UNIDO-ACMA-DHI AUTOMOTIVE SECTORIAL SYSTEM OF INNOVATION SURVEY

Industry Analysis Report

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1.1 - Automotive Industry: A Global Perspective

The automotive industry in the past few years has witnessed an unprecedented level of technological advances and innovation. This sector has invested billions of dollars in the fields of enterprise planning, automation solutions, and advanced product technologies. Leading manufacturers of automobiles are not fully equipped with the use of data and hence, technology companies are grabbing the competitive advantage over these automotive manufacturers. Technology companies have developed low-cost computing, high-speed connectivity, and machine learning that have enabled the digitization of the physical world, transforming insights into optimized actions. And now these technology leaders are entering the automotive sector and the traditional manufacturers are struggling to keep pace with these tech giants (Deloitte, 2020). One such company is Alphabet, the parent company of Google, has been working on its self-driving car project called Waymo since 2009 and has launched self-driving cars in some of the cities of the world.

The technologies that are disruptive and bringing a great transformation in the automotive sector are known as the CASE technologies where CASE stands for Connectivity, Autonomy, Shared Mobility and Electrification (Deloitte, 2020).

Connectivity:

Fourth industrial revolution, better known as Industry 4.0, focuses on smart manufacturing and connected machines and that is where smart factories come into picture. Smart factory mainly uses three key technologies that are connectivity, intelligent automation and cloud-scale data management. These cutting-edge technologies provide great assistance in manufacturing the vehide. Usage of these technologies will be helpful in efficiency improvement and cost reduction, also it will provide real time information for product lifecycle management (PLM) which is a crucial part of automobile manufacturing. Cloud-based PLM and whole ecosystems based on cloud, if implemented, can reduce the power required for computation. Also, these technologies will enable the companies to manufacture with comparatively less errors because they involve machines rather than humans in the manufacturing process.

Companies are moving towards smooth operations and implementing use of technologies in their day to day operations. Cloud computing is a technology which is getting into the nerves of any industry and the reason industries have to adapt to cloud technology is data. Data is the new oil and with things getting smarter, a large amount of data will be generated every day. Cloud computing can help the automotive industry in many ways starting from product design to aftermarket services. Cloud

computing and the Internet of Things are the two technologies which go hand in hand for better results. Industry is evolving and so are customer needs and in order to meet their expectations, companies will have to design more customer centric cars, and cloud computing helps in that. Original Equipment Manufacturers (OEMs) possess a large amount of data about the consumers and the users of the vehicles. OEMs are providing access to a wide range of cloud computing solutions to the product designers, who then use this information to improve the product as per the needs of the customers. Also, the service providers can track the performance of the vehicle and analyse it to improve the quality of services they provide to a customer. It can help the dealers in providing an overall better experience to a customer, which will ultimately lead to profit maximization for the companies. Apart from this, cloud computing also helps in improving the supply chain by reducing the cost of inventory planning and forecasting. It helps in providing a common interface to the suppliers and manufacturers, which is helpful in minimizing the communication gap and improving the quality standards. So, deployment of cloud-based services is the need of the hour for the automotive industry.

As every coin has two sides, the threat of cyber-attacks comes attached with the development of these technologies and availability of huge amounts of data. To become futureproof, many layers of cybersecurity need to be added. The smart cars of future need to be well secured so that they do not infringe on our data privacy rights, which is of utmost concern in this increasingly transparent world. Data protection and cyber security are very crucial for any industry. The Fourth Industrial revolution works on the concept of connectivity. All the systems in the factory are interconnected, the vehicles are connected with the infrastructure of the city, they are also connected with the dealer's cloud system for the purpose of better services. This complex system generates a lot of data every minute and all of it needs to be protected. Cyber threats can be in various forms such as financial risk, breaching of data, privacy, safety, and all these risks can lead to trust issues for a customer in a particular brand. Leading brands are focusing more and more on improving the cyber security system either by in-house support or by external collaborations. Large companies are collaborating with several other industries such as medical devices, aerospace and defence, and consumer electronics for the purpose of exchanging the knowledge and expertise within the ecosystem. To keep pace with time and stay ahead of its competitors, companies have to address the issue of cyber security from the root.

The world is changing in terms of Information and Communication Technology (ICT) and hence automotive companies can reap the benefits by establishing connectivity in the value chain. A new spectrum 5G has already been introduced in many parts of the world and India is also getting ready to acquire this new spectrum that will contribute to develop the smart cities. Evolution of 5G will completely change the face of many industries. Launch of the 5G spectrum will bring major changes in the automobile industry as well. 5G will provide support to sensors and devices that will help in building

the connected network of the vehicles. This technology will help in bringing safety measures. With the help of 5G, vehicles will not only be connected with each-other, but also be connected with pedestrians and roads. This will ultimately help in reducing the number of accidents that take place. This connectivity will bring some great changes of the century in automobile infotainment too. 5G operates on a very high bandwidth that also enables V2X (Vehicle-to-everything) communication. This technology is implemented in an automobile to connect it with the other objects on the road. This communication is used for building autonomous vehicles that operate without drivers. Vehicles will be able to communicate with the other vehicles and the objects that are there on the road by passing signals to them. V2X will enable a vehicle to identify the objects on the road, vehicles will receive signals from those objects and move accordingly. All these implementations require great infrastructure and high bandwidth connectivity, which will be possible with the access of 5G technology. Shanghai is the first city to implement an intelligent vehicle network using 5G. Shanghai tops the chart of the cities with the best infrastructure in China that makes it possible to implement the technological changes into the city. It will probably cover an area of 100 kilometres by 2020 (EY, 2019).

Autonomy:

With the advent of mobile technology and the need to stay connected round the clock, the modern cars became a blend of mobility and tech with state-of-the-art technology and sensors such as e-sim, touch screens, voice activation, smart parking assists etc. Cars are now being revolutionised as a mix of mechanical and electrical with the latest trend being of Autonomous Vehicles. Smart vehicles come equipped with a lot of safety prepositions along with the ability to assist the driver in driving the car. Along with it, there has been a surge in alternative fuel vehicles. Due to the fourth industrial revolution, technologies have made the car more akin to a gadget. This particular revolution has also brought in a host of technology companies to come up with their own smart vehicles. The day is not far when 'Internet of Cars' has a vital role in the sector's transition.

Autonomous vehicle has received a huge boost but it still has a long way to go. Safety is the aspect which needs to be considered while talking about autonomous vehicles. Light detection and ranging (LiDAR) is the key technology that is used in autonomous vehicles. This technology is used to detect the objects that appear near the vehicle. Light rays are used to capture the objects and sensors are used to measure the objects. Then with the help of wavelengths, 3D representation of the object is done. 3D mapping is another technology that is widely used in autonomous vehicles. With the help of this technology, cars will get the data about the paths and roads. This 3D map will be used to provide the direction to the vehicles that are on the road. These all are the technologies which will be a necessity for the autonomous vehicle. Apart from this, advanced smart sensors coupled with cameras, smart braking,

blind spot monitoring etc have made driving safer, in conflict conditions too. Fourth industrial revolution has also accelerated the development of flexible manufacturing systems, agile supply chains, higher monitoring capabilities etc. Autonomous cars are the future of mobility and big players of the industry are focusing on developing world class autonomous cars with some great technologies that can transform the industry.

Shared Mobility:

The future of mobility is changing with change in technological advancements. Shared mobility, as its name suggests, refers to sharing the vehicle for ride. Car as a service (CaaS) is a concept that is being adopted widely in the world today. For example, imagine that there are four people going to the same destination with their own cars, that means that four different cars are reaching the same destination. Rather than going in their own car, they can share the same vehicle to fulfil their purpose. This will have many benefits such as reduced cost per user, less carbon emission, reduced traffic on the road which will ultimately lead to reduced noise and air pollution in the cities. Traffic is becoming a huge problem for some of the megacities of the world. Because of the concept of shared mobility, cities will have to deal with comparatively less traffic, which will ultimately lead to a lesser number of accidents.

Electrification:

Carbon emission has raised significantly over the years. According to data released by the Carbon Dioxide Information Analysis Centre, U.S. Department of Energy, carbon emission was 4.981 metric ton per capita in 2014. Transportation sector contributes around 14 percent in carbon emission and this is considered as a great number (Wang & Ge, 2019). To reduce the carbon emission, automobile companies are now focusing on green mobility and electric vehicles which will not use fossil fuels and help in reducing the carbon emission caused by the sector. The world is rapidly transitioning to electric mobility and solutions.

