NOW AND FUTURE CHALLENGES OF THE AUTOMOBILE INDUSTRY IN THE DEVELOPING WORLD

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Abstract: The automotive sector has fuelled economic expansion in several countries. The automotive industry is changing quickly in response to shifting consumer tastes, the adoption of stronger government rules, and technology innovation. This study examines the current and future challenges faced by the automotive industry in developing countries and explores strategies for fostering growth and addressing these challenges. The automobile industry in developing countries confronts various obstacles, like infrastructure limitations, environmental concerns, lack of skilled workforce and market competitiveness. These challenges hinder the industrial growth and sustainability. However, there are also promising opportunities and future trends that can reshape the industry, such as electric vehicles, autonomous and connected vehicles, shared mobility services, advanced manufacturing techniques, and sustainable materials. To overcome these challenges and promote growth, several recommendations are proposed. These include: infrastructure development to improve accessibility, skill development programs to address skilled workforce shortage and effective policies. By addressing these challenges and implementing the recommended strategies, developing countries can advance growth, improve sustainability, and create a vibrant and competitive automobile industry. Conclusively, collaboration between governments, industry players, academia, and research institutions are vital for overcoming challenges, and achieving long-term success in evolving automotive landscape.
1. Introduction

1.1 Background to the study

Manufacturing, selling, and maintaining of automobiles are all included in the automotive business for trucks and passenger cars [1]. The automotive industry takes the primary responsibility for manufacturing, selling, repairs and other services of automobile products such as tractors, and motor vehicles among others [2]. The automobile industry is among the largest industrial sectors in the world. There are over five hundred (500) million registered passenger cars worldwide. By 2030, their population will have tripled and will continue to increase. In more than 100 years that it has been in existence, the manufacturing of automobiles has experienced multiple abrupt changes. Changes in supply and demand, as well as technology advancements and production method changes, have all been significant ruptures. Automobiles are a key player in modern-day life activities as it’s used for transportation and for pleasure. For definition purposes, automobiles are multi-wheeled vehicles which carry an engine and are used for transporting people and goods on land, this doesn't include rails, as automobiles are limited to road use [2].

Developing countries such as China, India, Brazil, and Mexico have witnessed remarkable growth in their automobile industries due to factors such as rising incomes, urbanization, and changing consumer preferences. These countries have experienced an increase in vehicle ownership, leading to the creation of employment opportunities, technological advancements, and the establishment of a domestic automotive manufacturing base [3]. However, the automobile industry in the developing world also faces unique challenges that hinder its sustainable growth. The socio-economic growth of these countries as well as the long-term success of the sector depend on an understanding of and response to these issues. Industrialization in Africa, particularly in Sub-Saharan Africa is on a low level which is one of the main factors inhibiting the growth of the automobile industry. Given that the industry has a trade deficit to the value of $16.3 billion as a result, there is need to draw investment into this sector to support the expansion of the industry in lower-income nations [4]. The domestic growth of this sector may be hampered by Nigeria and Kenya's current domestic automotive production, even though this is a positive development. A likely solution is the expansion of the domestic market into regional markets to enable higher production and investment [4]. In the developing world, expectations and reality may not be on the same page as regards the automobile sector, since lack of a skilled workforce, professionals and technological expertise in automotive engineering, manufacturing, and design is another challenge. Addressing this skills gap is crucial for developing countries to enhance their technological capabilities and competitiveness [5].

2 Literature Review

About 70 million vehicles are produced annually by the worldwide automotive industry, which is crucial to the world economy and significantly improves society. This demonstrates how important the automobile sectors are in both industrialized and emerging nations [6]. The automobile industry contributes significantly to worldwide employment, and its significance stems in large part from its connections to both the domestic and global economies and its intricate value chain [1]). More than 2 million people are employed in the automotive industry, which accounts for around 5.5% of all employment in the EU. The production of cars and trucks engages approximately 8.4 million people globally (which include the manufacturers with suppliers), and the Asia-Pacific region experiencing the highest significant expansion [1]. The achievement of Goal 8 of the SDGs (Sustainable
Development Goals), which focuses on promoting maintained, panoramic, as well as acceptable economic growth, complete and effective employment with standard work for all, depends on the automotive industry because of its dimension and effect on society. There are other ways the automotive industry can impart to the SDGs, by elevating road safety, occupational safety as well as health (SDG 3), excellent education, and long-lasting learning (SDG 4), transformative, comprehensive together with maintainable industrialization and durable infrastructure (SDG 9), feasible cities with communities (SDG 11), and accountable consumption with production, if the bad externalities of automobile usage together with production can be decreased further [7].

