FRAMEWORK FOR BUILDING INDIA'S INDIGENOUS TECHNOLOGY PRODUCT DEVELOPMENT LEADERSHIP

by

Mahesh Patil

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by

Mahesh Patil

APPROVED BY

Chair’s Name, Degree, Chair

RECEIVED/APPROVED BY:

<Associate Dean’s Name, Degree>, Associate Dean

Dedication

To my cherished family and esteemed Thesis Guide,

I dedicate this dissertation to my esteemed thesis guide, and my family and friends for your unwavering support.

With deepest appreciation and love,

Mahesh

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I am deeply grateful to all those whose unwavering support and guidance enabled me to complete my research. Firstly, I extend my sincere appreciation to my mentor, Dr. Minja Bolesnikov, for your invaluable guidance, unwavering support, and endless patience throughout this study. Your expertise has been instrumental in shaping this research and guiding me through its complexities.

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Mahesh

ABSTRACT

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Mahesh Patil

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Dissertation Chair: Dr. Minja Bolesnikov

The destiny of nations is intricately woven with their history, pivotal moments, and evolving factors. Despite India's rich past and recent strides in innovation, gaps persist in harnessing its potential for product development leadership. This research aims to bridge this divide by examining the challenges and opportunities facing Indian companies in achieving product innovation excellence.

The literature review highlights a scarcity of comprehensive studies on building sustainable product ecosystems in India, despite extensive research on related fields such as R&D, software services, and manufacturing. While India boasts successes in software services, a disconnect exists between these achievements and local market needs. Additionally, challenges in sectors like electric vehicles (EVs) underscore the need for holistic approaches to product development.

To address these gaps, a mixed method approach combining qualitative and quantitative analysis is adopted. Qualitative methods include semi-structured discussions and interviews with industry experts, aimed to understand barriers and identify opportunities.

A SWOT analysis aids in comprehensively assessing the challenges in electric scooter development and creation of a framework for positioning India as a global leader in this sector.

Findings reveal India's potential for indigenous manufacturing, strong domestic market preferences, and supportive government policies. However, challenges such as high initial costs and infrastructure limitations persist. Opportunities lie in technological advancements and growing market demand, while threats include import competition and regulatory uncertainties.

Through this research, India's transition from a service-oriented economy to an indigenous product innovation powerhouse is envisioned. By synthesizing insights from academia and industry, this study offers practical recommendations for policymakers, industry stakeholders, and researchers alike, paving the way for India's emergence as a global leader in product development.

Overall, this research contributes to a deeper understanding of India's product development landscape and offers strategic insights for driving sustainable growth and innovation in key sectors of electric vehicles.

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CHAPTER I:
INTRODUCTION

1.1 Background

In the contemporary landscape of technological advancement and economic growth, the role of product development stands paramount. Across various sectors, from software to manufacturing, countries strive to establish themselves as leaders in product development, driving forward innovation and global competitiveness. India, with its rich history in software services, engineering talent, and burgeoning manufacturing capabilities, holds immense potential to emerge as a global hub for product development. However, despite these strengths, there exists a significant gap in India's journey towards becoming an indigenous product development capability centre.

While there are discussions and literature available on various aspects of product development, such as R&D, collaborations, and manufacturing services, a comprehensive study integrating these components into a cohesive understanding of building sustainable high-technology products in India remains elusive. The need of the hour is to bridge this gap by conducting a detailed examination of India's product development landscape, identifying the challenges, and proposing actionable strategies to foster growth.

This research aims to address this gap by focusing on electric scooters as a case study. Electric vehicles (EVs) represent a burgeoning market globally, driven by sustainability initiatives and technological advancements. Despite India's efforts to increase the adoption of EVs, particularly electric scooters, the country continues to rely heavily on imports, particularly from neighbouring China. This reliance underscores the need for a deeper understanding of the challenges and barriers hindering India's ability to indigenously design, develop, and manufacture electric scooters.

Through this research, we aim to unravel the complexities of India's product development ecosystem and propose actionable strategies for fostering growth, particularly in the electric scooter segment. By focusing on electric scooters, we seek to provide valuable insights into the challenges and opportunities present in India's product development landscape, with the overarching goal of fostering innovation, economic growth, and global competitiveness.

1.2 Research Problem

India's journey towards becoming a product development capability centre is hindered by various challenges and barriers. Despite possessing pockets of excellence in software services, manufacturing, and engineering talent, the country struggles to integrate these strengths into a cohesive ecosystem conducive to product development. The specific problem this research seeks to address is the identification and analysis of the gaps in India's product development landscape, particularly concerning electric scooters.

While India has a rich history of designing and manufacturing electric scooters, the current scenario paints a different picture, with significant imports from China dominating the market. This disparity raises questions about India's ability to leverage its capabilities and compete in the electric scooter segment by developing indigenous capability and not depending on imports from countries like China. By delving deeper into the intricacies of product development, this research aims to uncover the root causes of this disparity and propose solutions to bridge the gap.

1.3 Purpose of Research

The purpose of this research is multifaceted. Firstly, it seeks to provide a comprehensive understanding of India's product development capabilities, strengths, weaknesses, and areas for improvement. Secondly, it aims to analyse the specific challenges and barriers hindering India's ability to develop and manufacture electric scooters indigenously. Thirdly, it endeavours to propose a comprehensive framework for India to establish itself as a leader in electric scooter development, encompassing design, engineering, manufacturing, regulatory policies, and infrastructure.