This trend has given rise to Hybrid and Electric Vehicles (EVs). Although hybrids were invented as early as the 1900's but they did not pick up pace due to less horsepower and speed (Matulka, 2014). Prius, courtesy of Toyota was the first commercial hybrid vehicle to be launched in 1997 and it has sold more than 6 million units including all the model's variation (htt2). It was followed by Honda's Insight launched in 1999 (htt4). Many other companies such as BMW, Ford, Honda, GM etc started launching EV/Hybrid Vehicles. The EV gradually moved to commercial transport also when Mercedes Benz and Micro-Vett SPA released Sprinter and Daily Bimodale Models respectively in 2004[1]. In 2010, Chevrolet

[1] https://electricvehiclesnews.com/Technology/Hybrid_Vehicle_Drivetrain.htm (Last accessed on 19th May ,2020)

and Nissan launched Volt and Leaf respectively, the former was the first plug-in hybrid and the latter was the first modern all Electric Vehicle (World Mysteries, 2013) (Matulka, 2014). One of the companies that became hugely successful was Tesla, its Model 3 became one of the best-selling plug-in vehicles and became the highest electric car brought in 2019 (Statista, 2019).[2]

Apart from these technologies, nanotechnology is also a promising technology which currently has many uses most commonly being in development of material such as the super light and expensive Carbon Black which is still a supercar only material. Besides, nanomaterials can also reduce corrosion effects and are high on durability. Nanomaterials are also used in coating of several automobile components and parts such as cylinder walls in order to reduce friction and in mirrors so as to avoid reflection and glare of light. The goal of every company is to improve quality and productivity while reducing the expenses. So, for a sector that is looking to invest in transformational technologies, nanotechnology can be the right choice[3].

Also, additive manufacturing, often known as 3D printing, is a key technology used to speed up the manufacturing process. 3D printing provides assistance in producing the prototype parts rapidly and it also helps in producing unique designs. This will help companies in differentiating them from their competitors. Also, prototyping of physical parts is a costly process and by making this process digital, companies can save both time and money.

The future of mobility will emerge as a combination of green, shared and electric mobility. However, here are some challenges that are associated with the CASE technologies. These technologies are complex in nature and include the involvement of ICT technologies. Companies are facing a shortage of people equipped with relevant skills to understand, execute and maintain these technologies (Deloitte, 2020).

Apart from this, buying the technologies to stay updated will not suffice. Companies have to use all these technologies efficiently and develop the operations continuously. Companies have to focus on investing in innovations and R&D also so that they can be ahead of their competitors (Deloitte, 2020).

1.2 - Automotive Industry: The Indian Perspective

Even before the COVID -19 pandemic began, the Indian automotive industry was in a slump in terms of sales. Number of vehicles sold in the year 2019-20 decreased to 21,546,390 from 26,266,179 in 2018-19 (SIAM,2020) India is the fourth largest producer of motor vehicles and the seventh largest manufacturer

[2] Contributed By Siddharth Baxi
[3] Contributed by Siddharth Baxi

of commercial vehicles as of 2018. Despite its overall position, India remains the largest manufacturer of the world in tractor, two-wheeler and three-wheeler segments. The sector contributes around 7 percent in the GDP of India. India is expected to become the third largest automotive manufacturer by 2026 (Invest India, 2020).

Under its Make in India initiative, the Government of India has identified the automotive sector as a key sector of development. To give a boost to the sector, the government has allowed 100 percent FDI(Invest India, 2020) in the sector. The automotive sector has received US $ 23.9 billion worth of Foreign direct investment (FDI) from April 2000 to December 2019 which consisted of about 5.23 percent of total FDI received till date (DPII, 2019). It is one of the largest employment generating sectors in India with about 35 million strong workforce and it is expected to raise this number to 65 million in 2026 (Invest India, 2020). India's annual production has been 29.09 million vehicles in 2018 as against 25.33 million in 2017, registering a healthy growth of 14.8 percent (SIAM, 2020). The industry is expected to reach $135 bn by 2020 and $300 bn by 2026 at a CAGR of 15 percent (Invest India, 2020). These figures show the importance of the automotive industry in India. It is important to develop the sector to develop the economy and to increase the GDP of the country.

India does not have a widespread use of electric vehicles especially in the private vehicle segment. The Paris Agreement which is ratified by India has the objective of limiting this century's temperature to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (United Nations Climate Change, 2015)

The Government of India is taking various steps for reducing the carbon emissions and electric mobility can be the key. It can also help India reduce its dependence on imported oil. Indian government has set up a mission for complete transition to electric vehicles by 2030. Electric vehicles in India fall under a 5 percent GST bracket which helps in cutting the overall cost of the vehicle (Prasad, 2019). Apart from that, the Indian Government has many initiatives and schemes to encourage purchasing of electric vehicles. All these moves are tremendous, but the country is lagging behind in terms of infrastructure that is required for the electric vehicles. The major infrastructural reforms are needed and so is the heavy investment to make the country fully equipped with electric vehicles. Currently there are only 150 community EV charging centres in the entire country (PR Newswire, 2019). However, in a recent move the government has decided to give a contract to state run companies for creating 2600 charging stations in big cities (Singh V. , 2020). Government has to take some steps to implement the infrastructure for charging these vehicles before the penetration of these vehicles in the market. Also, the manufacturing of batteries for the electric vehicles is equally crucial for the complete penetration of EVs by 2030. India will have to secure mines rich in lithium and other such materials that are widely

used in the batteries of EVs. India will face a huge demand for batteries as it aims to be completely equipped with EV by 2030. Therefore, the government is currently promoting domestic manufacturing of these batteries and also focusing on the recycling mechanism for these batteries. In case of 5G technology, India has a long road ahead of it in terms of bringing 5G technology and implementing it in cities to make breakthroughs in the infrastructure. India will be all set for the auction of 5G in the April-June quarter of the financial year 2020- (Invest India, 2020).

To reduce the risk of accidents, modern vehicles come equipped with the Advanced Driver Assistance System (ADAS), but this technology is more successful in countries that have a disciplined driving culture. So, there is an opportunity for scientists to carry out their research on providing Indian drivers with ADAS support. Research can be focused on major issues that have been faced by the Indian drivers, how those issues are different from the other countries and what can be done to address those issues. So, India has a long way to go in terms of autonomous vehicles because its structure is different from developed countries and currently the companies are focusing on the development of vehicles that are suitable for countries with good infrastructure.

Cyber security is a key aspect for autonomous cars as it can generate a huge amount of data. Government has set up a cyber security task force with the aim of making India a preferred destination for cyber security solutions (CII and Grant Thronton, 2017). Such initiatives in the area of cyber security will help the automotive players to launch the dream automotive vehicles without bothering about cyber security.

Looking at the connectivity aspect, India is also gearing up and getting ready to adopt major changes that are happening in terms of connectivity. Around 80 percent of the consumers in India believe that increased vehicle connectivity will be beneficial (Deloitte, 2020). A leading vehicle manufacturer of India has announced its plans for bringing in the new infotainment system which will have android assistance, for its flagship model (CII and Grant Thronton, 2017). It will enable the android phone users to connect with the car and use the apps on the dashboard screen. Apart from that, the car will also have Google maps, personalised services and online applications access through an infotainment screen.

Technologies like Big data and IoT can make a great impact on the Indian automotive industry. India has a population of 1.35 billion (World Bank, 2019) which is a huge benefit when it comes to the generation of data. India generates tons of data every day and with the help of IoT and other technologies, this data can be analysed according to the needs. This will help the companies in improving their products and services and help them achieve more customer centric products. The IoT ecosystem in India is mainly driven by three major players: Government, Industry and start-ups. Indian government's

objective is to create the IoT industry worth US $ 15 billion by 2020 (CII and Grant Thronton, 2017). Here are few examples of IoT innovations that have played a key role in transforming the automotive sector of India:

- An online truck booking service provider wants to revolutionise India's transport and logistics by introducing an online framework and structure for the transportation of goods.
- A popular rider assistant and activity tracker for motorcycle riders and commuters developed an artificial intelligence based connected helmet that promotes safety and keeps the rider informed of the risk on the outer. The helmet is equipped with Bluetooth for connectivity, rear view camera and GPS and navigation display. (CII and Grant Thronton, 2017)

Indian automotive companies are gradually embracing the fourth industrial revolution to increase their manufacturing competitiveness. Bajaj was the first to introduce automation in the industry in 2010. Today, it uses around 100-120 Cobots (collaborative robots) in its manufacturing units. This was followed by other players like Maruti-Suzuki which uses around 1700 robots in its process shops and assembly lines, Ford uses 437 robots in its assembly line, Hyundai is using 400 robots for cutting the labour cost and Tata uses around 100 robots in its Sanand plant (CII and Grant Thronton, 2017). Apart from these technical changes, availability of the manufacturing facilities in the country has also played its part. There are five large automotive clusters that have emerged in the country i.e. Delhi-Gurgaon-Faridabad, Sanand-Halol and Mumbai-Pune-Nashik-Aurangabad, Chennai-Bengaluru-Hosur and Jamshedpur-Kolkata respectively in the north, west, south and east region of the country (CII and Grant Thronton, 2017). They are attracting many world class automotive players to start production in India.

India is taking great initiatives to embrace the latest trends in terms of technology. Development of any sector is not possible without the support of government policies. Every year governments at the national and the state level keep improving their policies to help the industry in developing to keep pace with the other countries. To understand the development and growth of any industry, one has to understand different policies that affect that industry. Let us now have a close look at the policies that have been introduced by the Indian government to help the automotive industry to innovate and grow at an exponential rate.

