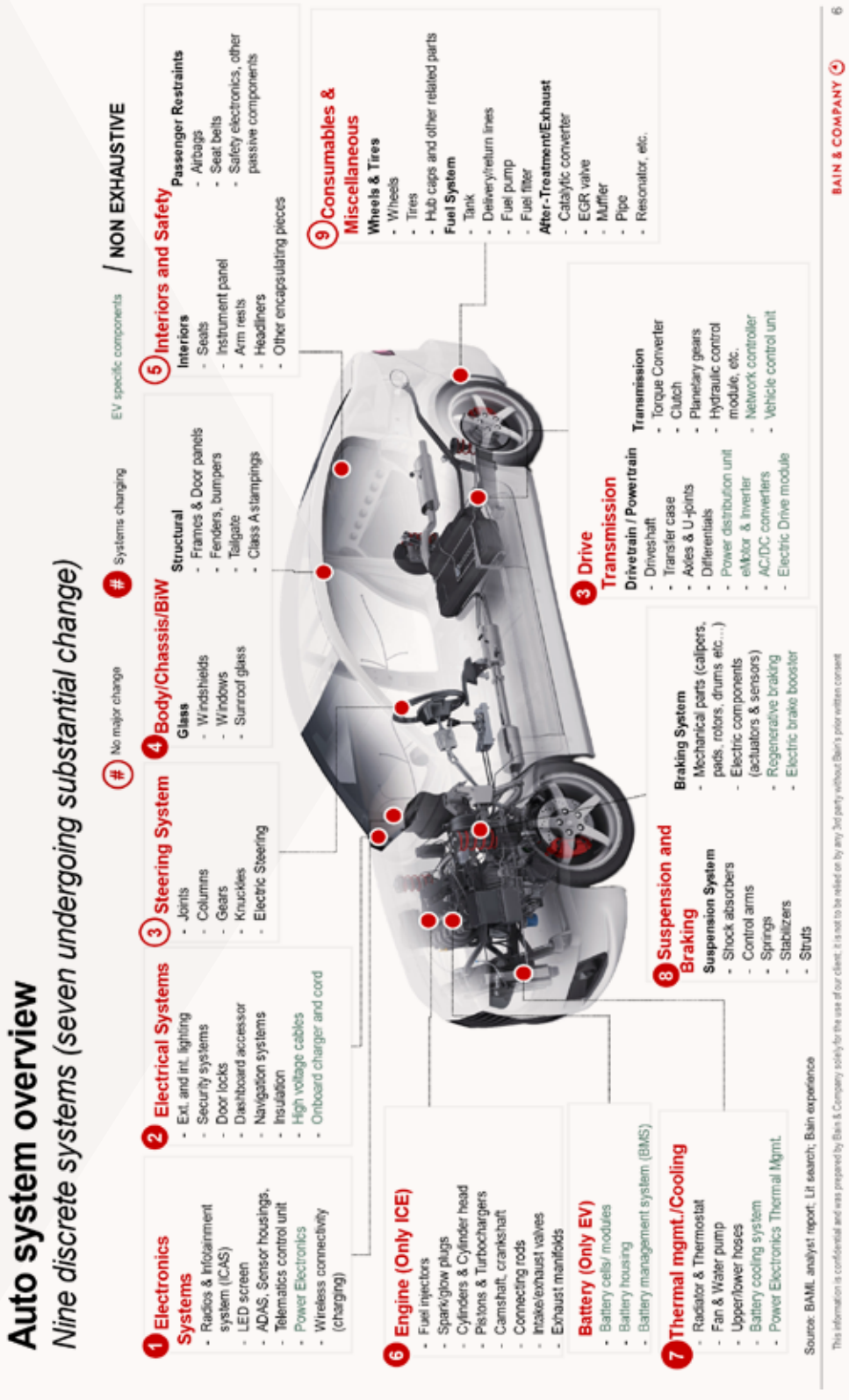
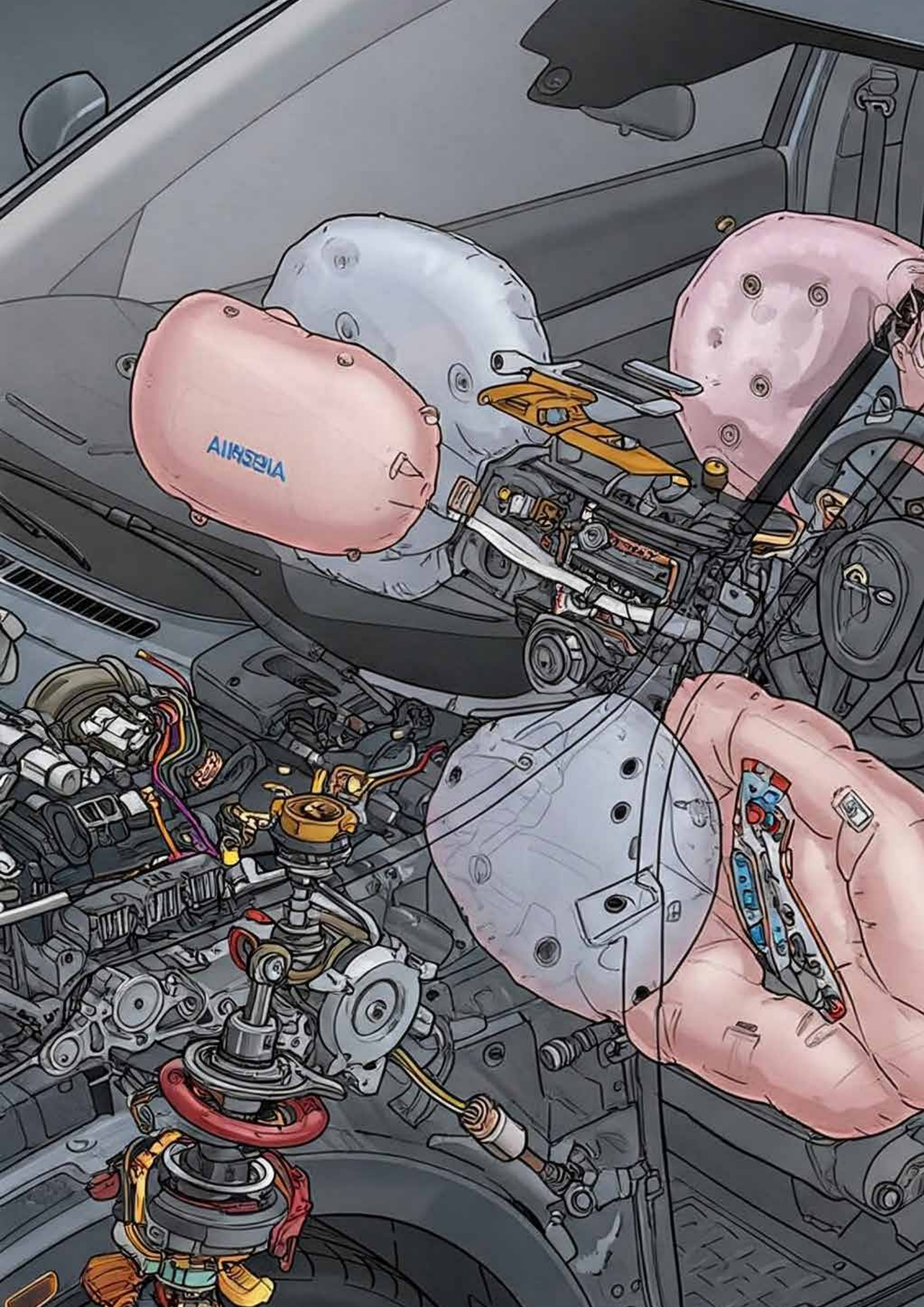
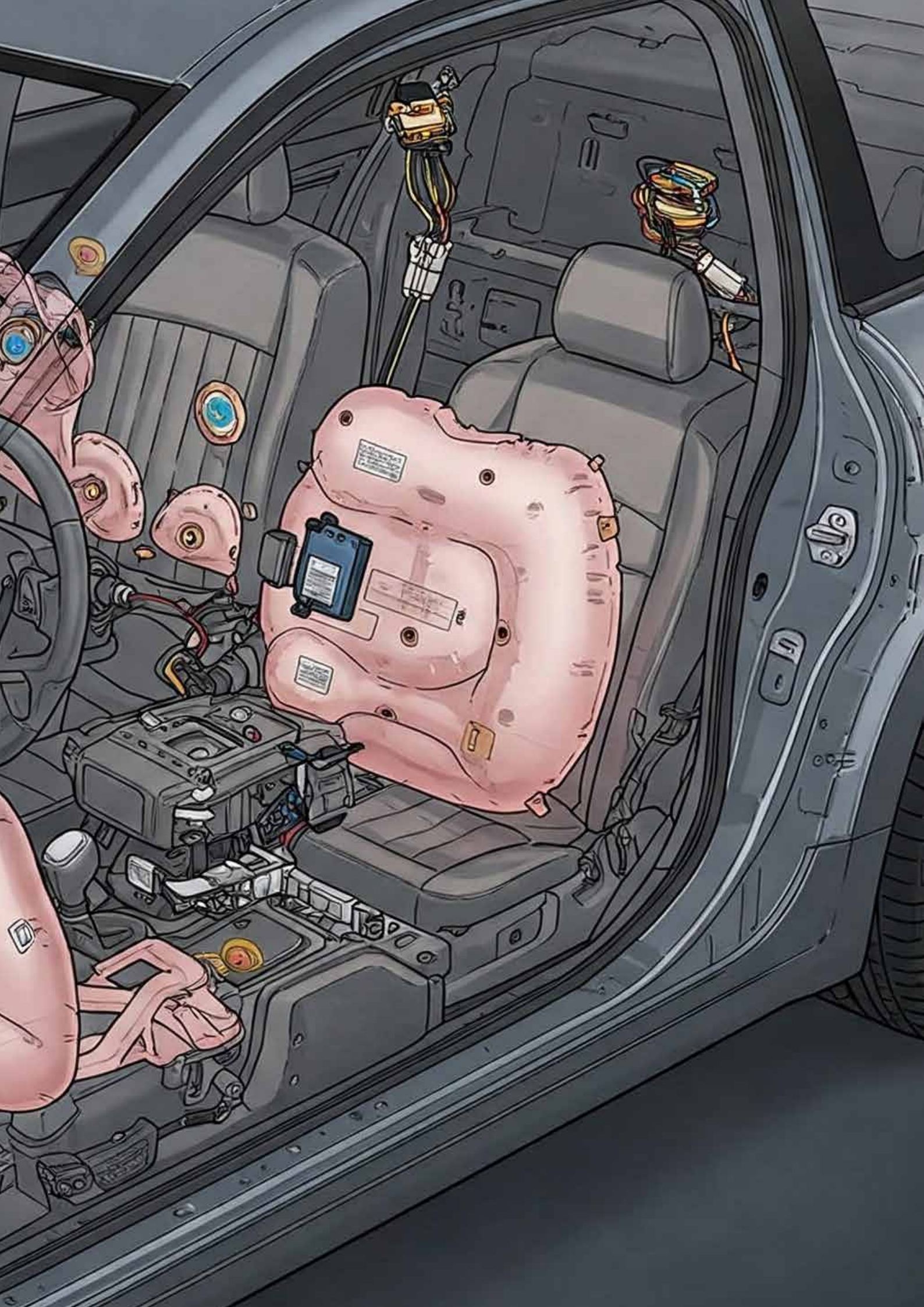


Figure - 1.1





2 Chapter

INDIA'S AUTOMOTIVE INDUSTRY AND ITS POSITIONING IN AUTOMOTIVE GVC

2.1 HISTORICAL EVOLUTION AND MARKET OVERVIEW OF THE INDIAN AUTOMOTIVE INDUSTRY

India's automotive journey started in 1942 after Hindustan Motors (HM) was established. In 1948, HM produced its first car which was assembled in India under the brand name Hindustan 10 (based on the 1947 Morris 10 Series M), which later evolved into Hindustan Ambassador. At that time, most of the automotive components that were needed to assemble the car were imported from UK. As the demand for the automobile was increasing, the government pushed for the localization of components and in the 1950s and 1960s, various local players including Bharat Forge, TVS, and Sundaram entered the Indian automotive market. At that time, the focused customers were upper and high-income segment of the population.

Representation of Automobile: An Ambassador Car

In 1981, Maruti Udyog Limited was established and produced their first car Maruti 800 in 1983 which was often referred to as "People's car" as it was affordable, reliable, and economical with a low service cost requirement. Maruti also started exporting their cars to neighbouring countries like Sri Lanka, Nepal and many others.

Until 1991, the Indian market was a protected market. As a result of which, the Indian economy was not performing well as India's economic access was limited to global players and investing in India was a herculean task. In 1991, the Government introduced Liberalization, Privatization and Globalization (LPG) reforms to liberalize and open up the Indian economy to foreign investors. As a result, various global automotive players like Hyundai, Daimler-Benz, Toyota, Honda, Renault, Volkswagen, Ford and many others entered the Indian market with the collaboration of Indian Industries to

set up their production plants and start their operations in India. During April 2000 to June 2024, India's automobile sector attracted a cumulative equity FDI inflow of approximately $ 36.26 billion representing 5.27% of the total equity FDI inflows into the country during this period.

In the early 21st century, the Indian automotive industry saw rapid growth expansion. Rise in middle-class income, urbanization and improved infrastructure fuelled the domestic demand for passenger vehicles. As the world is moving towards faster adoption of EVs, the Indian government introduced several schemes in the last decade such as Production Linked Incentives (PLI), Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME), PM E-DRIVE etc. to boost the automotive sector, especially the EV sector.

Currently ranked as the fourth-largest automotive market globally, the Indian automotive sector contributes 7.1% to the nation's GDP. With a population exceeding 1.4 billion, India holds immense potential, supported by a current market size of over $100 billion. The rapid pace of urbanization, coupled with rising disposable incomes and a burgeoning middle class, has further fuelled the demand. Benefiting from both a vast domestic consumer base and competitive manufacturing costs, India emerges as a compelling destination for global automotive investors seeking strategic opportunities.

2.1.1 AUTOMOTIVE MARKET AND GVC

Global Value Chains (GVC) refers to a phenomenon where production is broken into activities and tasks carried out in different countries. In GVC, the operations are spread across national borders instead of being confined to one location and hence, a single finished product often results from manufacturing and assembly in multiple countries, with each step in the process adding value to the end product.

The global auto component market was estimated to be around $ 2 trillion in 2022, which reflects the importance of the sector within the global automotive industry. Over the past five years, the market has consistently expanded at a steady annual growth rate of 4-6%. This consistent growth reflects the strong demand for automotive components in the global market and underscores the critical role automotive components play in supporting the larger automotive ecosystem, which includes both traditional Internal Combustion Engine (ICE) vehicles and the rapidly emerging Electric Vehicle (EV) segment.

The largest segment in the global automotive trade is Engine and Engine Components, accounting for approximately 23% of the total traded value. Close behind are Drive Transmission and Steering Components, which comprise 17% of the market value. Suspension and braking systems, now incorporating advanced technologies such as Advanced Driver Assistance Systems (ADAS), Autonomous Driving (AD), Hill Hold, and Traction Control systems, are becoming increasingly complex and represent 7% of the market. The relatively smaller market share of cooling systems, at 5%, reflects the technological shift towards electric vehicles, which typically demand less conventional cooling infrastructure compared to internal combustion engines.

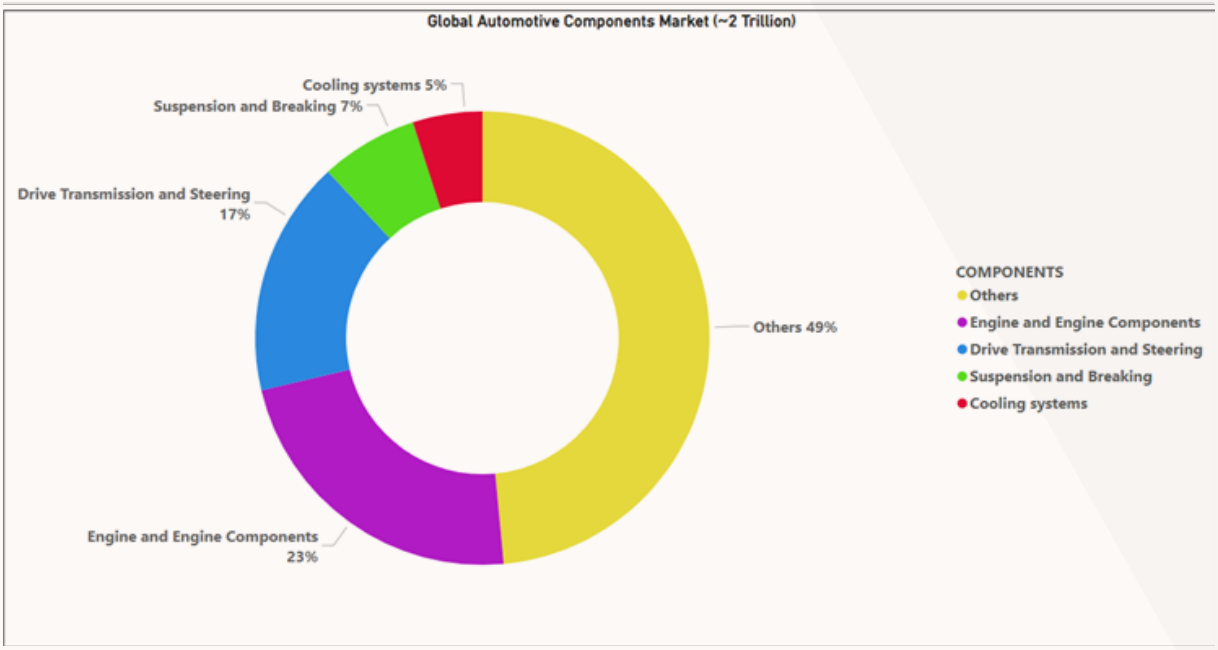


Figure - 2.1

Approximately 70% of automotive components are produced domestically for consumption within their respective markets, while a substantial 30% equivalent to $700 billion—comprises the global export market. Of this traded value, Drive Transmission and Steering components account for 38%, Engine and Engine components contribute 22%, Suspension and Braking systems represent 9%, and Cooling systems hold a 6% share.

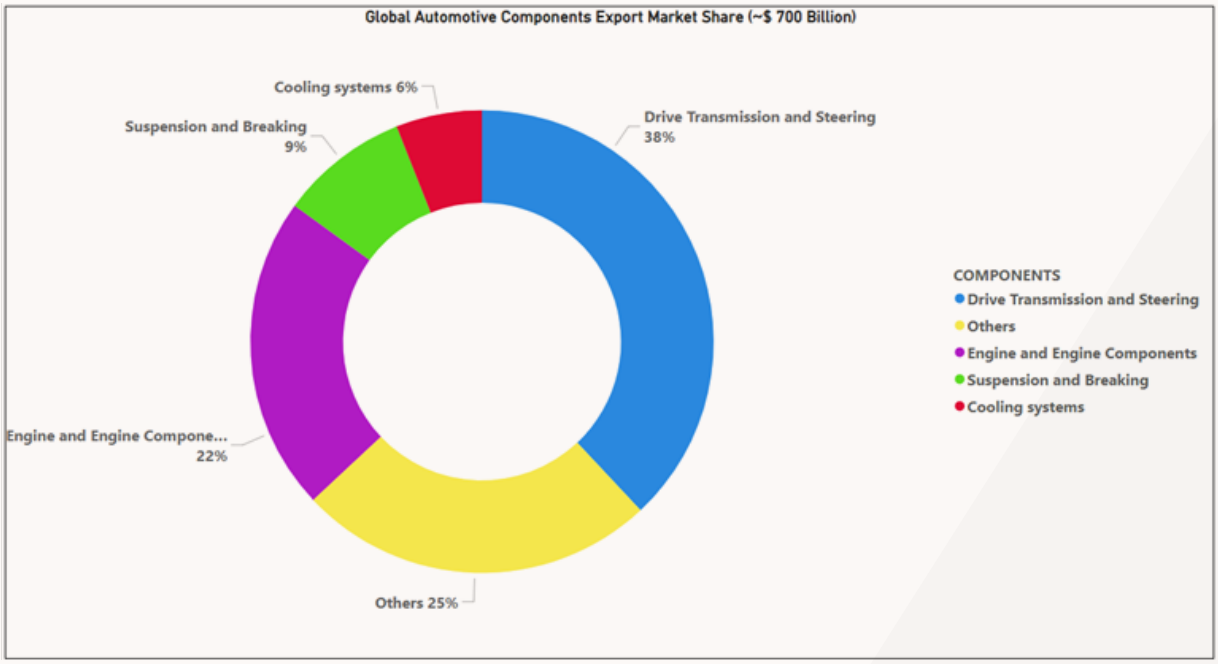


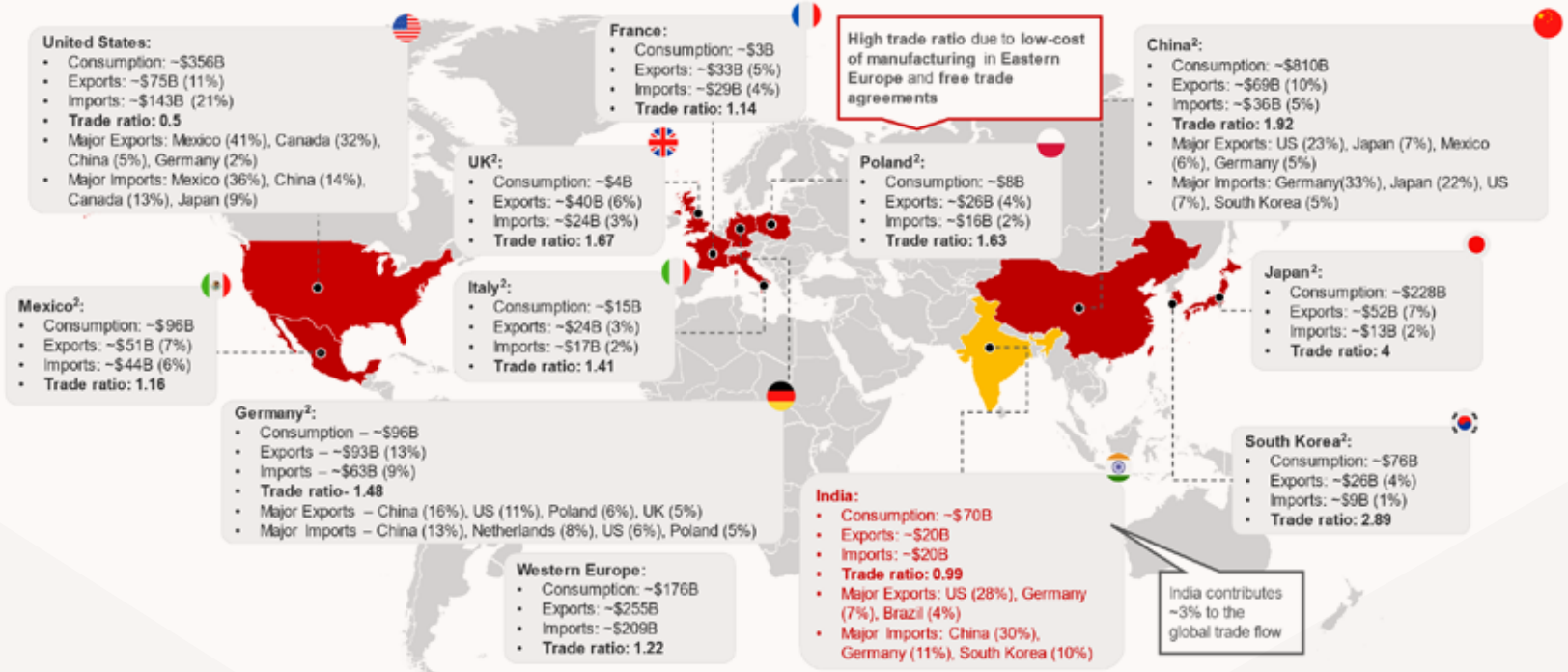
Figure - 2.2

2.1.2 CONSUMPTION AND TRADE DYNAMICS OF MAJOR MARKETS IN GLOBAL AUTOMOTIVE SECTOR

- **China:** China has a vast consumption market valued at approximately $810 billion, and in the calendar year 2022, its total automotive component production was estimated at around $850 billion. Of this, nearly $740 billion was absorbed by OEMs, while the aftermarket accounted for $70 billion. China's export of $70 billion worth of automotive components to the global market underscores both the global dependency on Chinese components and its dominant position in the global automotive industry. With imports amounting to just $36 billion, China's trade ratio of approximately 2 highlights that it exports twice as much as it imports.
- **USA:** The United States holds the world's second-largest automotive consumption market, valued at approximately $356 billion. It exports around $75 billion in automotive components but imports nearly $143 billion, yielding a trade ratio of 0.5, indicating that U.S. imports are double of its exports.
- **Japan:** As the third-largest automotive consumption market globally, with an estimated value of $228 billion, Japan exports approximately $52 billion in automotive components while importing only $13 billion. This results in a trade ratio of 4, highlighting that Japan exports four times of what it imports—a reflection of its advanced manufacturing capabilities and emphasis on innovation and continuous improvement.
- **Germany:** Renowned for its precision manufacturing and high-quality products, Germany has a consumption market of around $96 billion. The country exports approximately $93 billion in automotive components and imports $63 billion, resulting in a trade ratio of 1.48.
- **Mexico:** With a consumption market of approximately $96 billion, similar to Germany, Mexico exports about $51 billion in automotive components and imports $44 billion, producing a trade ratio of 1.16.
- **South Korea:** Known for its advanced manufacturing technology and semiconductor industry, South Korea has an automotive consumption market valued at around $76 billion. It exports $26 billion in automotive components while importing only $9 billion, leading to a trade ratio of 2.89.
- **Poland:** Situated in Eastern Europe, Poland has a relatively modest automotive consumption market of around $8 billion. Despite this, it exports $26 billion in automotive components and imports $16 billion, resulting in a trade ratio of 1.63. This high ratio is driven by the lower manufacturing costs in Eastern Europe and favourable free trade agreements.
- **India:** India accounts for merely 3% of the global automotive component market. In 2022, the total value of India's automotive and automotive component industry was approximately $109 billion, with automotive components alone valued at $70 billion. In 2022, India's consumption of $70 billion was matched by both imports and exports, each totalling $20 billion, resulting in a trade ratio of 0.99, indicating that imports are almost equal to exports.

Auto components GVC

India exports $20B, ~3% of global exports, most countries consume 70 -80% locally



Note: 1. All data points are for CY 2022; 2. Forecasted numbers for CY 22, 3. Top 10 geos by export
Source: S&P Capital - Using the C293 SIEC code for Parts and accessories of motor vehicles

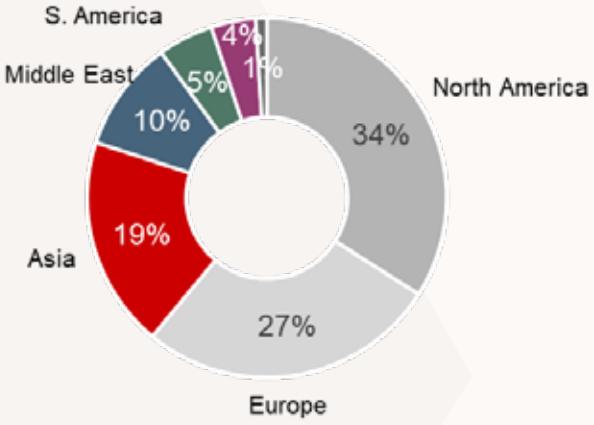
Figure - 2.3

2.2 AUTO COMPONENT GVC AND INDIA'S TRADE SCENARIO ACROSS COMPONENTS

2.2.1 ANALYSING AUTO COMPONENTS: GLOBAL SEGMENTATION AND INDIA'S CONTRIBUTION

India's automotive component exports are primarily directed toward North America (34%), Europe (27%), and Asia (19%), with the United States as the largest trading partner at approximately $3.5 billion (28%). Germany and Turkey follow, contributing around $0.8 billion (7%) and $0.7 billion (5%), respectively. In FY 2024, India's total automotive component exports reached an estimated $12.8 billion, marking a substantial 72% growth from FY 2021.

Share of Auto Components export by region / country, FY24

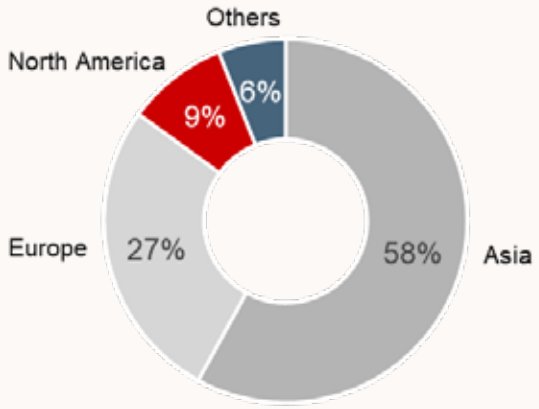


Top 10 Countries	Share of Exports	Value ($B)
US	28%	3.5
Germany	7%	0.8
Turkey	5%	0.7
Brazil	4%	0.4
UK	4%	0.4
Italy	4%	0.5
Mexico	4%	0.5
UAE	3%	0.3
Thailand	3%	0.3
Bangladesh	2%	0.2

Figure - 2.4
Source: Crisil Intelligence

On the import side, India sources 58% of its automotive components from Asia, 27% from Europe, and 9% from North America, with China as the primary supplier at $2.8 billion (23%). Other significant suppliers include Germany (approximately $1.6 billion, or 13%), South Korea ($1.3 billion, or 11%), Japan ($1.2 billion, or 10%), and the United States ($1.0 billion, or 8%). In FY 2024, imports totalled about $12.1 billion, growing ~80% compared to FY 2021. India's reliance on imports, particularly from China, underscores the urgent need for India to enhance its domestic production capabilities to mitigate import dependency.

Share of Auto Components import by region / country, FY24



Top 10 Countries	Share of Imports	Value ($B)
China	23%	2.8
Germany	13%	1.6
South Korea	11%	1.3
Japan	10%	1.2
US	8%	1.0
Thailand	5%	0.6
Singapore	5%	0.6
Italy	3%	0.3
Czech Rep.	2%	0.2
UK	2%	0.2

Figure - 2.5
Source: Crisil Intelligence

India's exports have grown by ~7% CAGR since FY19

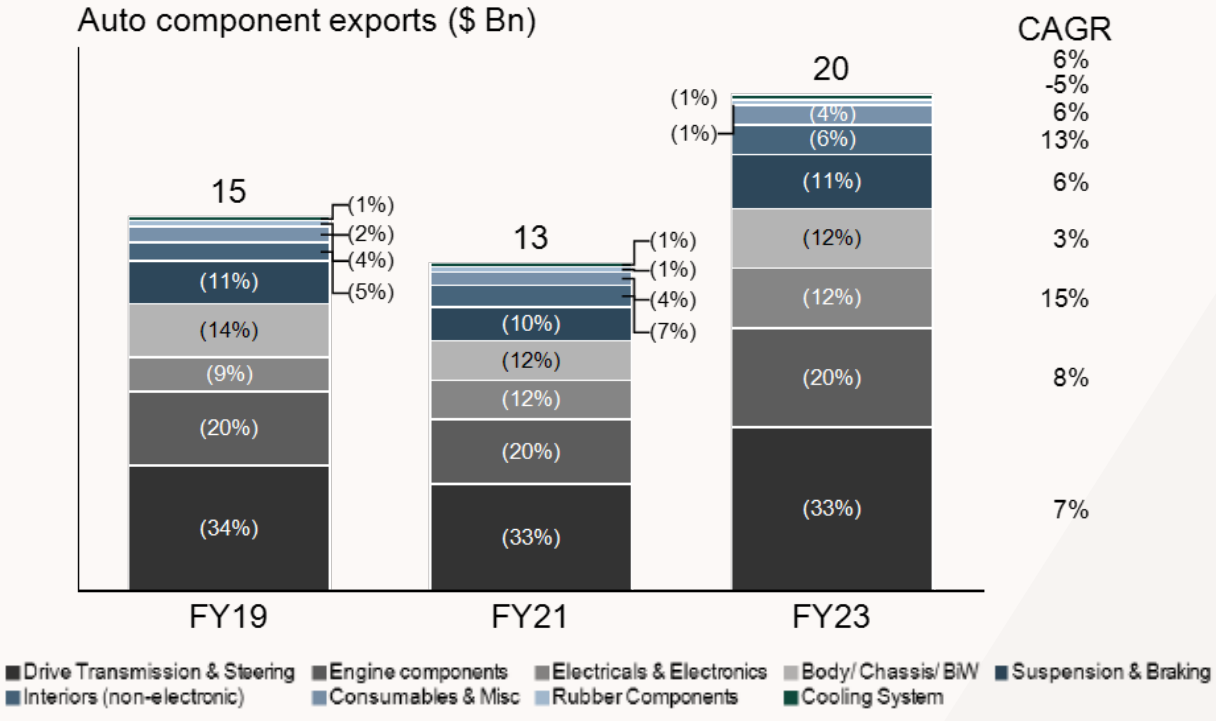


Figure - 2.6

India's trade landscape is witnessing a promising trend, with exports outpacing imports in recent years. Since FY19, the country's exports have demonstrated a robust growth trajectory, expanding at a compound annual growth rate (CAGR) of approximately 7% as shown in Figure 2.4.