Up until early 2000, most of the passenger automobiles were made and sold by the conventional automobile nations known as the Triad- the EU15, the United States/Canada as well as Japan/Korea. Over the past three decades, there has been a sharp rise in the significance of advancing and evolving economies to the international car sector. Automotive lead companies have resorted to emerging areas with high levels of car demand because the market in developed nations is saturated and stagnant. According to figures from the year 2000, the United States, Japan, Western European nations and Canada, accounted for 75% of the world's passenger car production [8].

Though manufacturing takes after the footsteps of new consumers as demand tends to new markets globally. By the time of the 2008–2009 international financial crunch, the conventional auto-manufacturing nations are lagging behind the evolving economies with regard to production and demand; ever since only they can control the dynamics of production and sales. Around 72% more passenger automobiles were produced globally between 2000 and 2014, and the rise of manufacturing facilities outside of the traditional industrialized nations is solely responsible for this increase [8].

China outshines all other emerging economies in this category. From a little basis in 2000, manufacturing and sales there have propelled it into the top spot on the global market, with unheard-of growth rates. Currently, China holds a 30% share of the global market. Other rising economies, though, have also picked up speed. India, which has experienced excellent increase, rose to the sixth position in the global production rankings in 2014, the next being Brazil and Mexico. India produced 3.6 million passenger automobiles in 2019, compared to China's 20 million, which was below one million in 2001. The majority of the African nations, Bangladesh, Indonesia, Columbia, Pakistan, the Philippines as well as Vietnam are among the other developing nations. These are the markets that the automotive industry may find lucrative in.

2.1 Current and Future Problems

2.1.1 Infrastructure Limitations

Infrastructural deficiencies such as inadequate road quality and faulty transportation systems have contributed significantly to the hindrance of automotive industry growth in developing nations [9]. [4] Captured a significant effect of poor manufacturing capacity on industry growth in developing nations, especially African nations. Kenya has in recent times been able to grow its manufacturing capabilities, however, against Asian counterparts, they are reported to have underperformed still, hence African nations have a lot of work to do in that arena. Despite starting from a poor base, the sub-Saharan African (SSA) automotive industry is expanding quite quickly. Because production is so scarce outside of South Africa, practically all of this need is being satisfied by imports. Used cars from developed nations began to flood the region as a result of liberalization. As a result, car imports serve as a
reliable proxy for market size. Since 2003, light vehicle imports into SSA (excluding South Africa) have increased at a rate of 14% annually, totalling 1.5 million vehicles in 2013 [4].

In actuality, SSA comprises a sizable quantity of primarily compact economies. The combined SSA market is still large even having a GDP valued at $1.66 trillion including 1.84 million units annually of passenger vehicle market. The size of the issue and the potential are revealed by a comparison with India. The average per capita GDP, population, and total GDP of SSA and India are all of the same magnitude. Similarly sized markets exist for vehicles. The primary distinction is in the output [4]. Africa imports cars while India makes its own. India is a large exporter of automobiles, having a total of $8.3 billion net exports. Additionally, Tata is one of its brands. However, SSA is made up of numerous, mostly tiny markets. Except for South Africa, it exports very little and is mostly dependent on imports. As a result, the area's automobile trade deficit in 2013 was $16.3 billion [4].

2.1.2 Environmental Concerns

Environmental sustainability is a growing concern for the automobile industry worldwide. In the context of developing countries, [10] conducted a study on sustainable strategies for the automobile sector. They emphasized the need for developing countries to adopt cleaner technologies and implement stricter emission standards to mitigate the environmental impacts of the industry.

It is common knowledge that automotive use and production have a substantial negative influence on the environment. It is also widely accepted that, shortly, there will be an increase in the number of automobiles in use worldwide, largely as a result of rising demand in developing nations. For instance, over the past ten years, the number of cars sold in China has surged by nearly 25% yearly, making China the largest market for automobiles worldwide. The number of automobiles on the planet surpassed one billion in 2012. Because of the booming auto industry, the automotive sector is responsible for 27% of global CO2 emissions [11].