Chapter 2 - Policy Review (Siddharth Baxi)

The fourth industrial revolution (Industry 4.0) brings with it a host of scientific and technological breakthroughs that are not only disrupting businesses but also challenging the existing national policies and regulatory frameworks. Industry 4.0 confers unique advantages for the automotive industry that has always been at the forefront of global technological innovation (PWC, 2017). This chapter reviews national policies to see if they are able to keep up with the rapidly evolving technologies in the sector. India being the 5th largest economy and the youngest country in the world needs a proper policy framework and a host of sustainable initiatives to position itself as the world leader and net exporter of the automobiles and auto ancillaries. It is an attempt to identify divergences between sectoral priorities and policies as well as an attempt to review the competencies of and coordination between various government bodies engaged in policy making. Furthermore, this chapter examines the directives established by Indian policy-makers to discern the economy's competitiveness in technology and innovation, and how synergies among the four NSI key actors [Government, Knowledge-based institutions (KBIs), Industry and Arbitrageurs] can influence policy implementation in the automotive sector.

The Indian automotive industry in many ways has been shaped by the government's industrial policy and nurtured in the microeconomic environment it helped to create (Miglani, 2019). It has evolved through policy regimes characterised by an era of protectionism (1950-1983), deregulation (1983-1993) and liberalisation (post-1993). In addition to direct impact through fiscal policy instruments, the industrial policy also contributed to development of innovation and technological capabilities at the firm level (Kale, 2012). Liberal policies of the 1990s exposed automotive firms to new competitors and encouraged them to innovate and acquire advanced technology through partnerships and investments in R&D. At the same time, the industrial policy protected the domestic firms by imposing local content requirements that led to development of basic capabilities in automotive manufacturing and laid foundations of the auto component industry (Kale, 2012). This process of indigenization is considered a key policy measure responsible for enhancing technological capabilities in the automotive sector (Sagar, D., & Chandra, 2005).

A lot has happened in the automotive sector post-liberalization as it has emerged as a 'sunrise sector in the Indian economy. The past decade has been a witness to policies and initiatives launched to support Industry 4.0 and Green Mobility. The major policies in the last decade which laid down the roadmap for

the development of the automotive industry were the National Automotive Policy, 2002 and the Automotive Mission Plan 2006-2016 (or AMP 2016) with the latter focussing on how the sector can be a double-digit contributor to the national GDP through ways such as growth in investment, creation of research and development (R&D) infrastructure, expansion of domestic demand etc. Besides, many analogous policies were launched in parallel to support the automotive sector.

Below explained are the core policies of the automotive sector in India that are addressed in turn, along with some of the secondary supporting policies that have a bearing on the Indian automotive sector.

2.1 - Key National Framework

With the intention of increasing the manufacturing output and employment in the sector, the Automobile Mission Plan (AMP 2016) was the foremost policy released on a Pan-India scale. "AMP 2016 was the outcome of a protracted in-depth dialogue with all stakeholders (industry, academia, authorities) over a period of fifteen months". (Department of Heavy Industry, 2016).

The key objectives of AMP (2016) were as follows:

a) To establish India as a key player in the manufacture and export of two, three wheelers, tractors and more importantly, auto components.
b) To provide favourable investment opportunities and appropriate tariff policy for the automobile sector
c) To integrate Automation and IT in manufacturing and to promote infrastructure development in the auto clusters.
d) To facilitate expansion of domestic demand and to encourage exports.
e) To support development of R&D and incentivise modernisation of the sector.
f) To undertake labour reforms and ensure availability of trained manpower.
g) To create world class infrastructure for testing, certification and homologation under National Automotive Testing and R&D Infrastructure Project (NATRiP).

The Government states that AMP 2016 had many of its objectives/targets completed (Department of Heavy Industry, 2016). It achieved its target of generating an incremental 25 million jobs as well as the sales target (number of units sold) of commercial vehicle and passenger vehicles. India's emergence as a global hub for small cars is one of the key accomplishments of AMP 2016. Apart from that, ''the sector achieved significant quantum of investments from global and local OEM's as well as component manufacturers, exceeding the target of ₹ 1575 billion'' (Department of Heavy Industry, 2016) .Despite these accomplishments AMP 2016 faced two main challenges that were taken into consideration while drafting its successor, AMP 2026. The first challenge pertained to low involvement of government

bodies and institutions at all levels (central, state and local levels) in the implementation of AMP 2016 and the lack of coordination among them. Secondly, AMP 2016 was positioned as a document primarily meant for the manufacturers and not positioned keeping in view other interest groups or stakeholders, which is why AMP 2026 seeks to be more inclusive in design than its predecessor (Department of Heavy Industry, 2016). "*AMP 2026 seeks to define the trajectory of the evolution of the automotive ecosystem in India including the glide path of specific regulations and policies that govern research, design, manufacturing, technology, import/export sale, use, repair and recycling of automotive vehicles, components and its ancillary services*" (Department of Heavy Industry, 2016). It emphasises that all such regulations and policies impacting the sector should be comprehensive in scope and scale and should be implemented harmoniously across the nation (Department of Heavy Industry, 2016). AMP 2026 mandates to "*position itself as the guiding document for all institutions that frame policies impacting the manufacture and use of automotive products in India"* (Department of Heavy Industry, 2016) as in with the coordination of various central ministries, state governments and local authorities to ensure a consistent policy environment for smooth implementation of the Automotive Mission Plan.

The *"AMP 2026"* Vision Statement itself announces that India will be among the top three globally in the fields of engineering, manufacturing and exports by 2026 encompassing promotion of safe, eco-friendly and affordable mobility for the majority (AMP 2026, pg. xii). The Final Draft document released by Government of India in January 2016 lists the core objectives of AMP 2026 as below:

a) To propel the Indian automotive industry to be the engine of the "Make in India" programme.
b) To make the Indian automotive industry a significant contributor to the "Skill India" programme and make it one of the biggest drivers of employment creation in the country.
c) To enhance mobility keeping in mind the environmental protection and affordability aspects.
d) To become one of the major automotive export hubs of the world.
e) To promote comprehensive and stable policy dispensation for all regulations and policies that govern the auto sector.

AMP 2026 recommends certain intervention in key areas such as in investments and trade, environment protection and for improving competitiveness. It also purports to make inputs to supporting policies of the Government of India that have a huge impact on the growth and well-being of the automotive industry (Department of Heavy Industry, 2016). With regards to the trade policy of the Government, AMP 2026 supports the rationalisation of custom duties on raw materials used in automotive components and vehicles and calls for emphasis on domestic capacity creation of imported items such as automotive electronics in order to boost local manufacturing (in support of "Make in India") and to improve export potential of the automotive industry. Considering the competitive nature of the

automotive sector, AMP 2026 suggests that Free Trade Agreements should only be signed with countries that do not have a significant automotive production base. Such inputs are expected to ensure that the automotive industry in India is subjected to a fair and predictable governing environment (Department of Heavy Industry, 2016). Lastly "AMP 2026 envisages that the Government and the Indian Automotive industry will work together to address all the key issues to take India to its rightful position in the global automotive industry's sweepstakes" (Department of Heavy Industry, 2016).

Complementing the AMP 2026; the National Automotive Policy (NAP) (2018) was drafted by DHI on the lines of NAP, 2002 for the holistic development of the automobile sector in India. With the objectives mainly aligned with AMP 2026, it identified five focus areas namely a) Innovation and R&D, b) Vehicle Manufacturing, c) Components Manufacturing, d) Green Mobility and lastly e) Ecosystem development for achievement of policy objectives. One of the most important aspects is that it solicits to integrate an Automotive Ombudsman to strengthen the redressal system with an emphasis on quality. Suggesting a Nodal Body for the industry which is envisioned to be an Autonomous Council thus being a consultative agency for the various ministries, statutory organisations and bodies involved in formulation of automotive related policies and regulation. The body will be responsible for reviews every four years and recommend course corrections. "It will also serve as the repository of technical, domain expertise and data on all aspects of automobiles and their manufacturing, and be the technical advisor and the secretariat. The proposed nodal body will be a two-tiered structure with an Apex Body supported by the National Automotive Council (NAC)" (Department of Heavy Industry, 2019)

AMP 2026, led to certain reforms and supporting policies to be implemented and devised in order to attain the set objectives. For any sector to drive its growth, strong linkages and synergetic effects of policy initiatives from different domains are crucial. The policies can be devised as per the applications or skills that govern the scientific progress of the sector such as research and development, along with a focus on the upgradation of the infrastructure and increasing the manufacturing power and sales. The harmony of both the types of policies with secondary policies is required so that sectoral policies can get duly enacted and fulfilled in a way that ensures rapid progress and technological advancement in the sector.

2.2 - Infrastructure Policies

Considering the current size and future scope of the Indian Automotive Market, it is essential to have certain plans and policies for upping the ante in the infrastructure part. Policies such as the National Manufacturing Policy with the Foreign Direct Investment Policy (FDI) have indirectly played a pivotal

role in the sector's progress. The sector is the 6th largest remitter of foreign inflows as 100 percent FDI is allowed in the automotive and its ancillaries sector. The National Manufacturing Policy, 2011 has distinct objectives such as creation of 100 million jobs and 25 percent contribution of the manufacturing sector to the GDP by seeking to increase domestic value addition, technological depth in manufacturing etc. Focussing on a few industry verticals, it lists the automotive sector as a sector where India has a competitive advantage. The Government's "Make in India" initiative has played an important role in elevating the country's position especially in the manufacturing sector. The 25 key sectors of the policy include automobiles and auto components. The significant ascension of India in the atmosphere of conducive business environment is evident as it leaped from 142 in 2015 to 63 in 2019 in ease of business rankings where it improved on nine out of ten parameters (Mckinsey & Company, 2019). In a discussion paper on the Industrial Policy-2017, the Department of Industrial Policy and Promotion, Ministry of Commerce and Industry states that having a clear vision and intent, establishing global linkages, enhancing industrial competitiveness and enabling ecosystems for sustainable technology and innovation as the key elements to have a future ready policy.