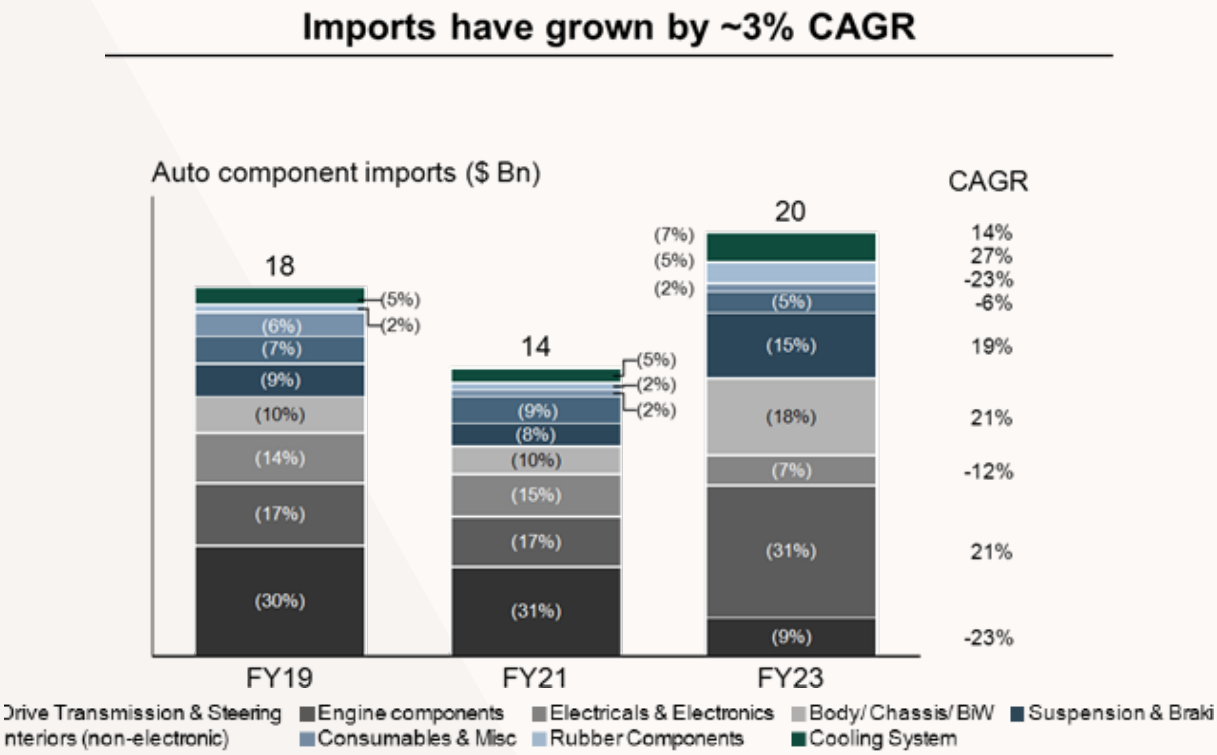


Figure - 2.7

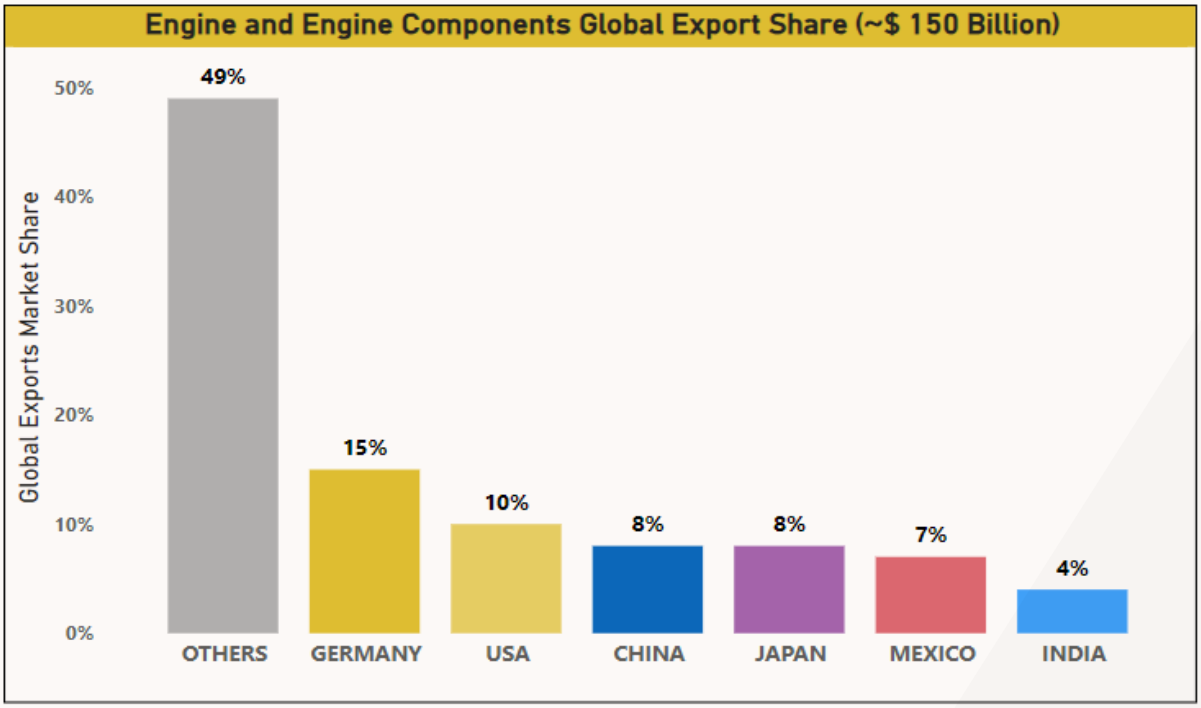
In contrast, imports have grown at a relatively slower pace, with a CAGR of around 3% during the same period. This divergence underscores India's improving trade competitiveness and its increasing integration into global value chains. The share of critical components in the Indian export basket has been on an upswing with critical components (Engine and Transmission components) accounting for 65 % of the total export basket in FY24 compared with 55% in FY14 which is explained in the sections below.

2.2.1.1 Engine and Engine components

Engine is a machine which converts chemical energy (generated from fuel) into mechanical energy. It is indeed the most important and crucial component of a car that propels the vehicle, operates the vehicle and its various systems. While Engine components consist of various parts that are designed to perform a specific function in the operation of an Engine.

Engine and engine components are fundamental to both Internal Combustion Engine (ICE) and Plug-In Hybrid Electric Vehicle (PHEV). In the global automotive export market, the trade value of these components is approximately $150 billion, representing a substantial 22% market share. Notably, 50% of the GVC for engine and engine components is concentrated among 6 to 7 leading countries, with Germany leading the pack, holding a significant 15% share of global exports. India's participation in this market is characterized by a balanced trade dynamic, as the country imports and exports an equal share of 4%, approximately valued at $6 billion of the total global automotive components trade.

The landscape of major exporters includes Germany (15%), USA (10%), China (8%), Japan (8%), and Mexico (7%). In terms of imports, the United States remains the largest importer at 20%, followed by Germany (9%), Mexico (5%), China (4%), and India (4%). This equilibrium in trade reflects India's strategic positioning, as it exports 4% of the estimated $150 billion global export flow in engine and engine components.



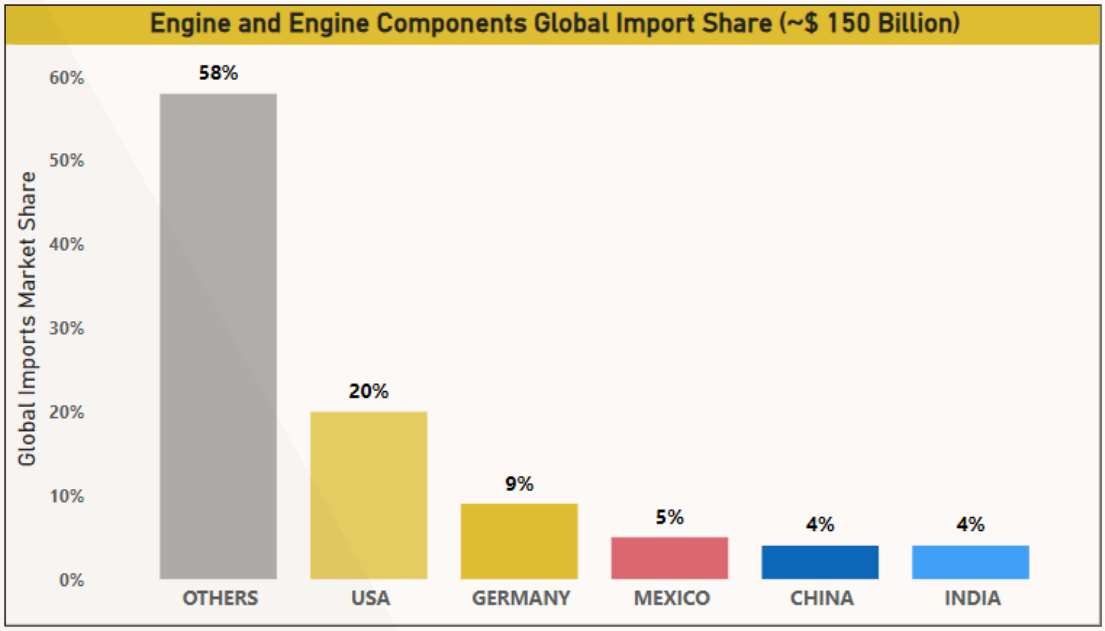
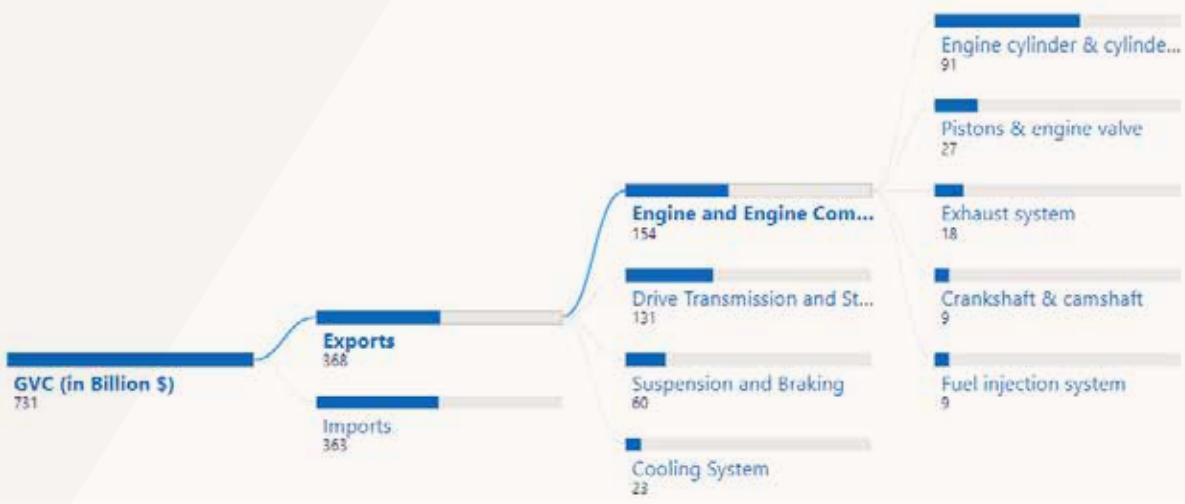
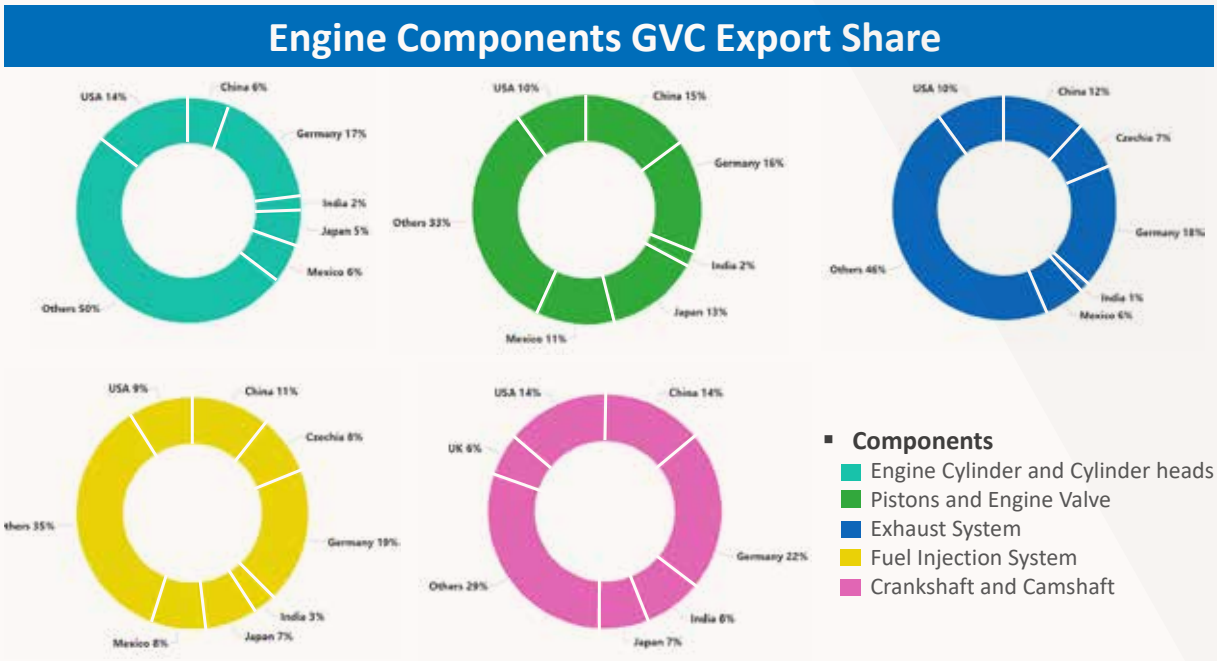


Figure - 2.8

Engine and engine components can be further classified into several sub-components, each with its own distinct market dynamics. The crankshaft and camshaft segment, valued at approximately $9 billion, shows Germany, USA, and China as major exporters, while the USA, China, and India are key importers. The engine cylinder and cylinder heads market, with a total value of around $91 billion, features Germany, USA, and China as leading exporters, while India contributes a modest 2% to global exports and imports 4% of the traded value. The exhaust system segment, valued at approximately $18 billion, shows Germany and China as the primary exporters, with India holding a 1% share. In the fuel injection system sector, also valued at $9 billion, India has a 3% export share, while the USA dominates imports. Lastly, the piston and engine valve market, estimated at $27 billion, sees India importing 3% and exporting 2% of the global trade. This underscores the significance of engine and engine components within the automotive value chain and highlights India's evolving role in this critical sector.





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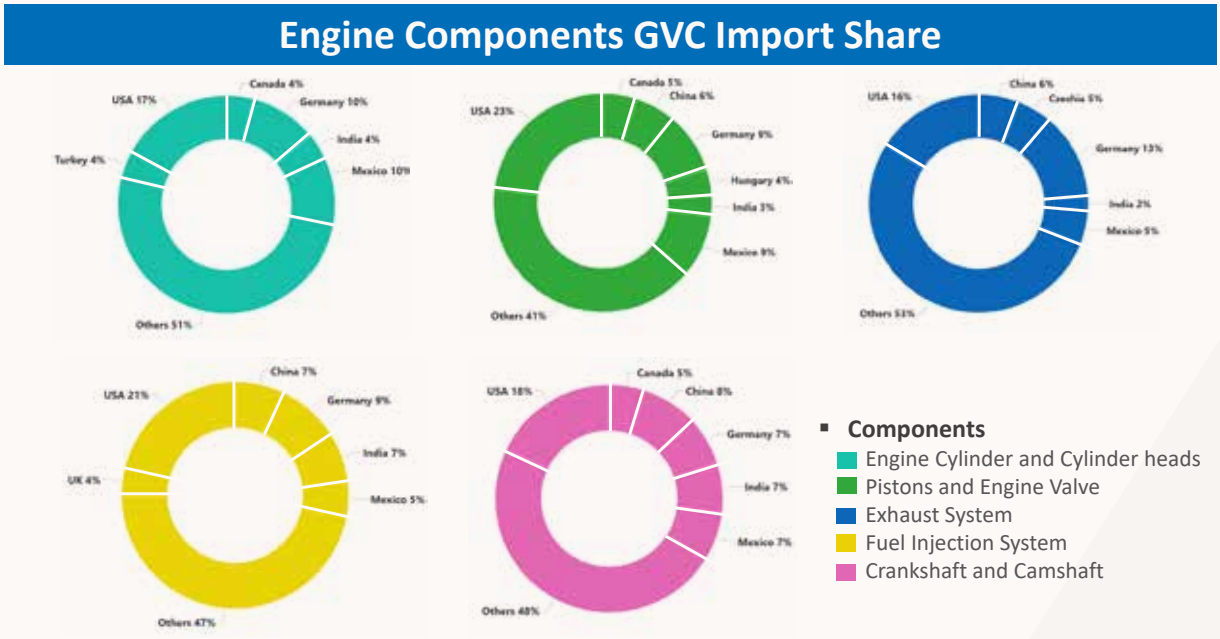


Figure - 2.10

India's competitiveness in Engine & components segment has been assessed by evaluating its exports of engine components, the total world exports of engine components, and the country's overall export performance relative to the world to determine relative competitiveness of India compared to other nations. Notably, India's global engine component competitiveness has shown a significant upward trend, increasing from 0.5 in 2014 to 0.8 in 2023. This growth can be attributed to the rising number of foreign collaborations, Global OEMs manufacturing in India, increased localisation push by Automobile OEMs and the increasing proportion of critical components in India's exports over the past decade. To sustain and

further enhance this momentum, continued investment in boosting India's competitiveness is essential.

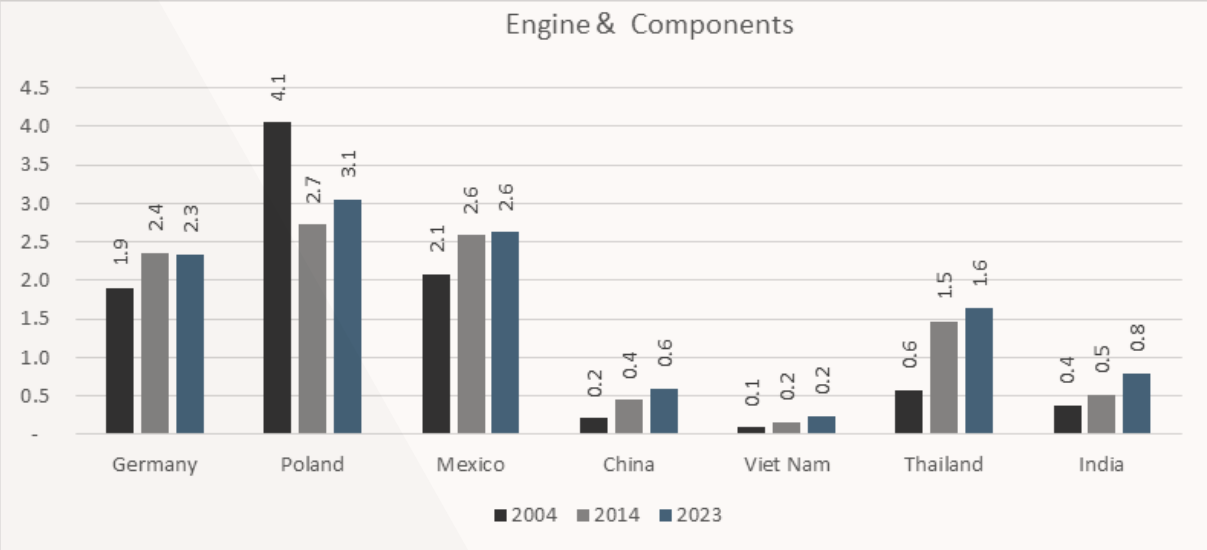
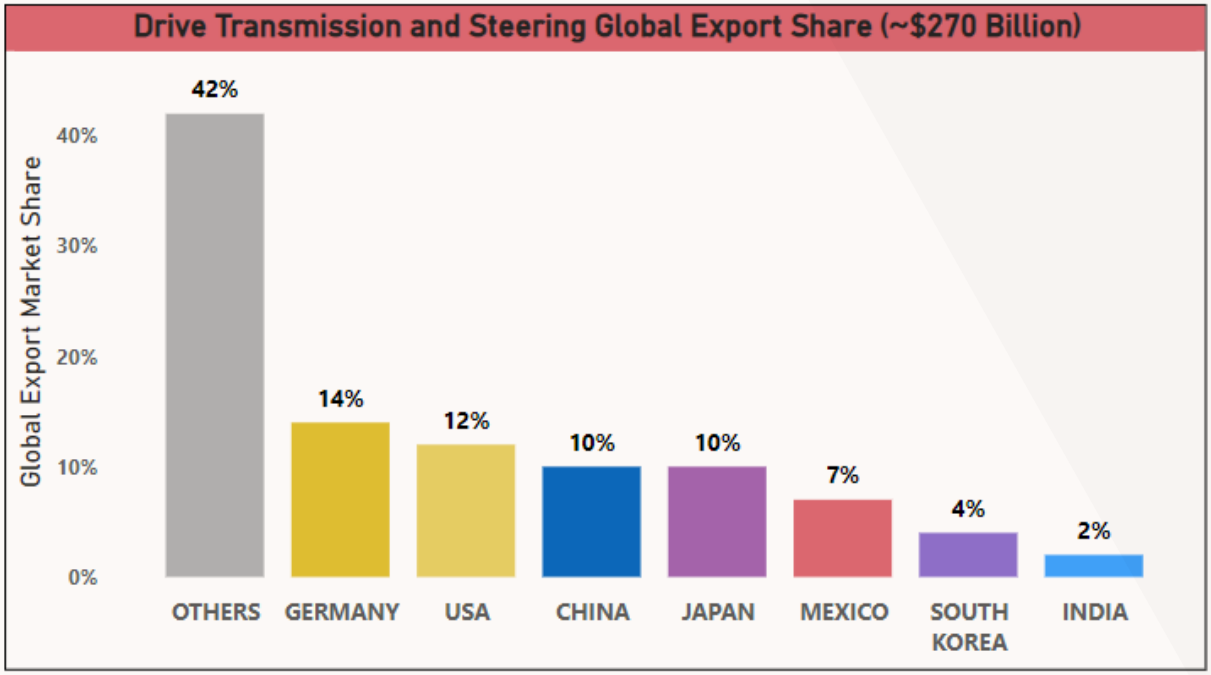


Figure - 2.11
Source: Crisil Intelligence

2.2.1.2 Drive Transmission and Steering

Drive Transmission usually refers to a system that transfers power generated from engine to the wheels and allow the vehicle to move while Steering refers to the system that provides direction to the vehicle and is crucial for vehicle handling.

Drive transmission and steering represent the largest segment in the global automotive component trading market, with a substantial traded value of $270 billion, accounting for 38% market share. This highlights the critical role that drives transmission and steering play within the automotive industry. The major exporters in this segment include Germany (14%), the USA (12%), Japan (10%), China (10%), Mexico (7%), and South Korea (4%). On the import side, the USA leads with a 21% share, followed by Germany (9%), Mexico (7%), China (7%), Canada (2%), and Brazil (2%).



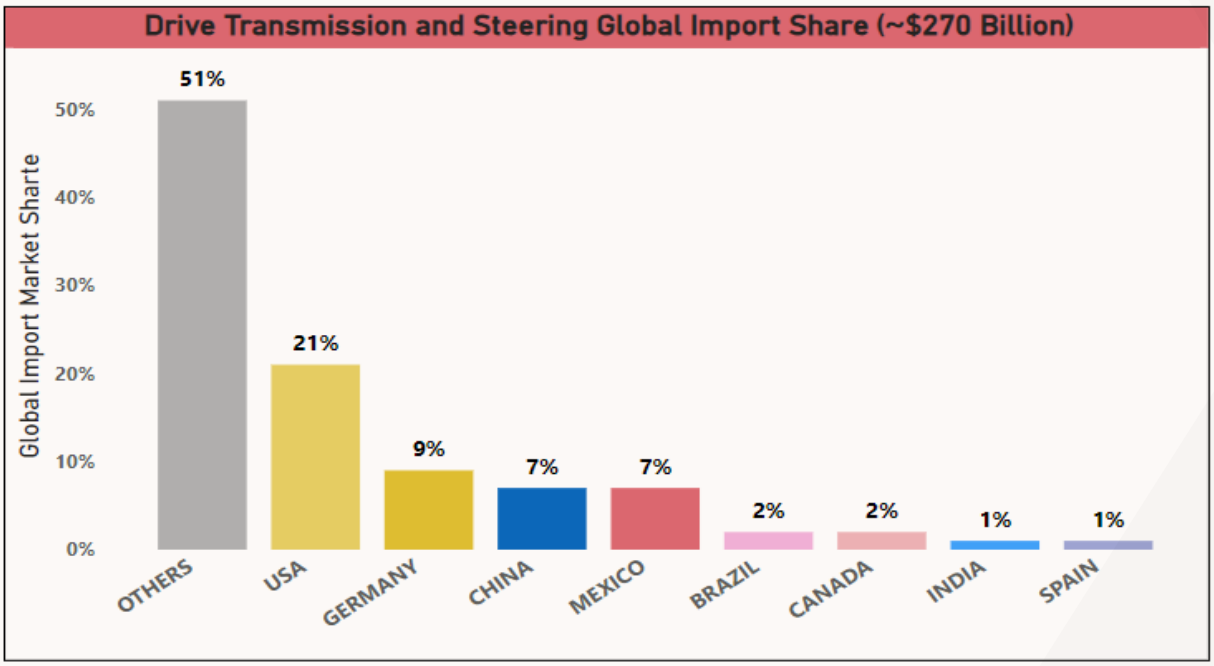


Figure - 2.12

India's position in this sector is negligible, as it exports 2% of the approximately $270 billion global export trade and imports 1% of the global import trade, indicating a trade surplus in the drive transmission and steering segment. The components within this category are further fragmented and classified into several sub-groups:

- **Transmission GVC (~$29 billion):** The primary exporters of transmission components are Germany (19%), the USA (11%), Mexico (10%), Japan (9%), and China (7%), with India holding a 2% share of the global export market. Major

importers include the USA (21%), Mexico (10%), Germany (10%), Canada (4%), and China (4%), with India importing 1% of the total global transmission trade.

- **Steering Components GVC (~$90 billion):** Key exporters in this segment are Germany (22%), Japan (18%), the USA (10%), Mexico (9%), and China (6%), while India retains a 1% share of the global export market. The leading importers are the USA (18%), China (13%), Germany (9%), Mexico (9%), and Brazil (3%), with India importing 2% of the global steering components trade.

- **Clutch GVC (~$12 billion):** The major exporters of clutch components are Germany (23%), China (10%), the USA (9%), Japan (8%), and Hungary (7%), with India possessing a 1% market share in global clutch exports. The principal importers include the USA (16%), Germany (10%), Mexico (9%), China (6%), and Hungary (4%), while India imports 2% of the global clutch trade.

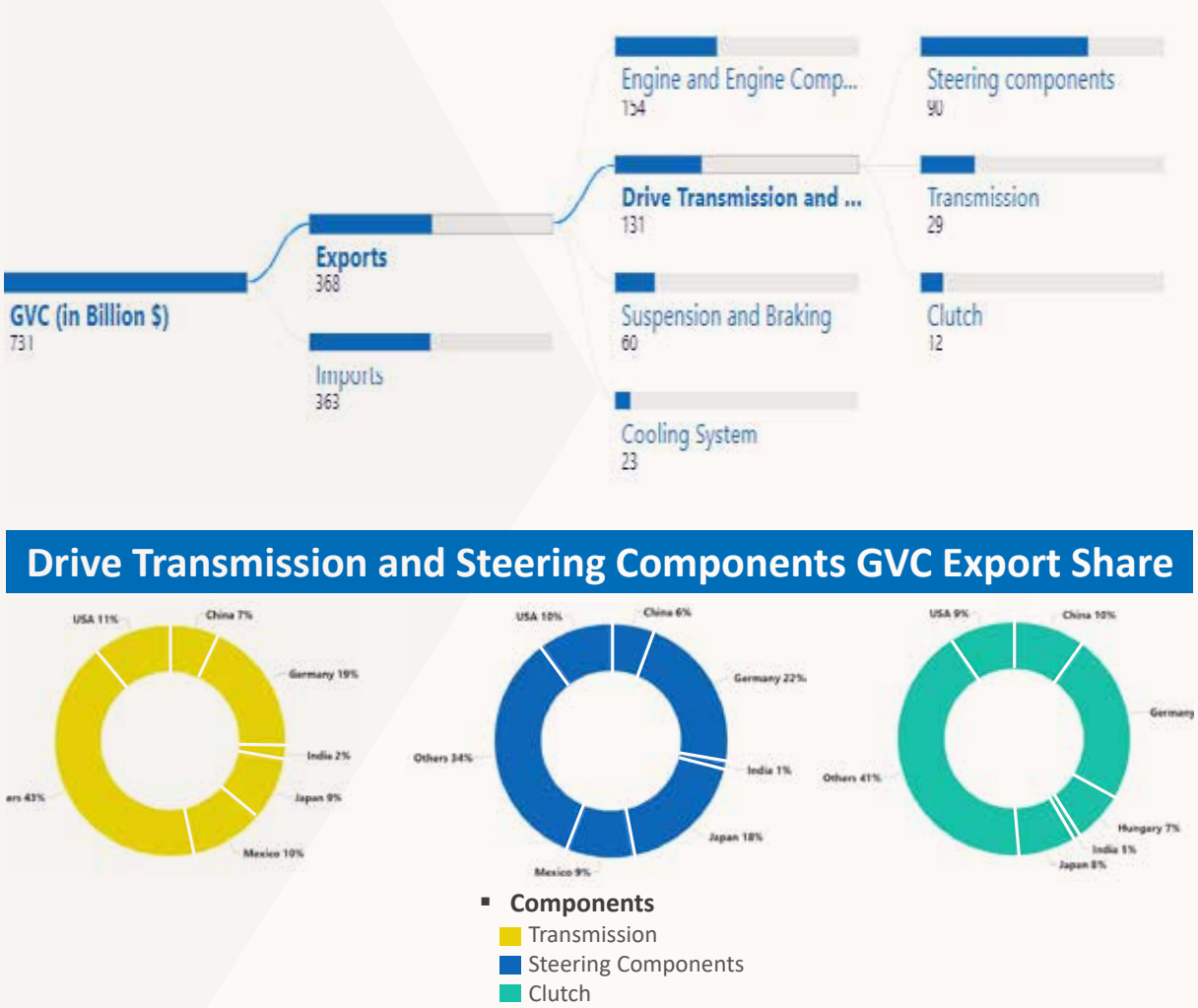


Figure - 2.13

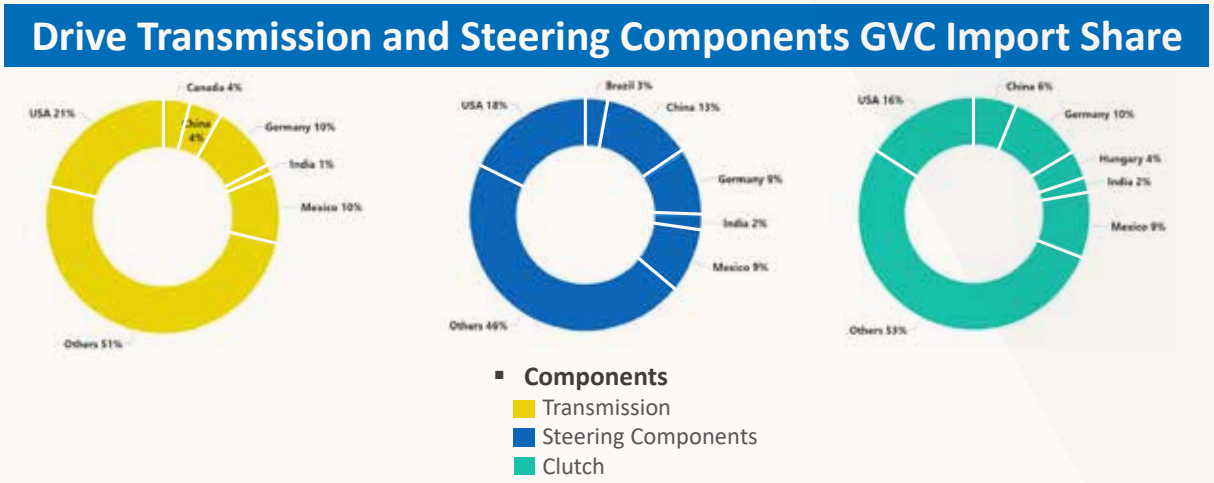


Figure - 2.14

The relative competitiveness of transmission component exports from India has been on an upswing rising from 0.5 in 2014 to 1.1 in 2023. Notably, in 2022, drive transmission and steering components accounted for a substantial 33% of the country's total auto component exports. Furthermore, India has made considerable progress in reducing its reliance on imports, with the import share declining dramatically from over 30% in FY21 to less than 10% in FY23. However, certain segments such as engine components, body/chassis, and suspension/ braking systems continue to dominate the import landscape. The key drivers behind this upswing in competitiveness in the transmission component market can be attributed to a combination of factors, including government initiatives for Auto sector, joint ventures with foreign players, foreign OEMs manufacturing transmission systems in India, making India the export hub for certain technologies, growing demand from global automotive hubs, and the expansion of Indian automotive companies.

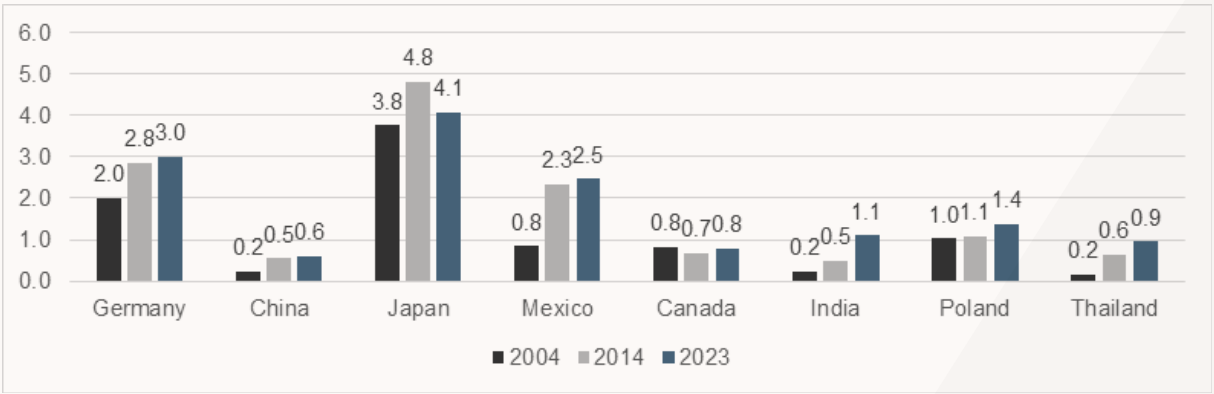


Figure 2.15

Source: Crisil Intelligence

2.2.1.3 Suspension and Braking GVC (~ $ 60 Billion)

Suspension refers to a system that connects the wheel with the upper body/ Chassis of the vehicle and is designed to absorbs the impact generated from

the road, maintain contact of tyres with the ground and provides stability and comfort during the ride while breaking refers to a system that works together to slow down or stop the vehicle's motion by converting the kinetic energy into thermal energy by the use of friction.

The suspension and braking industry is undergoing significant evolution driven by the rising demand for advanced features in vehicles. Within the global automotive export market, the trade value of suspension and braking systems is approximately $60 billion, representing a 9% market share. Major exporters in this sector include China (15%), Mexico (11%), Germany (10%), the USA (9%), Poland (5%), Japan (4%), and India (4%). On the import side, the USA stands out as the largest importer, accounting for 23% of the market, followed by Germany (11%), Mexico (7%), India (5%), and China (4%).