By achieving these objectives, the research aims to contribute to the body of knowledge on product development and inform policymakers, industry stakeholders, and academia about the steps needed to foster product development leadership in India. Ultimately, the research seeks to empower India to harness its potential and emerge as a leader in indigenous product development, particularly in the electric scooter segment.

1.4 Significance of the Study

The significance of this study lies in its potential to address critical gaps in India's product development landscape and pave the way for transformative change. By providing insights into the challenges and barriers hindering electric scooter development, the research can inform policy formulation, industry initiatives, and academic endeavours aimed at fostering indigenous product development leadership in India.

Furthermore, the study's findings can serve as a roadmap for industry practitioners looking to navigate the complexities of product development in India. By identifying areas for improvement and proposing actionable solutions, the research aims to catalyse efforts towards building a robust product development ecosystem that aligns with India's aspirations for global competitiveness and technological innovation.

Overall, the study holds immense significance for India's economic growth, technological advancement, and global positioning in the realm of product development. By addressing critical challenges and leveraging existing strengths, India can unlock new opportunities and emerge as a leader in the dynamic and ever-evolving landscape of technology-driven innovation.

1.5 Research Purpose and Questions

The overarching purpose of this research is to unravel the complexities of India's product development landscape and propose actionable strategies for nurturing product development leadership, with a specific focus on electric scooters. To achieve this purpose, the research will address the following questions:

1. What are the existing strengths and weaknesses in India's product development ecosystem, particularly concerning electric scooters?

2. What specific challenges and barriers exist in developing electric scooters in India, and how do they compare to successful models like those in China?

3. What policies, infrastructure improvements, and industry initiatives are needed to overcome these challenges and position India as a leader in electric scooter manufacturing?

4. How can India leverage its talent pool, manufacturing capabilities, and technological expertise to compete globally in the electric scooter market?

This research will provide insights for the government, corporations, and supply chain management experts. This will help achieve India's technology leadership in electric scooter technology and manufacturing in India.

CHAPTER II:
REVIEW OF LITERATURE

2.1 Introduction

India has emerged as a destination for software services with at least 5 companies crossing the 5 billion USD in revenue. At the same time, India is also a startup hub with a huge focus on innovation and strengthened by the funding scenarios. The MAKE in INDIA initiative from the government is also making its mark with manufacturing activity rising.

Even though United States is a developed economy and the foremost in the global order, US policy makers see a huge benefit to the U.S. economy like the above average wages to all demographics, innovation, reduce trade deficit through manufacturing, and a large contribution to manufacturing makes a large contribution to environmental sustainability. (Helper et al 2012)

Armed with a huge talent pool and having developed its core competence in the services sector, India still has a large import running a trade deficit.

However, the country attempts to reduce its dependence on oil, which is one of the largest of its imports, but there is still a dependence on electronics, machinery, and other goods.

While India has been making progress in various areas of technology primarily software services, electronics manufacturing, brick-and-mortar infrastructure, Digital infrastructure, ease of doing business, and other areas, there is still a huge gap to cover in terms of connecting the dots and bringing a holistic development effort to be a leader in indigenous technology product development.

The extremely important area of electronics manufacturing which entails chip manufacturing, software integrated with electronics to create technology products and hence the innovation challenges has been largely ignored.

All the developments in other areas in silos have a limited ability to leapfrog India into being a product development leader without harnessing the manufacturing opportunity and hence rebuilding the eroded talent in this area.

2.1.1 Key trends or perspectives

The global scenario is moving rapidly from a manual machine to automatic machines and with the rapid growth of INDUSTRY 4.0, sensors technology there is a huge shift in the way electronics manufacturing industry works.

The merging of the Internet of things also has changed the dimensions of possibilities.

The internet of things with all the sensor technology coupled with a huge ability to store and analyse data – BIG DATA has given an extraordinary leap to build intelligence in the supply chain networks and all industries from automobiles to pharma and healthcare.

The 5G will give a different dimension to the way data is transported from IOT devices to high payload like video streaming and hence create different avenues in various sectors.

While India is making huge progress in the information technology world across the sectors of software services, telecommunications infrastructure, and manufacturing in India, there is still an astronomical focus on services. The software services have the advantage of low Capital expenditure and the advantage of the talent pool coupled with the arbitrage advantage with the US dollar or the Euro. The manufacturing services have a challenge to compete with the low-cost East economies coupled with the capital expenditure for the machinery and other factors of labour laws and cost of labour.

India with its advantages of talent, software services, ability to scale manufacturing services still has a humungous gap to fill to connect these dots and build a sustainable ecosystem for PRODUCT DEVELOPMENT and be an indigenous developer of technology products.

2.1.2 Specific focus on literature review

The literature survey deals with a focus on product development leadership imperatives.

It addresses different facets of a technology ecosystem cutting across the areas of software services, skill development, manufacturing services, electronic design and development, semiconductor manufacturing, development of automatic machines, cost of capital, the brand of an emerging economy and attempts to connect these dots.

A technological product like an electric vehicle or a medical device would have all dimensions of technology specialty starting from a mechanical enclosure, electronics, embedded firmware, and software notwithstanding the costs of compliance across the globe.

All of this requires an R&D ecosystem, Electronics design, software development and manufacturing including compliance notwithstanding the cost of the final product to be competitive internationally.