The past decade has seen significant advocacy towards sustainability with the declaration of United Nations Sustainable Development Goals (UN SDGs), The Paris Agreement etc. So, with aim to increase Green and Sustainable Mobility, the National Mission on Electric Mobility (NMEM) was launched in March 2011. An empowered body was set up in the form of National Council for Electric Mobility (NCEM) chaired by the Minister Heavy Industries & Public Enterprises and the National Board for Electric Mobility (NBEM) chaired by Secretary, DHI was also constituted. The National Electric Mobility Mission Plan 2020 (NEMMP) released in 2013 was established to promulgate the use and manufacturing of EV's. In addition to that, the proposal of National Automotive Board (NAB) got approved in Oct 2012 and the board got registered under the Registration of Societies Act,1860 in August 2013.

NEMMP, in accordance with the objectives of AMP (2016) promotes the sales and manufacturing of electric vehicles through various reforms. One of the most common measures on the demand side was to incentivize buyers by giving them monetary support. It suggests that incentivization should be decided upon the battery capacity and that the Plug in Hybrid Vehicles (PHEV) should be incentivised more than Battery Electric Vehicle (BEV) and Hybrid Electric Vehicle (HEV) for 4 Wheelers and for 2 Wheelers the plan differentiates with respect to speed and durability (among same battery capacity). In order to overcome barriers faced for the manufacturing of EV's, the NEMMP gave sops in supply related interventions in the form of allowing various tax relaxations for EV manufacturing. The measures include tax breaks, excise duty concessions, direct cash subsidies etc. Apart from private transport, it also lists some incentives for the public transport, mostly for the buses (low floor and metro feeder) that can be done on a basis of Pilot Projects in a handful of metros of the countries. A volume-based cap

on incentives subject to technical parameters such as battery life, top speed, passenger capacity etc. is proposed as a thought. NEMMP is a plan that hopes to make India on par with the global leader of the EV Industry.

NEMMP is divided into 4 phases (Department of Heavy Industry, 2013) wherein the DHI, Automotive Components Manufacturing Association (ACMA), Automotive Skill Development Corporation (ASDC) and even the United Nations Industrial Development Organisation (UNIDO) have their respective tasks to do either jointly or individually in each phase. These phases constitute infrastructure upgradation as well as lay impetus on R&D in manufacturing, design etc. A prime focus on R&D of battery improvement is stressed as it nearly constitutes of approximately 40-50 percent of the total cost of a Battery-Operated Vehicle (Department of Heavy Industry, 2013). Globally, countries such as Japan, USA, Korea and China have more than 10,000 patents in this area of research only (Department of Heavy Industry, 2013). Furtherly, to promulgate and accelerate indigenous manufacturing, especially of 4W OEM's and supplies, a stage-wise plan is formulated (Figure 1).

NEMMP envisions that creating an e-mobility for the future will be helpful for a thrust towards a greener and a leaner environment albeit emphasizing that all this can be duly achieved if synergy is obtained between Knowledge Based Institutions, Government and the Industry. The objectives of the National Policies are oriented with various other documents which will help the sector to improve in a holistic manner. This includes initiatives like FAME- I, PMP, FAME – II catering to multiple facets of green mobility which come under NEMMP.

Figure 1: The Stage wise expansion of Indigenous Activities (Exhibit 38, Pg. 102, NEMMP 2020)

Similarly, to increase the quantum of electric vehicles on roads, Phase-I of the FAME [Faster Adoption and Manufacturing of (Hybrid) & Electric Vehicles in India] scheme under the ambit of NEMMP was launched on 1st April 2015. It had a slew of measures to achieve the objectives of NEMMP. Phase-I promoted manufacturing and encouraged buying of reliable, efficient and more importantly affordable electric/hybrid vehicles to ensure sustainable growth for the same.

Initially, launched for a period of 2 years, it was subsequently extended till 31st March 2019. The Phase had four focus areas namely (i) Demand Creation, (ii) Technology Platform, (iii) Pilot Project and (iv) Charging Infrastructure. Market creation through demand incentives was designed at incentivizing all vehicle segments i.e. 2,3 Wheelers, 4-Wheeler passenger vehicles, Light Commercial Vehides and later on in 2018 adding buses. NAB is the operating agency for the implementation of FAME India Scheme including for the disbursement of funds. A total of ₹ 8.95 Billion were earmarked for the phase.

Whilst Phase-I was ongoing, for the promotion of Sustainable Public Transport a Draft Taxi Policy was introduced by the Ministry of Road Transport and Highways (MoRTH) in December 2016 which enumerated provisions for e-rickshaws, to promote urban mobility. The policy suggests that e-rickshaws can be proactively used for last mile connectivity in cities as they offer low cost and zero-pollution transportation (E-RICKSHAW DEPLOYMENT IN INDIAN CITIES- 2019). With nearly 32 percent of the population living in Urban Areas (Census 2011) there has been a shift in the population to the urban pockets of the country and it is ever increasing. Seeking to get the most out of the opportunity, the Ministry of Housing and Urban Affairs launched the Urban Green Mobility Scheme in November 2017, with an outlook to promote a low carbon sustainable public transport system to reduce the carbon footprint.

The FAME Phase-I provided incentives for about 130 Automotive Models of 29 Companies which included models from leading companies such as Volvo, Hero Electric, Mahindra & Mahindra, Maruti Suzuki, Tata, Toyota Kirloskar etc. The total number of vehicles incentivised under this scheme was 2.8 Hundred Thousand units amounting to a whopping ₹ 3.43 Billion of incentives being disbursed. After receiving many time bound extensions, post March 2019 the next phase i.e. Phase -II was launched.

The Phase-II of the scheme came into effect from 1st April 2019 and has a larger allocation of funds at ₹ 100 Billion and is to be implemented for a period of three years Apart from budget, the policy brings new changes such as a cap on the demand incentives as per the ex-factory price, number of vehicles in each segment, new xEVs Technology Definitions etc. It advocates proactive support from the State Governments to complement and go hand in hand with the Central Government. DHI is the nodal agency for laying guidelines. A committee comprising secretaries of various ministries named Project

Implementation and Sanctioning Committee (PISC) and Headed by the Secretary (DHI) is constituted to overlook the monitoring, sanctioning and implementation of the Phase.

Eighty-six per cent of the outlay is designated for demand Incentives and the rest is for development of charging stations (infrastructure built up) and other administrative purposes. One of the major differences is that this phase focuses more on public transportation as it lays emphasis on being a provider of environment friendly and an affordable transport alternative to various cities of our country. Phased Manufacturing Program(PMP) announced alongside the Phase II was primarily focused on providing an impetus to manufacturing of ev's, sub-assemblies, parts, sub parts through a graded duty structure in order to increase value addition and capacity building in the country .The PMP announced an increase in the tariffs for the import of battery modules, electric buses and trucks so as to promote indigenous production. Until August 2019 a total of 5595 buses for 64 cities for intra city and intercity operation were sanctioned (PIB, 2019). Also, for development of charging stations the scheme sanctioned 2636 stations in 62 Cities across 24 States/UT's. As per the latest data available on the FAME II website, the number of models registered with the current phase is 54 of around 19 OEM's and over 21000 vehicles are sold with more than ₹ 530 million being disbursed.

The automotive sector needs to remain relevant in terms of making the product and manufacturing process innovative with respect to agile technology development, across the automotive ecosystem. There is no escape from integrating principles of Industry 4.0 with the Make in India initiative, if indigenous manufacturing has to win against global competition. India has a unique opportunity to innovatively pave its own road to Smart Manufacturing. So accordingly, Samarth Udyog Bharat 4.0, an initiative by DHI has been formed to set up Industry 4.0 centres (Demo cum experience) across the country for promoting smart and advanced manufacturing to help SMEs implement Industry 4.0 (automation and data exchange in manufacturing technology). In collaboration with Indian Machine Tool Manufacturers Association (IMTMA) and Central Manufacturing Technology Institute (CMTI) are developing a centre Smart Manufacturing Demo and Development Cell (SMDDC) which will be established as a "Centre of Excellence for Smart Manufacturing(Machine Tool Centric) encompassing Industry 4.0 and Industrial Internet of Things as a theme"

The technologies which are developing need to be integrated in the supply chain of the sector so that the benefits are reaped by all the elements of the same. Logistics being an important area of the supply chain, has a crucial role to play. As per the Economic Survey 2017-18, the Indian logistics sector provides livelihood to more than 22 million people and improving the sector will facilitate 10 percent decrease in indirect logistics cost leading to the growth of 5 to 8 percent in exports. The National Logistics Policy (NLP), 2020 allows for the seamless movement of goods through a single window with a focus on

employment, skills and making small and medium enterprises competitive. It aims at "enhancing efficiency across the value chain through increased digitization and technology adoption" (Ministry of Commerce, 2019), "Creating a single point of reference for all logistics and trade facilitation matters in the country which will also function as a knowledge and information sharing platform" (Ministry of Commerce, 2019) etc.