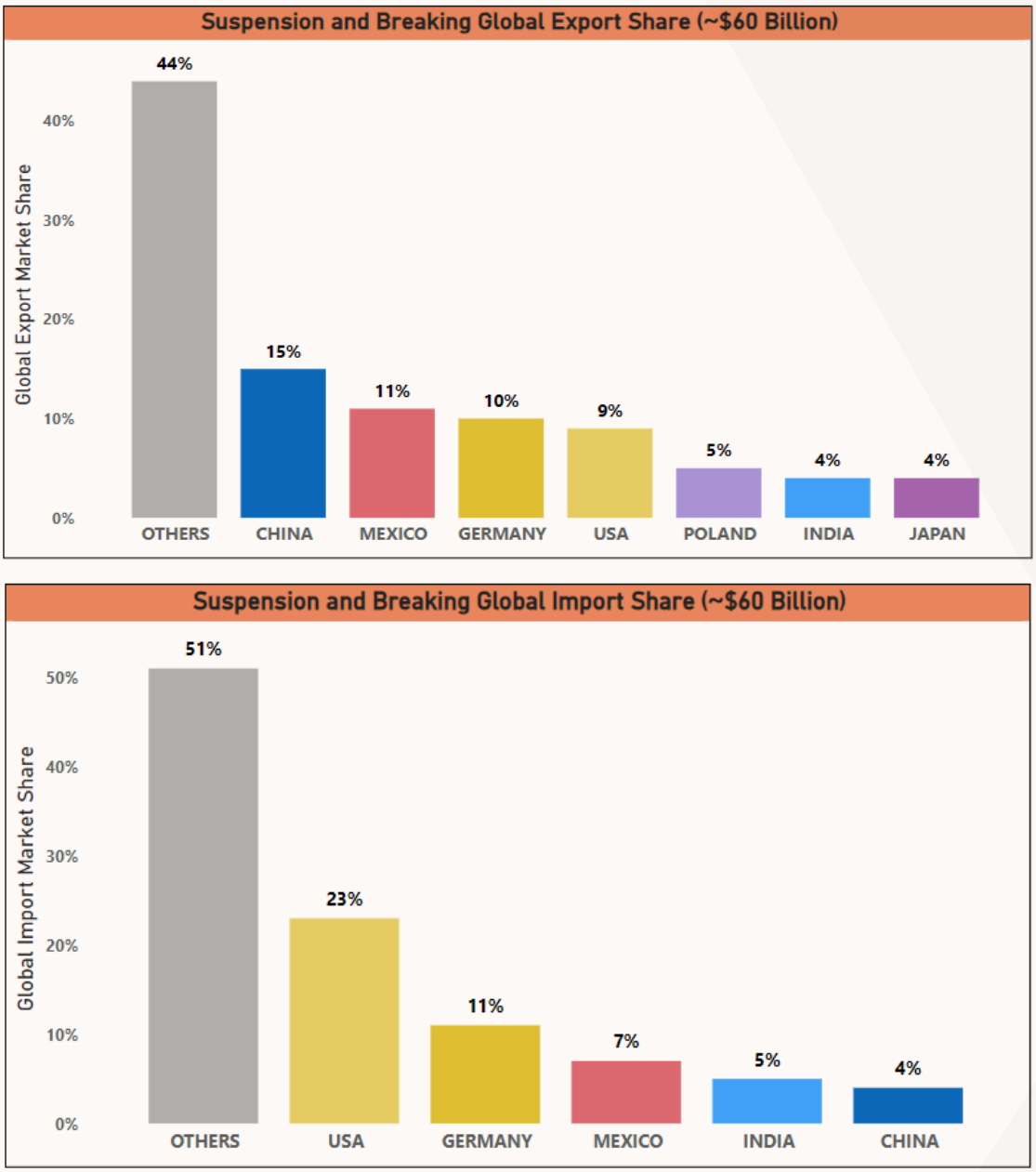
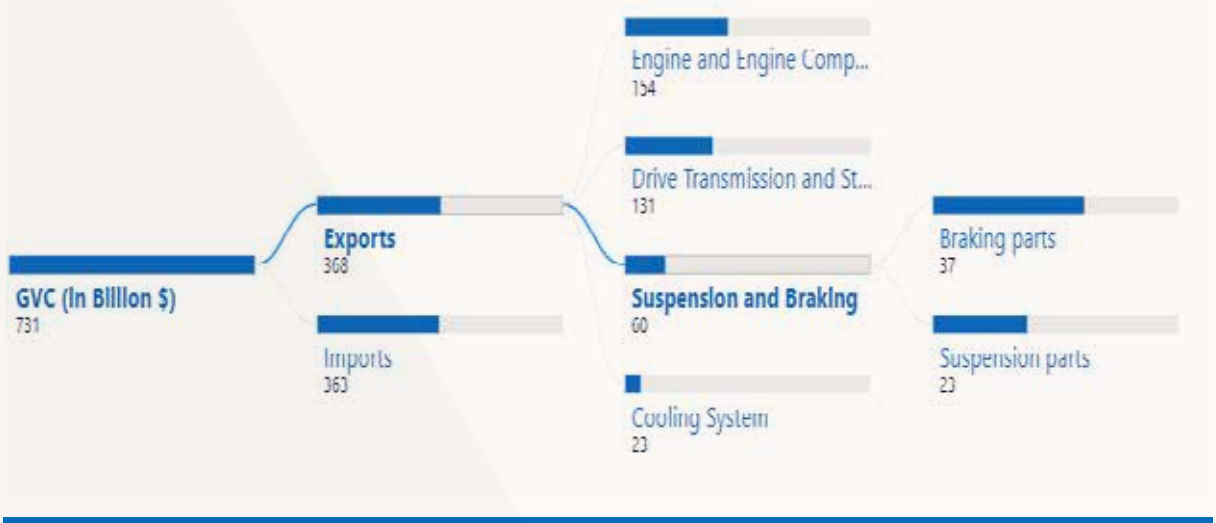


Figure - 2.16

India's participation in this segment reveals a trade deficit, as the country exports 4% of the global export trade flow, while importing 5% of the total global trade. The suspension and braking components can be further classified into two sub-groups:

- **Braking Parts GVC (~$37 billion):** The leading exporters of braking parts are China (22%), Germany (13%), the USA (7%), Italy (6%), and Japan (5%). India holds a modest 2% market share in the global braking parts export market. The major importers in this segment include the USA (21%), Germany (12%), Mexico (8%), Canada (4%), and France (4%), with India importing 1% of the total global trade in braking parts.

- **Suspension Parts GVC (~$23 billion):** In the suspension parts sector, the primary exporters are China (19%), Germany (16%), the USA (10%), Mexico (10%), and Poland (5%), while India accounts for 1% of the global export market. The major importers of suspension parts are the USA (25%), Germany (11%), Mexico (9%), Canada (6%), and China (5%), with India also importing 1% of the total global trade in suspension parts.



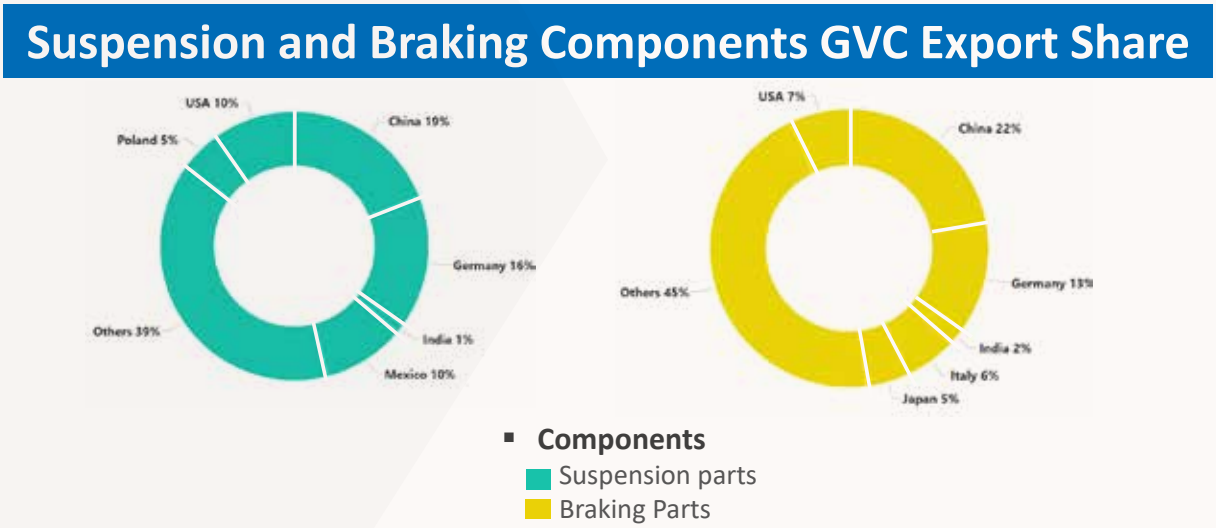


Figure - 2.17

Suspension and Braking Components GVC Import Share

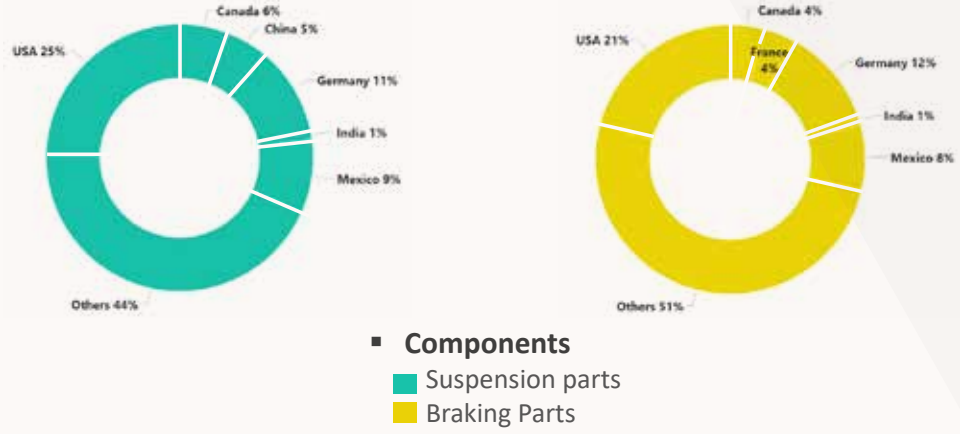


Figure - 2.18

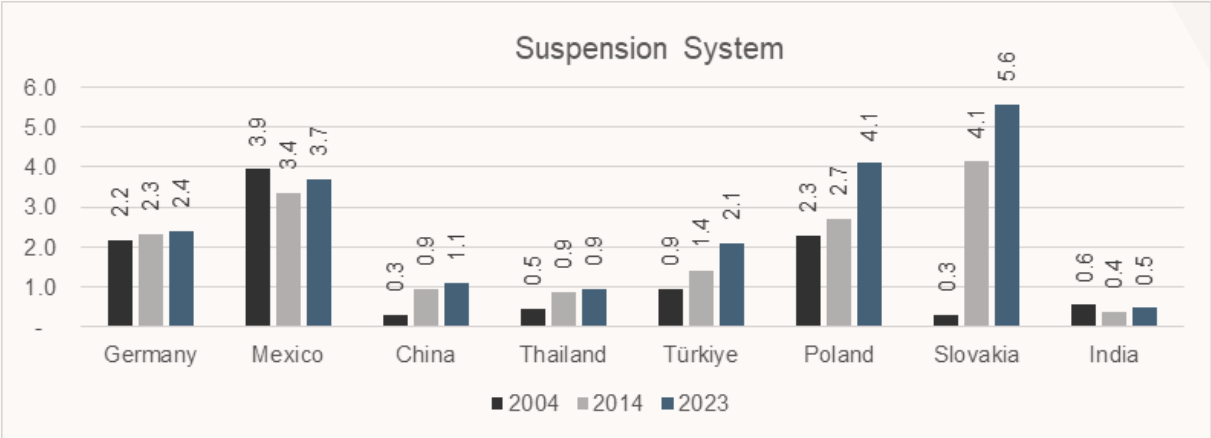


Figure - 2.19

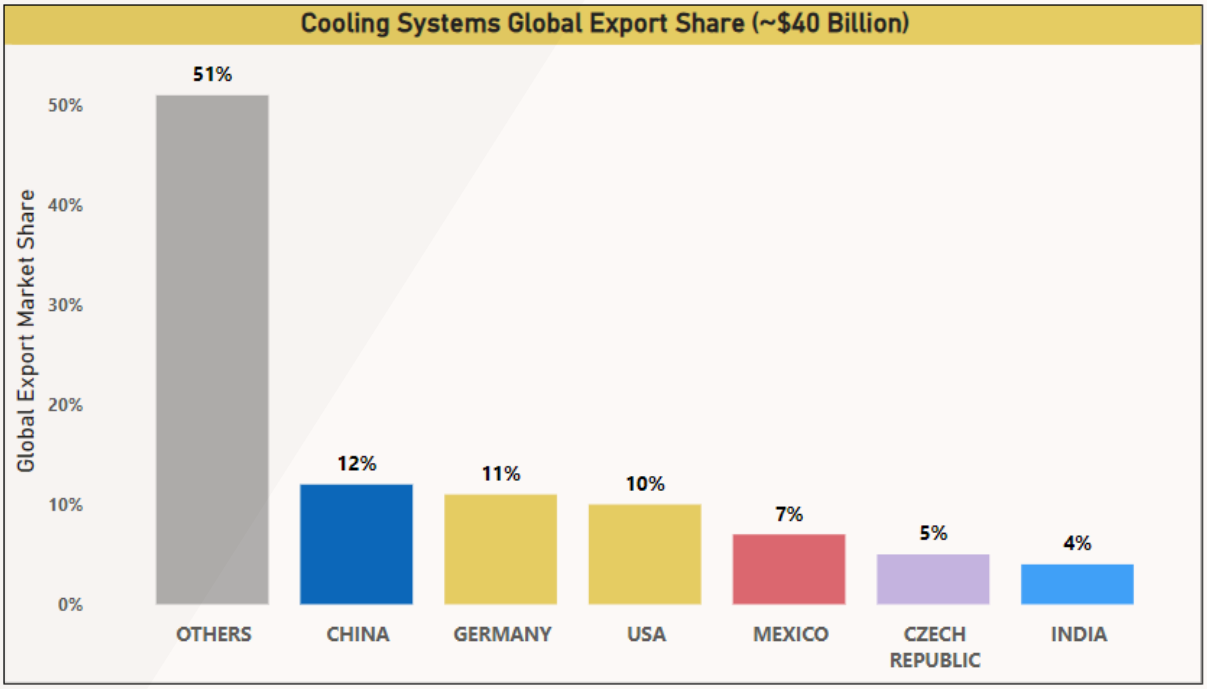
Source: Crisil Intelligence

India's suspension system has declined in competitiveness since 2004, lagging countries like Poland and Turkey. The sector has also experienced a substantial increase in imports of suspension and braking components, with a 19% CAGR between FY19 and FY23. However, suspension systems account for only a 7% share of the global automotive components market.

2.2.1.4 Cooling System GVC (~ $ 40 Billion)

Cooling system generally refers to a system that absorbs the heat generated from the engine, transmission and cabin of the vehicle and dissipates the heat into the atmosphere. Cooling system is used to manage the thermal regulation of critical vehicle systems including engine, transmission and cabin and prevents the vehicle from overheating, ensures vehicle performance and efficiency of the vehicle and driver's comfort.

The global automotive export market for cooling systems is valued at approximately $40 billion, capturing a market share of 6%. Major exporters in this segment include China (12%), Germany (11%), the USA (10%), Mexico (7%), and the Czech Republic (5%). On the import front, the USA is the largest importer, accounting for 18%, followed by Germany (9%), China (5%), India (5%), and Mexico (5%). India's involvement in the cooling systems market indicates a trade deficit, as the country exports 4% of the global export trade flow while importing 5% of total global imports.



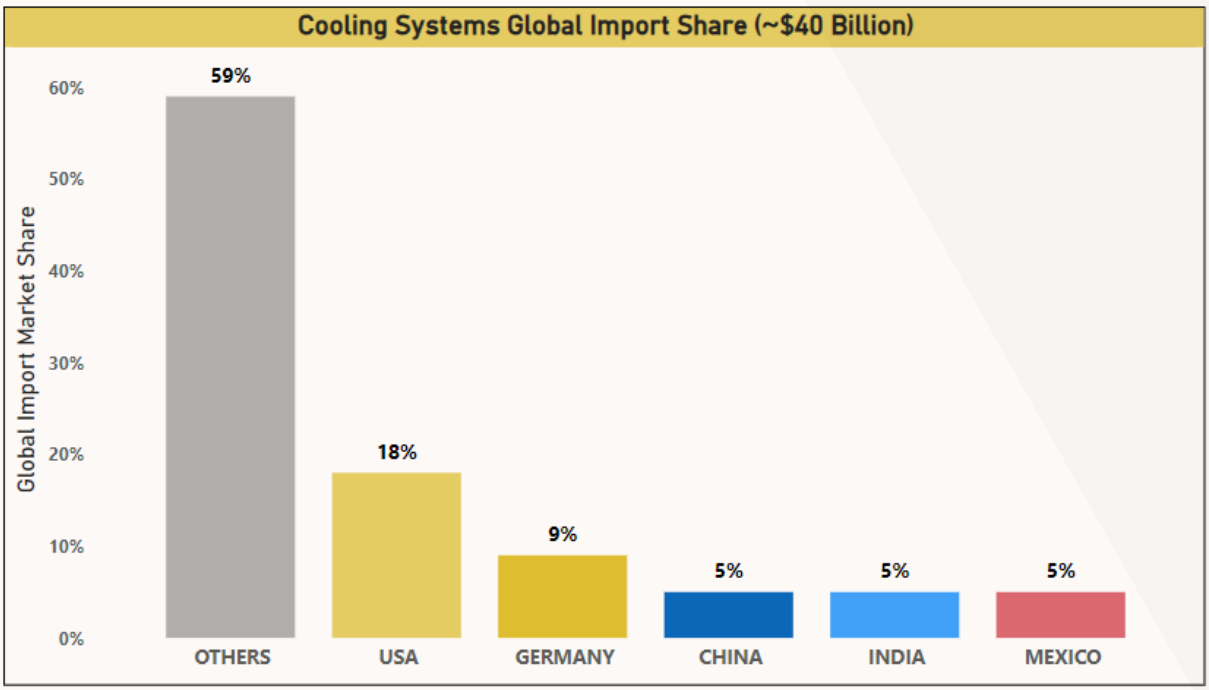


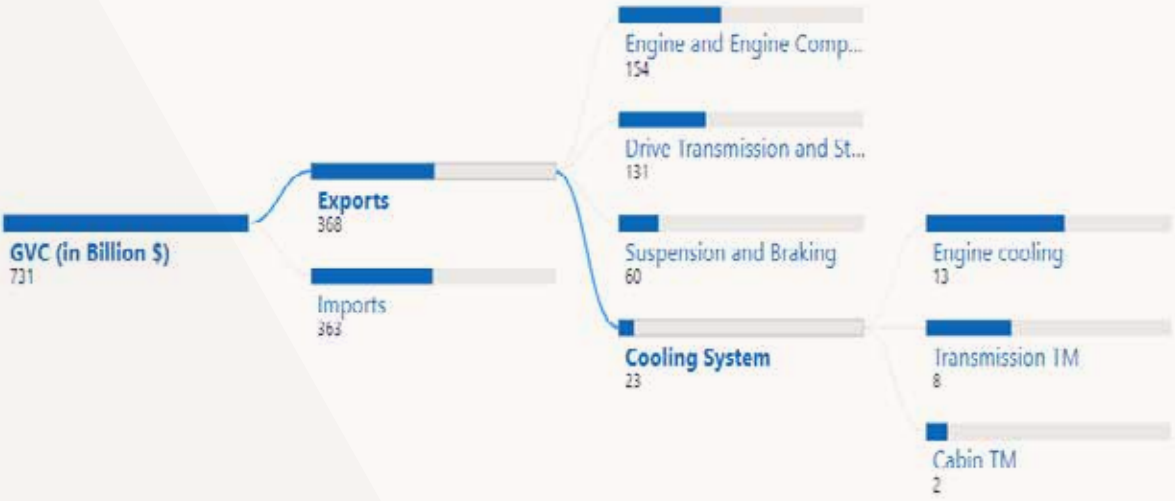
Figure - 2.20

The cooling systems supply chain is further categorized into three main sub-components, reflecting the sector's fragmentation:

- **Engine Cooling GVC (~$13 billion):** The leading exporters of engine cooling systems are Germany (20%), China (10%), the USA (9%), the Czech Republic (9%), and Mexico (8%), with India holding a 2% share in the global export market. The primary importers in this category are the USA (22%), Germany (10%), Mexico (6%), China (6%), and the UK (4%), with India importing 2% of the globally traded engine cooling systems.

- **Cabin Thermal Management (TM) GVC (~$2 billion):** Major exporters of cabin thermal management systems are Germany (15%), China (15%), Slovakia (11%), the Czech Republic (9%), and Poland (9%), while India captures a 1% share in the global export market. The key importers in this segment include the USA (15%), Germany (14%), China (9%), France (6%), and Belgium (5%), with India importing a negligible share of the cabin TM systems.

- **Transmission Thermal Management (TM) GVC (~$8 billion):** The primary exporters of transmission thermal management systems are China (27%), Germany (12%), the Czech Republic (7%), Poland (6%), and the USA (6%), with India again holding a 1% share in the global export market. The leading importers in this category are the USA (19%), Germany (15%), Mexico (5%), the Czech Republic (4%), and the UK (4%), with India importing 1% of the globally traded transmission TM systems.



Cooling system Components GVC Export Share

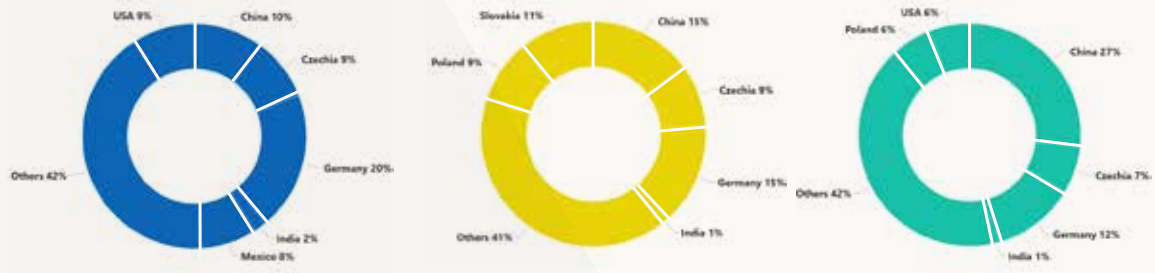
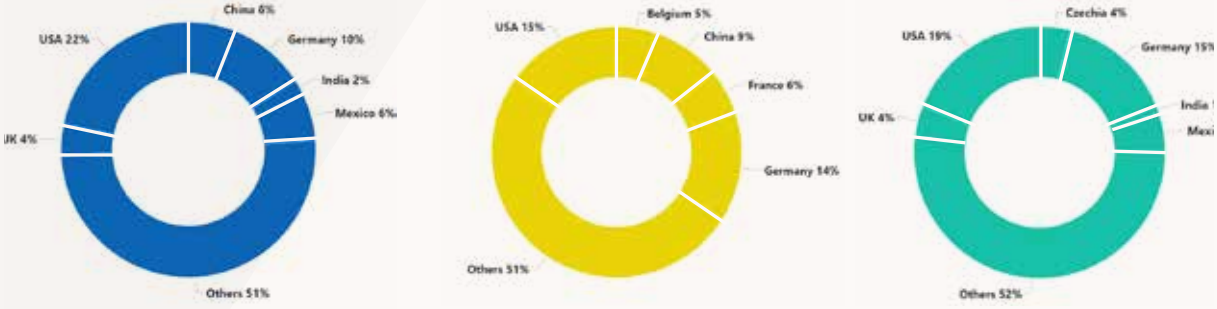


Figure - 2.21

Cooling system Components GVC Import Share



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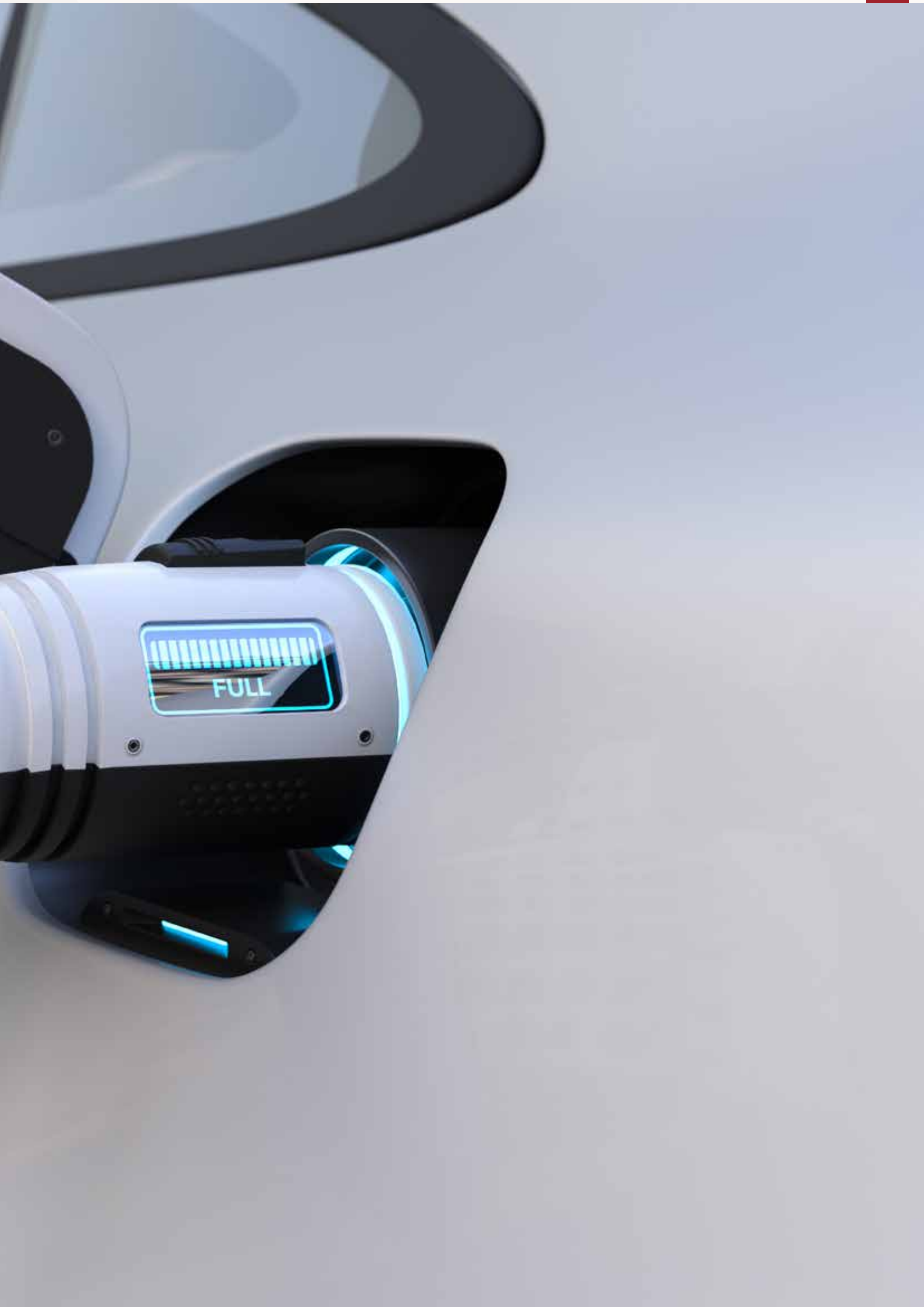

FULL

3 Chapter

KEY DRIVERS AND CHALLENGES FOR INDIA'S PARTICIPATION IN AUTOMOTIVE GVC

For the automotive industry, GVCs have become a cornerstone, reflecting the increasingly complex nature of modern vehicles comprising of thousands of individual parts sourced from a wide variety of suppliers globally. The automotive component manufacturing industry is one of the most important players within global value chains which was valued at close to $2 trillion in 2023 and is expected to become approximate $2.4 trillion industry by 2030 with the Asia Pacific region expected to grow the fastest between 2023-30, thereby reflecting the significant scale and importance of this particular sector within the global automobile industry.

Within the Auto components industry, there are several key product categories which form an integral part of the industry. These include engine and engine components, drive transmission, steering components, cooling system, suspension and braking system, body chassis etc. As technologies become rapidly advanced and complex with consumers preferring Electric Vehicles (EVs) as compared to vehicles with Internal Combustion Engines (ICE), electrical and electronic components along with battery components shall become extremely important alongside growing emphasis being placed on self-driving technologies and Advanced Driver Assisting Systems (ADAS) in vehicles.

3.1 GLOBAL TRENDS IN AUTO COMPONENT GVC

As the global auto components market continues to evolve, various factors such as technology and geopolitical conditions like China de-risking (supply pools shifting from China), chip wars (US-China semiconductor restrictions), and shipping bottlenecks (conflicts in Russia-Ukraine; Middle-East) are at the forefront of the rising growth being witnessed by the auto components industry within the automotive industry. Four factors are at present emerging to be the key drivers of growth for the auto components industry within global value chains.

3.1.1 ELECTRIC VEHICLES (EVS)

At global level, regulatory bodies push for reduced carbon emissions and more sustainable forms of transportation, EVs have emerged at the forefront of automotive innovation, thereby signalling a corresponding demand for specialised automotive components including batteries, power electronics, charging infrastructure, etc.

By 2030, it is projected that 40% of all light vehicles sold globally will be electric, up from just 3% in 2020. This rapid growth will be accompanied by a substantial reduction in the number of internal combustion engine (ICE) components, with an estimated 190 components being eliminated. This shift will not only help reduce emissions and improve fuel efficiency but also pave the way for the development of more sophisticated and connected vehicles.

The increasing electrification and automation of vehicles will also lead to a significant surge in the demand for semiconductor components. The average semiconductor content per car is expected to increase from $600 in 2022 to $1,200 by 2030, driven by the growing need for advanced driver-assistance systems (ADAS) and other connected technologies. In fact, it is projected that 90%[5] of all passenger vehicles sold in 2030 will be ADAS-enabled, featuring advanced safety features such as lane departure warning, adaptive cruise control, and automatic emergency braking. By 2040, the industry is expected to reach an even more significant milestone, with 80% of all light vehicles sold globally being electric, marking a major shift towards a more sustainable and environmentally friendly transportation system.

5 *Includes Level 2+ and AV ready passenger vehicles*

EV Components Global Value Chain (GVC)

The global electric vehicle (EV) industry is undergoing rapid growth, with a $40–50 billion opportunity in EV components trade. This dynamic value chain is dominated by a handful of countries, reflecting regional strengths and dependencies.

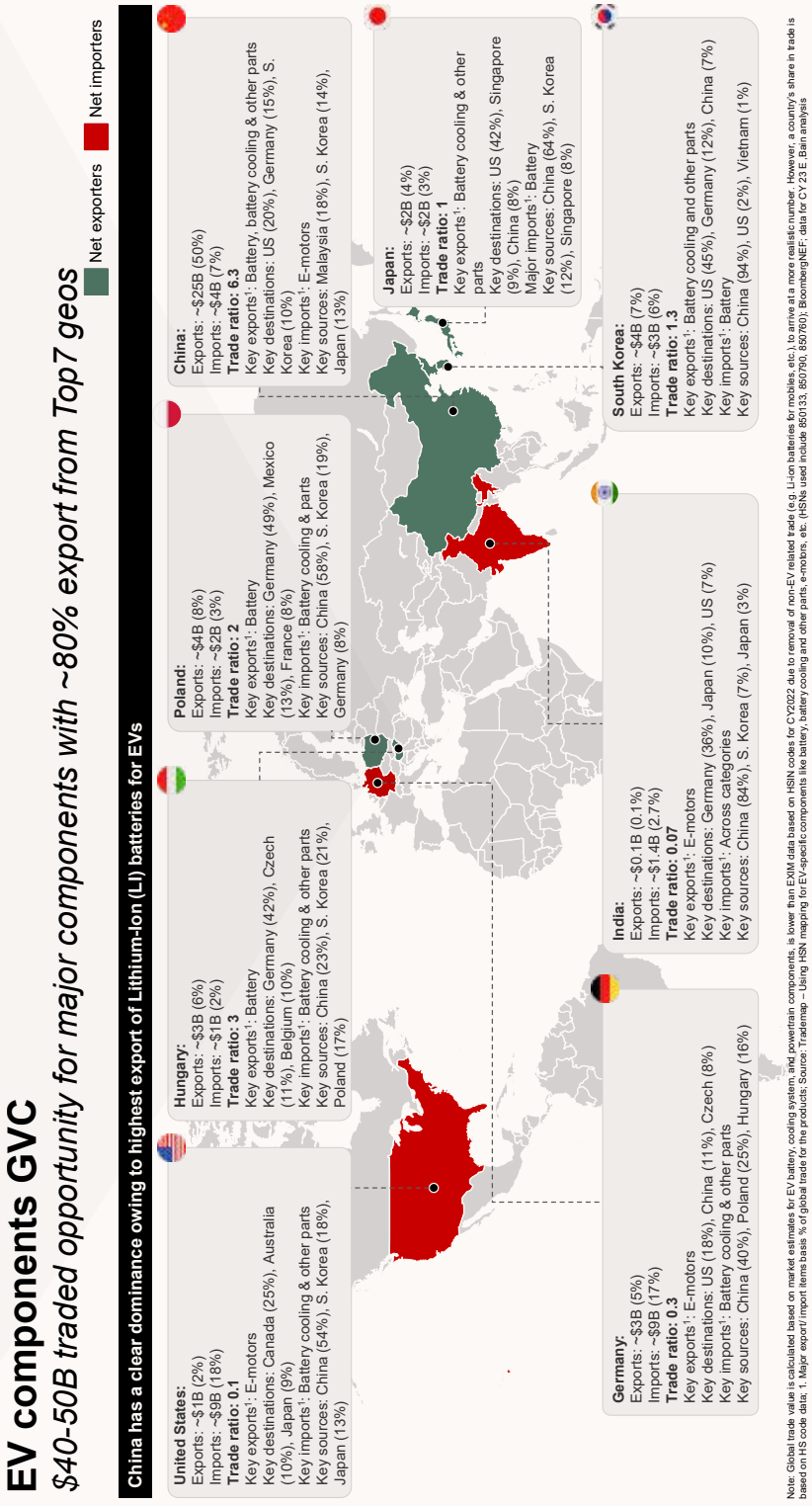


Figure - 3.1

China's dominance in the EV components market stems from its control over lithium-ion battery production, a critical component for EVs. With 50% of global exports ($25 billion) and a trade ratio of 6.3, China's exports vastly outweigh its imports. The country is a major supplier to key EV markets such as the United States, Germany, and South Korea, exporting batteries, battery cooling systems, and other essential parts. India's EV component market is in its infancy, with exports at only $0.1 billion and imports at $1.4 billion, resulting in a trade ratio of 0.1. The country heavily relies on imports from China (56%), South Korea, and Japan for batteries and cooling systems.

As illustrated in the figure below, the auto industry is poised to experience a substantial shift towards electric vehicles, with 80% of the market transitioning to EVs by 2040, and batteries representing 20% of the total demand in the auto component GVC market

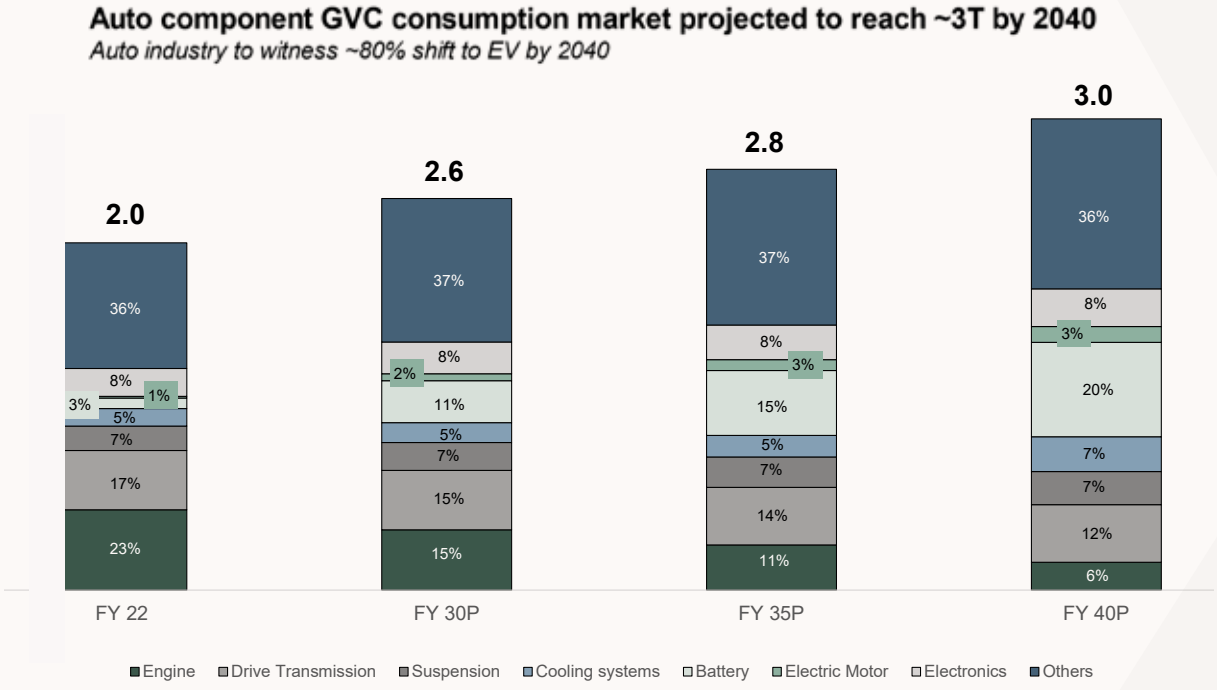


Figure - 3.2

3.1.2 TECHNOLOGY

In today's automotive market, car companies are no longer merely assembling mechanical parts but developing a complicated computer on wheels which is technologically advanced. Next-gen automobile ecosystem will include OEMs, software and service suppliers, system integrators, device manufacturers, and telecom operators as well. For example, in India when MG Motors launched their first car Hector[6] in the country in April 2019, it was a result of tech collaborations with Microsoft, Adobe, Unlimit, SAP, Cisco, Gaana, TomTom, Nuance, and others.