There are many successful companies in India which make industrial products where we were world leaders in quality and at the same time now world leaders in IT services. With a huge talent pool, we are yet to make a mark on the new generation products in the telecommunications space and automotive. The electric vehicle is the perfect combination of industrial products and software.

The make in India initiative also focused on making manufacturing an attractive destination for the world but does not lead towards a manufacturing leadership in indigenous products.

India has been forefront in the industrial product categories of transformers, motors, power systems and over the years as they integrated with software, we even lost the edge in this domain. Even though we have a large software capability, India for some reasons has not harnessed the revolution to build products having a software content coupled with the industrial products. All the products associated with supervisory control and monitoring are even being imported from western nations.

Another example if the Electric vehicle technology. India was in the forefront of industrial products like the motors, switchgear and is now having no dearth of software talent. But in today's global supply chain, India has to import all parts of an EV just because China manufactures in millions and Indian market is thousands. The missing link of indigenous Product development Leadership makes it impossible to build the EV.

The below depiction shows the key factors for any technological product development. Any product like an electric vehicle or a telecommunications product would need the basic domains below.

The literature survey is focused on product development imperatives and attempting to understand the present situation of India being not in the league of product development nations which in turn has a big limitation on the economic growth.

More focus is on the Product development and manufacturability research, software development and services and policies. The topics of R&D, innovation is touched upon.

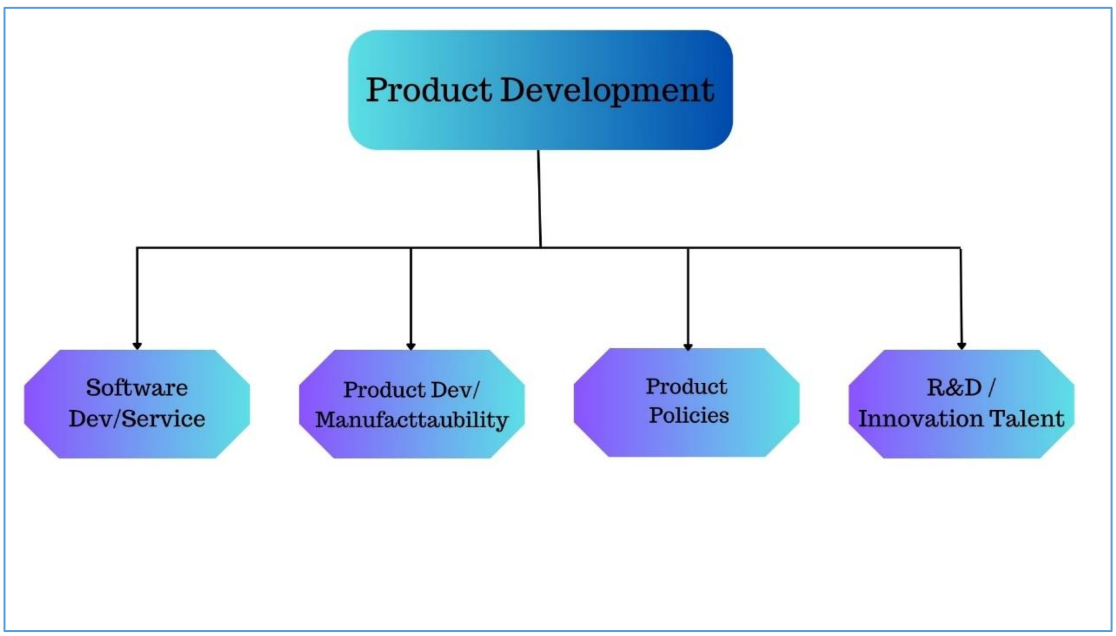


Fig.1. Product development flow chart.

2.2 India's Product Development Challenge

India gained its independence in 1947. India was a purely agrarian economy and with its new gained independence it had to leapfrog to an industrialized economy. The industrial revolution was missed by the country and the liberalisation due to its forex woes started the manufacturing economy ramp up. During this time east Asian countries had made huge progress in the manufacturing sector by way of low technology products and then adding value into complex manufacturing.

New Product Development was a not a part of the country's ecosystem as the jump from agrarian economy to the digital economy did not bring in the brick-and-mortar infrastructure. India was one of the largest exporters of textiles in the early 18th century and by the middle of the nineteenth century, India was a net import of textiles. India was on a rapid downturn on the industrialization path and by the late 19th century India's deindustrialization was over, from contributing to the worlds industrial output up to 25% in 1750 to 2% in 1900 India become a net importer. (Clingingsmith, D., & Williamson, J.G. 2005)

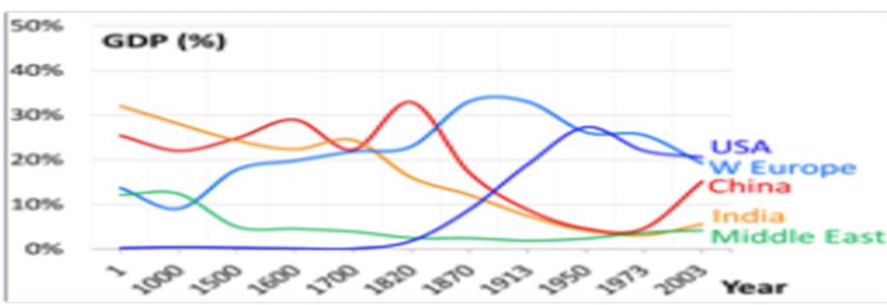


Fig.2. GDP Variation with respective of the year

(Source: https://en.wikipedia.org/wiki/Deindustrialisation_of_India)

The graph above illustrates the reduction in GDP of India and the slow rise in the late 20th century. These historical circumstances created a situation where there was a lack of buying power and due to the deindustrialisation, there were limited design skills and experience in the country. With no industrial economy, there was a lack of qualified vendors and talent. India being an emerging economy has a different set of barriers unlike countries like the United States and developed part of Europe. The specific local needs, buying and spending capacity and sensitivity to pricing firms must develop their own infrastructure for the labour and capital to be utilised.