Global issues now include lowering energy demand and reducing pollution from moving vehicles. To overcome these issues, it is essential to increase fuel efficiency and reduce emissions. Vehicle emissions are rising, especially in major cities where automobiles have become the primary source of air pollution. The ineffective public transportation infrastructure, lax pollution standards, and sluggish adoption of clean automobile technologies make the issue worse in developing countries [11]. According to reports, Beijing has some of the worst air quality among any major cities in the world. In agreement with the study on Global Burden of Disease (2010), 1.2 million premature deaths, or almost 40% of all premature deaths worldwide, were caused by outdoor air pollution in China in 2010 [11]. The consequent alarm signals redoubled attempts to implement stronger environmental rules, concentrate on cleaner transportation technology, and re-energize efforts to jump-start China's electric vehicle industry. India is a different developing nation example, where there were 620,000 premature deaths in 2010 as a result of the same intolerable levels of outdoor air pollution.[11].

Despite a higher tax on vehicles with large engine displacements, Chinese consumers are steadily moving away from midrange compact cars and sedans that consume less fuel to large sport utility vehicles (SUVs) and hatchbacks that burn more fuel. This is driving regulators to impose stricter regulations in addition to driving up China's import costs and contributing to air pollution [11]. Due to the high consumer demand for cars that are less innocuous to the environment together with environmental rules, auto manufacturers have shown an increasing understanding regarding the environmental impact which their products have. The
aim of CO2 reduction has been the main driving force behind mass-reduction technologies creation including less harmful automobiles such as electric and also hybrid electric vehicles.

2.1.3 Skilled Workforce Shortages

Internationally, a country may be said to have a skills shortage if it produces a workforce that is less qualified than that of its rival countries. A second description is when firms while offering in-house training programs, are unable to fill open positions with qualified candidates or increase their workforce to handle rising demand [12]. The lack of a skilled workforce in developing countries has been identified as a significant challenge for the automobile industry. [5] Conducted a study on the challenges faced by the automobile sector in India and found that there was a shortage of qualified professionals in areas such as automotive engineering, manufacturing, and design. This shortage hampers the industry's ability to compete globally and innovate.

Employment in manufacturing worldwide is heavily influenced by the car industry. Since the global 2008 recession, the number of workers in the Trailers “Motor Vehicles including Semi-Trailers” industry has a 35% increment [7]. Between 2009 and 2017, employment in the sector increased significantly in various nations. For instance, employment in the Chinese automobile industry expanded by more than 2 million, or 68%, during that time. In contrast, employment dropped in Italy, Brazil, South Africa, Australia, Belgium, France and the Russian Federation. [7]. Sectoral changes in the economy in the 1960s and 1970s may have had an impact on hiring engineers for the auto industry, both as apprentices and graduates. Graduates with engineering degrees have been drawn to the banking and investing industries due to the expansion of the financial sector, where their quantitative talents are highly valued and paid commensurately, especially in "The City.". For instance, for salaries in investment banking start at a value of £45,000 annually, whereas engineering and industrial enterprises pay an average of £27,500 [12].

2.1.4 Market Competitiveness

Competition from well-established global automotive companies poses a challenge for local automobile manufacturers in developing countries. [13] Conducted a study on the challenges from the Indian automobile industry in emerging economies and highlighted the need for strategic alliances, investments in research and development, and product differentiation to overcome market competitiveness challenges. This disparity demonstrates the domestic industry's incapacity to produce goods that are suitable for the growing demand and satisfy the needs and expectations of increasingly affluent consumers. These items must be imagined, created, and produced provincially using a great number of domestic constituents [14]. Irrespective of the import taxes in addition to Brazil adverse exchange rate, imported vehicles that were technologically advanced, had a higher level of value-added, and were less expensive gained market share [14].

In the automobile sector, a requirement necessary to minimizing costs of production is achieving economies of scale. Due to this, many developing nations attempt to preserve the sector through direct or indirect import restrictions as well as state-sponsored development initiatives [15]. The possibility for competition varies between regions. Because there was a sizable local market for specialist suppliers, automobile manufacturers together with their suppliers in North America congregated in commercial centres like Detroit. Now, North American automakers can take advantage of Mexico’s low-cost manufacturing, which is still close to the final market [15].

Due to the intense competition in Europe, which began in the 20th century, automakers were compelled to enlarge into the region's erstwhile socialist nations in Central and Eastern Europe. The CEE region having skilled labour pulled manufacturers, low salaries, with
physical nearness to Western European markets, however, Western European auto manufacturers maintained innovative activities and elevated value-added production for themselves. Additionally, Central and Eastern Europe started to matter as a market as living standards rose [15].