6 *https://www.businesstoday.in/magazine/industry/story/how-technology-is-transforming-the-auto-industry-331116-2022-04-25*

Globally, one of the biggest tech advancements in the automotive industry is going to be the applicability of CASE (connected, autonomous, shared and electric) concept in automobiles. In the concept[7] of CASE-

i. Connected refers to using various communication devices and automobile sensors to connect to external devices and services via the internet thereby enabling automobiles to access entertainment information, track vehicles, automatically report breakdown and traffic situations etc.

ii. Similarly, automation will enable technology in automobiles to be utilised for providing driver support and in some cases design fully autonomous self-driven vehicles.

iii. Shared refers to the concept of vehicles being jointly owned and used similar to how ride-sharing vehicles operate and function

iv. Electrification refers to EVs which run on a motor powered by electric energy

The rise of Advanced Driver Assistance Systems (ADAS) and self-driving technologies has also proliferated the demand for incorporating more technologically advanced auto components such as Radio Detection and Ranging (RADAR), Light Detection and Ranging (LiDAR) sensors, cameras and powerful computing systems which has the potential to redefine vehicle safety standards. The global Advanced Driver Assistance Systems (ADAS) and AD system sensor market is projected[8] to be worth $43 billion by 2030 with the global autonomous car market expected to reach a size[9] of $115 billion by 2030.

The global ADAS and autonomous driving component market is valued at $33.5 billion in 2024 and it is projected to reach US $83.6 billion by 2032 at an annual growth rate of 12% between 2022-30.

GLOBAL ADAS AND AUTONOMOUS DRIVING COMPONENT MARKET GROWTH[10]

Figure - 3.3

7 *https://mcc-ams.com/en/article/03/*
8 *https://www.statista.com/statistics/1076066/adas-autonomous-drive-system-sensor-market-by-type/*
9 *https://www.statista.com/statistics/428692/projected-size-of-global-autonomous-vehicle-market-by-vehicle-type/*
10 *https://straitsresearch.com/report/adas-and-autonomous-driving-component-market*

As more and more technologically advanced EV vehicles are seen on the roads, it is also to be considered that EVs use about six times more mineral inputs than ICE vehicles. Supply shortage of critical minerals utilized by EV batteries hamper the progress of this sector. To maintain pace, in this segment, adequate supply of critical minerals is important.

3.1.3. CHINA + 1 STRATEGY

While China is leading globally when it comes to manufacturing and production of auto components, western companies have been concerned11 with the increasing labour costs in China and the ongoing US-China trade war, which has led them to adopt a China plus one supply chain diversification strategy for manufacturing and producing auto components. While it is difficult in the short term to completely exit China, since they have spent 20-30 years building out their manufacturing supply chain. However, lot of companies are shifting from China for manufacturing and assembly purposes while the raw material may still be coming from Chinese suppliers.

Six nations stand to benefit from the China plus one strategy which includes India, Poland, Vietnam, Mexico, Thailand and Indonesia as these emerge as preferred alternatives for transnational companies seeking to reconfigure their supply chains and mitigate geopolitical risks. In the near future, it is predicted that finished goods[12] coming out of China shall be used to cater to developing countries solely while developed countries will be getting finished goods from Southeast Asia, India and Mexico.

Western companies seek to benefit from diversifying their supply chains outside China as this will help them spread their production across several countries making companies less prone to supply chain disruptions. Further, diversification will allow companies to operate in low-cost labour markets as China is no longer considered one, thereby providing companies with access to new markets. An example of a company adopting this strategy is Apple which is slowly shifting its device assembly processes to factories in India and Vietnam.

As geopolitical tensions combined with the Russia-Ukraine war and the ongoing wars in the Middle East are causing significant shifts in global supply chains, companies previously reliant on China for automotive components and semiconductors are now seeking to diversify their supply chains to mitigate risks. This provides an opportunity for India and other South East Asian nations to step up and position themselves as key players in global supply chains.

3.1.4 EUROPE + 1 STRATEGY

Europe is grappling with an energy crisis fuelled by rising inflation from the ongoing Russia-Ukraine war, further intensified by the shutdown of the Nord

11 *https://www.beroeinc.com/whitepaper/china-plus-one-strategy-an-imperative-to-achieve-supply-chain-resilience*

12 *https://www.freightwaves.com/news/china-plus-one-strategy-offers-best-of-both-worlds-for-manufacturers-retailers*

Stream I pipeline. This disruption has severely impacted manufacturing, with factories unable to operate at full capacity. Additionally, heating and electricity bills have now exceeded monthly labour wages in Europe. As a result, European manufacturers are actively exploring options for relocating their production elsewhere. This approach has been coined the term "Europe + 1" strategy which is similar along the lines of China plus one strategy. Further, as the EU recently voted[13] for increasing tariffs to 45% on China made EVs being exported to EU, manufacturers and OEMs of EVs are looking to shift their production facilities outside China.

Major European automakers such as Volvo, BMW, and Mercedes are planning to relocate their Chinese production facilities to neighbouring countries like Indonesia, India and even back to Europe as well. With the recently imposed tariffs and the Ukraine-Russia war European auto component manufacturers have been considering shifting to the Asian region as trade tensions will continue with China and geopolitical conflicts in the Middle East and Ukraine continue to rise.

3.2 OPPORTUNITIES FOR INDIA AMID GLOBAL DISRUPTIONS

3.2.1 INDIA'S POSITION IN AUTO COMPONENT GVC

For India, the growing auto components market represents a strategic opportunity to enhance its position in the automotive value chain. Currently, India constitutes almost 3% of global auto component exports.

India's presence in the global automotive component market is relatively small. However, India's growing manufacturing base and cost advantages position it suitably for potential market leader in coming years. India's auto component exports have risen from $7.4 billion in FY21 to $12.8 billion in FY24. Particularly, noteworthy is the fact that since FY21, India saw a ~73% surge in exports, thereby reflecting India's post pandemic recovery and increasing global demand for auto component parts. On the export front, India's exports are heavily dominated by Drive Transmission Systems (DTS), Engine Components, and Electrical and Electronics components which together account for 53% of India's total auto component export share.

As described earlier, major countries which are India's primary destinations for auto component exports are North America and Europe, which account for 34% and 27% of exports with USA standing out as a key export market for India since 28% of auto component exports are driven by its large automotive industry and aftermarket sector. Germany is another important auto component market for India as 7% of India's auto components export share is taken up by Germany. The demand for high quality automotive parts especially engine components and transmission systems are a testament to India's capabilities combined with the fact that many components produced in India are used in vehicles manufactured by global brands operating in Europe. Proximity to Africa and Southeast Asia also provides India an opportunity to further grow its export share through such

13 *https://www.bbc.com/news/articles/cly20n4d0g9o*

emerging markets where demand for auto components is expected to rise as auto sales and manufacturing grow in these countries.

Similarly, on the import front, India has witnessed a 80% increase in its auto components imports from $6.7 billion in FY21 to $12.1 billion in FY24 dominated by engine components and body/chassis/Body-in-White (BIW). China is the largest auto components supplier to India contributing close to 23% of India's imports.

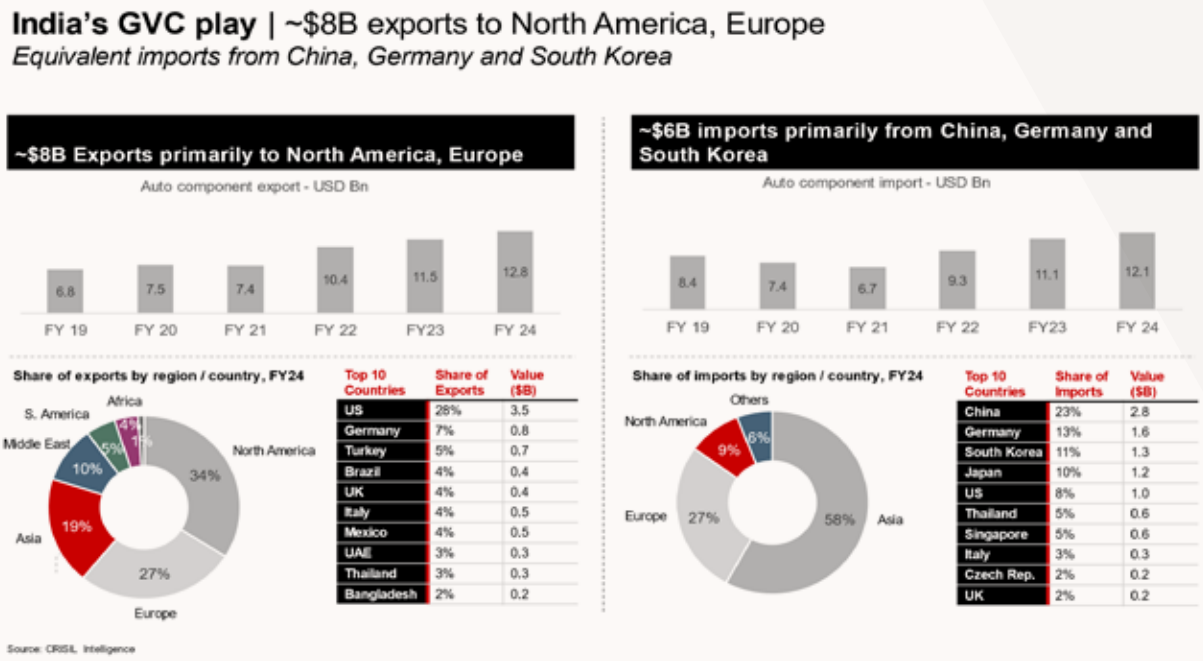


Figure - 3.4

Apart from China, South Korea and Germany are significant import partners of India as well. With the rise of the aftermarket sector, a consistent demand for replacement parts and components needed for vehicle repairs and upgrades has been created. The demand for imported components will see a continued rise in India as more and more vehicles come on Indian roads and increased consumer spending will be witnessed on vehicle maintenance and upgradation.

Today, India is renowned as a global hub for frugal and scalable engineering. Automotive clusters of Mumbai-Pune-Nasik-Aurangabad in the West, Chennai-Bangalore-Hosur in the South, and Delhi-Gurgaon-Faridabad in the North as well as upcoming ones in Sri City, Anantapur and Sanand are expected to drive the automotive and auto components industry in India. Further, with improvements in manufacturing capabilities, government initiatives such as Make in India, FAME, PLI scheme, PM E-Drive etc, and an increasing focus on quality and cost competitiveness India has immense opportunity to improve upon its current share in the auto components global value chain.

Through investing in advanced manufacturing technologies and innovation, India can establish itself as a major player of auto components within the global market.

Given, the strong supplier ecosystem and cost advantages India, is well positioned to attract foreign investment and integrate more deeply into GVCs.

3.2.2 FACTORS POSITIONING INDIA TO BECOME A DOMINANT PLAYER IN AUTO COMPONENT GVC

As India aims to become a leading player in the automotive global value chain, various factors are beneficial for India to make it a leading auto component player in GVCs. These primarily include:

1. **Rising Domestic Consumption and Middle-Class Aspirations:** Domestic macroeconomic trends suggest that India's consumption expenditure is set to witness a substantial growth as it is expected to reach nearly $5 trillion by 2030 from $1.4 trillion in 2018.

   Additionally, a growing middle class in India of close to 450 million people will fuel growth in the consumer demand for automobiles as the demand for high end premium vehicles grows primarily fuelled by the middle-class aspirations. As India's middle-class spending is expected to rise from 55% to 80% of total consumption by 2030, the demand for vehicles accompanied with advanced features such as advanced safety features, electric drivetrains, connectivity features, etc. will be on higher side. This shall further see a rise in need for high performance auto components, including more efficient engines, suspension systems, battery components, and electronic modules.

   As the increase in spending capacity of Indians keeps rising the need for aftermarket services and replacement parts is expected to grow with rise in vehicle ownership as well (SUVs and larger vehicles[14] make up 63% of all passenger vehicle sales in India).

   As the Government allocates INR 25,000 Crore PLI scheme[15] for the auto and auto component sector and PM e-Drive allocates INR 10,900 crore, it is expected that this shall motivate auto makers in India to further innovate and come out with advanced sustainable vehicles which can withstand the futuristic demands of consumers. Further, with strong investor and private equity support in the automotive sector demonstrated by strong capital inflows it is expected that the Indian automotive sector shall raise thereby fuelling innovation along with expansion in production capabilities which shall ultimately make India an attractive destination for domestic and foreign investors.

2. **Global Geopolitical Shifts and Supply Chain Diversification:** Larger global macroeconomic trends signify that amidst geopolitical tensions more and more automobile companies are looking to diversity their supply chain. Trade tensions and chip wars between USA and China along with rising conflicts in the Middle East region and between Russia and Ukraine have made China plus one strategy a lucrative option to pursue for automobile companies in order

14 *https://www.wrightresearch.in/blog/indian-consumption-theme-is-rising-indias-growing-middle-class-and-shift-toward-premium-consumption/*

15 *https://auto.economictimes.indiatimes.com/news/industry/neo-middle-class-will-take-india-mobility-sector-to-new-heights-pm/107376295*

to de-risk their supply chain from China and to make their supply chain more resilient. This shall be beneficial for India as it becomes a lucrative option to invest in for firms and aims to position itself as a key player in global supply chains. India possesses a favourable business environment, skilled workforce, and supportive Government policies which make India a very attractive option to setup their automobiles production and manufacturing facilities.

3. **Technological Advancements and India's Potential in the Global EV Market:** Technology shall play an instrumental role in order for India to become a leading nation in the auto components GVC. As per the report published by NITI Aayog and Rocky Mountain Institute, India could realize EV sales penetration of 30% of private cars, 70% of commercial cars, 70% of buses and 100% of two and three- wheelers by 2030. It is expected that there will be ~1.3 million EVs sales penetration in India by 2030. This presents a unique opportunity for India to develop an EV auto components market and to enhance its competitiveness in the global value chain.

   With substantial potential in manufacturing, cost competitiveness, and right investments in technology and infrastructure, India can become a major exporter of EV auto components. Further, with sufficient Government initiatives and policies, India has a unique opportunity to capitalise on the shift towards EVs globally as well as to venture into ADAS system components as more and more vehicles look at incorporating them in vehicles.

3.3 CHALLENGES IN ENHANCING INDIA'S PARTICIPATION IN GVC

As India seeks to become a dominant player in the GVC, it is essential to identify the various challenges it faces in order to scale up its production capacities and rise up to the global challenges.

1. **Cost competitiveness (Capex and Opex)-** India's operational cost competitiveness is impacted by balancing the costs between sourcing advanced technologies and investing in R&D. Top 5 sectors receiving highest FDI Equity Inflow during FY 2023-24 are Services Sector (Finance, Banking, Insurance, Non Fin/ Business, Outsourcing, R&D, Courier, Tech. Testing and Analysis, Other) (16%), Computer Software & Hardware (15%), Trading (6%), Telecommunications (6%) and Automobile Industry (5%)[16]. Significant sectors like electronics and technology remain underfunded.

16 *https://www.investindia.gov.in/foreign-direct-investment*

Cost component	India disability	Comments
Material	-9.5%	Increased **cost of raw materials** in India compared to China Higher **import duties & freight costs** in India
Employee	3.1%	Landed **labour cost** (including management costs) lower in India
Depreciation	-3.4%	**Higher depreciation** in India compared to China *(100% vs 50%)*
Power & fuel	0.3%	India's **avg. utility cost post-subsidies** is 10-15% lower than China
Tax	-0.02%	Slightly higher **effective tax rate** in India
Finance	-0.1%	Prime **lending rate** in *China at 3.45%* vs MCLR in *India at 9.37%*
Overall Cost Disability	**-9.6%**	

Figure - 3.5

In India, raw material costs are higher for non-traditional manufacturing due to import dependence and high tariffs, whereas China benefits from lower costs due to large scale production and efficient supply chains. Infrastructure and logistics in India still lag in efficiency despite significant investment17, while China benefits from advanced infrastructure and transport networks. Financial costs are also high in India compared to China and Vietnam.

Another aspect affecting India's cost competitiveness is the aspect18 related to FTA's India is a part of wherein, India suffers from inverted duty structures on raw materials such as Ferroalloys, aluminium, chemical products, etc. Import duties on machineries inflate costs, thereby affecting competitiveness.

Capital expenditure competitiveness of India is moderate due to domestic scale constraints which hinder volume benefits in segments such as EV components (batteries, motors).

Through a combination of strategic investments and financial incentives nations can bolster their cost competitiveness. For example, China provides $72 billion of EV tax breaks to stimulate consumer demand as well as support domestic manufacturers. Similarly, USA employs financial mechanisms to mitigate capital expenditure pressures for manufacturers by offering long term loans of up to 25 years at treasury rates which reduces financial burdens associated with large scale investments.

17 *https://www.deccanchronicle.com/business/economics/india-needs-to-improve-cost-competitiveness-to-attract-businesses-gtri-1815059*

18 *https://www.business-standard.com/economy/news/india-reviews-asean-trade-pact-to-address-domestic-manufacturing-anomalies-124041200297_1.html*

2. **Quality Constraints-**India's competitiveness in the global automotive value chain is significantly hindered by quality issues, which stem from disparities between domestic quality standards and stringent international benchmarks. For instance, in 2023, the rejection of 50% of iPhone covers produced at a Hosur manufacturing plant highlighted the serious quality gaps prevalent in Indian manufacturing. This problem is particularly acute in the SMEs sector, where many manufacturers struggle to meet OEM standards due to a lack of quality control and investment in advanced manufacturing processes. Without consistent attention to quality at every stage of production, Indian manufacturers often find themselves falling short of global requirements.

   Furthermore, the inefficiency of production systems exacerbates the quality gap. Many Indian manufacturers lack defect traceability systems, making it difficult to identify and rectify issues in real-time. This, combined with limited debugging capabilities, leads to an inability to ensure product quality consistently, as required under OEM liability agreements. If India aims to strengthen its position in the global value chain, there must be an overhaul of quality management practices, starting with better training, technological upgrades, and the implementation of global standardization processes.

3. **Ease of Doing Business -**The ease of doing business remains a significant challenge for the automotive industry in India, largely due to the complex regulatory environment and infrastructure constraints. Automotive firms must navigate a web of regulations related to emissions, safety standards, and import/export policies, which can often be inconsistent and difficult to comply with. These stringent regulations, though necessary for environmental and safety reasons, are not always aligned with the actual capabilities of manufacturers, particularly SMEs. This creates delays and increases compliance costs, making it more challenging for businesses to operate efficiently.

   In addition to regulatory complexities, infrastructure limitations—such as underdeveloped road networks, logistical bottlenecks, and inadequate charging infrastructure for electric vehicles—create operational hurdles for automotive firms. Moreover, inconsistent production incentives and unpredictable trade policies add to the uncertainty, making long-term planning difficult for manufacturers. Land acquisition issues, lengthy regulatory approval processes, and persistent red tapeism further slows down the establishment of new production facilities, limiting expansion and innovation. This unpredictability discourages potential investors and hampers the growth of the automotive sector, creating significant barriers to scaling up manufacturing capacity in the country.

4. **Lack of Innovation -**One of the most critical barriers to India's growth in the global automotive sector is the lack of innovation, largely driven by inadequate Research and Development (R&D) infrastructure. India currently spends less on R&D in the world, particularly when compared to global automotive leaders like Germany, Japan, and the United States. This underinvestment severely limits the country's ability to compete in emerging technologies such as EVs,

autonomous driving, and smart mobility solutions. While Indian manufacturers excel in low-cost, high-volume production, the absence of a strong innovation culture stifles the development of advanced products that could differentiate the country's offerings in global markets.

The lack of innovation is compounded by the minimal collaboration between industry, academia, and research institutions, which limits the flow of ideas and breakthroughs in automotive technology. Without sufficient funding and focus on future-oriented research, Indian firms are forced to rely on foreign technologies, which increases costs and reduce the ability to produce cutting-edge vehicles domestically. In particular, the country lags in areas like battery technology, ADAS (Advanced Driver Assistance Systems), and AI-driven manufacturing—all of which are critical for the future of automotive manufacturing. To remain competitive and achieve long-term growth, India must significantly increase its R&D expenditure and build a robust ecosystem that fosters innovation and technological advancement.

5. **Talent and Skilling Issues -** India's automotive manufacturing sector faces significant talent and skilling challenges, particularly as the industry transitions toward electric vehicles (EVs), automation, and advanced manufacturing processes. Many workers currently possess skills suited for traditional internal combustion engine (ICE) vehicle production, but there is an increasing demand for expertise in areas like electric powertrains, battery management, software integration, and AI-driven manufacturing. Roles such as battery engineers, robotics specialists, and software developers are emerging as critical to the industry, but a significant skills gap remains in these areas. Technical training institutes and vocational schools have not yet fully adapted their curricula to meet the evolving demands of the automotive sector, resulting in a shortage of qualified professionals who can handle these new technologies.

6. **Limited Access to Global Markets -** Limited access to global markets remains a significant challenge for India's automotive industry. While India has established itself as a key low-cost manufacturing hub, its participation in the global automotive supply chain is restricted by several factors, including non-tariff barriers, lack of Free Trade Agreements (FTAs) with major markets, and fierce competition from established players like China, Japan, and South Korea. Without adequate trade deals, Indian automotive exports are subject to high tariffs, which diminishes their competitiveness, especially in high-value segments like electric vehicles, advanced driver-assistance systems (ADAS), and powertrain components.

7. **Inadequate R&D Infrastructure-** India's automotive sector also struggles with inadequate R&D infrastructure, which limits its ability to innovate and compete globally. The absence of significant R&D investment means Indian firms often rely on outdated technologies and miss opportunities to lead in automotive innovation. This lack of innovation is particularly problematic as global automotive trends shift towards smart mobility, AI-driven manufacturing, and sustainable vehicle technologies.

In addition to above mentioned challenges, India also lacks advanced testing and validation centres that are critical for developing next-generation automotive technologies. Facilities for battery research, vehicle safety testing, and simulation labs for autonomous vehicles are either underdeveloped or unavailable. Without proper infrastructure in place, Indian manufacturers are often forced to outsource R&D to foreign labs, increasing both costs and lead times. Furthermore, the disconnect between industry and academia prevents the kind of collaboration seen in other countries that drives innovation in automotive technologies. This lack of ecosystem support hampers India's ability to compete with countries that have robust R&D capabilities and a strong focus on automotive innovation.

Table: Comparison of research productivity and innovation metrics in selected countries (2021-22)[19]

Country	Researchers per million inhabitants (2021)	PhDs produced annually (2021)	Publication output (2021)	Top 1% most cited articles (% share)	Patents granted (2022) (Rank)
India	262	40,813	3,06,800	0.7	30,490 (6)
USA	4,452	69,525	15,06,000	1.88	3,23,410 (2)
UK	4,491	27,366	2,87,200	2.35	10,578 (15)
China	1,687	53,778	9,78,100	1.12	7,98,347 (1)
S. Korea	9,082	13,882	1,09,200	1.02	1,35,180 (4)
Japan	5,638	15,804	1,71,000	0.88	2,01,420 (3)

In order to increase its share in the GVC, it is essential that there is impetus from the private sector through investments to develop advanced auto components and cars which are futuristic in the long run.

In addition to the specific challenges mentioned above, India currently faces a broader issue in scaling up for GVCs, primarily due to the limited engagement of Indian auto firms with global OEM players. This is further supported by the fact that there is a moderate cross border industry collaboration taking place in India which affects global integration as well as the ability to leverage international expertise and market opportunities.

19 *https://www.readipwave.com/indias-r-d-funding-landscape/*


Electric Vehicle Charging

4 Chapter

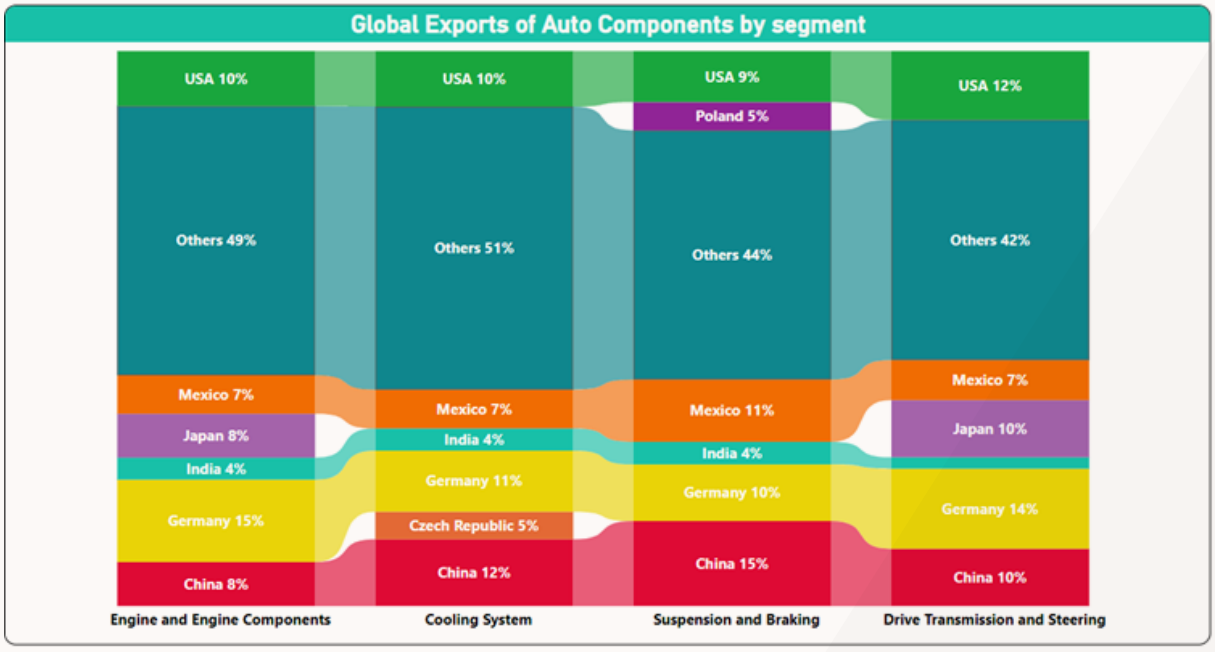
TECHNOLOGICAL TRANSITION OPPORTUNITIES AND GLOBAL BENCHMARKING IN AUTOMOTIVE COMPONENT MANUFACTURING

The global automotive components market is influenced by a complex interplay of imports and exports across key segments such as Engine Components, Drive Transmission Systems (DTS), Suspension and Braking, and Cooling Systems. Particularly, engine components and DTS together account for approximately 60% of global trade in automotive parts, with major exporting countries like Germany, the United States, China, Japan, and Mexico utilizing their strengths to dominate the key segments in automotive component industry.

India's presence in the global automotive component market is modest with export shares ranging between 2-4%; however, it is well-positioned for significant growth. Projections indicate that India's domestic auto component consumption could rise from $70 billion in FY23 to $120 billion by FY30, driven by increasing disposable incomes and an expanding middle class demand for vehicles. Despite holding only 2-3% of global engine component exports compared to leading players like Germany and the U.S., India is working to strengthen its participation in GVC. A comparative analysis describes that developed economies dominate exports across various automotive segments, while developing economies like India is actively seeking strategic areas to enhance its contributions.

By adopting best practices from around the globe, India can strengthen its position in the automotive industry. For example, lessons can be drawn from Ford's assembly line techniques in the U.S., Toyota's just-in-time production methods from Japan, and Hyundai's smart factory automation in South Korea. Additionally, China's innovation with BYD Blade Batteries showcases advancements in battery technology. India can establish a presence in the GVC of the automotive industry by leveraging the key takeaways from best practices.

4.1 GVC IMPORTS-EXPORTS BY SEGMENTS



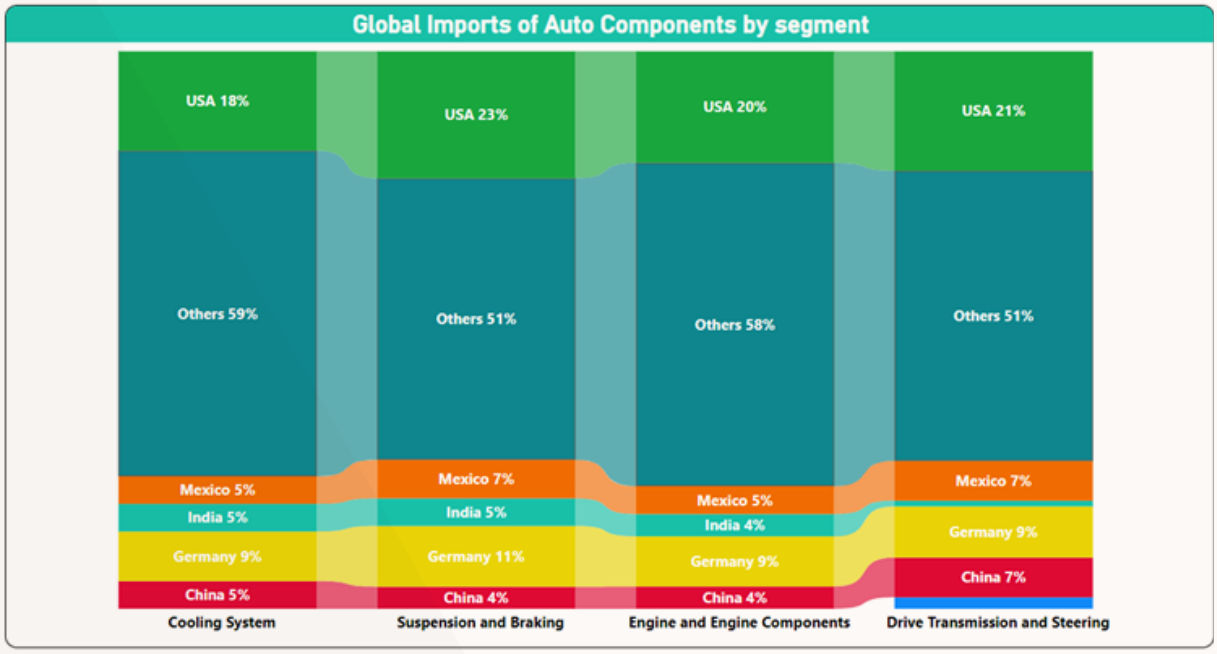


Figure - 4.1: *GVC Imports-Exports by Segment Country-wise*

The global auto components market is shaped by interplay of imports and exports across five key segments as given in Figure 4.1: Engine Components, Drive Transmission Systems (DTS), Suspension and Braking, Cooling Systems, and Other Components. Key segments like engine components and Drive Transmission Systems (DTS) are the dominant players, representing around 60% of the traded components worldwide. Countries like Germany, United States, China, Japan, and Mexico emerge as leading exporters across most segments within the industry whereas Germany and the United States stand out as the leading exporters across most segments within the industry. The manufacturing capabilities of Germany and its presence is attributed by producing high-quality, precision-engineered components, and its commitment to innovation and R&D. Similarly, the United States maintains a presence in export in the global market by capitalizing on its domestic market and advanced technological infrastructure, significant investments in R&D as well as an established network of manufacturers and suppliers.

The developed economies are performing better in exports of key segments under automotive components but reply on imports to meet specific demands, like there is a high import of suspension and braking segment by the US as given in **Figure 4.1**. China has rapidly scaled to become a major player, showing a significant growth in both exports and imports, particularly in engine components and DTS, representing 10% of the global market. Japan, known for its engineering and innovation excellence, maintains a significant, with 9-10% in various segments. Mexico has established as a cost-effective manufacturing hub with an export share of 7% to North America.

The presence of India in the global automotive component market remains relatively modest where the export shares are between 2-4% across the key segment. For example, India accounts for only 2-3% of global engine component exports, in comparison to the 10-15% share held by dominant players like Germany and the

U.S. Overall, the share of export and import reveal a competitive market where developed nations continue to lead, while developing economies like India vision for greater influence.

To effectively engage in the GVC of auto components, it is essential to conduct an in-depth analysis of specific components and subcomponents country-wise. This examination will help identify the strategic areas where India can strengthen its participation and align with the country's vision for GVC involvement by 2030.

4.2 COUNTRY- WISE BEST PRACTICES AND COMPARATIVE ANALYSIS OF KEY SEGMENTS

Given that the Global Value Chain (GVC) in the auto component market is predominantly controlled by 5-6 key countries, this section presents an in-depth comparative analysis of exports and imports across major segments on a country-by-country basis. The objective is to pinpoint potential target shares for India's exports and imports within the automotive components GVC. A detailed examination is conducted for critical segments such as engine components, drive transmission and steering components, suspension and braking systems, and cooling systems, along with their sub-components, as illustrated in **Figure 4.2**.

4.2.1 ENGINE COMPONENT GVC

The global trade of engine and engine components, valued at approximately $150 billion, showcases varying dominance among different countries across five sub-components: Engine Cylinder & Cylinder heads, Pistons & engine valve, Exhaust System, Fuel Injection System and Crankshaft & camshaft where 50% of value is driven by top 6-7 countries i.e. Germany, USA, Japan, China, Mexico, Turkey, and Canada.

- **Germany:** Germany is a leading exporter in several automotive segments. It holds a 17% share of total exports in engine cylinders and cylinder heads, along with 16% in pistons and engine valves. Additionally, Germany contributes 18% to exhaust system exports and leads the market in fuel injection systems with a 19% share. In crankshafts and camshafts, Germany dominates with a 22% export share. The country also plays a significant role in imports, particularly in crankshafts and camshafts (7%) and fuel injection systems (9%).

- **United States:** The United States is a major player in imports and exports within the automotive sector. It leads in exporting of engine cylinders and cylinder heads (14%) as well as Crankshaft & camshaft (14%). On the import side, the U.S. has a 23% share in pistons and engine valve, fuel injection systems (21%) and 17% in engine cylinders and cylinder heads.