Also, the Indian government has resorted to what was typically called the licence Raaj which did not allow business to thrive and had a very strong centralised control. This policy did not bring in competition from global markets, created a monopoly of few family-owned businesses and hence created a void in developing functional expertise and a market centric outlook (Krishnan et al.,1999***).***

All these reasons bring in specific issues in emerging markets as against the developed markets. Product development is a huge upfront investment with no guarantees of return. Especially in a capital scarce economy this was a major impediment.

Any product development required core competencies in multiple areas. For example, in the 60's till the 90's India had well established public-sector organisations like the Bharat Heavy electricals limited, Bharat electronics limited and the kind which had developed expertise in building industrial products like the motors, transformers, switchgears and had hence been able to spawn a supplier based which also created a talent pipeline.

With all the constraints typical of an emerging economy, there are also factors like honest failures need to be tolerated and creativity has to be rewarded to facilitate innovation. Could India Leapfrog to the product development curve is the question.

The challenges of time to market and first-time right product was the same for even India companies and with all the historical challenges. It was impossible to develop a functional correct product and at the same time be innovative and cost effective. The deindustrialisation exacerbated this issue of availability of a deep functional knowledge base and a demanding customer to create a stronger R&D.

India had its own contextual issues as articulated earlier. The management response to unique economic, social and competitive challenges faced in the developing economy or an Indian context created the term Frugal innovation. Frugal innovation has no framework but very specific to the context in hand.

With the industrialisation across the globe the focus shifted from manufacturing to product development. The time to market goal was achieved through efficient global supply chains, assembling capability and hence firms were able to create product variants through product platforms (Tyabji 2014).

Though India's industrial development was late as compared to other east Asian countries, the educational institutions in India were way ahead of many countries. The IITs of India are hallowed institutions of higher learning. In the field of science and technology, the names of these institutes are well known across the globe. This talent is leveraged and contributed across the developed countries but have not been able to make a similar impact in the Indian environment and hence brain drain as the term does was a worrisome factor.

The domain of software which did not require manufacturing capability has been our main economic export activity. With a large software export base, we have not made a mark in the software product development space. With our engineering talent base, it was relatively an easier task to be a product developer economy but the relative risk free and ease of earning revenue through service is a barrier to entry for local firms. The similar reasons of a lack of a strong domestic market and a demanding knowledgeable customer base have limited Indian companies to work on product development.

Also, the Government did not focus on product development and there no local communities championing the same. This neglect has been detrimental to the competitive advantage India would have gained. Product development needs more attention in India.

As a result of all the above, there was no creation of suppliers with experience and that also has its ramifications for product development. The benefits of expertise and scale is a gap in the Indian scenario.

The similar issue also is in the size of our domestic market and hence economies of scale do not play a role. With the exposure to aesthetically developed products, Indian products need to match up to the international standards.

Even where machinery and huge capital expenditure is not required in the case of software product development, Indian companies have not taken the step to develop products. Venture capital funding was hard to come by and socially failure is not an acceptable paradigm as a society.

Also, the urge to have a good living which is a natural instinct, has resulted in the students getting into engineering and irrespective of their discipline enter into software jobs. The lure of a high paying and an attractive career is more motivating than the real inquisitiveness and interest in the subject. In addition to this also the disinterest on innovating but only focus on reengineering is a barrier to an innovative culture. India’s need to leapfrog the industrial revolution has many barriers. The system of education has been one of the principal barriers to an innovative mindset. A culture of obedience, intolerance of failure stemming from the education system and a lack of risk-taking capital has its pitfalls. The vicious circle of lack of capital hence investments in cutting edge manufacturing equipment, talent not available due to brain drain to software and learning opportunities on the job, lack of understanding of commercial costs and skills on product development all contribute to the lack of a product development ecosystem. (Krishnan et al 2006).

Even when we were leaders in some segments and great public sector organisations like Bharat Heavy electricals limited were creating new technologies there were no takers in the utility sector and such was the risk averse behaviours.

The limited talent for innovation was also a barrier as during the earlier decades, universities were not a lucrative option and public research laboratories were hiring them. In the present day there are no good talent for the brick-and-mortar industry including the hardware sector as the services sector is very lucrative mainly the software.

Manufacturing plays a very important role during accelerated periods of growth. This needs services to complement but not as important as manufacturing. (Attiah, E.,2019)

The lack of a simple regulatory structure, a performance linked compensation to public funded research, a thinly spread R&D funding across institutes and a complex process for accessing government infrastructure and funds are big barriers to an innovative hence product development ecosystem. On the other hand, the success of transferring technology from government labs to commercialisation through private enterprise has yielded phenomenal results. Taiwan being another success story through the semiconductor giant Taiwan semiconductor Manufacturing corporation TSMC.