Looking towards soft competencies, i.e. the skills and technical knowhow, skill policies are also needed to align with the infrastructure policies so that together in tandem they both propel the overall growth of the sector.

2.3 - Education and Skill Based Policies

As India is home to the largest youth population of the world, there is an imminent need to cater the ever-growing technical aspirations and provide employment, driven by skill development and R&D. An EY and NASSCOM study on the future of jobs in India found that by 2022, around 46 per cent of the workforce will be engaged in entirely new jobs that do not exist today or will be deployed in jobs that require radically changed skill sets. India needs a new approach to education and skill development. When the National Policy on Education, 1986/1992 was formulated, it was difficult to predict the path of technological innovation, particularly the impact of disruptive technologies, which is why the government initiated the process of formulating new education policy. The draft National Education Policy 2019 document clearly states that "Our present education system's inability to cope with these rapid and disruptive changes places us (individually and nationally) at a perilous disadvantage in an increasingly competitive world…India must take the lead in preparing professionals in cutting-edge areas that are fast gaining prominence such as artificial intelligence, 3-D machining, big data analysis and machine learning among others in technical education." Disruptive technologies, such as artificial intelligence (AI) hold great potential for the manufacturing sector, particularly the automotive sector. Recognising this, the Finance Minister of India, in his budget speech for 2018 – 2019, mandated the premier policy think tank of the government - NITI Aayog, to establish the National Program on AI with a view to guiding the research and development in new and emerging technologies. A discussion paper entitled "*National Strategy for Artificial Intelligence: #AIForAll*" released by NITI Aayog emphasises that AI-enabled mobility solutions can address the challenges being faced by the Indian automotive sector. The draft National Education Policy 2019 also endorses the recommendations made by NITI Aayog pertaining to education.

AMP 2026 recognises that among all the sectors, the automotive sector offers one of the highest potentials for providing skills to youth and is more proactive about up-skilling. One of the objectives of AMP (2026) is to be a prime exporter in terms of technology and research, so policies and councils for

the same allow expedite management and arrange for vital inputs for the sector. It envisages a bigger role for the Automotive Skill Development Council (ASDC) by making it an apex industry body for skill development under various programmes by the government and an independent testing and certification agency for sector skills. ASDC was the first sector skill council set up as part of the initiatives taken to strengthen the automotive sector under the AMP 2006-16. Currently governed by the National Skill Development Corporation (NSDC), ASDC aims to accelerate skill generation as a blend of industry and academia. A joint initiative of the Government of India, SIAM, ACMA and FADA it was in place before the government launched the 'Skill India Program'. In collaboration with the Ministry of Skill Development & Entrepreneurship (MSDE) and under Pradhan Mantri Kaushal Vikas Yojana (PMKVY)

ASDC offers 208 Courses taught through various centres across the country known as Industrial Training Institutes in fields such as Manufacturing, Supply Chain Development, Vehicle Service etc.ASDC is adding new job roles (called Qualification Packs or QPs) in order to address the policy initiatives of moving over to electric mobility as outlined in the FAME II initiative. Emerging job roles with respect to Industry 4.0 are being validated with the support from the industry and academia. Existing QPs are getting enhanced by ASDC Expert Group, consisting of members from industry. These QPs are based on Robotics Process Automation, 3D Printing and Big Data Analysis (ASDC Brochure, 2019).

ASDC has driven various initiatives with the latest being a partnership with TCS iOn. Announced at the Annual Condave – 2019 a "Skill Hub" was launched which consisted of a platform for imparting skills through a Phygital (Physical+Digital) Medium, a listing portal for Jobs, Digital Skill Assessment Process etc. ASDC interfaces with various industry bodies for skill-aided capital creation, which in turn leads to higher economic activity. It has participated in every edition of the Biannual World Skills Competition since 2011. ASDC participation in the World Skills has been a success so far, winning *15 Medallions for Excellence* in the 2019 Edition held in Kazan, Russia. The Annual Report 2018-19 states that ASDC has more than 70k+ Candidates Assessed, has about 550 Certified Trainers and 815 Training Centres.

To keep pace with the global technology and promote cutting edge research, a project named National Automotive Testing and R&D Infrastructure Project (NATRiP) was set up under AMP 2006-16 as an independent society in July 2005 for creating core global competencies by having state of the art automotive testing, homologation and R&D infrastructure facilities in India. Set up with an initial outlay of 17.18 billion ₹ which was increased to ₹ 22.88 billion and finally hiked to 37.27 billion ₹ in 2016, it is one of the largest and most significant initiative in the sector so far (National Automotive Testing and R&D Project, 2018). There are a total seven centres under its ambit, with four of them being green field projects (refer to table 1) and set for different areas of automotive testing with state-of-the-art infrastructure and three facilities have been upgraded with new technology and equipment.

Table 1: Centres of Excellence under NATRiP

Facility	Location	Centre of Excellence (COE)
International Centre for Automotive Technology (ICAT)	*Manesar*	*Components, NVH,*
Global Automotive Research Centre (GARC)	*Chennai*	*Passive Safety and Infotronics*
National Institute of Automotive Inspection, Maintenance & Training (NIAIMT)	*Silchar (Assam)*	*Automotive Inspection and Training (Hilly Terrain)*
National Automotive Test Tracks (NATRAX)	*Pithampur (Indore)*	*Vehicle Dynamics and R&D Tracks*
National Centre for Vehicle Research & Safety (NCVRS)	*Rae Bareli (UP)*	*Accident Data*

Data Source: http://www.natrip.in/download/Natrip_architecture.pdf

The two existing facilities, the Automotive Research Association of India (ARAI-Pune) and the Vehicle Research & Development Establishment (VRDE – Ahmednagar) have been upgraded with new technologies. The International Centre for Automotive Technology (ICAT) is also being upgraded since the past two-three years for passive safety and test tracks. Each and every centre contributes to a different area of automobile and mainly focuses on indigenous R&D.

Moreover, with sector specific R&D, an overall Policy for Science and Technology is also required. The Science and Technology Innovation Policy (STI), 2013 was released by the *Department of Science and Technology (DST)* with an aim to accelerate the pace of discovery and increase the quantum of science led innovations for a faster and sustainable and inclusive growth. It laid focus on areas "such as prioritizing critical R&D areas, promoting interdisciplinary research, supporting STI driven entrepreneurship viable models" (STI, 2013; pg. 14). The policy also talks about how Intellectual Property Rights are important for stimulating creativity and innovation. Since the automotive sector is highly competitive and innovation-driven, any modification in the country's Intellectual Property (IP) regime can have major implications for the sector. Recognising the important role of a robust IP ecosystem in fostering the direction and quality of innovation, the *Department for Promotion of Industry and Internal Trade* (under the Ministry of Commerce and Industry), designed a National IPR Policy, which was adopted by the Union Cabinet in 2016 (Chawla & Mukherjee, 2018). The IPR policy and supporting initiatives such as the amendment of the Patent Rules 2003 to streamline the process making it faster and more user-friendly, augmentation of technical manpower handling the IP applications and setting up of a network of Technology and Innovation Support Centres across India have opened up new opportunities for firms in the automotive sector.

With an objective to develop programs and policies for fostering innovation across industry sectors, Atal Innovation Mission (AIM), a flagship initiative set up by NITI Aayog was launched to promote a culture of innovation and entrepreneurship in the country. The Atal New India Challenge (ANIC) one of the sub programs seeks to provide resources for piloting, testing and for market creation for new challenges/project ideas. The activity has many "challenges" that have been given monetary grant and support which include Smart Mobility Projects under the aegis of the Ministry of Road Transport and Highways.

For the same purpose, a sector specific program named *"Technology Platform for Electric Mobility"* (TPEM) which focuses on the rapid development of Electric Mobility was formed in 2016 as a joint program between the DHI and DST. The main goal of the platform is to develop technologies and products that cater to the development of e-mobility. Besides, a function of the platform is also to keep updated the technology roadmap, having a prioritized list of R&D Programs and lastly to develop white papers on critical technologies. DHI being a nodal agency has many platforms and policies formed under its purview with one of them being Development Council for Automobiles and Allied Industries (DCAAI). DCAAI is formed for the productive utilisation of the cess fund allocated to DHI's annual budget to promote R&D Projects for automobiles & its allied industries. Chaired by the Secretary (DHI), it consists of 25 members and has projects approved amounting to ₹ 135.6 million and ₹ 88.8 million for the years 2018-19 and 2019-20 respectively.