India likewise launched a state program for the automotive industry's development at the beginning of the 1990s. The nation benefits from a knowledgeable and also educated English-speaking manpower, though it has subpar infrastructure, complex tax system, with rigid labour rules that outweigh the advantage of lower labour costs [15].

FDI together with labour productivity development in China, was 1.5 times stronger than in India, were the main drivers of economic expansion. The lower levels are still below world norms, but automakers and Tier 1 suppliers very rapidly attained them. China also enforces local content laws along with tariff and quota rules. The Chinese auto sector is broken into separate parts, poor quality, together with managerial and technological advancements are required [15]. However, domestic need for vehicles keeps growing, there is competitive cost of the finished product, also in 2012 China accounted for half of the increase in sales globally [15].

2.2 Relevant Theories and Frameworks

The study of challenges in the automobile sector in the developing universe can benefit from the application of various theories and frameworks that provide a conceptual lens and analytical tools. The following are some relevant theories and frameworks that can be applied to this research:

2.2.1 Institutional Theory

The objective of institutional theory is to make available a more inclusive, inter-organisational structure for comprehending the mechanisms, causes, and also effects of communication researchers, business, organizational behaviour, Sociological, and all conduct research on organizational establishments, which aids public relations experts comprehend the legitimacy and also reputation of corporations [16]. The influence of institutional forces and regulatory frameworks on the car industry in emerging nations can be examined with the aid of institutional theory. Its main goal is to comprehend how both official and informal norms, regulations, and practices influence organizational behaviour and market dynamics. This theory can explain the difficulties encountered by the sector including the methods employed to surmount those difficulties by looking at the institutional backdrop, including governmental regulations, industry associations, and cultural norms [17].

2.2.2 Technology Diffusion Theory

This can be applied to study the adoption and diffusion of technological advancements regarding the automobile sector of developing countries. This theory emphasizes the influencing factors of the rate and extent of technology adoption, which include technological complexity, cost, compatibility with existing systems, and social acceptance. It can help analyse the challenges and opportunities associated with the adoption of innovative technologies like electric vehicles, autonomous driving, with advanced manufacturing techniques in the developing world [18]. The propulsion system technology is undergoing significant transformation in the worldwide car industry. OEMs are compelled to develop traditional technology or it’s alternatives like electric drives or fuel cells because of carbon emission rules and a growing societal desire for sustainability. OEMs are, however, now only
modestly moving away from traditional technologies in favour of electro-mobility. This behaviour is known as the "sailing ship effect," which describes how an outdated technology responds to a more modern one by encouraging innovation in the [19].

2.2.3 Resource-Based View (RBV)

The RBV provides a framework for analysing the strategic resources and capabilities of firms operating in the automobile industry of developing countries. It emphasizes that sustainable competitive benefits resulting from unique and valuable resources, including tangible assets, intangible assets, and organizational capabilities. Applying this framework can help identify the key resources and capabilities that add to the competitive benefit of firms in the developing world and how they can be leveraged to address industry challenges [20] [21]. The RBV (Resource-Based View) looks at businesses' performance in the marketplace from the "inside-out" or a firm-specific angle. RBV establishes that a firm's abilities make some firms to develop into novel markets, make new commodities, or also add value to the customer value chain. To design durable competitive benefits, the RBV employs internal organizational resources together with competencies. It is not company's complete resources, and also, competitive advantage sources, will be strategic. Competitive advantage arises solely in situations of resource immobility with heterogeneity [22].

2.2.4 Approach of the Triple Bottom Line (TBL)

The TBL approach emphasizes the interconnectedness of environmental, social, economic, and social aspects of sustainability. This framework can be applied to analyse the bottlenecks encountered by the automobile sector in developing countries from a holistic perspective. It helps examine the economic viability of the industry, environmental impacts, such as emissions and resource consumption, and social considerations, such as job creation, equitable access, and community development. The TBL approach can guide the exploration of strategies that balance these dimensions to achieve sustainable growth in the industry [23]. The Triple bottom line is a structure which takes into account the environmental, financial, and also social dimensions of performance. As a result of environmental in addition to social metrics, that might be difficult to assign adequate modes of measurement, which deviates from the normal reporting structures. Another name for the TBL dimensions is the three Ps (People, planet, and profits). The TBL "captures the necessity of sustainability by weighing the effect of the activities of the organization globally, involving its shareholder values and profitability, as well as its human, social, and environmental capital" [24] [25].