Though there have been barriers to cross the orbit on technology product development and all the barriers for the same there have been reasons for not venturing into this domain. This is true even for the software industry. Software services from India have achieved world leadership and even with such stupendous success as outlined below has not been able to enter the product developer category. The cheap labour which was the initial entry point for the software industry is no longer the reason. Also advantages of not getting stuck into legacy technologies and organisation inertia are some of the reasons why latecomers could have advantages. Taiwan's semiconductor success, Singapore's manufacturing success through government support are examples on how catch can be possible. India's software services have seen the initial low-cost advantages, going up the value chain through process capability and project leadership and, hence improving their competitive position. The technology disruption from a mainframe to client server and the ubiquitous internet have all helped the India software services. At the same time the government liberalization and the software export zone all converged to help this industry.

This research clearly articulates that the government support has not been a factor in the success of the industry unlike the automotive in India, electronics in Korea, semiconductors in Taiwan. India software firms have overtaken process capabilities in developed nations but have lagged in technological prowess. At the same time there is no threat to this industry in terms of competition or cost as the pressure on costs in developing countries is advantageous to the developing countries. Also, the large technical talent credit to the Indian government and the English-speaking pool is a barrier to entry to the other countries. Cost arbitrage adding to the above (Krishnan et al.,2010).

India's regulatory policies were a big hindrance to the software development growth.

Foreign firms shut shop in India including firms like s Coca-Cola and IBM,

The software development story was stemmed at its root.

Here is an example of a contextual innovation from local firms. The lack of software development opportunities created an alternate business model of exporting talent to developed countries.

Initially, the exported programmers worked for global multinational entities and later they started converting software for mainframe computers. The tipping point was the New Computer Policy 1984 where import tariffs were reduced to 60%. The software exports did not require a licence and made eligible for bank finance. Foreign firms were allowed to set up export dedicated units and cheap infrastructure through software parks. (Dossani 2005).

In addition to all the external factors of macroeconomics and policies also these factors helping the Indian software companies move up the value chain are motivations, willingness, their capabilities, and availability of suitable product market opportunities.

From a low-cost skilled manpower based the software services industry moved up the value chain through project management, quality processes. And manage large projects.

Moore's law is the famous observation of Dr. Gordon Moore in 1965. The doubling of transistors every two years of an integrated circuit is the practical definition of this law.

Intel expects this to remain at least through the end of this decade.

The Moore's law which the ICT boom and has made the internet ubiquitous along with cheap process power has helped the software industry move up the value chain.

The Indian companies leveraged the talent and the code base to create a structured solution, fixed price contracts. This has all helped the Indian companies leverage the structures to modularize, deliver quick solutions, and ramp up on new technologies as learning organizations.

But the organizations have not been able to transition to the product development curve.

The high upfront investments, lack of a knowledgeable demanding market away from home, lack of functional domain expertise and hence an inability conceptualize products have been the impediments to transition. The risk averse tendency due to the arbitrage advantages and easier path to earn revenue through services which still has no threats have been the barriers (Krishnan et al., 2003).

The offshore development centre concepts, the movement of professionals across borders, the government support through earlier exports and imports policy have been in favour of the software services industry.

The example of Infosys, Wipro and other such organizations achieving scale has been tremendous success but despite these role models there has been no organization willing and motivated to transition to a product development organization.

Also, the switching costs for the clients is high in case of software services as it is skill and knowledge based., creation of brand is not a short cycle and most importantly these are intangible and hence standardization is difficult. This is unlike in the manufacturing industry where commoditization is relatively easy.

The key question remains – With all the success and building an ability on process, talent and engineering solutions what will catapult Indian organizations to a product development or a technology leadership mindset.

Indian software companies have a great degree of technological skills but lack in domain experience. This coupled with the low sophistication of most Indian user industries creates a gap in building domain expertise. This gap can be filled by appropriate Government policies to enable Indian companies to be globally competitive and create a local competitive market through foreign firms' entry.

While the economy is moving to an industrial economy from an agrarian economy and with the low productivity in the agricultural sector, there should be a movement of labour out of agriculture into manufacturing and services. The challenge in India lies in the low level of education in the agriculture sector and hence the skilling challenges to meet the demand of the industry in the urban world. The world's largest population is in India and a rising share of working age population. The dichotomy is the extremely low level of India's labour force. The literacy level is not even 29% of the labour force as in 2016. And 24% of the labour force has below the primary level of education. An additional 102 million, or nearly 24% of the labour force has below primary. (Ahmad et al., 2018).

The salaries of rural service sectors do not compare to the service sector in urban areas. These Employment opportunities in the modern service sector can alleviate poverty for rural and urban populations. (Barry Eichengreen 2011)

The rise of the services sector is impressive in India and the manufacturing sector is lagging. Also, the productivity in the services sector is consistently above that of manufacturing in all segments of the sector. The irony is that the informal sector in manufacturing is large, the share of this economy is higher in dragging the productivity down in overall manufacturing and the formal sector manufacturing productivity is higher than even services (Gbenoukpo Robert Djidonou et al 2022).

In many industrialized nations, rapid productivity growth in agriculture releases individuals from that sector, prompting a shift towards manufacturing and services (SerranoQuintero, R., 2022).