Dealing with aspects of logistics infrastructure and last mile connectivity, the Pradhan Mantri Gram Sadak Yojana (PMGSY) was launched in the year 2000 with the purpose of providing a proper all-weather road connectivity to remote villages across India so that the automotive sector can reach the hinterlands of the country. Similarly, intending for a cleaner environment and wanting to lower the import dependency of fossil fuels the National Policy on Biofuels (NPBF) by the Ministry of New and Renewable Resources (MNRE) was approved in May 2018. It envisages a target of 20 percent of blending of ethanol and 5 percent of biodiesel in petrol and diesel respectively by 2030 (MPNG, 2018). For providing sustainable mobility and accessibility to all citizens. With a focus on urban mobility, the Ministry of Urban Development (MoUD) in 2014 issued an updated version of the National Urban Transport Policy (NUTP),2006 with an approach of 'Avoid, Shift and Improve' (Bellagio Declaration,2008). Apart from it, a prescribed framework for vehicles on roads, The Motor Vehicles Act, (1914) is an act which was amended in 2019 with respect to the issues of recall of vehicles, taxi aggregators, various offences and its related fines. Besides it also suggested a probable development of a National Transportation Policy

In addition, fiscal measures are indispensable and are needed so that a balance is obtained. The Union Budget is an important document announcing significant outlays in key sectors. Measures such as reduction in excise duty for Hybrid Vehicles, or increase in custom duty on imported vehicles greatly impact the automotive sector The Budget 2019-20, announced that an additional income tax deduction of ₹ 150,000 would be provided on the interest paid on the loans taken to purchase EVs. The introduction of Goods and Services Tax (GST) led to an overhaul of taxation regime in India. Tax rates for commercial, used and personal cars varied across all slabs of GST. Initially EV's, its chargers, charging stations were taxed at 18 percent, and it was subsequently revised to 5 percent by the 36th GST Council Meeting held in July 2019 (post the start of FAME Phase II) thus underlying the need to promote sustainable and green mobility.

Regardless of the policies and steps taken by various levels of Government, there remains a constant challenge of consolidation across platforms. Also, implementation of the same for the common people so that the benefits are widespread still remains a key thing that is left desired. Various hindrances which have a negative effect hamper the growth of the sector often leads to an uneven and an undesired fallacy for the industry. Finally, a sector-level analysis of vital parameters is equally necessary to ascertain where India stands in the scheme of things.

Chapter 3 - Sector Level analysis (Dharmik Vasani)

Growth of any industry depends on several factors. It is important to analyse an industry on a macroeconomic level to understand its importance for the country. It is also important to determine the future of the automotive industry, especially in light of technological developments and the extent of impact that external factors have on the auto sector. STEEP is one such framework that helps in analysing the industry at macroeconomic level.

STEEP stands for Social, Technological, Economic, Environmental and Political factors. STEEP is a robust model that provides a 360-degree view of any sector. STEEP is considered a powerful tool because these five factors of the model are important to understand external as well as internal environment of any sector or organization. These five factors further include various aspects that are explained in the Table 2 below.

Table 2: STEEP Factors (Szigeti, et al., 2011)

Social	This includes demographic factors, safety awareness, Spending power of individuals, purchasing power parity, lifestyle of people, changes in behaviour etc.
Technological	This factor includes technological initiatives, spending on R&D, innovation factors, etc.
Environmental	Environmental changes increase in carbon emissions, recycling technology, natural mineral reserves etc. fall under this factor.
Economic	Economic factors include contribution of the sector to GDP, employment generation, infrastructure spending by the country, taxation changes etc.
Political	Lastly, this factor consists of sector specific policies, foreign investment policies, trade related policies and all other policies that directly or indirectly affect the sector.

Advantages of STEEP:

- This framework is easy to understand and it covers all the necessary information that can be used to study the strengths and weaknesses of any sector.
- It can also be used to make a comparison between different countries and hence, can help in finding the flaws in the system of a country and address them strategically.
- It also provides a detailed overview of the five sectors that have major influence on the growth of any sector.

Disadvantages:

- One major disadvantage of this framework is that all these factors can see the change rapidly. This is mainly due to their dependence on various other aspects such as government policies, technological advancement in the country, human behaviour etc., as these aspects keep changing with time.
- Another disadvantage is that it is subjective, that means interpretation of these factors varies from person to person.

In spite of these disadvantages, the STEEP framework includes the key factors needed to analyse any sector at national and international level. This gives us a strong reason to use the STEEP framework for complete analysis of the automotive sector.

3.1 - Social Factors:

Social factors play a huge role in the growth of any sector because people consume goods and services for reasons beyond their basic use-value (Firat, 2013). It becomes important to study the society in various aspects such as human behaviour, demographic advantages/disadvantages (such as gender ratio, age and family size) and education level in order to understand the consumer needs. For example, India has a culture of joint family, so the size of family also matters while purchasing an automobile. Apart from this, level of awareness in terms of safety, environmental changes and shared mobility concepts can also be included under this factor.

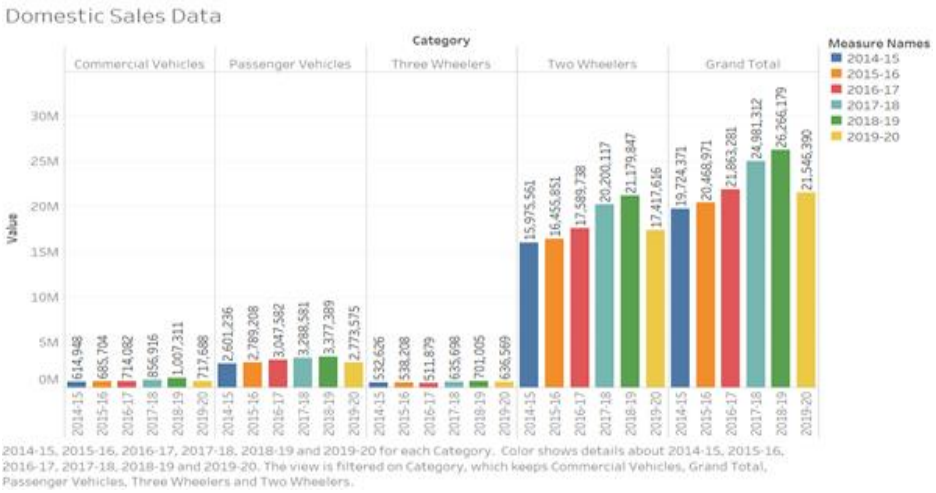

Figure 2:Sales data of vehicles sold in India

Data Source: SIAM

This data shows that sales of vehicles are continuously rising during the period and the two-wheeler segment dominates Indian automobile market. India has a huge potential for any sector taking into consideration its huge population

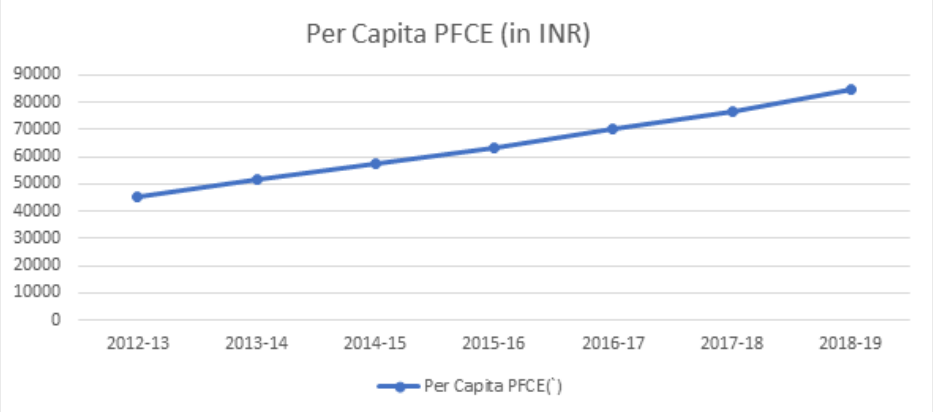

Figure 3:Per Capita PFCE of India (in INR)

Data Source: Reserve Bank of India

Due to its large population, India has a huge potential in terms of consumption. The above figure shows per capita private final consumption expenditure (PFCE) of the country and it has been constantly

increasing for years. These numbers show that the purchasing power of India is rising though it is not at par with many leading countries. Apart from that, people are looking for a safe environment around them and they also consider this while purchasing a vehicle. With the evolving technologies, companies need to focus on the safety aspect as well. Around 58 percent of people in India think that autonomous vehicles will not be safe, which is high compared to the US, Japan, Germany and China where this percentage is 48, 47, 45 and 35 respectively (Deloitte, 2020). All these countries are considered the leading manufacturers of automobiles in terms of volume.

3.2 - Technical Factors:

Future of the automotive industry revolves around four key technologies that are connectivity, automation, shared mobility and electrification (Deloitte, 2020). Somewhere, all of these technologies involve use of ICT connectivity and access. Therefore, it is important to have a look at ICT access and usage of various countries. Table 4 shows the ICT access and usage rankings given by WIPO as a part of the global innovation index.

Table 4: ICT Access and Usage rankings (2019)

Country	ICT Access score	ICT Access Rank	ICT Usage Score	ICT Usage Rank
USA	84.8	14	77.2	21
Germany	90.3	6	77.2	22
China	60.0	75	61.5	55
Japan	86.3	11	81.3	12
India	38.5	105	20.8	106

Data Source: WIPO

These rankings show that countries other than India are far ahead in terms of both, access and usage of ICT. ICT access and usage play a very important role in development of infrastructure of the country and India has a long way to go. Another such ranking is given by the world economic forum which is known as Network Readiness Index.

Table 5: Network Readiness Index (2019)

Country	Rank
USA	8
Japan	10
Germany	9
China	41
India	79

Data Source: World Economic Forum

These rankings have four key pillars based on which every country is ranked. These pillars are people, technology, governance and impact (Dutta & Lanvin, 2019).All these pillars have been monitored in terms of availability and accessibility of technology. Technology pillar includes availability of latest technologies, type of technology that is being produced and how prepared a country is in terms of accepting the future technologies. People as a pillar includes availability of technology to individuals, businesses and governments. The governance pillar talks about trust, regulations and the digital divides within the country. The impact pillar talks about the impact of economic, social and sustainable development goals in the network economy. All these pillars are very important to understand how a country is overall performing in terms of network readiness. India's rank in table 5 shows that India needs to improve its network economy if it wants to embrace future vehicles that demand high usage of information and communication technologies.