2.2.5 Value Chain Analysis

VCA (Value chain analysis) gives a systematic framework for comprehending the processes and activities that add value to the automobile industry. By examining the entire value chain, from raw material sourcing to product manufacturing, distribution, and service, this analysis can help identify the key challenges and potential areas for improvement in developing countries' automobile industry [25]. It can also shed light on opportunities for collaboration, innovation, and value creation along the value chain. Applying these relevant theories and frameworks can provide a comprehensive and multi-dimensional understanding of the difficulties the automobile industry face globally. It can help uncover underlying dynamics, relationships, and strategic considerations that inform the development of effective solutions and policies. [26] applied GVC (global value chain) analysis to modern trends in the world automobile industry. It was found that the impact of the crisis has been substantially handled inside each significant producing region or country due to the industry's regional production
structure. There are ample opportunities for suppliers in evolving nations to progress up the value chain and they are also projected to advance even more so as more creative models are designed expressly for regional markets. Although it seems that a number of the large developing nations, particularly India and China, are slowly getting more freedom and autonomy as their markets and industries grow in dimension and relevance, while nations that are suppliers like countries in East Europe and Mexico continue to depend on outposts of nearby geographical production systems.

Figure 1: The performance of developing and emerging countries in the auto GVC. Source: [4]

3.0 Methodology

3.1 Research Approach

The investigation of case studies was the research methodology used in this study to provide a thorough grasp of the problems and trends in the automobile sector in developing countries.

Case Studies: Case studies were conducted to examine specific contexts or instances within the developing world's automobile industry. These case studies involved in-depth analysis of selected countries or regions that represent unique challenges or demonstrate innovative approaches to overcome industry obstacles. The case studies included data collection through document analysis, providing detailed insights into the specific challenges faced by the industry in different contexts and the strategies implemented to address them.

The case studies provided an understanding of the challenges and trends in the automobile industry in the developing world.
3.2 Data Collection methods

To gather relevant data for studying the challenges and trends in the automobile industry in the developing world, a combination of primary and secondary data collection methods was employed. This approach ensures comprehensive data coverage and supports the research objectives. Industry reports which include existing industry reports, market studies, and publications from reputable sources such as research firms, industry associations, and government agencies will be collected. These reports provided valuable insights into market trends, sales figures, production volumes, and industry analysis. Also, relevant government publications, like policy documents, regulations, and economic reports, were reviewed to gain an understanding of the policy environment and its impact on the automobile industry. Peer-reviewed journals, conference papers, and scholarly publications were examined to gather theoretical frameworks, case studies, and previous research findings related to the challenges and trends in the automobile industry. Finally, in-depth case studies were conducted in selected countries or regions to gain a detailed understanding of the challenges and trends in the automobile industry within specific contexts. Data collection for case studies involved document analysis.

4 Technological Advancements and Future Trends

4.1 Electric Vehicles (EVs) and Hybrid Technology:

The increasing number of internal-combustion automobiles that employ non-renewable conventional fuels have resulted in environmental and energy issues. To reduce their dependence on the oil and air pollution produced by conventional automobiles, many countries/nations have taken to the NEV (new energy vehicles) as options to conventional vehicles. Hydrogen vehicles, Electric vehicles (EVs), ethanol and methanol vehicles, as well as natural gas vehicles, are basically the most popular new energy vehicles that run on unconventional energy. The EVs are known and noted as being the most successful in achieving environmental and socioeconomic benefits [27].

EVs are a post-industrial revolution evolving technology and have been around for more than a century. The first workable electric vehicle in 1884 was invented by Thomas Parker. Another popular example of an early electric vehicle was 1899 German-made electric car which was designed by Ferdinand Porsche. The Electric cars produced then were simple to drive, quiet and also there was no pungent production as when compared to gasoline and steam engines. In the 1920s, when 28% of all vehicles built in the U.S. were electric, EV manufacturers saw some degree of advancement before Henry Ford created the Model T with a revolutionary mass production method. Due to the exorbitant cost of electric vehicles with the quick advancement of conventional vehicles, however, promotion of electric vehicles has halted. Problems related with energy and environmental pollution problems have driven electric vehicles research right from the start of the 21st century. Government together with business involvement has enhanced EV technology and infrastructure. One million EVs were sold globally in 2016, while more than five million light-duty electric vehicles and plug-in hybrids were sold globally in 2018. Known automakers like Ford, Mercedes and Volkswagen have spoken about their goals to promote electric vehicles [27].
The three basic types of electric vehicles are: PEVs (Pure electric vehicles), HEVs (hybrid electric vehicles) and FCEVs (fuel cell electric vehicles). A fuel cell, either in conjunction with a battery or a supercapacitor or alone, is used to power an electric motor in an EV, which is referred to as an FCEV. Although technically mature HEVs make up the majority of electric vehicles, they do not eliminate the need for fuel [27].