- **China:** China emerges as a strong key player in both imports and exports. It holds 15% of the global export share in Pistons & Engine Valves, contributes 14% to Crankshafts & Camshafts and 11% of Fuel Injection Systems. On the

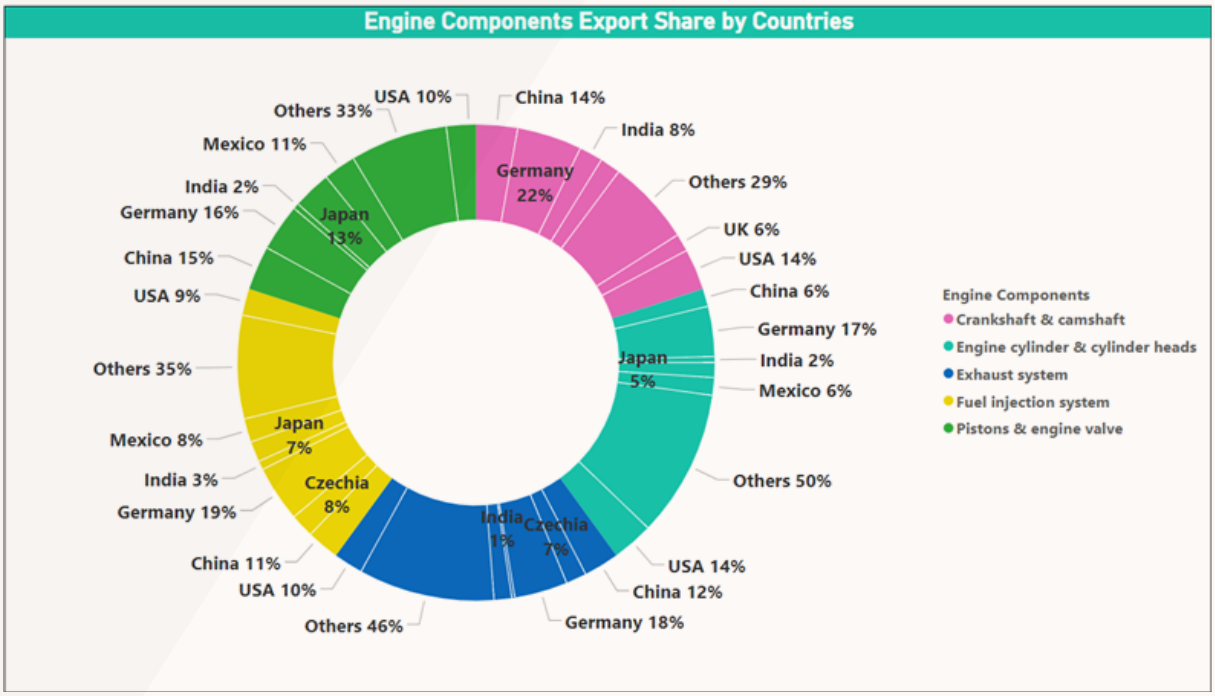
import side, China commands 6% in Pistons and engine valve, 8% in Crankshaft & camshaft and 7% in Fuel injection system

- **Japan:** Japan's presence is particularly strong in Pistons & Engine Valves, where it contributes 13% to global exports. It also maintains a modest export share in Engine Cylinders & Cylinder Heads (5%) and Fuel Injection Systems (7%).

- **Mexico:** Mexico plays a crucial role as both an exporter and importer. It holds an 11% export share in Pistons & Engine Valves, exports 8% of the Fuel injection system and 6% each in Engine cylinder heads and exhaust system. Mexico also imports 10% of Engine cylinder heads, 9% of pistons & engine valve, 7% of Crankshaft & Camshaft, making it a critical player in this segment.

- **India:** India's presence in the global market is relatively modest, contributing 2-4% across most segments. It exports 8% of Crankshaft & Camshafts while also importing at 7% of the crankshaft and camshaft sub-component segment.

Other importers include Turkey (4%) in engine cylinders and cylinder heads, while Canada (5%) and Hungary (4%) are significant importers of pistons and engine valves. Czechia stands out as a key exporter of exhaust systems, holding a 7% share of global trade, and it also imports 5% of exhaust systems. Additionally, Czechia exports 8% of fuel injection systems. The UK exports 6% of crankshafts and camshafts and imports 4% of fuel injection systems, while Canada imports 5% of crankshafts and camshafts.



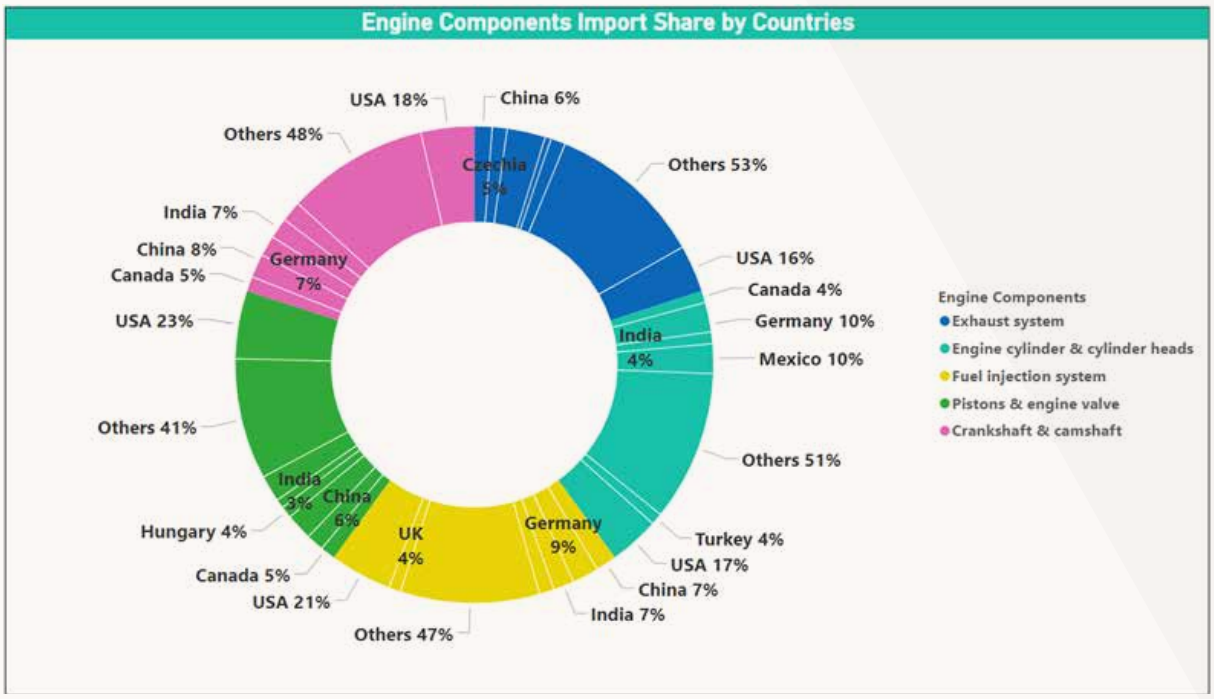


Figure - 4.2: *Engine Component GVC Country-wise*

4.2.2 DRIVE TRANSMISSION AND STEERING GVC

The global trade of Drive Transmission and Steering Components, valued at around $130 billion, involves several key countries across three sub-components: Transmission, Steering Components, and Clutches where 45% value is driven by top countries i.e. Germany, USA, Japan, China and Mexico, described in Figure 4.3.

- **Germany:** Germany leads the export market, especially in clutches, where it holds 23% of the market. Germany also accounts for 22% of Steering Component exports and 19% of transmission. On the import side, Germany plays a major role as well, particularly in Transmission and Clutches with 10% and Steering Components 9%.

- **United States:** The US is a key player as the largest importer in several categories. It imports 21% of Transmission components, 18% of Steering Components and 16% of Clutches. In terms of exports, the USA contributes 11% to global Transmission exports and 10% in Steering Components. For Clutches, the USA is a significant exporter with 9% of the global export trade market share.

- **China:** China holds a strong position in Clutches, contributing 10% to global exports and 6% to imports. In Transmission, it accounts for 7% of exports and 4% of imports. For Steering components, China exports 6% and imports 13%, reflecting its growing role in the global market.

- **Japan:** Japan is a key player in Steering Components, leading with 18% of global exports. It also contributes 9% to Transmission exports and 8% in Clutches. However, Japan's role in imports is particularly small compared to other countries.

- **Mexico:** Mexico has a balanced role, contributing 10% to both Transmission exports and imports. Additionally, it imports and exports 9% of Steering Components, playing a strong role in North American supply chains. For Clutches, Mexico imports 9% of total trade of DTS.

- **India:** India is emerging in this market, contributing 2% to Transmission exports and 1% to imports. It has a minor share in Steering Components and Clutches, with 1% each in their exports and 2% each in their imports, marking significantly balanced in global trade.

Other notable importers include Canada, which imports transmission components at a 4% share, and Brazil, a significant importer holding a 3% share in steering components. Hungary, meanwhile, stands out as both a major exporter and importer of clutches, accounting for 7% of global exports and 4% of imports.

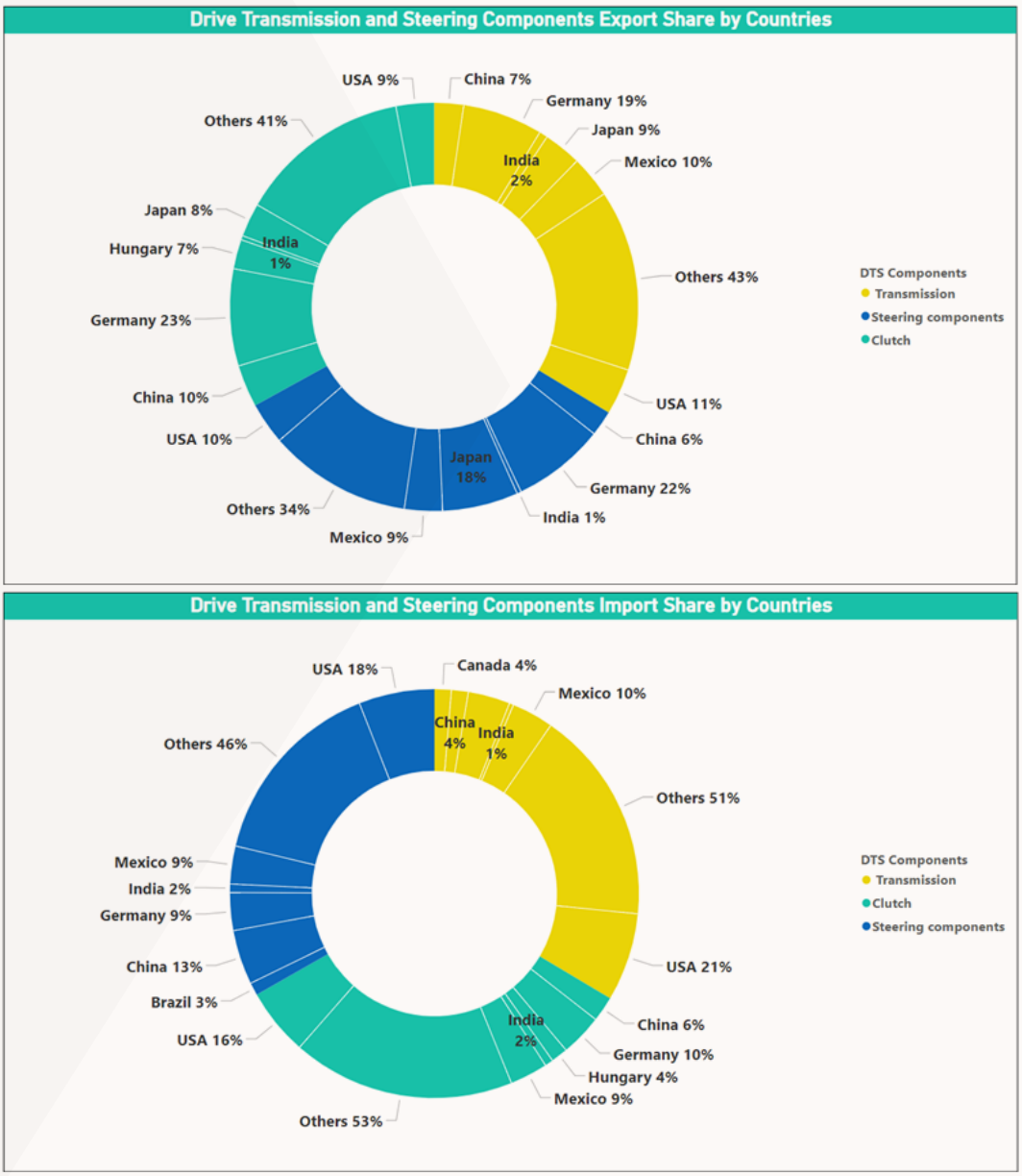


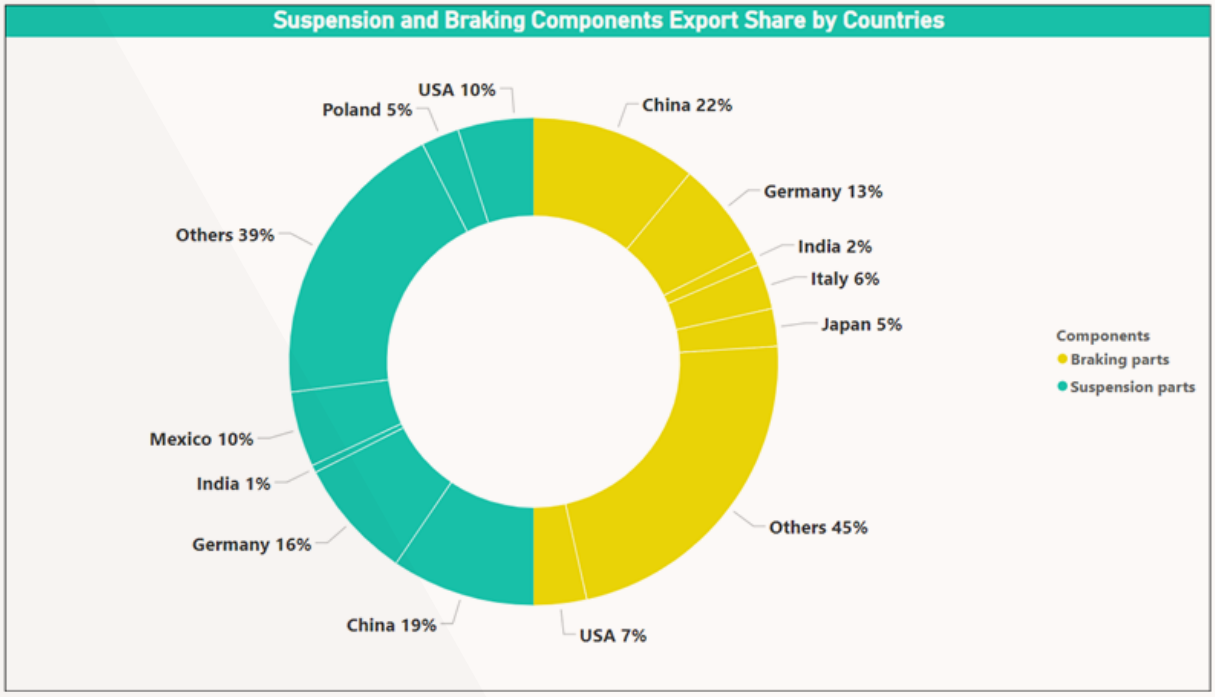
Figure - 4.3: *Drive Transmission and Steering GVC Country-wise*

4.2.3 SUSPENSION AND BRAKING GVC

The global trade of suspension and braking components, valued at approximately $60 billion, highlights various countries dominance across sub-components – Suspension parts and Braking parts where 40% of the value is driven by top countries- Germany, USA, Japan, China and Mexico, given in Figure 4.4.

- **Germany:** Germany is the second-largest exporter of suspension and braking components after China and the second-largest importer after the USA. It exports 16% of suspension parts and 13% of braking parts, while importing 11% of suspension parts and 12% of braking parts.
- **USA:** The United States is the largest importer of suspension and braking parts, accounting for 25% and 21% of global trade, respectively. Additionally, the U.S. exports 10% of suspension parts and 7% of braking parts.
- **Japan:** Japan is one of the major exporters of Braking parts with 5% of its global trade.
- **China:** China leads the export market for suspension parts, holding a 19% share of the global market, and dominates the braking parts sector with a 22% share. Additionally, China accounts for 5% of global imports of suspension parts.
- **Mexico:** Mexico plays a significant role, exporting 10% of suspension parts whereas it is importing 9% of suspension parts and 8% of braking parts.
- **India:** India makes a minor contribution in exports, with just 1% of suspension parts and 2% of braking parts whereas it is importing 1% of global traded value of suspension and braking parts.

Other significant importer is Canada importing suspension and braking parts, accounting for 6% and 4% of global trade, respectively. Meanwhile, Poland exports 5% of suspension parts. France imports 4% of braking parts, while Italy is a notable exporter, contributing 6% to the global market for braking components.



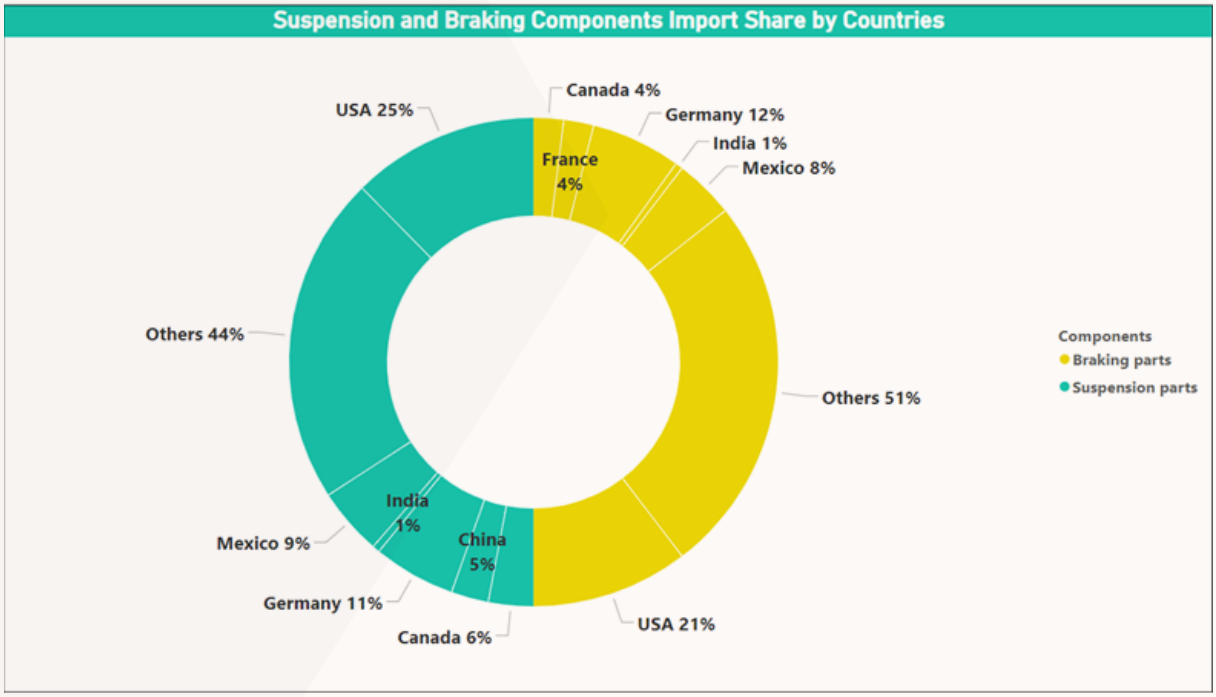


Figure - 4.4: *Suspension and Braking GVC Country-wise*

4.2.4 COOLING SYSTEM GVC

The global trade of cooling system components, valued at approximately $23 billion in CY22, reflects significant contributions from various countries across different segments like engine cooling, cabin thermal management (TM), and transmission TM where 50% value is driven by top 5 countries – Germany, USA, China, Mexico and Czechia, mentioned in Figure 4.5.

- **Germany:** Germany is a dominant player in the export market for engine cooling components, holding a 20% share of the global market for engine cooling systems and 15% of the cabin thermal management component market. Additionally, it ranks as the second-largest importer of cooling system components worldwide, following the United States. This robust position underscores Germany's critical role in the automotive supply chain, particularly in the production and distribution of essential component GVC.

- **USA:** The United States is the largest importer of cooling system components globally, accounting for 22% of engine cooling components, 15% of cabin thermal management components, and 19% of transmission thermal management sub-components. In addition to its significant import activities, the U.S. also exports 9% of engine cooling components and 6% of transmission thermal management sub-components, highlighting its active role in the global cooling component GVC.

- **China:** China is a leading exporter of transmission thermal management components, holding a 27% share of the global market. In contrast, its exports of engine cooling components are relatively modest at 10%, while it exports 15% of cabin thermal management components. On the import side, China is a minor player, with a 6% share of engine cooling component imports and 9% for cabin thermal management components. This data highlights China's significant role in the transmission sector while indicating lower involvement in the engine cooling and cabin thermal management Component GVC.

- **Mexico:** Mexico is a minor player in the global cooling system market, exporting 8% of engine cooling components. Additionally, it imports 6% of engine cooling components and 5% of transmission thermal management components. This data highlights Mexico's limited yet noteworthy participation in the engine cooling and transmission component GVC.

- **India:** India has a minimal presence in the global market for engine cooling components, with a share of only 2% in both exports and imports. Additionally, India exports 1% of cabin thermal management and 1% of transmission thermal management components. The country's share in the global improte trade of cabin thermal management components is nearly negligible but it contributes 1% in the global import trade of transmission thermal management components. This data highlights India's limited role in the cooling systems GVC, indicating potential areas for growth and development.

- **Czechia:** Czechia is a significant exporter of cooling system components, contributing 9% of the global market for both engine cooling and cabin thermal management components, as well as 7% for transmission thermal management components. On the import side, Czechia accounts for 4% of the total global imports of transmission thermal management components. This data highlights that Czechia has an important role in the cooling systems GVC, highlighting its extensive manufacturing capabilities and export strength.

The United Kingdom is another notable importer of cooling system components, holding a 4% share of both engine cooling and transmission thermal management components in the global market. Meanwhile, Slovakia stands out as a major exporter of cabin thermal management components, contributing 11% to the global share, while Poland follows closely with 9%. On the import side, Belgium and France are also significant players in the cabin thermal management sector, with import shares of 5% and 6%, respectively.

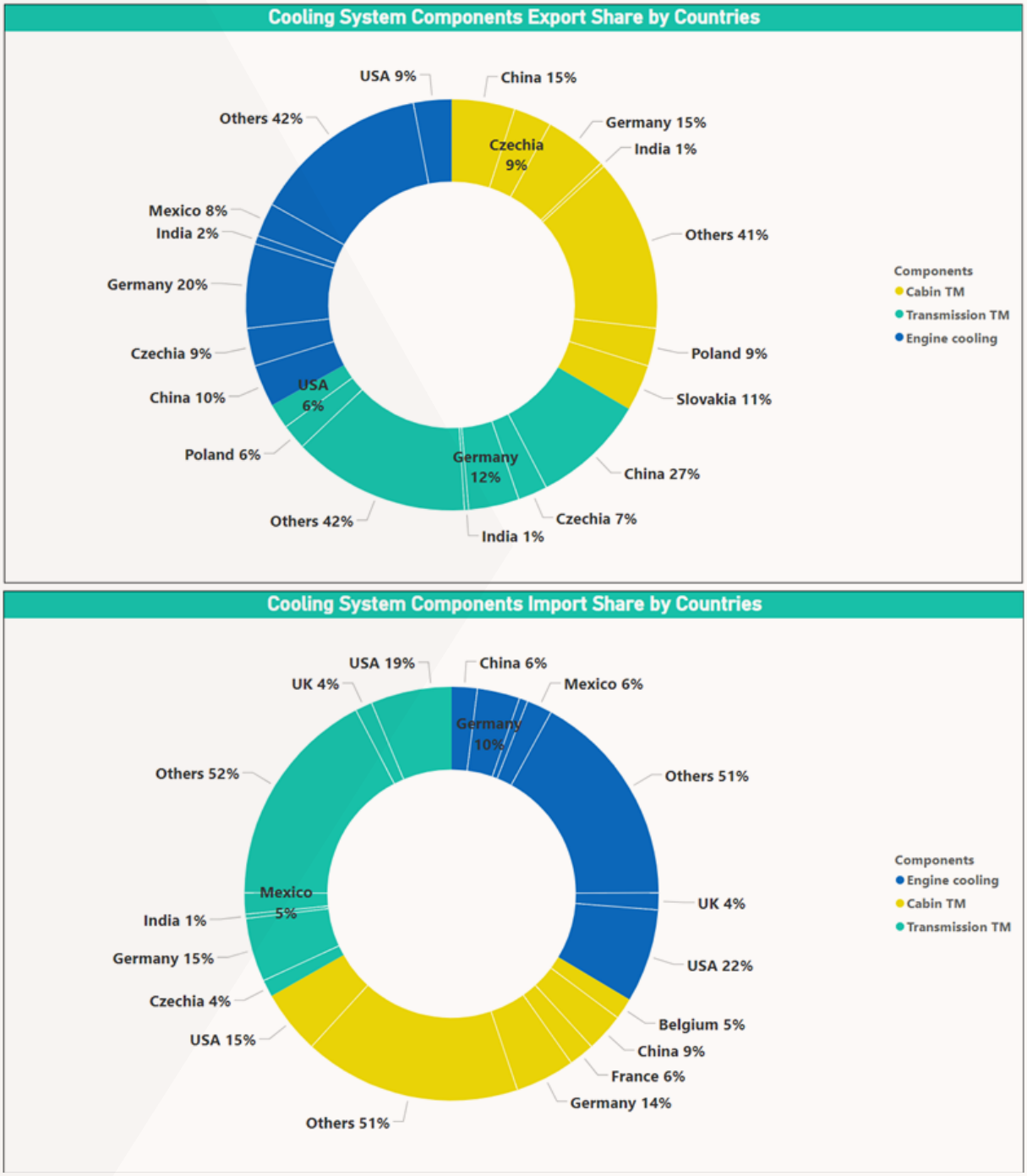


Figure - 4.5: *Cooling System GVC Country-wise*

4.3 EV AND TECHNOLOGICAL TRANSITION OPPORTUNITIES IN THE AUTOMOTIVE SECTOR

The automobile industry stands to gain significantly from the shift to electric cars (EVs), since EV-specific parts are predicted to account for about half of the vehicle's overall value. This change emphasizes how important it is for manufacturers to innovate and adapt with components like electric motors, lithium-ion batteries, and sophisticated electronics get more and more essential.

1. Increasing Demand for BEVs and PHEVs

- **Market Projections:** By 2030, battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) are expected to account for 40% of global light vehicle sales, with over 50% in key **markets** like Europe, the U.S., and China.
- **Driving Factors:** Growth is driven by fossil concerns, government incentives, technological advancements, and decreasing total cost of ownership.
- Electric light-duty vehicle (LDV) sales are projected to grow significantly, reaching 40% of total LDV sales by 2030 and nearly 55% by 2035 due to strong policy support, improved EV models, and increasing market size. Policies in Canada and the UK target zero-emission vehicle (ZEV) sales of 60% and 80% for passenger LDVs, respectively, by 2030.

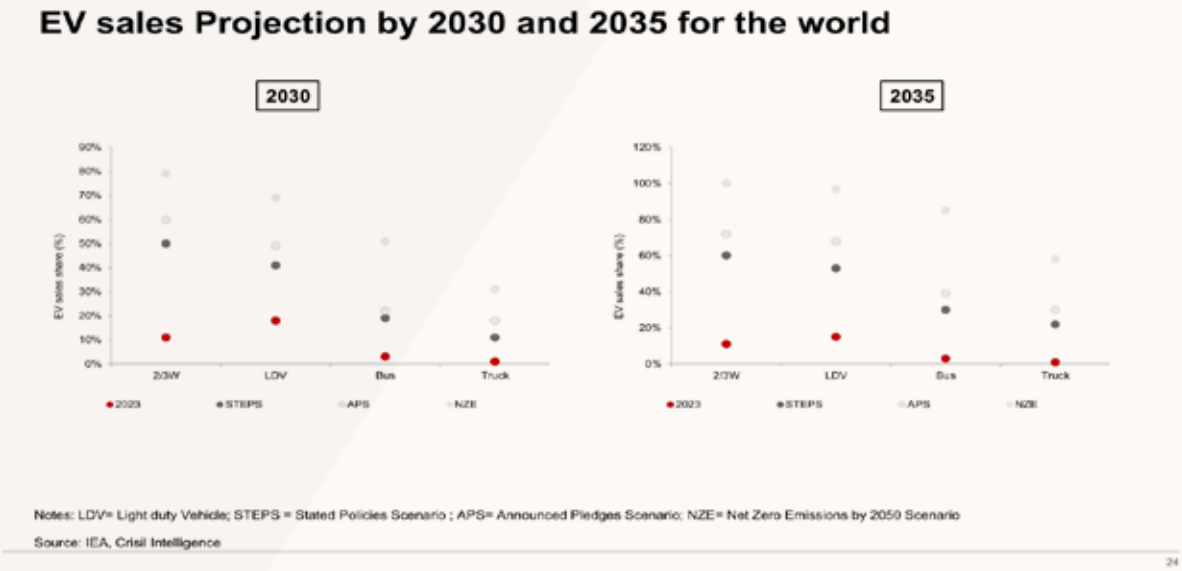


Figure - 4.6: *EV sales share by mode and scenario, 2030 & 2035*
Source: Crisil Intelligence, IEA

2. Technological Advancements: ADAS and Autonomous Driving

- **ADAS Growth:** Advanced Driver-Assistance Systems (ADAS) are projected to rise from 42% of new vehicle sales in 2020 to **90% by 2030**, spurred by consumer demand for safety features and regulatory requirements.

- **Autonomous Driving Adoption:** Technology penetration is expected to grow from less than 1% in 2020 to over **30% by 2030**, increasing the importance of sensors, computing power, and AI in vehicles.

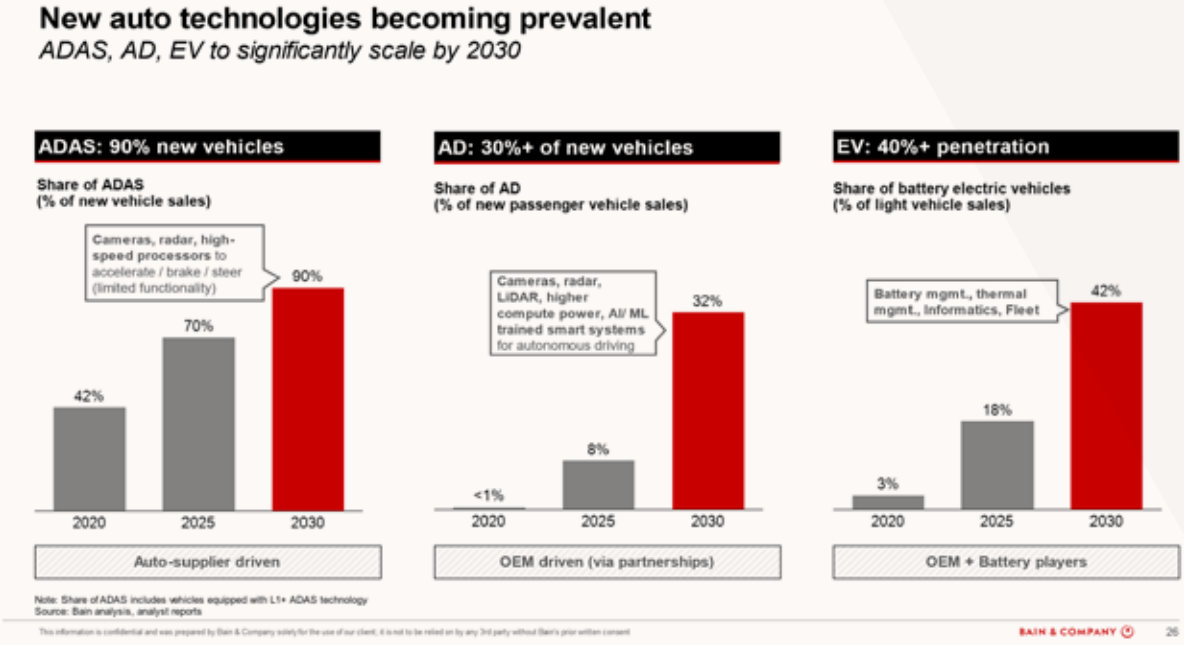


Figure - 4.7

3. Future of Mobility: Software and Electronics Integration

- **Rising Electronics Content:** The average semiconductor content per vehicle is anticipated to **double by 2030**, reaching a total value of around **$1,200 per vehicle**. This reflects the increasing complexity of vehicle electronics.
- **Software Value Increase:** Currently making up about 2% of a vehicle's total value, software is **projected to rise to 4-5% by 2030**. This growth is driven by connected vehicle technologies and over-the-air updates, with the total addressable market for automotive software expected to reach $80 billion.

The automotive industry's future is poised for transformation, driven by the rapid growth of electric vehicles, advancements in automation technologies, and a significant increase in the role of software and electronics. Manufacturers that can innovate and scale production will be well-positioned to capture the opportunities arising from these shifts. Collaboration with technology partners will be essential to meet the demands of the next generation of vehicles, ultimately shaping the future of mobility.

4.4 CASE STUDIES OF BEST PRACTICES

CASE 1: FORD'S ASSEMBLY LINE - THE USA[20]

About Ford Motor Company: Founded in 1903 and headquartered in Dearborn, Michigan, Ford Motor Company stands as one of the pioneers in automotive manufacturing, mobility, and financing. With a global workforce of approximately 177,000 employees, Ford reported impressive revenue of $177.5 billion in 2023, alongside a net income of $4.3 billion. Despite facing a net loss of $526 million in the fourth quarter due to special items, the company remained resilient, generating $46 billion in revenue during the same period. Ford continues to focus on electric vehicle innovation and sustainability, projecting an adjusted EBIT between $10 billion and $12 billion for 2024.The evolution of Ford Motor Company's manufacturing techniques from 1906 to the present provides valuable insights for India's automotive components sector.

Ford's Journey of Manufacturing Innovation:

Ford's evolution in manufacturing techniques, beginning in the early 20th century, offers valuable lessons for India's automotive components sector.

Phase 1 (1906-1912) – Early Innovation:

Henry Ford's vision to employ workers from diverse technical backgrounds sparked a wave of innovation and mechanization. With the introduction of the Model T in 1909, demand soared, prompting Ford to open the Highland Park facility in 1910. It was here that his engineers experimented with revolutionary production techniques, including the first movable assembly line in 1911, dramatically boosting efficiency.

Phase 2 (1913) – The Birth of the Moving Assembly Line:

In 1913, Ford officially launched the world's first moving assembly line, cutting down the assembly time of the Model T from over 12 hours to less than 3 hours. This breakthrough not only transformed Ford's manufacturing capabilities but set new standards for global industrial production.