3.3 - Environmental Factors:

Carbon emission is the key issue faced by many countries today and a lot of it is caused by vehicles. To address this issue, the Government of India is promoting EVs under its Faster adoption and manufacturing of (Hybrid) & electric vehicles in India (FAME-India) policy and FAME-II policy. These two policies are primarily focused on promoting EVs in the country.

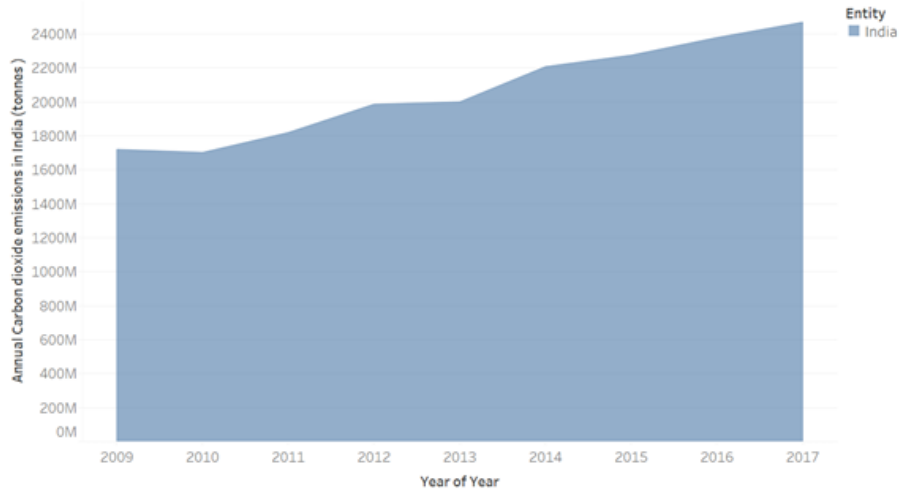

Figure 4: Carbon dioxide emission data

Data source: Our world in Data

Figure 4 shows the level of carbon dioxide emission in India. It is clearly visible that the emission has increased at a significant rate. This emission causes great harm to the environment. Penetration to EVs will help in reducing this level of emission to a great extent. However, to make this happen, India needs EV supporting infrastructure and widely available public charging points. Apart from the aspect of pollution, environmental factors also consist of availability of natural resources. India is a rich country in terms of material reserves, around 97 percent of all materials consumed in the country are extracted domestically although it is required to increase resource efficiency and use of secondary raw materials to preserve the natural resources (NITI Ayog, 2017).

3.4 - Economic Factors:

Economic aspects are important to analyse because they help us in assessing industry's performance in terms of contribution to a country's economy and GDP. Automotive industry has a significant contribution in India's GDP. The sector contributes around 7 percent in the total GDP of the country. Around 3.5 million vehicles are exported from India which holds 4.3 percent share in India's total exports (Invest India, 2020). Infrastructure spending also comes into picture when considering economic factors. Figure 6 shows the total inland transport infrastructure spending by the leading automotive manufacturing countries. Only Germany is spending less than India, all the other countries' spending is

much higher than India. Infrastructure is the key component for penetration of EVs, specially the charging infrastructure that is required for the EVs.

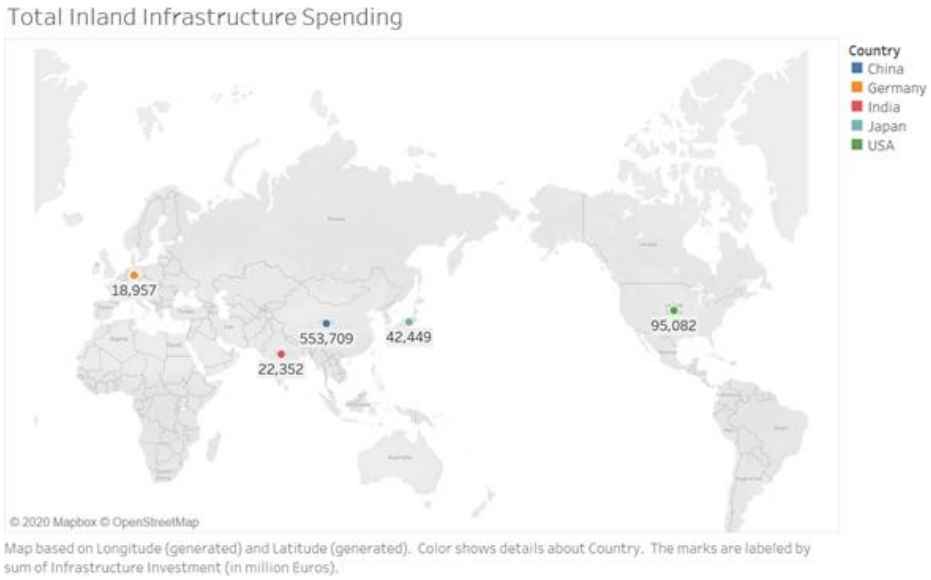

Figure 6: Total inland transport Infrastructure spending (in million Euros, 2016)

Data Source: OECD

The Government of India released guidelines for charging infrastructure for EVs, with a proposal to cover 70 cities and 20 percent of highways at a cost of ₹ 50 billion by 2025. Government is also promoting EV sales by reducing GST on EVs from 12 percent to 5 percent and also allows tax rebates up to ₹ 150000 on interest paid on the loan taken for EVs (EESL, 2020).

3.4 - Political Factors:

Growth of any sector depends on the policy framework and support by the government. Automotive sector is a pillar for Indian economy and the government is taking some good initiatives in terms of policy implementation for the automotive sector. Government has allowed 100 percent foreign direct investment (FDI) in the Auto and Auto ancillaries sector to make the latest technologies available to India. The government has launched Automotive Mission Plan 2016-26 (AMP 2016-26) with the vision to make India among the top three of the world in engineering, manufacturing and export of vehicle and auto components. This policy covers significant reforms that need to be taken. Policy reflects on emission norms, safety regulations, trade policies, skill development and some other aspects which are beneficial for development of the auto sector in India. Government has also taken some political steps

to promote EVs. Under its Faster adoption and manufacturing of (Hybrid) & electric vehicles in India (FAME-India) policy, the government is pushing the adoption of EVs. In 2019, the government launched the second phase of the FAME policy (FAME-II) with an outlay of INR 100 billion for a period of three years starting from 1st April 2019. All these policies come under the ambit of National electric mobility mission plan 2020 (NEMMP) which was launched by the government to promote reliable, efficient and affordable EVs. Apart from the sector specific policies, the government should also focus on improving the business environment in the country. Though India has made a jump in ease of doing business rank, it is still lagging behind the leading economies of the world. Table 6 shows the ranking of the countries that are considered leading manufacturers of automobiles in the world.

Table 6: Ease of doing Business (2019)

Country	Rank
USA	6
Germany	22
Japan	29
China	31
India	63

Data Source: World Bank

India has improved its rank to 63 in the past few years. Doing business rankings includes 12 different measures which are starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, resolving insolvency, employing workers and contracting with the government (World Bank, 2019). Improvement in these measures will not only attract foreign automotive players but also revive the domestic automotive industry.

Chapter 4 - Challenges: (Siddharth Baxi)

A sector as large as the automobile sector, called "the industry of industries" by the famous management consultant Late Mr. Peter Drucker has seen its own share of highs and lows. With challenges on every front, overcoming them is quite a task to complete, sometimes due to their sheer scale or lack of liquidity. In spite of this, the automotive world has constantly reimagined its opportunities and succeeded in being on top of the challenges. As discussed earlier in the policy review, each respective policy is directed towards solving a unique challenge which has to be better at, in order to achieve the objectives. The previous section on analysis of the sector shows that India as a country lags on some of the vital parameters, such as cars per million, purchasing power parity etc. The year 2020 has been quite a ride for the world, with challenges mounting at an umpteen pace, courtesy of the deadly pandemic of coronavirus (COVID – 19), its outbreak has caused global distress and economic problems for consumers, businesses and communities. "The pandemic has disrupted business as usual and thrown the economic outlook into uncertainty, the automotive industry is on the front line. Some of the most affected regions are major production hubs and home to key links in the sector's global supply chain" (Sorenson & Telang, 2020). Seemingly, India being one of the largest automobile markets is facing some major challenges on the back of the already 20-21 percent decline in the sales in the year 2019 (SIAM, 2020). According to Mr. Deepak Jain (President, ACMA) *"Now, it's all about how do we survive this period. Covid-19 is not going away anytime soon. We have to adjust shop floors to the new normal with a staggered approach. What will be key is to give confidence to the workforce to come back to the shop floor.",* implying that the sector will be put across through a lot of hardships in the coming times.