The adoption of electric vehicles and hybrid technology is expected to continue growing in the coming years. Advances in battery technology increased charging infrastructure, and government incentives are driving the shift towards cleaner and more sustainable mobility solutions. Improvements in battery range, charging speed, and affordability of electric vehicles are key areas of focus for manufacturers. The development of more efficient and lightweight batteries will enhance the feasibility and appeal of EVs [28]. The universality of the EVs is on the increase for many reasons, which include reductions in price and increased climate and environmental consciousness. With the combination of public transportation, shared mobility and other factors, electric vehicles in imminent years will play a major role in smart cities. In order to make the charging procedure less difficult, there is need for further work for the purpose of battery improvement. Their greatest flaw is EVs autonomy. To enlarge the driving area while reducing cost, charging time and weight, better battery technology is being developed by scientists. These elements will eventually determine how EVs develop [29].

4.2 Autonomous and Connected Vehicles

Many auto manufacturers are announcing their plans to enter the automotive market with novel vehicles as technology of transportation progresses. These include EVs, autonomous vehicles (AV), and CV (connected vehicles) [30]. Vehicles that make use of any of several varying communication technologies to interact with the driver, the "Cloud" [V2C], other vehicles on the road (V2V) and also roadside infrastructure (V2I), and are referred to as connected vehicles. Autonomous or fully automated or "self-driving" vehicles refer to those where at least some aspects of a safety-integral control function (such as steering, throttle, or braking) occur regardless of direct input of the driver, according to NHTSA (National Highway Traffic Safety Administration) of the United States, Department of Transportation. The AVs were categorized by SAE (The Society of Automotive Engineers), into 6 levels of automation in the year 2014 ranging from level 0—where there is no obstruction of driving tasks by systems—to level 5, representing total automation [30]. The phrases Plug-in Hybrid Electric (PHEVs), Battery Electric (BEVs), and Hybrid Electric (HEVs) relate to how the vehicle is powered, whereas the terms "Connected Vehicle" or "Autonomous Vehicle" refer to how a vehicle's route is managed. According to published definitions, electric vehicles, sometimes known as EVs run entirely on electric rechargeable batteries. Vehicles that combine electric batteries and also a gasoline or diesel engine, on the other hand, are known as plug-in hybrid electric vehicles. Therefore, either electric, plug-in hybrid electric or conventional gasoline/petrol can be used to power connected and autonomous vehicles. Improved vehicle and road safety as well as lower vehicle emissions are some of the fundamental reasons motivating scientists to advance vehicle technology when it comes to transportation. There has been a lot of work put into defining the environmental impact of CAV deployment, both in terms of emissions and noise [30].

New innovative opportunities for enhancing the security, efficiency, and environmental effect of transportation networks have been made possible by the development of intelligent transportation systems (ITS). The innovative "intelligent vehicle" project known as a connected vehicle (CV) is quickly becoming the next big thing in traveller empowerment.
technology. Through the creation of a comprehensive Intelligent Transportation System, this technology will contribute to greater roadside safety for drivers in addition to increasing the capacity of current transportation networks. Although the concepts of connected and autonomous vehicles are not new, recent advancements in processing power, wireless technology, and software development are bringing the application of these concepts into the present. New automotive technologies portend a future in which computers and sensors will take the role of people behind the wheel. While Google's self-driving car is grabbing attention, other autonomous cars are in test mode and automakers are already marketing vehicles that can brake on their own in an emergency. The way these developments will affect the surface transportation systems infrastructure and the transportation engineers including experts who operate and manage them is not mentioned in the headlines [28]. Due to their increased safety, effectiveness, and convenience, autonomous vehicles have the potential to completely change the automotive industry. To allow self-driving capabilities, advancements are being made in fields including sensor technology, artificial intelligence, and data processing. Advanced communication systems-equipped connected cars are becoming more and more common. These vehicles can communicate data with infrastructure, other moving objects, and the environment, enhancing traffic control, navigation, and safety features [28].