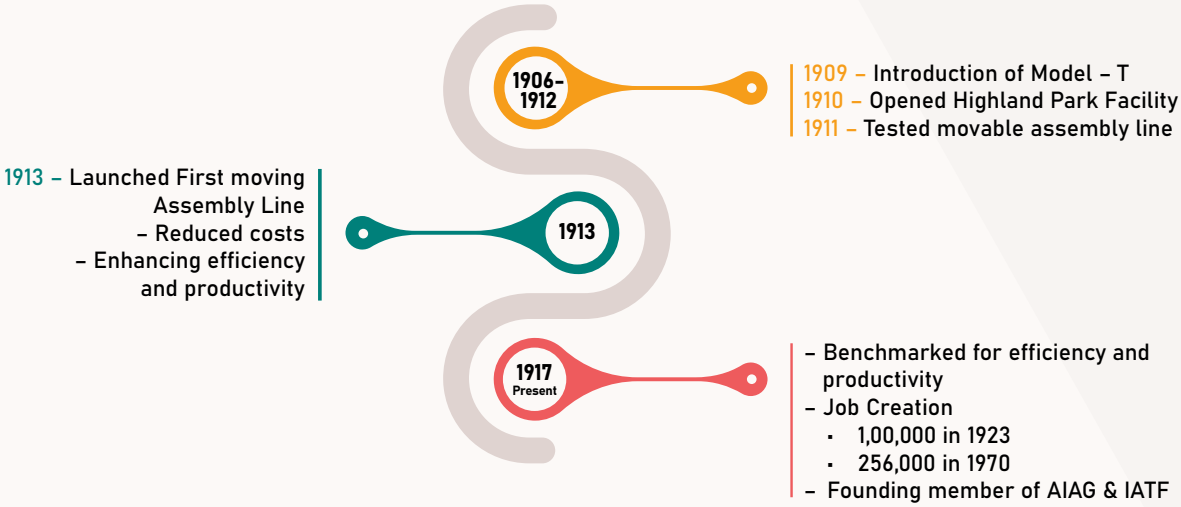
Phase 3 (1917 – Present) – Global Influence:

The success of Ford's assembly line became a global phenomenon, establishing benchmarks for efficiency, productivity, and cost reduction. Ford's continuous focus on innovation, workforce development, and process improvement offers a blueprint for manufacturers worldwide.

Key Takeaways for India: The evolution of Ford's manufacturing techniques from the early 1900s holds valuable lessons for India's automotive components sector. Ford's approach of blending skilled labour from diverse technical fields with a focus on mechanization and efficiency was key to its success. India can draw inspiration from this by investing in talent development and soft infrastructure to boost productivity, like Ford's early strategies. Moreover, Ford's ongoing focus on innovation and continuous improvement serves as a guide for India to strengthen its position in the global value chain (GVC) for automotive components. By

20 *https://www.assemblymag.com/articles/91581-the-moving-assembly-line-turns-100*

adopting cutting-edge techniques from other sectors and fostering a skilled workforce, India can accelerate its growth and compete on a global scale.



CASE 2: TOYOTA'S JUST-IN-TIME PRODUCTION- A GLOBAL LEADER IN EFFICIENCY - JAPAN[21]

In 2023, Toyota Motor Corporation reported robust revenue of $173 billion, reflecting a 4% increase from the previous year's $166 billion. Over the five-year period from FY2019 to FY2023, Toyota Industries Corporation demonstrated significant growth, with net sales climbing from $20.1 billion to $25.6 billion. Operating profits grew from $1.2 billion to $1.3 billion, while net profits increased from $1.5 billion to $1.8 billion. Additionally, Toyota's workforce expanded by more than 10,000 employees, growing from 64,641 to 74,887, underscoring the company's continuous expansion and contribution to global employment.

Toyota's Evolution of Production Techniques:

Phase 1: Foundational Concepts and Early Developments (1896-1938)

Toyota's journey began with the groundbreaking invention of the Toyoda Power Loom by Sakichi Toyoda in 1896. This innovation introduced a weft-breakage automatic stopping device, which was a key step towards automated production. By 1924, the first automatic loom with a non-stop shuttle-change motion was developed; further enhancing production efficiency and quality control. Kiichiro Toyoda later introduced flow production using chain conveyors for automatic looms in 1927, laying the foundation for Toyota's future automotive assembly lines. By 1938, this method was implemented at Toyota's Koromo Plant, marking the beginning of modern production techniques.

Phase 2: Development of the Toyota Production System (TPS) (1945-1950s)

In the post-World War II era, resource shortages led Toyota to innovate its production techniques. Kiichiro Toyoda's Just-in-Time (JIT) philosophy, introduced in 1949, became central to Toyota's strategy, focusing on producing only what was needed, precisely when it was needed. The 1950s saw the formalization of the

21 *https://global.toyota/en/company/vision-and-philosophy/production-system/*

Toyota Production System (TPS), which integrated JIT, continuous improvement (Kaizen), and employee involvement, transforming the way Toyota operated.

Phase 3: Global Recognition of TPS (1960s-1980s)

During this period, the Toyota Production System gained international recognition as the leading model for lean manufacturing. Its focus on efficiency, waste reduction, and continuous improvement resonated with industries worldwide, setting new standards in production.

Phase 4: Refinements and Resilience (1990s-2020s)

In the 1990s and 2000s, Toyota continued to refine TPS to maintain its competitive edge amid global challenges, including the impact of the COVID-19 pandemic. The effectiveness of TPS was evident when Toyota regained its position as the top-selling automaker in North America by 2021, demonstrating the system's ability to adapt and manage complex supply chain challenges.

Key Takeaways for India's Automotive Manufacturing Industry:

India's automotive manufacturing sector can benefit significantly from adopting Toyota's Just-in-Time (JIT) philosophy.

Waste Reduction & Cost Efficiency:

By producing only what is needed, when it's needed, JIT minimizes waste and reduces holding costs. This approach not only improves operational efficiency but also enhances profitability by cutting down on excess inventory.

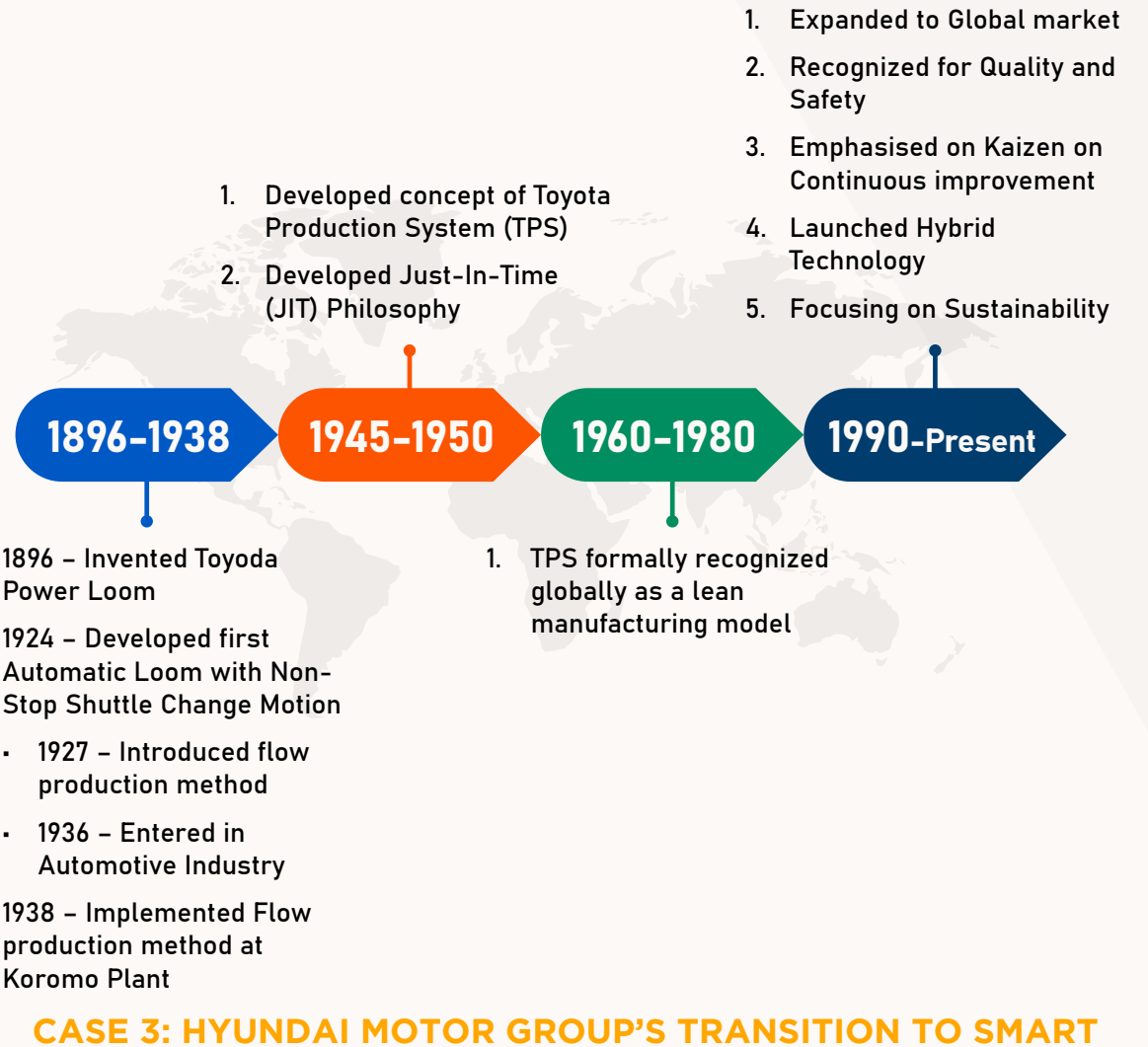
Enhanced Responsiveness:

JIT encourages greater responsiveness to market demands, enabling manufacturers to quickly adapt to changes in customer preferences and production requirements. This agility is particularly critical during periods of disruption, such as natural calamities or pandemics.

Strengthened Supplier Collaboration:

Implementing JIT also fosters closer collaboration with suppliers, ensuring timely delivery of components and a smoother flow throughout the supply chain. This can enhance overall productivity and competitiveness for Indian manufacturers in the global market.

By embracing the principles of Toyota's production system, India's automotive industry can elevate its position in the global value chain, driving efficiency, innovation, and long-term growth.



CASE 3: HYUNDAI MOTOR GROUP'S TRANSITION TO SMART FACTORIES IN PREPARATION FOR INDUSTRY 4.0 – SOUTH KOREA

In 2023, Hyundai Motor Group reported revenue of $123.57 billion, a notable increase from the $109.60 billion generated in 2022. With global sales of approx. 4.22 million vehicles, marking a 6.9% year-on-year growth, Hyundai saw remarkable success across key markets, including Korea, North America, Europe, and India. Despite global challenges such as rising interest rates and inflation, the company sold an impressive 342,919 units in December 2023 alone, with 280,747 units in international markets and 62,172 in South Korea. Looking ahead, Hyundai aims to exceed 4.24 million vehicles in global sales for 2024, continuing its leadership in electric vehicle (EV) innovation and strengthening its position in the automotive industry.

Hyundai's Journey toward Smart Factories:

Phase 1: Laying the Foundation (2015-2017)

Hyundai Motor Group established its Manufacturing Engineering R&D Centre in 2015, initiating its journey into smart manufacturing. By 2016, the company began

integrating advanced technologies into its facilities. In 2017, Hyundai introduced the Smart Tag System, which integrated position tracking sensors and wireless communication chips to enhance assembly line efficiency, marking a key milestone in its smart factory transition.

Phase 2: Automating Processes (2018)

In 2018, Hyundai revolutionized vehicle inspections with automated protocols for Advanced Driver Assistance Systems (ADAS), employing six collaborative robots to streamline the process. Additionally, Hyundai introduced the Chairless Exoskeleton (CEX) and Vest Exoskeleton (VEX) to support factory workers, improving both efficiency and worker health.

Phase 3: Virtual Reality and Global Implementation (2019)

Hyundai embraced virtual reality for vehicle design, allowing engineers to simulate models and environments, enhancing design accuracy and safety checks. The VEX exoskeleton was successfully tested in Hyundai's Alabama and Kia's Georgia plants, demonstrating its effectiveness in enhancing worker productivity and ergonomics.

Phase 4: AI Integration (2020)

Hyundai began leveraging artificial intelligence (AI) across its manufacturing processes, focusing on quality improvements and real-time data analysis. One of the early trials involved using deep learning to enhance paint quality, showcasing the company's commitment to innovation.

Phase 5: Hyundai Mobility Global Innovation Centre (2021-2022)

In 2021, Hyundai commenced the construction of its Hyundai Mobility Global Innovation Centre (HMGIC) in Singapore, which was completed in 2022. This centre serves as a hub for smart manufacturing technologies and future mobility solutions, fostering an open innovation ecosystem.

Phase 6: Pioneering Smart Manufacturing (2023 and Beyond)

From 2023 onwards, Hyundai continues to advance its AI-based, IoT-assisted, human-centred intelligent manufacturing platforms. These cutting-edge technologies aim to reduce development costs, improve vehicle quality, and solidify Hyundai's vision for a sustainable and innovative future.

Key Takeaways for India:

India can draw several insights from Hyundai's transition to smart factories. The establishment of dedicated R&D centres, such as Hyundai's Manufacturing Engineering R&D Centre, highlights the importance of investing in innovation to boost manufacturing capabilities. Adopting advanced technologies like AI and IoT can significantly enhance productivity and quality control in Indian automotive

manufacturing, making it more competitive and cost-effective in the global market.

CASE 4: BYD BLADE BATTERY - CHINA

BYD was founded in China and named after a phrase "Build Your Dreams," which initially focused on batteries and electrical appliances before expanding into the automotive industry. This transition was driven by the Chinese government's push to promote electric vehicles, leading BYD to manufacture cars, buses, trucks, and forklifts. In 2023, BYD reported remarkable revenue of approximately $46 billion, with profits soaring to $1.2 billion, showcasing a significant turnaround in its financial performance. By 2022[22], BYD had sold over 1.5 million electric vehicles globally, positioning itself as a leader in the market. The BYD Blade Battery, developed by BYD Auto Co., Ltd., represents advancement in EV battery technology.

BYD's Blade Battery Revolution:

Phase 1: Emergence of the Blade Battery (2020-2021)

BYD introduced its ground-breaking Blade Battery in 2020 as a response to key challenges in the EV industry, particularly regarding battery safety and efficiency. Using Lithium Iron Phosphate (LFP) technology, the Blade Battery significantly enhances safety compared to conventional lithium-ion batteries. It underwent rigorous testing, demonstrating minimal thermal runaway risks, making it one of the safest battery options in the market.

Phase 2: Gaining Global Attention (2021-2022)

By 2021, the Blade Battery had gained widespread recognition, attracting interest from major players like Tesla. This phase marked a shift in battery technology, with several manufacturers adopting BYD's innovative design due to its superior safety standards and efficiency.

Phase 3: Industry Impact and Widespread Adoption (2023)

In 2023, the Blade Battery was increasingly integrated into various EV models, contributing to the global adoption of electric vehicles. With its lower production costs, higher energy density, and superior safety, the Blade Battery became a viable alternative to traditional batteries. Countries around the world recognized the potential of this innovation to mitigate environmental impacts and accelerate the shift to electric mobility.

Key Takeaways for India:

For India, the BYD Blade Battery presents a significant opportunity to accelerate the growth of its EV market. By adopting this advanced battery technology, Indian manufacturers can enhance vehicle safety, extend driving ranges, and reduce costs. As India pushes toward net-zero emissions and increased EV adoption, innovations like the Blade Battery could address concerns about battery

22 https://www.deccanherald.com/auto/explained-how-china-built-byd-its-tesla-killer-2890643

performance and infrastructure, enabling the production of more efficient and environmentally friendly vehicles.

CASE 5: TATA AUTO COMP - INDIA

Tata AutoComp Systems is a leading Indian automotive components manufacturer, catering to both domestic and global markets. Established in 1995, the company specializes in a wide range of products, including interior and exterior components, EV solutions, and advanced technologies. Through strategic partnerships and R&D, Tata AutoComp has become a trusted supplier to major global OEMs. Its focus on sustainability and innovation positions it as a key player in the evolving automotive landscape.

Phase 1: Entry Phase (1995 – 2005):

Tata AutoComp initially focused on supplying components to the domestic market, establishing itself as a trusted partner for leading OEMs. The company also formed joint ventures with global leaders in the auto component industry, such as TRAD (automotive seating) and Ficosa (automotive mirrors), bringing advanced technologies to India. In 2002, Tata AutoComp began exporting select components to European and Asian markets, marking the beginning of its global aspirations.

Phase 2: Growth Phase (2006-2015):

During this period, Tata AutoComp expanded its global operations and diversified its product portfolio. The company prioritized exporting labour-intensive products like plastics and interior components to international markets. Between 2008 and 2010, it established manufacturing facilities in China and Latin America and collaborated with Korean and Japanese firms to develop lightweight, fuel-efficient components. By 2015, Tata AutoComp had become a preferred supplier for major automakers such as Toyota, GM, and BMW.

Phase 3: Diversification and Specialization (2016-2020):

With the global shift toward electric vehicles (EVs), Tata AutoComp began focusing on innovation in EV components and advanced technologies. The company invested in R&D for EV-related products, including battery packs, charging systems, and lightweight composites. In 2019, it set up an advanced engineering centre in Pune, India, to drive innovation and provide technical support to global markets.

Phase 4: Consolidation and Global Leadership (2021-Present):

In recent years, Tata AutoComp has emphasized sustainability, digital transformation, and the circular economy. In 2021, it announced a carbon-neutral roadmap for its manufacturing operations by 2035 and initiated work on "Green Factory" projects. The company also expanded its presence in North America and Europe through partnerships with local suppliers. In 2023, it launched an AI-driven supply chain solution to enhance efficiency and reduce costs.

Key Takeaways for India:

Tata AutoComp has a total of 61 manufacturing facilities spread across the worldwide including 8 facilities spread across North America, Latin America, Europe and China. They have also 18 businesses (7 fully owned, 9 Joint Ventures, 2 service units) in their portfolio. Tata AutoComp's integration into Global Value Chains (GVCs) highlights India's potential as a competitive player in the global automotive industry. Its success in exporting labour-intensive products, forming strategic global partnerships, and establishing manufacturing hubs abroad demonstrates the value of aligning domestic capabilities with international demand. Investments in EV components and sustainability initiatives position India as a key contributor to evolving GVCs.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12%

5 Chapter

POLICY RECOMMENDATIONS FOR INDIA'S AUTO COMPONENT SECTOR

5.1 INTRODUCTION

5.1.1 OVERVIEW OF INDIA'S AMBITION: $120 BILLION AUTO COMPONENT PRODUCTION BY FY30

As per the Vision, India's auto component sector is poised for substantial growth by 2030, with plans to increase production from $70 billion in FY23 to $120 billion by FY30. It has also been envisioned to triple auto component's exports, growing from $20 billion to $60 billion during this period, positioning itself as a formidable player in global markets. Domestic production is projected to rise from $70 billion to $145 billion, driven by increasing demand and a focus on high-quality, value-added products. This ambitious growth strategy highlights the sector's commitment to enhancing its contribution to both the national economy and global supply chains. However, realizing these targets will require overcoming significant challenges, including improving scale and cost competitiveness, bolstering R&D capabilities, and upgrading infrastructure. Keeping above aspects in mind, strategic policy interventions will be crucial to supporting industry growth and elevating its global competitiveness.

	Present Scenario (FY23)	Vision (FY30)
Global Autocomp consumption	$2000B	$2400B
Global Autocomp GVC	$700B	$750B
India Autocomp consumption	$70B	$120B
India Exports	$20B	$60B
India Net Exports	$0B	$25B
India Production	$70B	$145B
India GVC salience (% share of global)	3%	8%
Direct Employment	1.5M	3-4M

Figure - 5.1
Vision for Automotive Industry FY 2030

5.1.2 STRATEGIC NEED FOR POLICY INTERVENTIONS

As seen in section 3.3, India's automotive manufacturing sector faces a disability of around 10% compared to China as the country on account of higher raw material costs, steeper import duties, and increased freight costs. Moreover, India's depreciation rates are twice that of China, at 100% versus 50%, and the prime lending rate is substantially higher, with China's rate at 3.45% compared to India's MCLR of 9.37%. These cumulative disadvantages underscore the need for targeted support to enhance the competitiveness of India's automotive industry.

Cost component	India disability	Comments
Material	-9.5%	Increased **cost of raw materials** in India compared to China Higher **import duties & freight costs** in India
Employee	3.1%	Landed **labour cost** (including management costs) lower in India
Depreciation	-3.4%	**Higher depreciation** in India compared to China *(100% vs 50%)*
Power & fuel	0.3%	India's **avg. utility cost post-subsidies** is 10-15% lower than China
Tax	-0.02%	Slightly higher **effective tax rate** in India
Finance	-0.1%	Prime **lending rate** in *China at 3.45%* vs MCLR in *India at 9.37%*
Overall Cost Disability	**-9.6%**	

Figure - 5.2

The auto component sector plays a crucial role in India's economic growth, offering significant potential for job creation and export revenue. To compete effectively on the global stage, robust policy support is of utmost importance to overcome structural challenges, attract investments, and foster innovation. Achieving these objectives will require a strategic blend of investments, enhanced global competitiveness, and measures to improve the ease of doing business.

There are a whole host of components Chassis & Body, Drive transmission & Steering, Engine, Suspension & Braking, Telematics, battery, etc. To further understand the state of each of the components, they have been divided into four quadrants based on their maturity and complexity as shown below in Figure 5.3. Complexity refers to the degree of difficulty in designing, developing, and manufacturing a component or system whereas maturity refers to the degree of development, testing, and validation of a component or system, as well as its acceptance and adoption in the market.

Classification of Automotive Component Based on Manufacturing Complexity of Technology

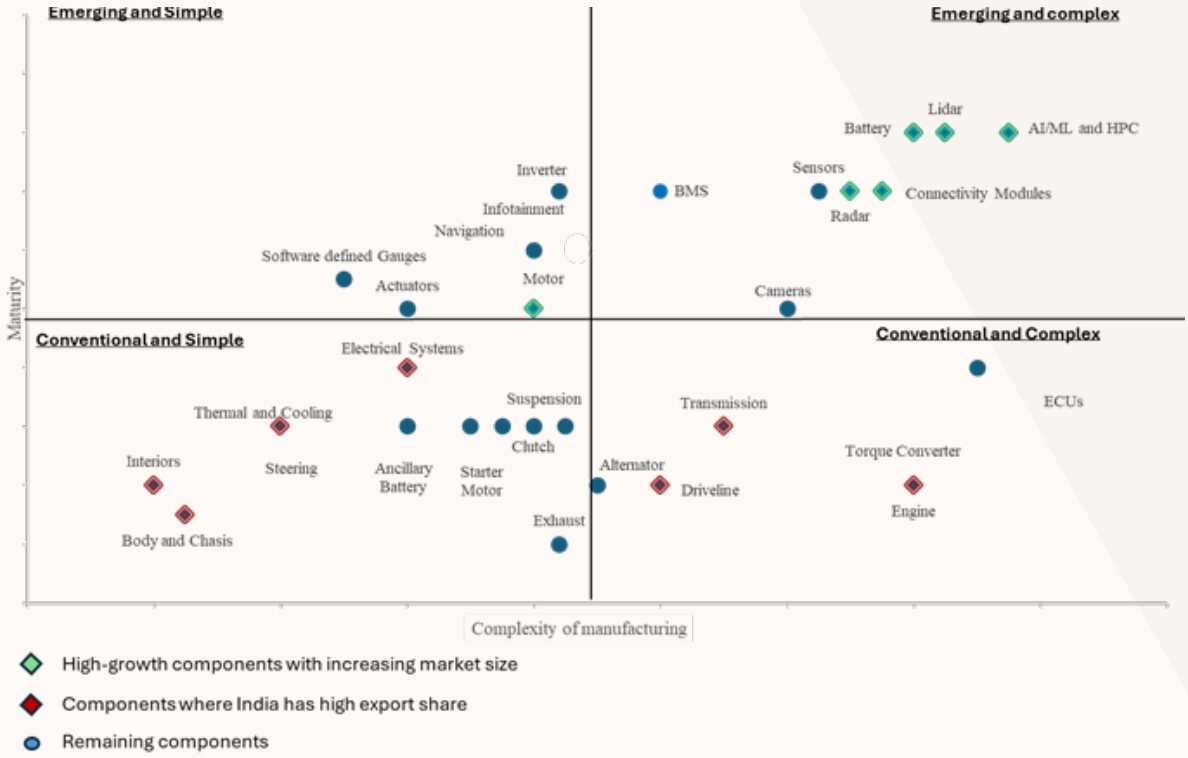


Figure - 5.3

Source: Crisil Intelligence

The plot reveals a clear trend, with components such as Body and Chassis, Exhaust, and Steering, which have been staples of traditional automotive design, clustering in the lower left quadrant, characterized by conventional technology and relatively simple and established manufacturing processes. Components like Driveline, Transmission Systems, and Engines, which are also conventional but have complex manufacturing processes, are positioned in the lower right quadrant. Components like Software defined Gauges, Motor, and Navigation systems, which are continuously evolving and emerging technologies, are positioned in the upper left quadrant, albeit with still manageable manufacturing complexities while components such as Batteries, Lidars in the top right which are emerging as well as complex. This plot provides a framework for understanding the transformative changes underway in the automotive industry and the implications for manufacturers, suppliers, and policymakers. Additionally, we assessed each quadrant's characteristics, challenges, and barriers to entry to identify areas where innovation and investment can have the greatest impact.

5.1.3 EMERGING AND COMPLEX QUADRANT

5.1.3.1 Characteristics

This quadrant includes components that lay the foundation for the future of global mobility. The components included are advanced in terms of technology and complex in terms of manufacturing and functioning. They require high R&D as well as capex investments. The items are mostly smart and require high

computational ability. The components within this quadrant not only involves hardware that functions inside the vehicle but also the systems that are present outside the automobile system performing executing functions of the vehicles. Most of the technology is at a nascent stage, which provides a fair competitive field to become a leader in the respective technological space.

This quadrant is marked by complex manufacturing processes and intricate vehicle subsystems. It features advanced raw materials, such as high-performance battery systems, which require sophisticated manufacturing to ensure energy density, safety, and reliability. Additionally, the quadrant includes cutting-edge technologies like advanced sensors, 5G connectivity, and High-Performance Computing (HPC) and Artificial Intelligence/Machine Learning (AI/ML) components. These components demand specialized manufacturing expertise and precision engineering, making manufacturing challenging. Despite the difficulties, companies that can master these complexities will be well-positioned to capitalize on the opportunities in this space.

With a well-developed domestic automotive market, focus on this technology adoption and its manufacturing can help India achieve meaningful market share in the future of global mobility, at the same time ensuring our dependence on imports for meeting domestic requirement is minimized.

5.1.3.2 Challenges

The quadrant of emerging technology and complex manufacturing offers a challenging and complex environment, marked by technological uncertainty, integration risks, and significant investments in research and development.

An analysis of the manufacturing process in this quadrant reveals several key factors that contribute to its complexity. Firstly, the production of advanced components requires a high degree of technological expertise, including materials science, electrical engineering, and computer architecture. For instance, the development of advanced Lidar sensors requires expertise in photonics, optics, and semiconductor design, as seen in companies like Velodyne Lidar and Quanergy Systems. Secondly, the integration of multiple technologies increases the risk of errors and defects, making quality control a critical aspect of the manufacturing process. For example, the production of 5G connectivity modules involves the integration of multiple components, including antennas, amplifiers, and processors, which can lead to errors and defects if not properly calibrated, as seen in companies like Qualcomm and Intel. Finally, the production of advanced components requires significant investments in research and development, as well as in capital equipment and manufacturing infrastructure. For instance, the development of advanced battery systems requires significant investments in research and development, as well as in specialized manufacturing equipment, as seen in companies like Tesla and LG Chem.

To thrive in this quadrant of nascent technology and complex manufacturing, companies must be prepared to overcome three significant challenges. Firstly, they must be willing to invest heavily in Research and Development (R&D) to

stay at the forefront of technological innovation, as the development of advanced components requires continuous advancements in materials science, electrical engineering, and computer architecture. Secondly, they must be prepared to make substantial capital expenditures (Capex) to acquire and maintain the specialized manufacturing equipment and infrastructure necessary to produce these complex components. Finally, they must possess a highly skilled workforce with expertise in multiple disciplines, , to design, develop, and manufacture these advanced components.

5.1.3.3 Barriers

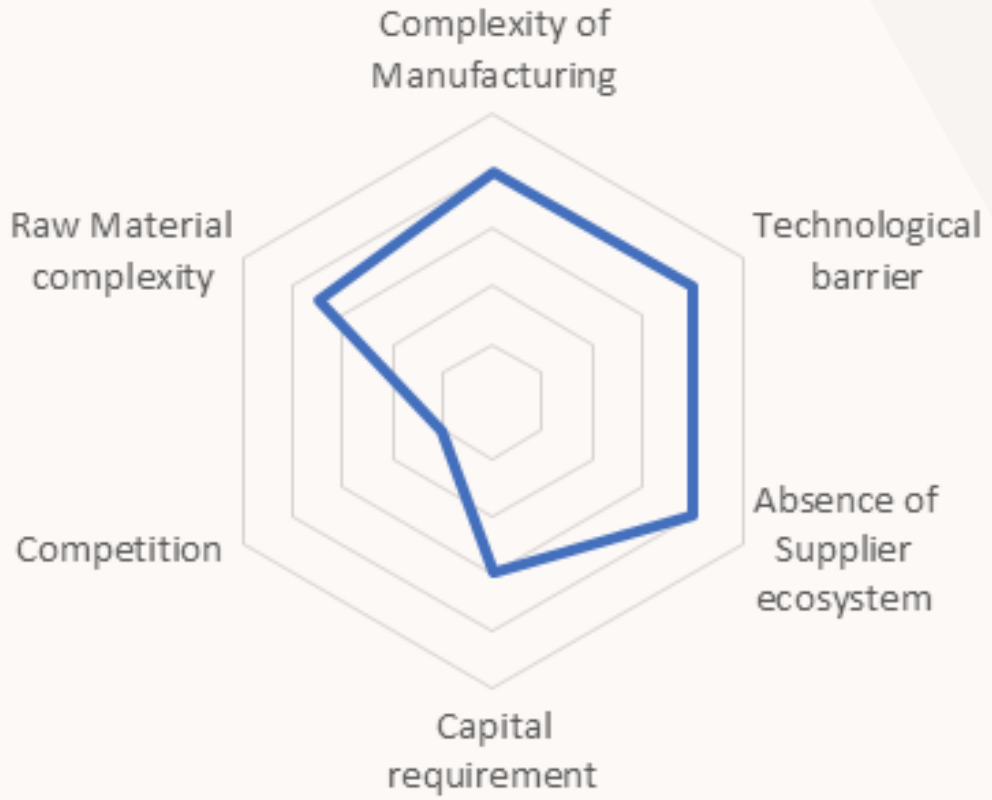


Figure - 5.4

The emerging and complex quadrant poses significant challenges for companies. The complexity of manufacturing is a significant hurdle, requiring substantial expertise and specialized machinery. Additionally, the complexity of raw materials used adds another layer of difficulty. Technological barriers are also very high, involving cutting-edge technologies like AI and advanced sensors, which demand significant R&D investment and expertise. The absence of a robust supplier ecosystem limits access to reliable and high-quality components, leading to higher costs and delays. While capital requirements are significant, funding is available through government incentives, venture capital, banking ecosystem and industry partnerships. Finally, competition is relatively low, providing an opportunity for early movers to capture market share, but it will increase as the technology matures.

5.1.4 CONVENTIONAL AND COMPLEX

5.1.4.1 Characteristics

This quadrant comprises components that are well-established in the automotive industry, yet require sophisticated manufacturing processes and expertise. These components have matured over time, with their technologies being refined and optimized through years of development and iteration. While they may not be as evolving as their emerging counterparts, they are no less critical to the functioning of modern vehicles. Notably, many of the components in this quadrant have a high share in India's export market, underscoring their importance to the country's automotive industry.

The Conventional and Complex quadrant is characterized by powertrain and drivetrain components that are intricate in design and demanding in terms of manufacturing tolerances. The Engine, Transmission, Gearbox, and Torque Converter are all examples of components that require high-precision engineering and advanced manufacturing techniques to ensure optimal performance, efficiency, and reliability. The raw materials used in these components, such as steel, aluminum, and copper, are also undergoing significant advances, with the development of new alloys and materials that offer improved strength, durability, and sustainability. As these advances continue, we can expect to see even more innovative and efficient components emerge from this quadrant, further solidifying India's position as a major player in the global automotive industry.

5.1.4.2 Challenges

The Conventional and Complex quadrant is characterized by established industries with well-defined products and processes, but it faces significant challenges that threaten to erode its competitiveness. One of the primary challenges is the technology laggardness compared to other nations. For instance, while German manufacturers have adopted advanced robotics and automation in their production lines, many companies in this sector still rely on manual labour and outdated machinery. This has resulted in a significant gap between the sector's domestic manufacturing capabilities and those of other countries, making it difficult for companies to compete on a global scale. Furthermore, the quality of products manufactured in this sector often lags those of other nations. For example, while Japanese automakers are known for their high-quality vehicles with advanced safety features, some companies in this sector still produce vehicles with outdated safety features and lower quality materials.

Another significant challenge is the lack of a skilled workforce, as the existing workforce ages and retires, and companies struggle to find qualified replacements with the necessary skills and expertise to operate and maintain complex manufacturing systems. For instance, a leading aerospace company in this sector has reported a shortage of skilled welders, resulting in production delays and increased costs. This shortage of skilled labor is exacerbated by the lack of

investment in vocational training and education, making it difficult for companies to find the talent they need to remain competitive. To overcome these challenges, companies in the Conventional and Complex sector must be willing to invest in technology upgrades, workforce development, and innovation to revitalize their competitiveness and ensure a sustainable future. This includes embracing Industry 4.0 technologies, such as automation, artificial intelligence, and data analytics, to improve efficiency and productivity, and closing the quality gap with other nations.

5.1.4.3 Barriers

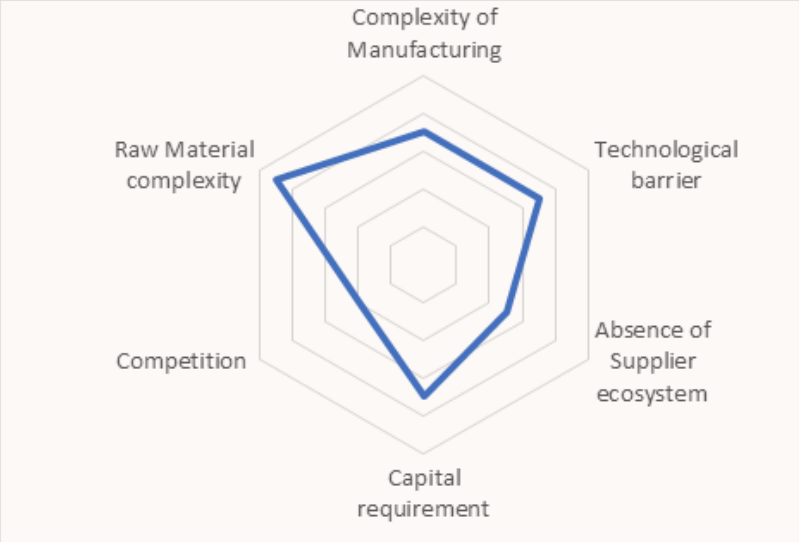


Figure - 5.5

The Conventional and Complex quadrant is characterized by a multitude of barriers that hinder its growth and competitiveness. The complexity of manufacturing processes and technological hurdles contribute to the sector's challenges. Furthermore, the high capital requirements and intricate raw material sourcing and processing needs, which are becoming increasingly advanced, add to the sector's difficulties. Further, the supplier ecosystem, while not absent, is dominated by a few prominent large players, limiting options and increasing dependence on these key suppliers. These barriers can lead to increased costs, reduced efficiency, and decreased innovation, ultimately affecting the sector's ability to adapt to changing market conditions.