This section displays how the existing and forthcoming challenges can be classified according to their nature and how they can be solved. To analyse the difficulties faced by a sector an all-round framework is needed. So, an integrated system-level approach is imperative due to the interdependency of various economic, social and institutional, technical and environmental factors. The framework on which this section is based covers all the broad areas mentioned in the previous statement and can be also referred to as the ESTE framework where E stands for economic, S stands for social and institutional, T stands for technical and E stands for environmental factors . The economic factors of an industry especially as large as automobiles cannot be overlooked when discussing the challenges. India being the second most populated nation in the world, the social issues also need to be studied. Apart from the above two, technology plays an important role in this sector, with the Internet of things, artificial intelligence and Industry 4.0 becoming the norm. Lastly, in the time where we are facing issues such as global warming, depletion of the ozone layer etc. it becomes requisite to focus on the environmental aspect because sustainability is the key to the way ahead. The automotive industry depends on all of the

above factors either directly or indirectly, and therefore this particular framework which encompasses the majority of the challenges with respect to the factors is used for the evaluation.

4.1 - Economic Challenges

1. Liquidity Crunch – In the backdrop of a negative growth for the year 2019-20 (SIAM, 2020) and with the virus surfacing in 2020, many automotive and its components manufacturers are facing the pinch due to an unavailability of an economic bailout. Though there has been an extension of the moratorium on payment of principal and interest of loans till august the crunch can further be reduced by measures such as levying minimal taxes in the short term and by creation of exclusive Special Economic Zones (SEZ's) for the sector in the long term.

2. Supply Chain – The supply chain disruption has deeply affected the sector, apart from that demand uncertainty and closure of showrooms due to the lockdown has had a bad effect on the already reeling sector. For the same, digitizing certain aspects of the supply chain can help in solving the problem. Mr. Deepak Jain (President, ACMA), states that "*Balancing seamless supply chains is a key challenge going forward*" hinting that an agile and flexible supply chain is necessary to resolve the issue.
3. Implementing Industry 4.0 – The fourth industrial revolution is the latest trend and is a methodology which helps in optimizing the overall dynamics of the field/sector in which it is applied. Though very efficient and effective, Industry 4.0 has huge capital costs. So, an outlook for developments in this direction indigenously is the way forward for getting an affordable inhouse application of Industry 4.0

4. High duties – High import duties on certain categories of raw materials such as aluminium leads to an overall rise in production costs, a push for "Make in India" or reduction in the duties can help to mitigate the problem. Apart from that, signing up free trades agreements and regional trade agreements can have a "big impact on the fortunes of the vehicle and auto component sector in India" (AMP 2026).

4.2 - Social and Institutional Challenges

1. Low competitiveness - India ranks 68th in the Global Competitiveness Report, 2019. The sector, though crucial in a nation's development, lacks world class transportation infrastructure in

India due to poor linkages among various other modes of transport. For the same, a set of policies which bring all the modes under a unique regulatory framework will help ease the problem.

2. Lack of coordination - This challenge is prominent between the nodal agencies for matters related to the automotive sector, leading to decision constraints. To solve it, the National Automotive Board can be vested with more powers and enforcing authority. Also, the Central Government can engage actively with the state governments to address the issues bothering the sector (Department of Heavy Industry, 2016).

3. Shortage of Labour – For returning to normalcy "Labour availability is a larger issue for the suppliers, as they hold onto most of the contracted ones." (RC Bhargava, Chairman, Maruti Suzuki India Limited). Vijay Kirloskar, Vice Chairman, Toyota Kirloskar Motor believes that it being a tough issue needs to be handled sensitively. He further says that "If the situation continues, we might even have to consider opening factories in rural areas or smaller towns for a long-term solution"[4].

4. Acceptability of Green Vehicles – Pricier electronic vehicles as compared to the conventional counterparts and the de-escalation in the global crude prices (Ambrose, 2020) act as a deterrent for the consumers to shift towards greener alternatives. To address the issue bailing heavy incentives and perks on the demand side can help increase the quantum of them.

5. Human Resource – If India were to become an automotive manufacturing hub, it would require a significant number of skilled personnel. The skill gap needs to be addressed on priority basis so that India does not lose out on critical talent that may be important for it to become a globally important automotive hub. There has to be an expanded outreach of Skill Councils like Automotive Skill Development Council and Industrial Training institutes with an impetus on soft skill development and R&D.

6. Number of fatalities – There are 22.6 deaths per hundred thousand people in India due to

[4] https://auto.economictimes.indiatimes.com/news/industry/automakers-attempt-to-deal-with-migrant-labour-shortages/75827255 (Accessed on 5th June, 2020)

road accidents, second only to Thailand (32.6 deaths per hundred thousand people) in the South East Asian region (WHO, 2018). With 1,46,133 fatalities in 2015 (Ministry of Road Transport and Highways, 2016)this is an area, which India needs to look upon. Though stringent laws and legislations like Motor Vehicles Amendment Act, 2019 have various disciplinary actions in the form of heavy fines, confiscation of license etc. for over speeding, not wearing of helmets and seat belts but the enforcement of them is lenient. Besides, implementation of laws regarding safety measures on the supply side such as electronic stability control (ESP), anti-lock braking system (ABS), air bags etc. can help to reduce overall impact on the sector.

4.3 - Technological Challenges

1. Smart Cars – Connected cars and digitization is becoming very common in modern vehicles. CASE technologies are the upcoming trend (Deloitte, 2020). The cars collect humongous amounts of data on a daily basis which have often led to the concern of privacy. Though connected technologies do not pose a direct challenge but with increased technological integration comes increased complexity, pertaining to data protection and consumer safety, which car manufacturers are required to address.

2. Product and Process upgradation – There is a need to make more sophisticated products and develop new and improved processes. Navas-Aleman (2011) suggests that the former can be done through i) increasing product quality by using new materials ii) reduction in reworking rates (recall and maintenance) through stringent quality practices etc. and the latter can be achieved by i) purchasing new production machinery ii) reduction in delivery times by training workers iii)introduction of new organizational/ management techniques and iv) improvements in the production process by increasing digitization. Industry 4.0 needs to be a vital cog for the upgradation because the process upgradation and product innovation need to be aligned with the latest technology and in synchronization with the global standards.

3. End of Life Policy – There is an absence of a policy which regulates the scientific and safe recycling of old vehicles which contribute nearly 65 percent to vehicular pollution. A Vehicle Scrap Policy has been given an "in-principle" approval at a high-level meeting at the Prime minister's office (PTI, 2020). The draft Voluntary Vehide Fleet Modernization Plan (Ministry of Road Transport and Highways, 2016). proposes payback of the scrap value of used cars, incentives worth 8-12 percent in form of total discount for the new vehicle, 50 percent

relaxation on excise duty etc. If implemented it can help in streamlining the process of shifting from old to new cars coupled with fiscal and monetary benefits.

4.4 - Environmental Challenges

1. Air Pollution – A majority of the automobile supplementary industries are classified as red and orange in terms of pollution index score. The sector is also a major contributor to vehicular emissions as 31 percent of NO_x emissions is by the transport sector (TERI, 2015). To reduce pollution, congestion pricing and parking, odd-even schemes, inducing greater acceptability for EVs can be initiated. Also, building Bus Rapid Transit System (BRTS), promoting e-rickshaws etc. can be one of the solutions. Though shared mobility is a very sustainable solution, it is due to take a hit because of the contagious nature of the virus. Various ride hailing platforms such as Meru and manufacturers such as TVS, Volvo have come up with services that provide a sanitized ride at a minimal amount and complete vehicle sanitization respectively.

2. Green Infrastructure - The lack of adequate green mobility infrastructure such as the availability of charging stations, efficient batteries etc. has led to relatively poor adoption of electronic vehicles in India in comparison to major countries of the world. Sanctioning and implementation of schemes cantered around the infrastructure build up are needed, also initiatives in areas for scaled manufacturing, systems Integration, and shared infrastructure need to be developed. "*Besides, empowering a Forum of Regulators (FOR) to create regulatory frameworks that make EV charging ubiquitous, affordable, and a grid asset is also needed*" (NITI Ayog, 2017). Apart from focus on private vehicles, emphasis on green public transport is also required.

3. BS VI Norms – The norms were to be adopted nationwide from 1st April 2020 but got extended due to the coronavirus (Autocar India). A major problem in shifting to BS VI is that a lot of parts will have to be imported. "*Before BS VI, almost every part could be sourced from India. With BS VI, a lot of parts had to be quickly sourced from Europe or China. Indian industry did not get enough time to collaborate & the scale of production quantity & investment was not tenable."(Rajan Wadhera, Chairman SIAM).* So proper implementation in a systematic manner is the key to its success.

There is no denying that the proliferation of digital technologies has fundamental implications for OEMs and their suppliers in the automotive sector. Industry 4.0 has resulted in digitization and interconnection of products, value chains and business models. With cars becoming autonomous, electric and connected, the manufacturers and suppliers need to shift their focus from product to mobility and digital services. The policies being an integral part have to be determined according to the needs and in a way such that the parameters in which India is behind on a global scale are overcome. With the right mix of accelerators - including national policies, regulatory frameworks, supporting infrastructure, research and innovation ecosystems - India can lead the fourth industrial revolution in a responsible, scalable and inclusive manner (Brende, 2018). Despite the hurdles posed by rapid digital transformation, emerging trends have also opened up new avenues for the automotive sector, how the sunrise sector of India rebuilds its strategy to overcome these challenges and exploit new opportunities is yet to be seen.

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