4.3 Shared Mobility and Ride-Hailing Services

Shared mobility and ride-hailing services are experiencing significant growth, driven by changing consumer preferences, urbanization, and the rise of digital platforms. Car-sharing, ride-sharing, and micro-mobility solutions, such as e-scooters and bike-sharing, are reshaping the transportation landscape. These services offer potential benefits like reduced traffic congestion, decreased parking demand, and increased access to transportation for underserved areas. Integration with autonomous and electric vehicles is expected to further transform the shared mobility sector [31]. The key to using vehicle automation and electrification to lower traffic and pollution and build sustainable urban neighbourhoods is shared mobility with pooled rides. Sharing rides pre dates the use of horses and buggies for transportation. Sharing is now simpler, more practical, and more effective thanks to recent advancements. Innovative mobility services built on sharing can bring down travel costs, ease traffic, and cut greenhouse gas emissions [31]. They also give travellers additional options for getting around than the classic alternatives of owning a car and taking public transportation. The topic of this chapter is pooled services, or packing more people into a single vehicle, even though the field of shared mobility is broad and includes shared bikes, scooters, and automobiles. Significant economic, social, and environmental advantages result from doing so. The purpose of pooling is straightforward [32]. Economics comes first and foremost. Our economy's underutilized capital assets include cars, which are driven by just one person for the majority of the time and sit unused 95% of the time. The cost per rider would significantly decrease if a car were utilized more frequently than 5% of the time and transported two, three, or four passengers [32]. The advantages go far beyond more affordable mobility. There would be fewer cars on the road, less need for parking, less air pollution, and less energy use and greenhouse gas emissions because the car would be carrying many riders who may otherwise be driving. The potential for significant reductions in pollution and greenhouse gases is enormous, both in the United States and most other nations, given that there are more than 1 billion cars and light trucks on the planet. Now is the time to make the switch to a world where most rides are shared. It will be interesting to watch if and under what circumstances people are willing to make the change [32].

When compared to individual private car ownership, shared mobility is a method to minimize congestion of traffic, transportation infrastructure costs, emissions of CO2, in addition to the environmental effect of travel. On journeys of various lengths and degrees of flexibility,
sharing a method of transportation is an option. Having the ability to improve people's wellness and lessen environmental effect of daily travel, such developments in the mobility sector are seen as a method geared towards improving daily activities accessibility [33].

4.4 Advanced Manufacturing Techniques and Industry 4.0

Advanced manufacturing technologies (AMTs) are large technical packages that facilitate product design and manufacture, increased connectivity, and resource planning that is optimized. AMTs offer a range of benefits for manufacturing businesses, from enhancing process efficiency to boosting productivity and developing sustainable business models. Through the advancement of robotics and automation technology over the past 20 years, manufacturing automation has changed factory floors. For instance, adding more customization options to products opens up new prospects for innovation ecosystems. AMTs’ potential has led governments in both wealthy and developing nations, like the UK, USA, Russia, and China, to prioritize innovation and manufacturing in their policies [34]. The manufacturing processes in the automotive sector are being revolutionized by cutting-edge manufacturing methods like additive manufacturing (3D printing), robotics, and automation. These innovations enhance capacities for customization, flexibility, and efficiency. Cloud computing, big data analytics and also The Internet of Things (IoT) are all examples of the principles of Industry 4.0 which enable real-time monitoring, preventive maintenance, and improved supply chain management. These developments improve resource use, productivity, and quality assurance.

4.5 Sustainable Materials and Energy-Efficient Designs

The industry is moving towards sustainable materials and energy-efficient designs to reduce the environmental impact of vehicles. Lightweight materials, such as carbon fibre composites and aluminium alloys, contribute to improved fuel efficiency and reduced emissions. The integration of renewable energy sources, such as solar panels and regenerative braking systems, helps enhance the energy efficiency of vehicles. Additionally, the use of recycled materials and eco-friendly manufacturing processes supports the industry's sustainability goals [35]. These technological advancements and future trends have the capacity to reshape the automobile sector thereby resulting in safer, more connected and sustainable transportation. They offer opportunities for innovation, collaboration, and market growth. Though obstacles/difficulties like regulatory frameworks, infrastructure development, consumer acceptance and also cyber security need to be thoroughly looked into so that the potential of these advancements can be realized fully. [35] [36].

5 Conclusion
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