5.1.5 EMERGING AND SIMPLE

5.1.5.1 Characteristics

This quadrant includes components that are becoming important for global mobility. They use advanced technology but are manageable to manufacture and operate, given their applications in numerous other industries, making production feasible. These components also need relatively low investment. Nascency of the technology provides a great opportunity for India to invest, both to meet local demand and to stay competitive in the export market.

This quadrant of emerging technology and simple manufacturing is characterized by vehicle subsystems that are still evolving rapidly on the technology front and but can still be manufactured using relatively lesser complex process. It houses components such as Infotainment system, which is an in-car system that provides information and entertainment, usually in the form of a screen mounted in the car dashboard. Additionally, automotive navigation system is a computer mapping tool used to assist drivers in locating their destination. The quadrant also includes software define gauges which typically use software to render and display information rather than traditional electromechanical gauges. It is also home to certain components of electric vehicles such as electric motors which use power from the traction battery pack and drives the vehicle's wheels. Overall, these components are characterized by their high degree of innovation as well as scalability as they can grow and expand as demand increases or as they become more refined.

5.1.5.2 Challenges

The quadrant of emerging technology and simple manufacturing is marked by technological uncertainty, funding gap, risk aversion and talent shortage.

The regulatory landscape in India is evolving, and businesses especially dealing with nascent technologies often struggle to keep up with changing laws, especially related to data privacy and intellectual property. The government is introducing new frameworks keeping in mind evolving needs, and hence companies need to keep their product portfolio and their growth strategy in compliance with the evolving dynamics. Also, such technologies usually require a shift in mindset, both for businesses and consumers. Indian businesses and consumers may be slower to adopt to new technologies due to cost concerns, trust issues and preference for traditional methods, slowing down the market's readiness for innovation. For instance, in case of electric motors, the transition to electric vehicles is essential. However, despite the availability of incentives, EV adoption in India remains below 10% across most of the vehicle categories, this is not just owing to consumer inertia, but also due to enabling ecosystem as well as manufacturing waiting for economies of scale to kick in.

Secondly, the introduction of emerging technologies although comparatively simpler in nature require special knowledge and workers who can operate new machines, maintain quality control and ensure production efficiency.

5.1.5.3 Barriers

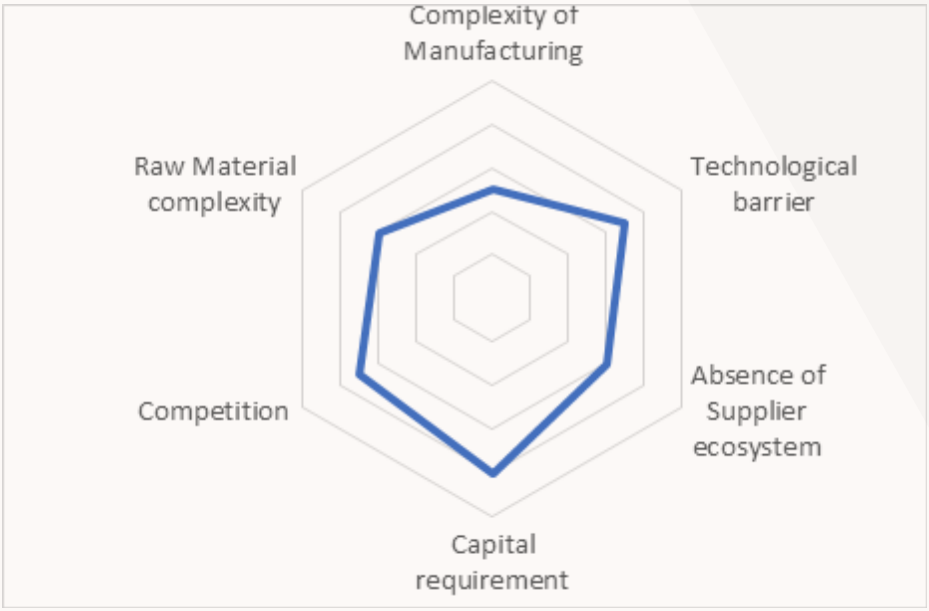


Figure - 5.6

The emerging and simple quadrant poses significant challenges for companies. Competition is very high, due to limited R&D investment and a feasible manufacturing process. The absence of a robust supplier ecosystem limits access to reliable and high-quality components, leading to higher costs and delays. Capital requirements are limited; however, funding is difficult due to emerging technology as organizations usually like to invest in proven technologies. Finally, capital requirement is moderate, with innovation and expertise required, but can be managed with due efforts.

5.1.6 CONVENTIONAL AND SIMPLE

Majority of components that we currently export and required by domestic market are in this segment

5.1.6.1 Characteristics

The conventional and simple quadrant comprises components that have reached a high level of maturity in terms of technology and manufacturing processes. These components are well-established in the market, with widely accepted standards and specifications, and are produced using relatively simple and well-understood manufacturing processes.

This quadrant is home to components such as traditional mechanical components, electrical systems, and interior and exterior trim components. These components are characterized by their high-volume production, low complexity, and relatively low R&D requirements. The manufacturing processes for these components are well-established and widely available, with many suppliers offering similar products.

The conventional and simple quadrant is marked by high competition, low margins, and a focus on cost reduction and efficiency improvements. Companies operating in this quadrant must be able to produce high-quality components at low costs, with a focus on lean manufacturing, process optimization, and supply chain management.

Overall, the quadrant is characterized by its focus on efficiency, cost reduction, and high-volume production, with relatively simple manufacturing processes and well-established technologies.

5.1.6.2 Challenges

Components in the conventional and simple quadrant, such as wiring harnesses and basic interior components, involve straightforward manufacturing processes with minimal technological advancement. These components have standardized designs and established supply chains, making them accessible to a broader range of manufacturers. However, maintaining quality standards is still critical, especially for safety and durability. The main challenges here include cost competitiveness and achieving economies of scale. Companies need to focus on optimizing production efficiency, better access to raw materials and lean manufacturing techniques to reduce costs and improve margins. Government and industry associations can support small and medium enterprises (SMEs) by offering fiscal incentives, facilitating access to low-cost capital, and providing quality certification support to enhance market competitiveness.

5.1.6.3 Entry barriers

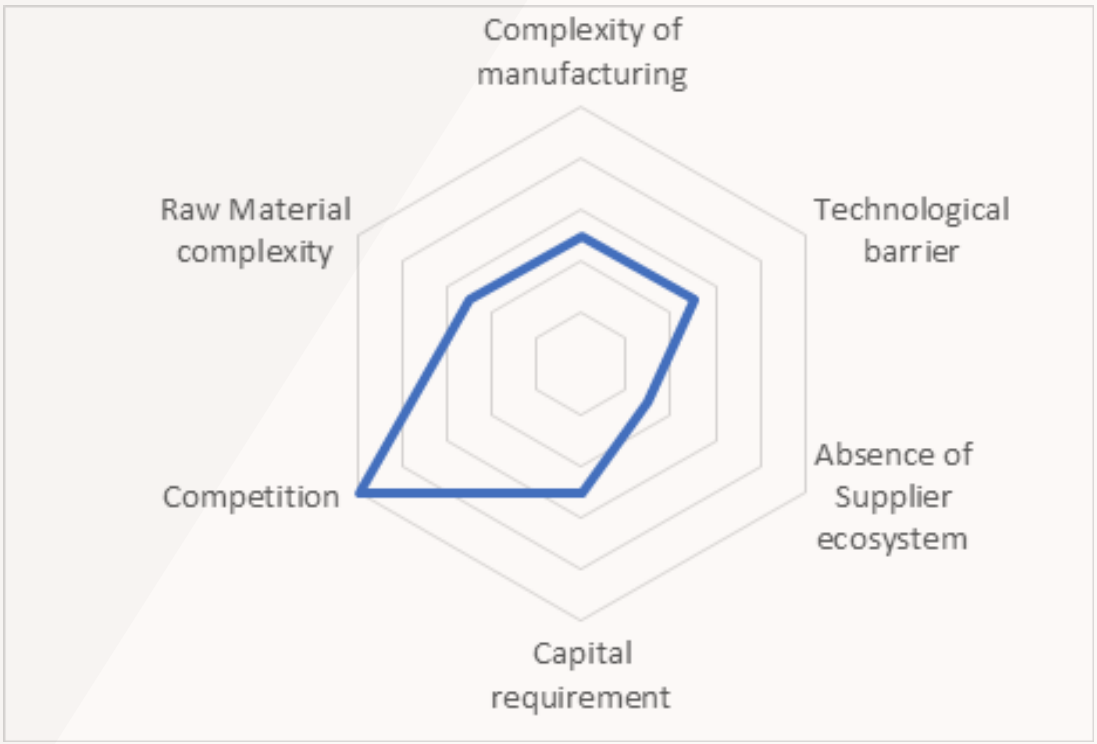


Figure - 5.7

The mature and simple quadrant presents moderate entry barriers for companies. The complexity of manufacturing is low due to standardized processes and well-established techniques, which makes production accessible to many players. Technological barriers are minimal, as mature technologies require limited innovation, focusing more on efficiency improvements. The supplier ecosystem is robust, given the widespread availability of materials and components needed for relatively simple manufacturing processes, reducing risks associated with procurement. Capital requirements are relatively low, primarily needed for scaling operations and incremental process improvements. Competition remains high, driven by low entry barriers and a focus on price competitiveness. Finally, raw material complexity is minimal, with most inputs readily available, but companies must manage raw material as well as supply chain costs effectively. Success in this quadrant hinges on operational efficiency and cost management rather than technological innovation.

5.1.7 FRAMEWORK

To achieve the Vision 2030 goals, India must focus on its core competencies and prioritize specific segments with the greatest potential. These segments should be chosen based on market opportunity and India's strengths. Incentives and policy interventions, therefore, needs to be concentrated on these prioritized segments to maximize growth and competitiveness rather than spreading them thin across several components.

Negative | No major effect | Positive

Key systems in ICE auto component value chain

Key systems	Key sub-components	Share of ICE BOM *(excl. Assembly costs)*	Growth Trend
Engine	Cylinder, pistons, turbochargers, exhaust, etc.	~23%	↓
Chassis & Body	Chassis components, frame, and body structure, exterior panels, etc.	~20%	→
Drive transmission & Steering	Clutch, transmission gears, axles, etc.	~17%	↓
Electronics & Electrical	Display units, infotainment, connectivity, Inverter, DC-DC converter, onboard charger, HV cables etc.	~13%	↑
Interiors	Seats, airbags, seatbelts, etc.	~11%	→
Suspension & Braking	Actuators, sensors, shock absorbers, stabilizers, etc.	~7%	→
Cooling system	Radiator, thermostat, fan, water pump, etc.	~5%	→
Telematics	Audio and telematics	~2%	↑
Consumables & Misc.	Wheels, Tires, engine oil, etc.	~2%	↓

Key systems in EV auto component value chain

Key systems	Key sub-components	Share of EV BOM *(excl. Assembly costs)*	Growth Trend
Battery	Battery cells, BMS,	~28%	↑
Electronics & Electrical	Display units, infotainment, connectivity, ADAS, Inverter, DC-DC converter, onboard charger, HV cables etc.	~23%	↑
Chassis & Body	Chassis components, frame, body structure, exterior panels	~15%	↑
Interiors	Seats, airbags	~8%	↑
Suspension & Braking	Regenerative braking, electric brake, shock absorber, etc.	~5%	↑
Drive transmission & Steering	E-drive module, drive computer, etc.	~11%	↑
Cooling system	HVAC systems	~6%	↑
Telematics	Audio and telematics	~2%	
Consummables & Misc (Tires)	Wheels, Tires, fasteners, adhesives, and other assembly components	~2%	↑

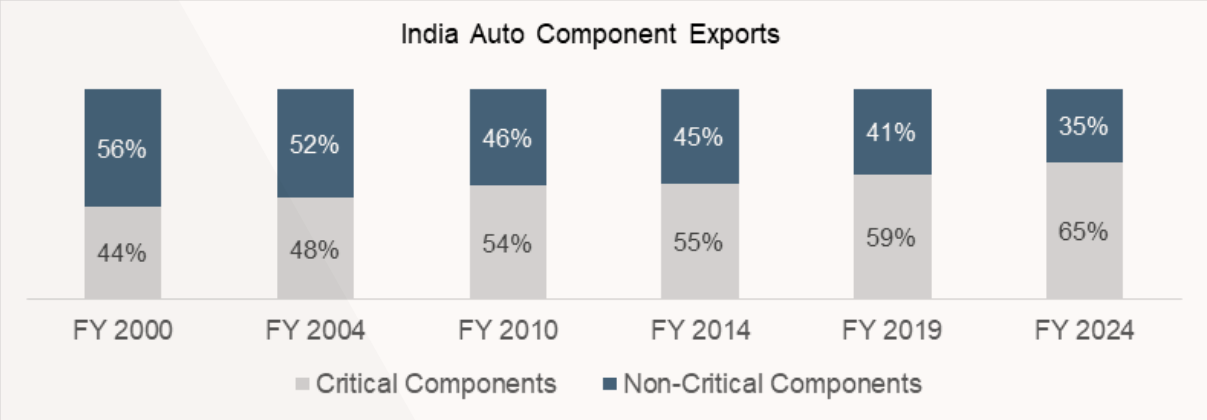
Auto Components included in PLI | Auto Components partially covered by PLI

Figure - 5.8

The Production-Linked Incentive (PLI) scheme for ACC batteries and auto components has partially incentivized the production of these critical components, as illustrated in the Figure 5.8. While the scheme has provided a boost to the industry, more investments should be directed towards engine and transmission components to further propel the Indian auto component market.

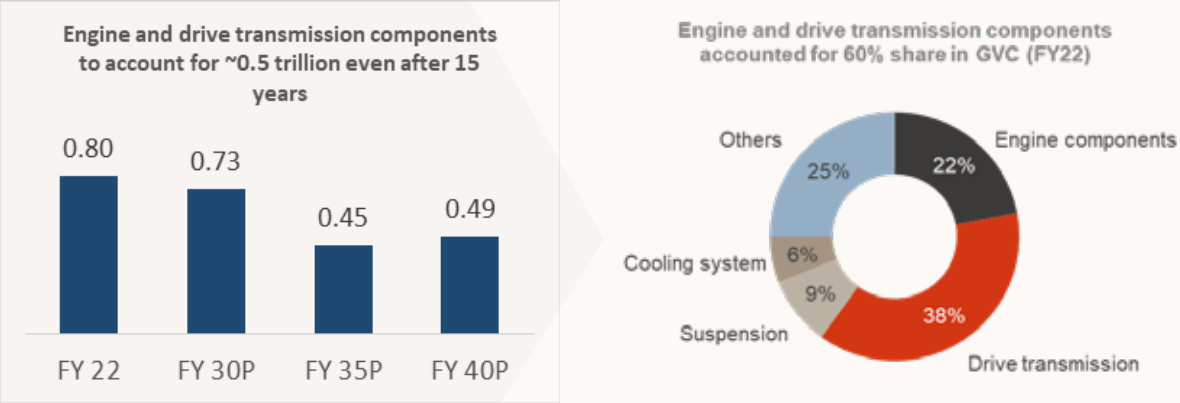
Engine and drive transmission components contribute nearly $0.8 trillion to global consumption. Even with the advent of EVs, these components continue to demonstrate market potential, driven by the ongoing presence of internal combustion engine (ICE) vehicles and replacement demand. In fact, they account

for over 50% of global auto component exports, underscoring their significance in the industry. Moreover, In India, the export mix has undergone a significant shift, with high-value components, particularly engine and transmission system parts, increasingly dominating the country's export landscape as highlighted below.



Source: Crisil Intelligence

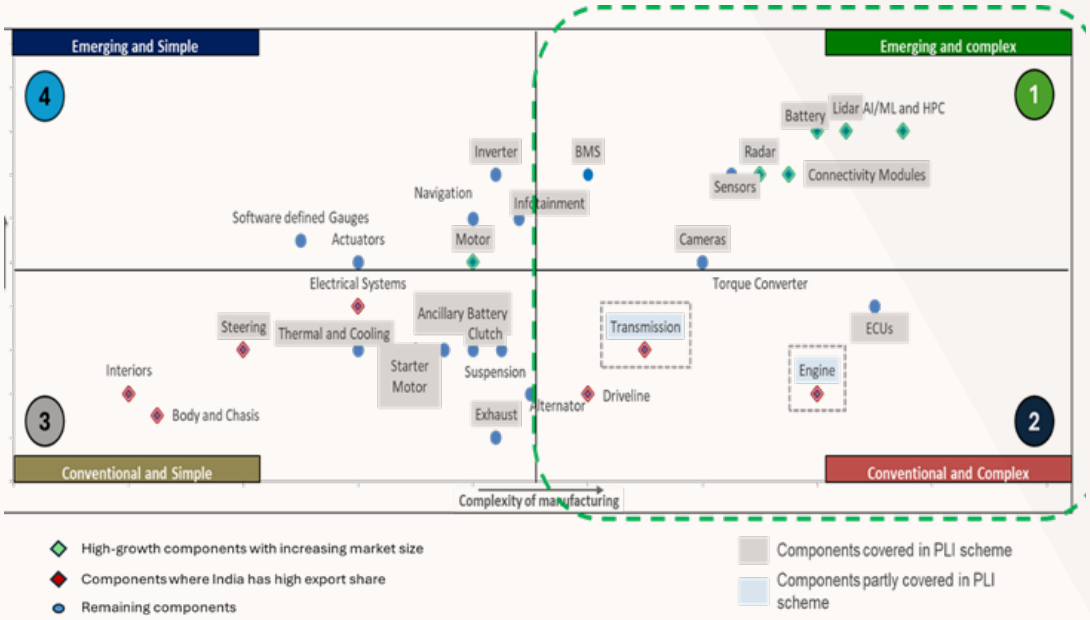
Figure - 5.9



Source: Crisil Intelligence

Figure - 5.10

Given their significant contribution to India's export basket and substantial growth prospects, components in the 'Emerging & Complex' and 'Conventional and Complex' quadrants are poised to drive the country's automotive export growth. Incentives should be strategically focused on these two quadrants, with a specific emphasis on engines and transmissions as other components are already covered under the PLI scheme to capitalize on its existing strengths in these areas and establish a larger presence in the global auto component market, as illustrated in the figure below.



Source: Crisil Intelligence

Figure - 5.11

5.2 A SUMMARY OF FISCAL AND NON-FISCAL INTERVENTIONS IS AS UNDER:

Based on the above-mentioned quadrants, the necessary policy initiatives and reforms to help the industry scale up production, enhance capabilities, and integrate into global supply chains have been broadly categorized into two major heads:

i. Fiscal interventions for Production support for auto components manufacturing, Improving India's R&D ecosystem, Enhancing Skilling and industrial infrastructure development; and

ii. Non-fiscal interventions encompassing technology transfer, enhancing ease of doing business, exploring FTAs and others in the auto component sector.

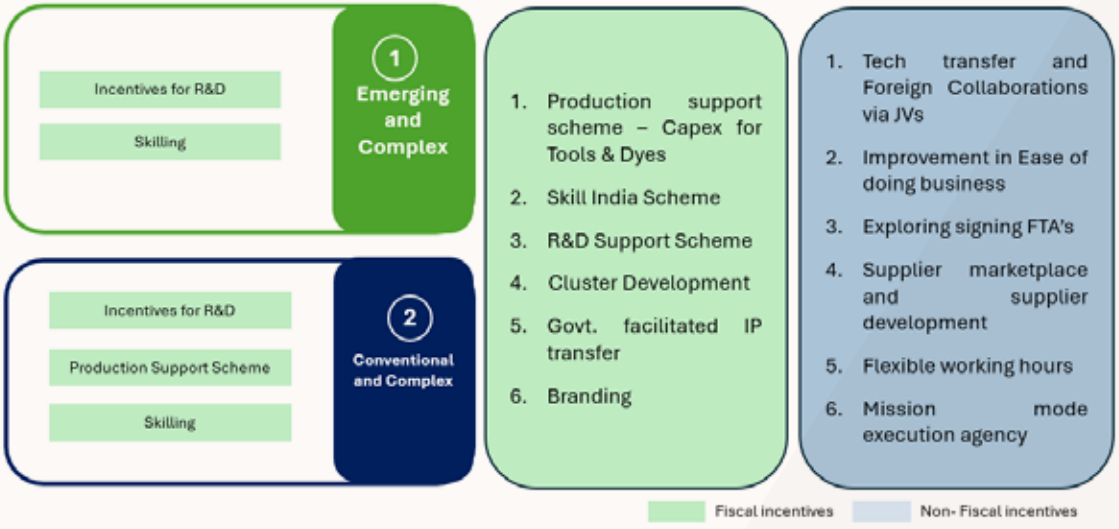
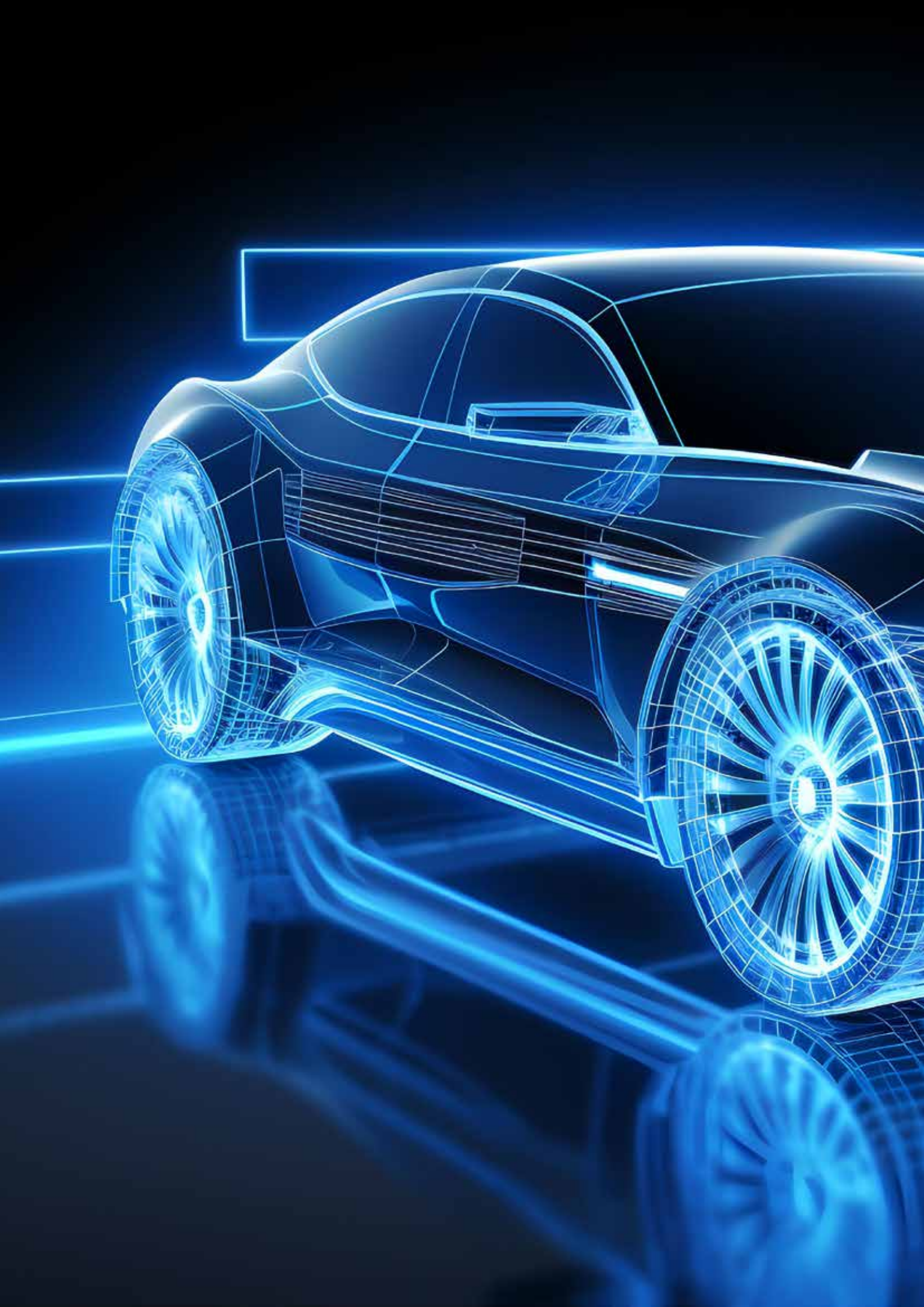
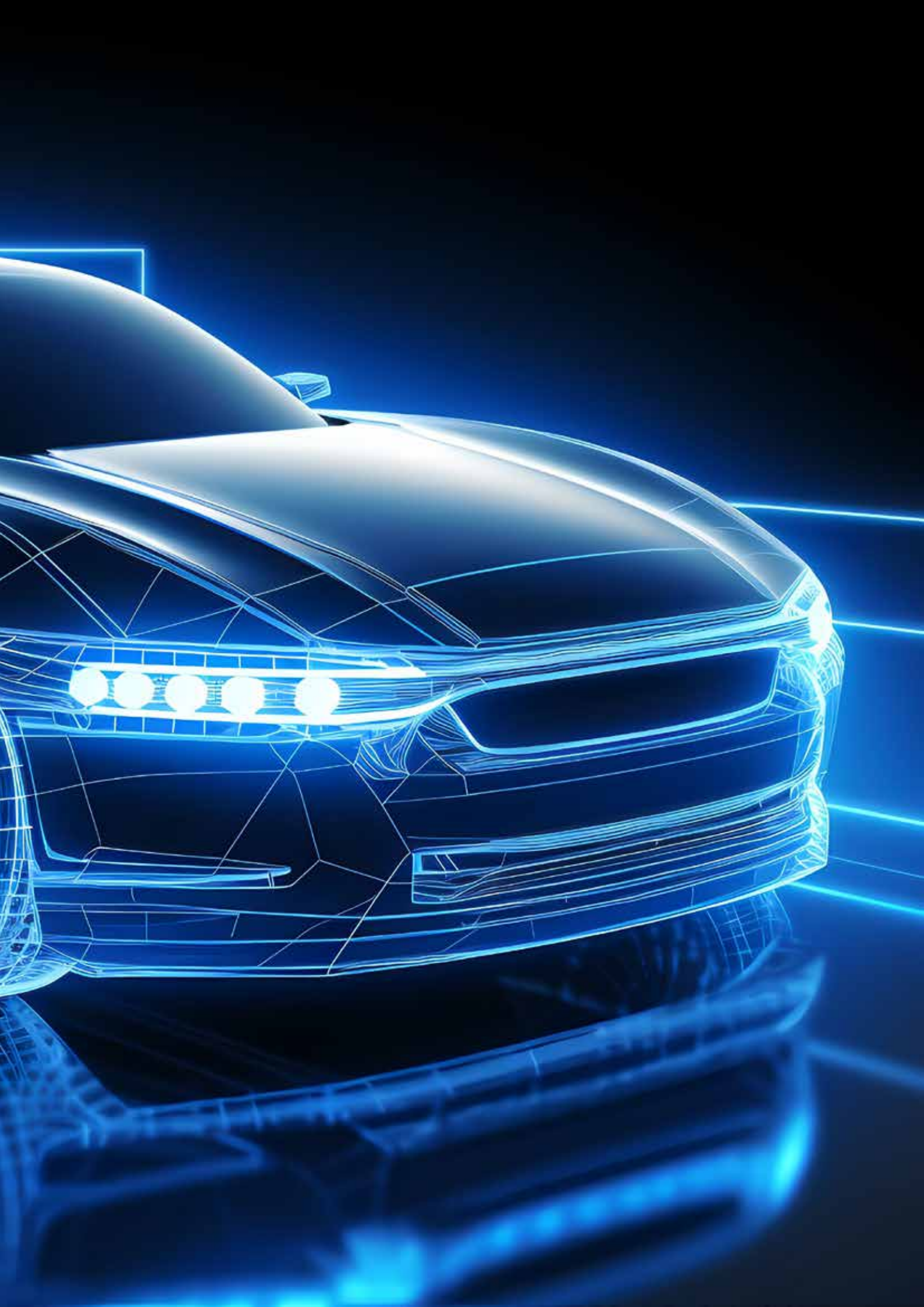


Figure – 5.12





6 Chapter

INTERVENTIONS AND RECOMMENDATIONS

6.1 FISCAL INCENTIVES FOR COMPONENT MANUFACTURING:

Numerous government programs are designed to boost domestic production of cutting-edge automotive technologies, draw in investments, and enhance the supply chain. These schemes are intended to offer targeted financial incentives, foster economies of scale, and tackle key industry hurdles. However, their effectiveness is often undermined by a misalignment with the specific needs of the auto components sector. Unlike assembly, which benefits from a capital-to-output ratio of 1:8 to 1:16, the auto components industry operates with a much lower ratio of 1:1 to 1:2. This means that investments in auto component manufacturing yield less output compared to assembly operations.

As highlighted in Para 5.1, Indian companies and components face a cost handicap of 10% and to bridge this gap, there is a need to provide fiscal incentives for auto component manufacturing. While providing the incentive, it is pertinent to incentivise only selected components as done in figure 5.11.

6.1.1 SCHEME 1: PRODUCTION SUPPORT SCHEME:

The Production Support Scheme – The scheme is proposed to comprise of 2 major aspects for incentivising automotive components and tools and dies for manufacturing of these components

i. Opex support for scaling manufacturing of components in quadrant 2 identified in Figure 5.11

ii. Capex support for manufacturing of tools and dies for manufacturing auto components in India

Details of the scheme is as below:

Scheme 1A: Opex support to achieve scale of components

Recommendations: New scheme with incentive rate and qualification thresholds curated for component specific unit economics, making it attractive for manufacturing these components in India

Target Segments: Components identified under Quadrant 2, Refer Fig 5.11.

List of eligible products:

- Engine & engine components: Engine cylinder & cylinder heads, Pistons & engine valve, Crankshaft & camshaft
- Transmission Systems: Transmission gears, Axles

(Components that have been covered under auto-components PLI have been excluded)

Scheme 1B: Capex support for tools and dies

Recommendations: New scheme with incentive rate and qualification thresholds curated for specialized equipment required to manufacture focused tools and dies for auto component manufacturing

Target Segments and List of eligible products: Tools and Dies for manufacturing of automotive components

6.2 SKILLING INCENTIVES FOR COMPONENT MANUFACTURING:

India is home to one of the world's largest engineer populations, yet it faces a talent shortage of manpower in high-precision manufacturing. Companies often incur high costs to build training infrastructure and provide specialized training, primarily due to outdated curricula in educational institutes and graduate engineers not having the required skills. Global companies also struggle to find local institutes that offer the necessary skills training, often turning to partnerships with foreign universities. Addressing this issue requires a strategic focus on developing skilled manpower to meet short-term, medium-term, and long-term talent needs.

India has a vast pool of human resources, yet the employability of its youth remains a significant challenge. To address this issue, the government has recently introduced several initiatives aimed at enhancing skill development and providing employment opportunities:

a. Employment Linked Incentive Scheme (ELI):

In the Union Budget of 2024-25, the Prime Minister's package of ₹2 lakh crore has been allocated to promote employment, focusing on both employers and employees, with a particular emphasis on the Employees' Provident Fund Organisation (EPFO). This package includes a range of schemes:

- **Scheme A: First-Time Employment Scheme:** This scheme is expected to benefit 2.1 crore youth over 2 years will provide one-month wage to all persons newly entering the workforce in all formal sectors. The eligibility limit will be a salary of Rs. 1 lakh per month. Direct benefit transfer of one-month salary will be up to Rs. 15,000 in 3 installments to first-time employees, as registered in the EPFO.

- **Scheme B: Job Creation in Manufacturing:** This scheme aims to drive significant hiring of first-time employees in the manufacturing sector, benefiting 30 lakh youth and their employers. It offers incentives to both employees and employers based on EPFO contributions during the first 4 years of employment. However, if the employment ends within 12 months, the employer must refund the subsidy.

- **Scheme C: Support to Employers:** Financial assistance for employers hiring additional employees. This employer-focused scheme covers all additional employment with a salary of up to ₹1 lakh per month across all sectors. New employees under this scheme do not need to be first-time EPFO entrants. The government will reimburse employers up to ₹3,000 per month for 2 years towards EPFO contributions for each additional employee. The scheme aims to incentivize the creation of 50 lakh jobs.

Incentive rates in first 4 years: 24%: 24%: 16%: 8%

Eligibility:

- Applicable to first-time employees in the manufacturing sector.

- All employers, both corporate and non-corporate, with a three-year track record of EPFO contribution will be eligible.
- Employees must work directly for the entity that pays them salary or wage, i.e., an in-sourced employee.
- Employees with a wage or salary of up to Rs.1 lakh per month will be eligible, subject to the EPFO contribution.

b. Employment and Skilling:

- **Scheme D: Skilling Programme and Upgradation of Industrial Training Institutes:** This new Central Sector Scheme (CSS), with a total allocation of ₹60,000 crore, aims to skill 20 lakh youth over the next five years. To achieve this, 1,000 Industrial Training Institutes (ITIs) will be modernized in a hub-and-spoke model with a strong focus on tangible outcomes. The course curriculum will be updated to align with industry requirements, and new programs will be introduced to cater to emerging skill demands.
- **Scheme E: Prime Minister's Internship Scheme:** PM Internship Scheme has been launched to enhance youth employability by providing internship opportunities in top companies across the country. Scheme offers 12 months internship opportunities for Indian citizens aged between 21 and 24 years who are not engaged in full-time education or employment. Each intern receives a monthly stipend of ₹5,000, along with one-time financial assistance of ₹6,000.

Eligibility:

- Indian citizen between the age of 21 and 24 years
- 10th pass, 12th pass, or a UG degree or diploma holder
- Candidates must also not have either a part-time or a full-time job already

The Indian auto component sector, set for substantial growth, needs a highly skilled workforce to sustain and boost its global competitiveness. Addressing this critical requirement calls for a comprehensive approach centred on skilling initiatives. These initiatives are designed to bridge the gap between the current educational curriculum and industry needs, attract top talent, and elevate the overall skill levels of the workforce. To enhance the auto component sector in India, several strategic targeted skilling initiatives are essential:

6.2.1 SCHEME 2: GVC SKILLING INDIA SCHEME:

Recommendation: To offer a incentive capped at a certain amount, to eligible players in the Auto component industry

Target Segments: Components identified under Quadrant 1 & Quadrant 2, Refer figure 5.11.

6.2.2 NON-FISCAL SKILLING INCENTIVES:

A multi-faceted strategy is required to facilitate short-term, medium-term and long-term skilling requirement. Some of the skilling initiatives required are as under:

1. **Attract overseas talent and motivate high-level Indian talent to return to India:** There is a need to attract highly skilled NRIs by offering various incentives and for retaining highly skilled overseas talent. For this, India should consider a two-pronged approach as under:

    - Firstly, implement attractive incentives like providing right to purchase residence in India to foreigners, streamlined visa processes, and guaranteed long-term employment opportunities, mirroring China's Thousand Talents Program (TTP).

    - Secondly, develop designated foreign townships within existing auto component hubs, fostering a sense of community and cultural exchange. These measures will make India a more competitive destination for global talent, ultimately driving innovation and economic prosperity.