2.2.1 Bottom of the pyramid:

A very important segment for product development and market penetration is to tap under developed markets with large populations.

Exhibit 1: **The World Economic Pyramid**

Annual Per Capita Income*	Tiers	Population in Millions
More Than $20,000	1	75–100
$1,500–$20,000	2 & 3	1,500–1,750
Less Than $1,500	4	4,000

* Based on purchasing power parity in U.S.$
Source: U.N. World Development Reports

Fig.3. The World Economic Pyramid

(Source U.N World Development Report)

As per the above exhibit 1, the largest population is in tier 4 which has an annual per capita income less than $1500 and with a population of 4000 million. This tier has a large informal economy, and this economy is the largest of all economic activity.

Exhibit 2: **Innovation and MNC Implications in Tier 4**

Drivers of Innovation	Implications for MNCs
Increased access among the poor to TV and information	Tier 4 is becoming aware of many products and services and is aspiring to share the benefits
Deregulation and the diminishing role of governments and international aid	More hospitable investment climate for MNCs entering developing countries and more cooperation from nongovernmental organizations
Global overcapacity combined with intense competition in Tiers 1, 2, and 3	Tier 4 represents a huge untapped market for profitable growth
The need to discourage migration to overcrowded urban centers	MNCs must create products and services for rural populations

Fig.4. Innovation and MNC implication (Prahalad, C. K., & Hart, S. L. 2001)

The multinational companies must pay attention to this untapped market, and this will require a low cost uncompromised on quality and making profits by virtue of sheer scale as articulated in Exhibit 2. The GOTO MARKET strategies will be completely different from how they cater to the above Tiers.

The MNC's have no visibility to this Bottom of the pyramid and that is evident because the largest MNC's are concentrated in the US & Japan. The MNC's are unfamiliar with is market and hence lack of knowledge. It is not possible to penetrate the bottom of the pyramid by the same product. service mix as in Tier 1 considering the income of Tier 4.

The telecommunications penetration in the Indian rural villages is phenomenal and the pioneering effort goes to Sam Pitroda. His idea was "rural telephones." A woman operated telephone and the margins as livelihood was the concept. The telephone is now ubiquitous in India.

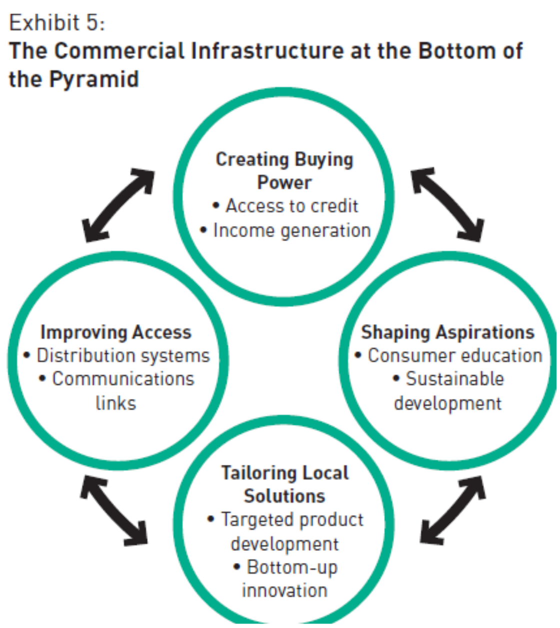


Fig.5. The Commercial Infrastructure at the Bottom of the Pyramid

(Prahalad, C. K., & Hart, S. L. 2001)

The digital divide could be broken by bringing communications technology to villages in Tier 4 and with the different advances coming together. Education to agriculture gets a fillip (Prahalad, C. K., & Hart, S. L. 2001).

The possibility of Multinational Corporations to learn from their success in emerging markets can bring about a possibility to generate innovation and export that knowledge and those innovations to the developed world. This creates new business possibilities and also the MNC's have a potential to find new markets in search of growth (Govindarajan, V., & Trimble, C. 2012).

The penetration Into the BOP market is a key element for success in this demography. The distribution channel decision is crucial for successful product adoption. It is important for the channel partner to satisfy all requirements to understand the product and consumer base (Sachin Shukla Sreyamsa Bairiganjan, 2014, September 5).

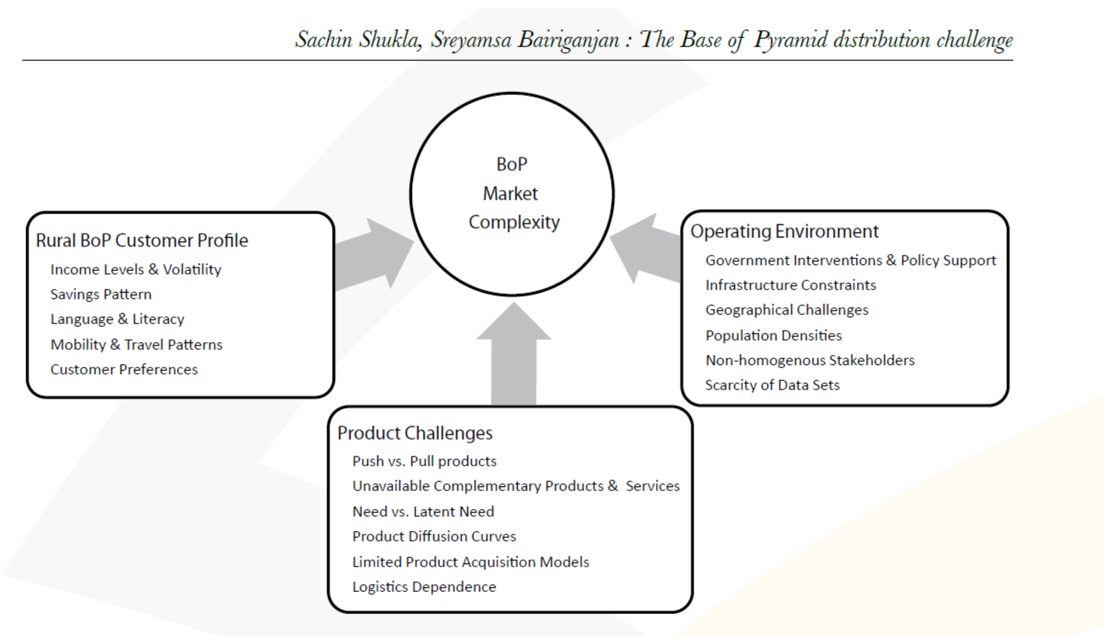


Fig.6. Rural BOP Market Complexity – Contributing Factors

(Sachin Shukla Sreyamsa Bairiganjan, 2014, September 5).

Another dimension of our lack of technology and manufacturing is the example of LCD panels and we do not have any local manufacturing. The current tariff regime is not conducive to this foray. Combined with timebound tariffs or incentives, Viability Gap Funding could help the setting up of manufacturing for these products (Rajat Dhawan, McKinsey 2020).

2.3 Policies

India developed as the largest exporter of software services and in turn developed a huge talent pool of software engineers. Software services required a huge telecommunications network and electronics hardware requirements. The underlying physical infrastructure along with the digital capability was the backbone of the booming software services. All the information and communication technology hardware were a basic requirement for the software world. Unfortunately, this software services boom did not translate to an equivalent increase in hardware manufacturing and exports. The policy framing and implementation was one of the main reasons for the divergent trajectories of both these worlds. The complete disconnect in the vertical industrial policies had no incentive for local IT hardware and components producers and hence they could ride the software services wave. Economics of scale were not achievable and hence unviable. This created a vicious circle of not building up capability in tandem. Information and communication technology (ICT) sector and semiconductor build up were divergent in progress (Francis, Smitha 2018).

The east Asian countries mainly Taiwan, China have already a strong ecosystem, with

Original Equipment's Manufacturer/Original Design Manufacturer companies for the last four decades. This was not possible without a strong Government support in the form of effective Policies to ensure investments are productive and there is no risk of investment due to political upheavals. They also provide a world class infrastructure which includes uninterrupted power supplies and other basic amenities. A strong manufacturing base also helps the design activities to be close to manufacturing and these countries are also ahead in semiconductor design (Himanshu Kushwah 2015).

Multinational entities (MNEs) help in building in knowledge to the local developing ecosystem. For a multinational firm to be successful in a foreign country it needs to develop local linkages. The firm's capability is tied to the capability of the linkages it forms (Reddy, 2011). The goods sold by domestic firms to foreign entities are called backward linkages. Forward linkages mean domestic sales. Interactions with domestic firms engaged in similar activities are called Horizontal linkages (UNCTAD, 2001). Employees mobility also adds to knowledge transfer. MNEs also enhance the value of their suppliers to increase their efficiency which is a voluntary mechanism (Patra, S.K., Krishna, V.V., 2015)

The outcome of short-term policy implementations was the electronics manufacturing sectors was limited to the establishment of assembly plants. This did not encourage the original equipment manufacturers (OEMs) to invest in localisation due to lack of encouraging incentives (Ernst 2014; Saripalle 2015).

India could not develop indigenous capability for component manufacturing. Integration of GVC's with Indian entities was lagging. China and Brazil had a very innovative vertical industrial policy to support localisation of major parts like the picture tubes and India kept importing such critical parts at high tariff (Francis 2016).

China's strategy of collaboration with foreign partners with equity stake gave shorter experiential curve to become world leaders like Haier group example (Zhongxiu Zhao et al 2007).

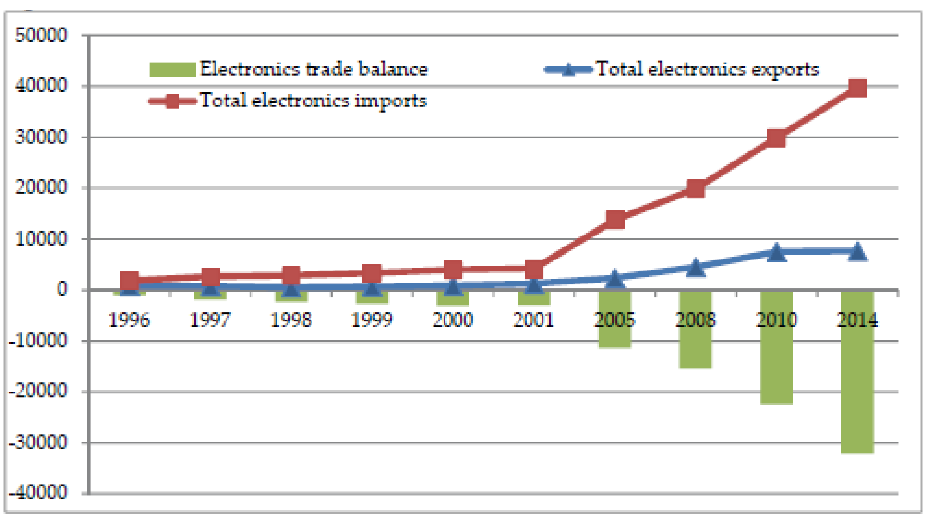
The software sector got a fillip from the government, but the electronics manufacturing remained a backburner.