2. **Develop specialized engineering, research and design courses:** There is a need to develop specialized engineering, research, and design courses at Indian higher education institutions to prepare the future workforce by focusing on advanced technologies and industry needs.

3. **Support Training of Trainers (TOT) through exchange programs:** Support the Training of Trainers (TOT) program through international exchange initiatives and partnerships with global institutes and multinational corporations (MNCs) for curriculum development and research and development (R&D) in the automotive component manufacturing.

4. **Bridge the gap between university curricula and industry requirements:** Bridge the gap between university curricula and industry requirements by identifying key skills, promoting apprenticeship programs, and expanding initiatives such as the National Apprenticeship Promotion Scheme (NAPS).

5. **Upgrade curricula and run specialized training courses in partnership with OEMs and tech institutes:**

    - Upgrade educational curricula and develop specialized training programs through partnerships with Original Equipment Manufacturers (OEMs) and leading technical institutes.

- Establish advisory boards comprising industry experts, academia, and technical professionals to ensure curriculum alignment with evolving industry needs. These boards will provide guidance on incorporating the latest technological advancements and industry best practices into the training modules.

- Additionally, promote e-Learning initiatives to make skill development more accessible and flexible, allowing trainees to acquire knowledge at their own pace while keeping up with industry standards and innovations. This integrated approach will help create a workforce equipped with relevant, up-to-date skills.

6. **Expedite Visa approvals for training/ business visits: T**o facilitate the movement of skilled professionals, especially in Auto and Auto components industry, India could establish Memorandums of Understanding (MoUs) with partner countries. These MoUs should aim to simplify visa regulations and expedite the visa processing for professionals traveling for training and development purposes. This initiative would promote knowledge exchange and strengthen collaboration within the industry, accelerating India's technological progress and innovation in these sectors.

6.3 INCENTIVES FOR R&D ECOSYSTEM DEVELOPMENT

The auto component sector in India is on the brink of significant growth but faces intense global competition and rapid technological advancements. To stay competitive and meet future demands, there is a critical need to strengthen R&D efforts within the industry. Investing in R&D will enable the Indian auto component sector to position them as a global leader, driving sustainable growth and expanding export potential over the next 4-5 years.

To support R&D in this sector, the government should establish a dedicated, outcome-based R&D fund that partially incentivises R&D expenses. This initiative would encourage innovation by reducing the financial burden on companies. Additionally, offering incentives for product innovation can further stimulate technological advancements and enhance the quality and efficiency of auto components made in India. Such efforts will not only enable Indian manufacturers to compete globally but also promote the development of advanced technologies like electric vehicle components, cutting-edge safety systems, and fuel-efficient parts.

A multi-faceted strategy encompassing incentives, setting up of Research institutes and transitioning to build to design models is required to facilitate short-term, medium-term and long-term R&D initiatives in India.

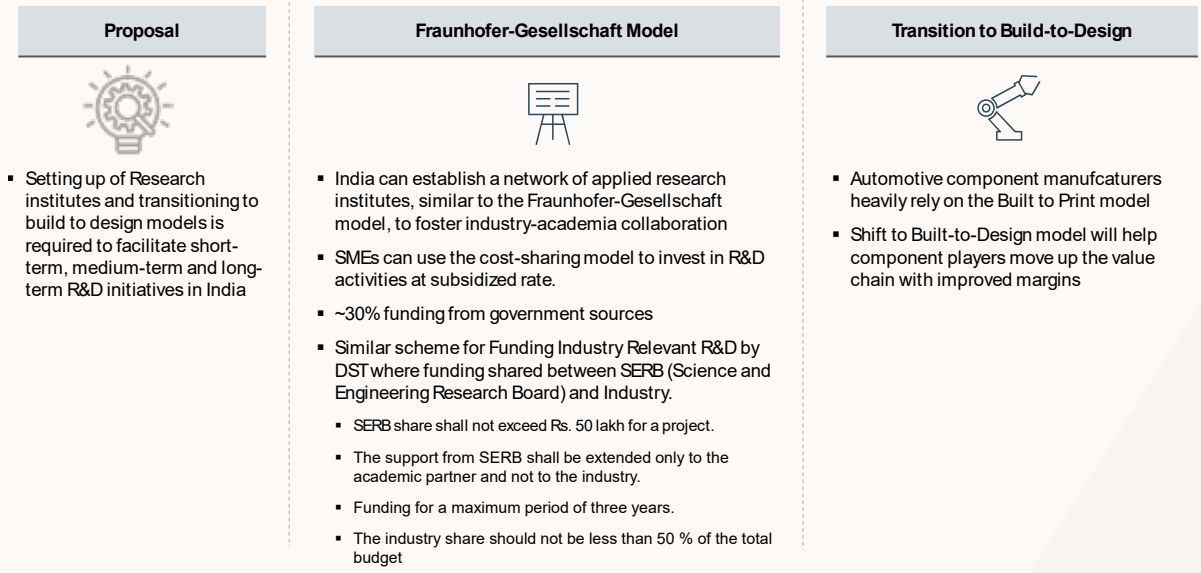


Figure 6.1

Fiscal policies should focus on incentivizing R&D investments and fostering collaborations between industry and research institutions.

6.3.1 SCHEME 3: FISCAL INCENTIVE FOR ELIGIBLE COMPONENTS FOR R&D SUPPORT:

Recommendation: Implement a strategic R&D support scheme with financial incentives across product categories to foster innovation and build globally competitive Indian auto component manufacturers

Target Segments: Components identified under Quadrant 1 & Quadrant 2, Refer Figure 5.11.

The R&D incentives could also be used for acquiring IP by Indian companies only on a case-to-case basis.

6.3.2 NON-FISCAL INCENTIVE FOR ELIGIBLE COMPONENTS FOR R&D SUPPORT:

Fraunhofer-Gesellschaft Model:

India can establish a network of applied research institutes, like the Fraunhofer-Gesellschaft model, to foster industry-academia collaboration.

- SMEs can use the cost-sharing model to invest in R&D activities at subsidized rate.
- ~30% funding from government sources
- A similar scheme for Funding Industry Relevant R&D by DST where funding shared between SERB (Science and Engineering Research Board) and Industry.
  - » SERB share shall not exceed Rs. 50 lakhs for a project.
  - » The support from SERB shall be extended only to the academic partner and not to the industry.
  - » Funding for a maximum period of three years.
  - » The industry share should not be less than 50 % of the total budget

Case Study on Fraunhofer-Gesellschaft

Objective

The Fraunhofer-Gesellschaft is a German research organization that focuses on applied research and development in various fields of science and technology.

- Fraunhofer *consists of over 75 institutes* spread across Germany, each specializing in a specific area of applied science, such as materials, manufacturing, digital technology, or life sciences.
- The organization has a strong focus on collaboration with industry and has developed partnerships with many leading companies in Germany and around the world. The organization's research activities are designed to address real-world problems and to develop innovative solutions that can be applied in industry and society.
- Performance Based Funding allocation: The Government funding (30%) is not equally distributed to Fraunhofer institutes. Instead, it is linked to performance – Institute that generate more money from contracts get more public funding as a reward.

Impact

Growth in Sales and Productivity

Short-term Effects: A 1% increase in the size of contracts with Fraunhofer led to:

- 1.3 percentage points increase in sales growth
- 0.8 percentage points increase in productivity growth

Long-term Effects (15 years):

- 18% cumulative growth in sales
- 12% cumulative growth in productivity

Increased patent filings

Firms engaging with Fraunhofer reported increased patent filings and the introduction of new products or processes into the market

Sector-Specific Impact

High-tech and manufacturing sectors benefited most due to their higher dependence on R&D and innovation

Cost Sharing Model benefitting SMEs

For joint projects, companies often pay only a fraction of the cost, as government funding subsidizes the rest. This incentivizes businesses, especially SMEs, to collaborate.

Figure – 6.2

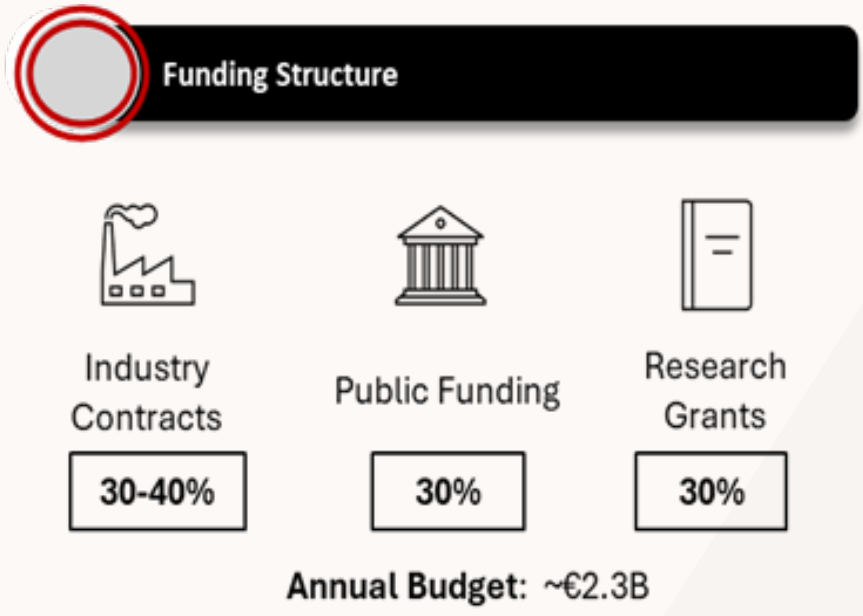


Figure – 6.3

Transition to Build-to-Design:

India's manufacturing sector is currently dominated by the "Build to Print" model, where components are produced based on customer designs, particularly in sectors like automotive components, textiles, and light engineering, which leverage the country's low-cost, high-volume production capabilities. However, to ascend the value chain and compete globally in high-tech sectors, India must transition to the "Build to Design" model, where manufacturers design, engineer, and produce products, thereby owning intellectual property (IP) and commanding higher margins, enabling the country to move beyond its traditional low-cost manufacturing image and emerge as a hub for innovative, high-value products.

6.4 FISCAL INCENTIVES FOR HARD INFRASTRUCTURE

A. Developing world-class industrial infrastructure with plug and play facilities is crucial for enhancing efficiency and reducing operational costs in the auto component sector. Creation of Plug and Play Facilities will ensure minimal set-up time for industries and provide common and shared infrastructure in clusters. India's auto clusters have successfully attracted both domestic and global players in the automotive and auto component industries, offering access to advanced manufacturing facilities and extensive logistics networks. However, these clusters face significant challenges, including limited access to modern technological tools and inadequate warehousing facilities. These limitations impede operational efficiency and competitiveness, highlighting the need for focused infrastructure improvements.

B. Recommendation: A scheme is proposed to develop brownfield large-scale auto clusters with world-class facilities in collaboration with anchor players focused on specific segments, products, or components. There is also a need to undertake a thorough audit of existing auto clusters to evaluate utilization, implementation problems, and the state of facilities provided. The essential suggestions are listed below: -

i. Scale and performance: There is a need to upscale auto clusters and make it attractive to achieve supplier agglomeration and efficiency. It is proposed to revamp 8 existing auto clusters by undertaking a thorough audit of these clusters. Additionally, to ensure success, monitoring metrics such as export turnover, investment levels, and other performance indicators is recommended for tracking progress.

ii. Provisions within a cluster: The cluster should have some common facilities that make them attractive, which inter-alia includes:

- **Common design and R&D Facilities:** Enhance Auto cluster's R&D facilities to suit changing industry requirements (e.g., EVs, hybrid tech, batteries, etc.) by offering design labs (with CAD, CAE, CAM software), material research labs, Prototyping and manufacturing machinery (CNC, 3D printers) and Testing equipment (environment chambers, vibration test chambers).

- **Factories and tool rooms:** Develop factories with state-of-the-art facilities and equipment, Invest in advanced manufacturing technologies and tool rooms (heat treatment, quality control etc.) in proximity to existing major auto clusters.

- **Testing facilities:** Develop testing and validation centres such as environment chambers, electrical and electronic testing, chemical and material analysis, NVH testing, simulation and modelling, compliance testing in multiple hubs for vehicle performance evaluations, durability mileage accumulation, etc.

- **Training Centres:** Establish comprehensive training programs in collaboration with nearby technical universities; focus on specific skills required for the industry in the form of technical training, equipment workshops, classrooms, industry partnerships, and apprenticeship programs.
- **Logistics & warehousing:** Improved connectivity and logistics by providing ready-built warehouses, truck terminals, customer freight stations, connectivity to ports, raw material transportation.
- **Common & social infrastructure:** Ensure a sustainable, efficient, and well-rounded ecosystem for both workers and operations by providing housing, primary healthcare, dormitories, schools, drainage and effluent treatment systems, solid waste management, and utilities including power, gas, and water.

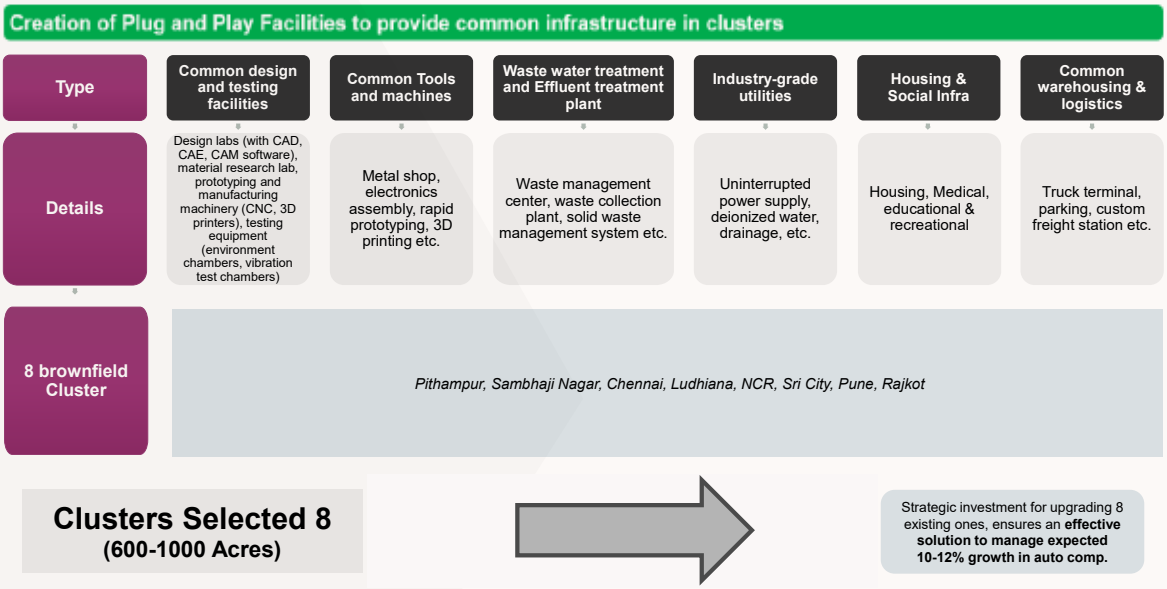


Figure 6.4

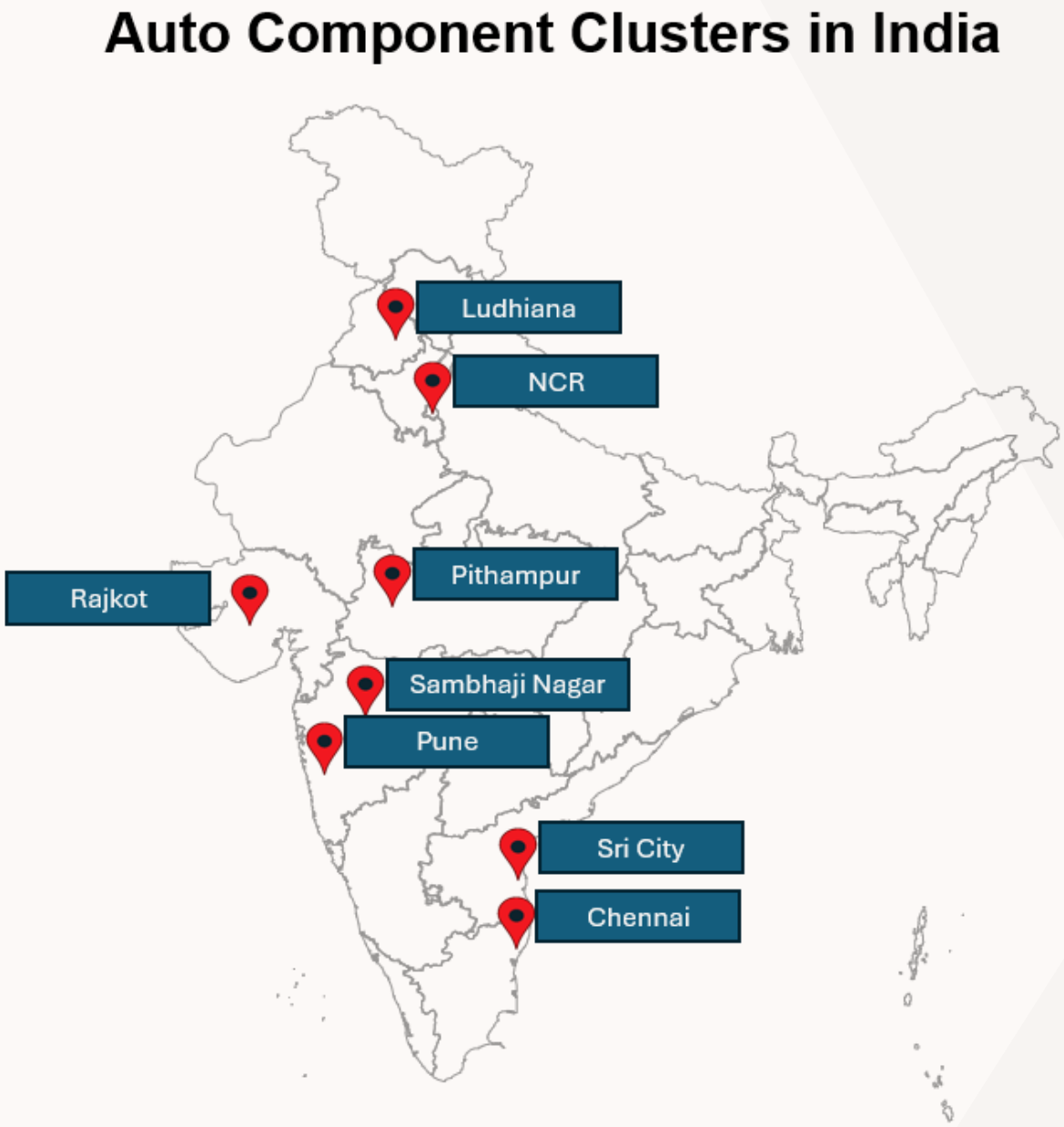

Auto Component Clusters in India
Ludhiana
NCR
Pithampur
Rajkot
Sambhaji Nagar
Pune
Sri City
Chennai

Figure – 6.5

6.5 GOVERNMENT-FACILITATED IP TRANSFER

To improve the strength of auto-component SME's, improve local manufacturing and localisation for improving competitiveness as well as reducing R&D cost, a scheme could be formulated where the Intellectual Property rights (IP) of components identified by the auto-component SME's are acquired by the Government and then democratised across MSME players for manufacturing. This helps reducing the time and cost involved in development and helps foster competition among MSME's.

The broad contours of the scheme are drawn out below:

- Identification of IP to be acquired: Government and industry jointly identifies strategically valuable IP from global patent repositories
- Government Acquisition of IP: The government acquires high-potential intellectual property (patents, technologies) from R&D institutions or startups
- IP leasing
- Targeted Support for MSMEs

Target Segments:

- Government Acquisition of IP: Government procures high-potential IPs from global patent repositories and domestic R&D institutions (CSIR, IITs, DRDO, startups). Aimed at building a National IP Pool. IP from National IP pool is licensed to MSMEs on low-cost lease basis.
- Targeted MSME Support for IP Commercialization: Infrastructure, tools, and expert mentoring support for:
  - » Prototyping, testing, adaptation
  - » Integration of IP into production
  - » Budget includes cost of legal support and tech transfer facilitation.

6.6 BRANDING SUPPORT

To expand their global footprint, Indian automobile component manufacturers must prioritize investing in brand development in international markets. A robust brand image is essential for creating top-of-mind awareness, driving customer preference among global OEMs, and ultimately, securing a competitive edge.

Indian auto-component manufacturers must develop targeted international business-to-business (B2B) marketing strategies that foster consistent market engagement and meaningful relationships with global customers. One effective approach to promoting the "Made in India" brand is by harnessing the power of digital marketing channels, which can help reach a broader audience, enhance brand visibility, and showcase the country's manufacturing capabilities

Recommendation: Launch a Branding support scheme to help improve branding of Indian auto component manufacturing companies.

6.7 EXPECTED BENEFITS:

The aforesaid interventions are anticipated to generate a multitude of benefits.

i. Stimulating production, R&D, and innovation: The interventions are expected to create a more dynamic environment for automotive sector, fostering growth in all these areas.

ii. Job creation: Estimates suggest the creation of 2 to 2.5 million new direct jobs, providing significant employment opportunities along with taking the total count of indirect jobs to 15 to 20 million.

iii. Positive net foreign exchange inflow: The growth in manufacturing is expected to lead to a net inflow of foreign exchange, benefiting the country's balance of payments.

iv. Increased tax revenue from employees: The newly employed workforce as envisaged after the potential for boosting production, R&D, and innovation, coupled with the economic benefits of job creation, positive foreign exchange flows, and increased tax revenue, would unleash the Potential of India's Auto component manufacturing ecosystem.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7 Chapter

OVERARCHING LIST OF NON-FISCAL INTERVENTIONS AND RECOMMENDATIONS

Overarching List of Non-Fiscal Recommendations

7.1 ENCOURAGING TECH TRANSFER AND FOREIGN COLLABORATION VIA JOINT VENTURES:

Foreign joint ventures can be a game-changer for the Indian auto component industry, enabling the development of high-value, mature products that cater to the growing global demand. Complex manufacturing processes have hindered the production of these products in India, including high-performance fuel injectors, advanced transmission systems, and lightweight composite materials. By partnering with foreign companies from countries like Germany, Japan, and the United States, Indian manufacturers can gain access to cutting-edge technology, expertise, and resources, bridging the gap in specialized manufacturing capabilities.

These partnerships can empower Indian auto component manufacturers to produce complex products, tap into the lucrative global market, and increase their revenue.

To ensure the success of foreign joint ventures, it is essential to create a conducive business environment that attracts foreign investment. This can be achieved by offering incentives such as tax breaks, subsidies, and investment promotion schemes. Additionally, the government can play the role of a facilitator by providing support for joint venture partnerships, facilitating technology transfer, and ensuring a smooth regulatory process to safeguard the interests of both entities, thereby building an environment of trust (major obstacle for foreign technology players). Furthermore, Indian companies must be willing to adopt new technologies and processes and invest in upskilling their workforce to ensure a successful partnership.

The Chinese auto component industry has significantly benefited from tech transfer and foreign collaborations, upgrading their technology, quality, and manufacturing capabilities. For example, Wanxiang's joint venture with BorgWarner has enabled the company to produce high-performance turbochargers, such as those used in the Ford Mustang, increasing its exports and establishing itself as a significant player in the global turbocharger market. Similarly, Indian companies can learn from China's experience and leverage foreign joint ventures to enhance their competitiveness and tap into the global market.

7.2 ENHANCING EASE OF DOING BUSINESS

a. To enhance the ease of doing business in the auto component sector and improve India's risk perception, the government should focus on targeted interventions such as streamlining the permit approval process and ensuring time-bound disbursement of incentives. These measures will help reduce bureaucratic delays and enhance overall business efficiency.

i. **Streamlining permits and approvals for utilities and operations** is a critical step. This can be achieved by implementing the following:

- Pre-embedded approvals for the commencement of operations, construction, power, property, and taxation in auto clusters.
- Rationalizing and reducing the number of permits and approvals required across regulatory departments at the central, state, and local levels will further expedite processes.
- Easing land acquisition, regulatory, and compliance requirements by addressing delays and reducing turnaround time in granting licenses and clearances can significantly improve operational efficiency.

ii. **Enabling time-bound disbursement of incentives and transfers** is vital for supporting businesses financially. This includes providing clarity in documentation required to claim disbursements under various schemes and resolving document audit requirements in a timely manner to maintain consistency and expedite financial support.

iii. **Improving transport connectivity and promoting sustainable practices** are essential components of this strategy. This can be achieved by following ways:

- Investing in the enhancement of road, rail, and port infrastructure which will ensure the efficient movement of goods and reduce logistics costs.
- Providing incentives for the adoption of green technology and implementing strict emission norms with support measures and awareness programs will promote sustainability.

7.3 EXPLORING FREE TRADE AGREEMENTS

	Imported values in Billion USD	China	Germany	Japan	Korea	Mexico	India
Top automotive importers	USA	25.1	40.6	49.4	33.2	114.8	4.2
	China		37.6	15.5	2.4	3.5	0.3
	France	2.7	17.5	1.6	1.7	0.1	0.3
	Canada	3.4	3.5	4.6	3.7	5.9	0.2
	Mexico	9.1	4.5	3.8	2.3		1.7
	Italy	3.3	13.9	1.6	0.8	0.1	0.6
	Germany	6.7		3.0	2.5	3.7	0.9
	Spain	3.1	10.0	1.1	1.2	0.2	0.2
India's major FTA partners	Korea	4.8	8.8	1.4		0.7	0.2
	Japan	7.2	5.0		1.0	0.6	0.5
	Thailand	3.8	0.9	5.2	0.2	0.0	0.6
	Bangladesh	0.4		0.5			0.9
	Nepal	0.0					0.5
	Sri Lanka	0.1					0.1
	Afghanistan	0.1					0.0
	Bhutan						0.1
	Maldives	0.0					0.0

Countries with FTAs

Figure 7.1

Upon examining export patterns, it becomes evident that countries predominantly engage in trade with nations that have existing free trade agreements (FTAs) in place. Mexico, a substantial exporter that contributes significantly to global exports, relies heavily on the United States, which accounts for approximately 89% of its total exports. The active FTA, the United States-Mexico-Canada Agreement (USMCA), facilitates trade in automobiles and auto parts, thereby favoring North American production.

Japan, a major Asian exporter, has established FTAs with all its major importing partners. The bilateral trade agreement between Japan and its primary importer, the United States, has led to a significant increase in trade in vehicles and auto components since 2019. The United States accounts for 54% of Japan's exports, followed by China, which accounts for 17%. The Regional Comprehensive Economic Partnership (RCEP) between Japan and China has substantially bolstered trade relations between the two nations.

In the case of Germany, approximately 65% of its exports are directed to countries within the European Union (EU) free trade areas. Germany's key export destinations, including France, Italy, and Spain, constitute around 25% of its exports and benefit from the EU single market's free movement of goods, services, and capital. Additionally, Germany has established trade agreements with countries like Canada, Mexico, and South Korea, such as the EU-Canada Comprehensive Economic and Trade Agreement (CETA), EU-Mexico Global Agreement, and EU-South Korea Free Trade Agreement, which further enhance its trade networks.

India's current FTAs are primarily limited to nations like South Korea, Bhutan, Afghanistan, Thailand, and Sri Lanka. As of 2022, India's presence in major import markets remains limited, with an estimated market share of around 3%. To enhance its export prospects, India should adopt a more strategic approach to FTAs. By expanding and diversifying its FTA network, India can potentially tap into larger markets, access a wider consumer base, and foster greater economic integration. Such agreements can provide Indian industries with increased market access, reduced trade barriers, and a competitive edge, thereby catalyzing export growth and economic development. Furthermore, strategically negotiated FTAs can encourage foreign investment, technology transfer, and innovation, positioning India as a more formidable player in global trade.

To improve its export competitiveness, India should focus on negotiating FTAs with key trading partners, such as the European Union, the United States, and the Association of Southeast Asian Nations (ASEAN). By doing so, India can increase its market access, reduce trade barriers, and enhance its economic integration with major trading blocs. This, in turn, can lead to increased export growth, economic development, and a more prominent role for India in global trade.

7.4 SUPPLIER DISCOVERY AND DEVELOPMENT

Several nations, including Japan, China, etc. have implemented measures to support MSMEs in enhancing their marketing capabilities and boosting their market presence. Some notable initiatives undertaken by these countries include:

Japan:

- The Japanese government has established the SME Support Japan organization, which provides a range of services to MSMEs, including financing, marketing, and management assistance.

- SME Support Japan provides support for branding and advertising to help SMEs promote their products and services.
- With the help of branding and marketing support, Micro, Small, and Medium Enterprises (MSMEs) in Japan are empowered to establish a strong presence in the market and effectively compete with larger corporations.

Canada:

- The Canada Small Business Financing Program (CSBFP) is a loan guarantee program that provides financing to small and medium-sized enterprises (SMEs) in Canada.
- The program provides financing for marketing and advertising expenses, such as website development, social media advertising, and trade show participation.
- It also provides financing for export development activities, such as market research, trade missions, and export marketing.
- The program is administered by the Government of Canada and is designed to help SMEs access financing for marketing and other needs that they might not otherwise qualify for.

South Korea

- The SME Support Centre is a government-funded organization that provides a wide range of support services to MSMEs in South Korea. The centre was established to promote the growth and development of MSMEs, which are considered the backbone of the Korean economy.
- The centre provides marketing and branding support to help MSMEs enhance their visibility in the domestic and international markets. This includes support for market research, advertising, and trade show participation.
- The centre provides export promotion support, including market research, trade mission organization, and export marketing.

  With India home to several MSME's in machine tools, auto components and light engineering spread across clusters, discovery and development of these MSMEs play a key role in boosting their strength as well as improving domestic value additions.
- The government can establish a dedicated organization or an SME support centre to provide a range of services to MSMEs in the auto-component sector, including financing, marketing, and management assistance.
- A loan guarantee program can be introduced, to provide financing to MSMEs in the auto-component sector for marketing and advertising expenses, such as:

    * Website development and e-commerce platform integration
    * Social media advertising and digital marketing
    * Trade show participation and exhibition expenses

- This support centre can provide support for export development activities, such as:
    * Market research
    * Export marketing and branding initiatives
    * Compliance with international regulatory requirements

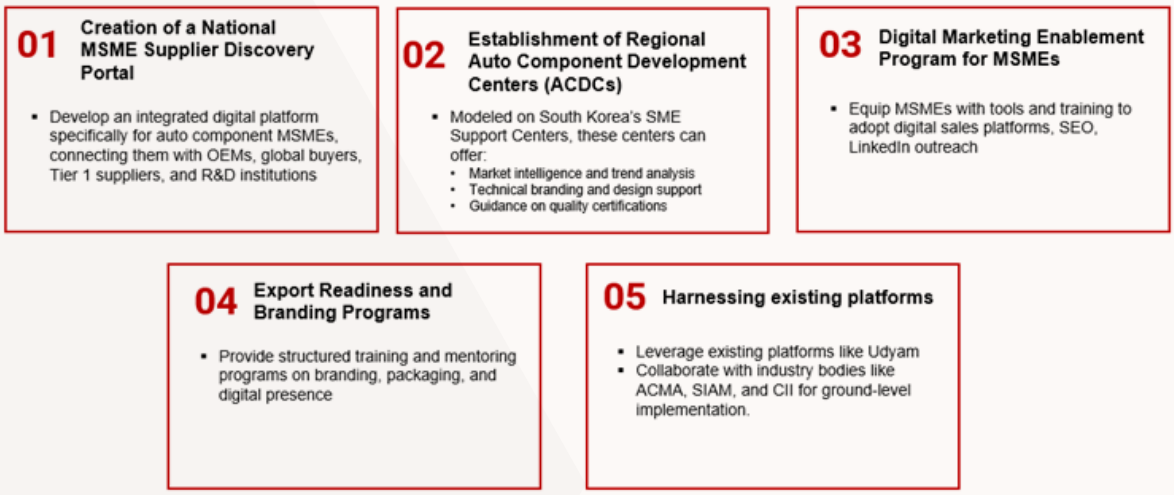

Figure 7.2

Eligibility:

- The enterprise must be classified as a Micro, Small, or Medium Enterprise (MSME) as per the definition provided by the Government of India and the enterprise must be operating in the auto-component/machine tools/light engineering sector.
- The enterprise must be registered with the relevant authorities, such as the Ministry of Micro, Small, and Medium Enterprises (MSME), or the State Government's Department of Industries.
- The enterprise must have a minimum turnover of ₹25 lakhs and a mixiumum turn over of ₹100 crores.
- The enterprise must have a minimum of 10 employees.
- The enterprise must have a potential for exporting auto-components, with a minimum export turnover of ₹10 lakhs in the previous financial year.

7.5 WORKER HOUR FLEXIBILITY

The traditional Indian labor laws have imposed a cap of 10.5 hours per day, including overtime, on working hours. This contrasts with countries like China, Denmark, Switzerland, Norway, and Indonesia, where there is no limit on working hours. Other countries like Bangladesh and Vietnam have slightly higher limits, with 11 hours and 12 hours, respectively. However, the trend of flexible working hours has been gaining traction, particularly in countries like China and Vietnam, where it has been beneficial for manufacturing sectors.

The advantages of flexible working hours in China and Vietnam are multifaceted:

- Increased output: Flexible working hours allow continuous operations, which is particularly beneficial in the manufacturing sectors where production needs to be ongoing to meet demand.
- Attraction of Foreign Investment: Multinational companies often seek environments with flexible labor regulations to optimize production schedules and reduce operational costs.
- Reduced operational costs: By adjusting working hours, businesses can reduce costs associated with overtime, labor, and other operational expenses.
- As a result, multinational companies often seek environments with flexible labor regulations to optimize their production schedules and reduce operational costs. This has led to countries like China and Vietnam becoming attractive destinations for foreign investment, particularly in the manufacturing sector.

In India, states like Karnataka, Tamil Nadu, and Telangana have been at the forefront of attracting foreign investment due to their business-friendly policies, strong infrastructure, and skilled workforce. Recently, Karnataka amended its labor laws to allow 12-hour shifts, aligning itself more closely with global manufacturing hubs like China and Vietnam and the 4 labour codes passed by the Indian government. This move is expected to make Karnataka a more attractive destination for foreign investment, particularly in the manufacturing sector.

Tamil Nadu, which is home to major electronics and automobile manufacturers, has also taken steps to enhance labor flexibility. The state has become a preferred destination for companies like Apple, Foxconn, and Hyundai, which are looking to expand or diversify their manufacturing base outside China.

While adopting more flexible labor laws can offer economic benefits, it's essential to balance these with worker welfare. Extended working hours should be accompanied by adequate compensation and rest periods.

7.6 MISSION MODE EXECUTION STRATEGY:

To drive the growth of the auto and auto parts manufacturing sector in the country and enhance our participation in Global Value Chains, the above recommendations may be considered for implementation. These recommendations address critical areas such as infrastructure development, fiscal support, and technological innovation, and require coordinated action among various Ministries/ Departments and State Government for a holistic approach. Given the complexity and cross-ministerial/ departmental nature of these initiatives, it is suggested that they be executed in a mission mode. To facilitate this, a dedicated unit may be established within the Ministry of Heavy Industries (MHI) / National Manufacturing Mission (NMM) to spearhead these reforms and oversee their implementation, ensuring efficient coordination among stakeholders, monitoring progress, and driving significant advancements in the automotive sector.

Designed by:

AKHYA INDIA


सत्यमेव जयते
NITI Aayog