Electronics manufacturing in India will need a restructuring of its industrial growth model. A high-cost low volume and a high volume for domestic markets as a strategy. With the advent of advanced 3D technologies, robotics, and Moore's law still relevant the technology landscape has made it more attractive to make manufacturing more productive and hence focus on niche products. With a weak link of education, research and industry, a fragment talent base catering for MNCs and a delink with Indian manufacturing ecosystem it is challenge though a possibility (Ernst 2014).

Make in India initiative relies on the manufacturing capacity. Also, regulation for industry including land and technology culture play an important role (Sherwani, N.U.K et al., 2018).

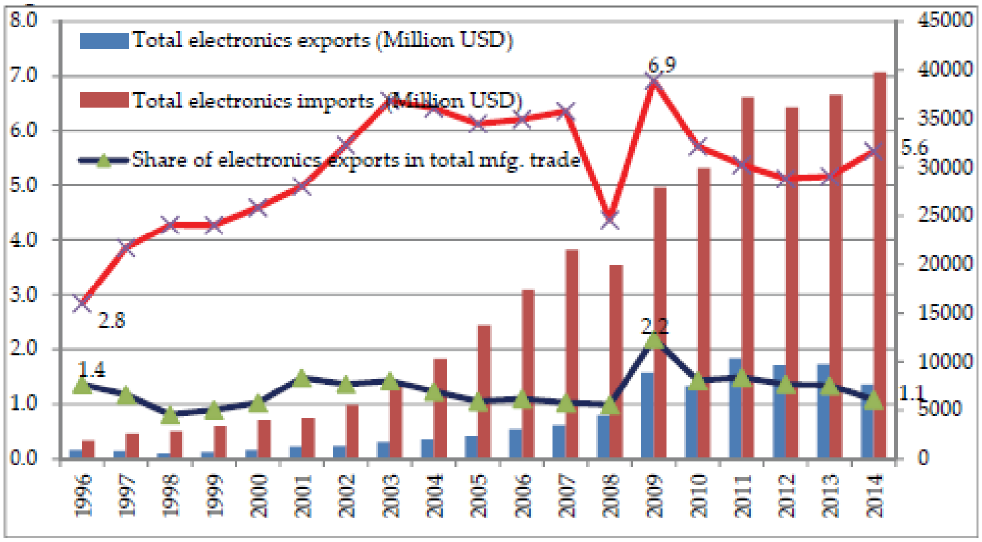
India has brough it the production linked incentive (PLI) scheme which aims to bring an investment of around USD 22 billion and create 135000 employment opportunities within four years. An "India Semiconductor Mission" is also in the offing. Subsidizing/ incubating through government vehicles is envisaged subject to manufacturability of the design. With substantial fiscal incentives coupled with nonfiscal benefits (Kirtane Pandit 2023).

China entered the International Trade agreement when it was the third largest importer and fourth largest importer of these goods and in contrast India was not in the position of strength. India was disadvantaged due its inverted tariff structure of duty-free finished products versus duty on components. With the MNC's having superior technology, processes, and a large base in cost effective countries, it was easy for them to import goods to India. It was important for Indian companies to come up with frugal innovation and business models to compete with these markets and these can be possible only with a collaboration of Indian government and private sector (Ernst 2014).



Source: Author's calculations based on WITS COMTRADE data.

Fig.7. Trends in India's Overall Electronics Trade, 19962014 (Francis 2016)



Source: Author's calculations based on WITS COMTRADE data.

Fig .8. Electronics Share in India's Total Manufactured Goods Trade, 19962014 (Francis 2016)

The Chinese value proposition is waning down primarily to the wage inflation, strengthening currency, commoditisation of technology. For India considering all this it is an imperative that we need to look at the pressing issue of EASE OF DOING BUSINESS. Labour and energy, a friendly policy and regulatory regime, and a simplified tax procedure structure (Varas, A.et al April 2021).

While all this is the governmental jurisdiction, there is a complete landscape shift in Technology. The advent of the Lean Manufacturing Techniques given a new paradigm to the Technology and Manufacturing domains.

Also, with these advancements in technology and process like Lean manufacturing, it also improved the creation of an efficient ecosystem. For manufacturing to thrive it is imperative to have organisations create small medium and large industries around as ancillaries. It is also possible to have these ancillaries learn from large organisation through direct knowledge transfer and over time.

Lean Manufacturing can help increase productivity and efficiency with reduction in waste and hence costs. The lack of adequate resources such as human labour, capital, marketing costs, and advanced technologies can be to a large extent compensated with lean manufacturing processes. This directly translates to high quality products and cost-effective products (Yogesh 2014).

The people form the most important part of the lean manufacturing initiative. They need to be enabled with the right tools and support to make changes in the positive direction. A systematic problem-solving approach is required to eliminate waste. Continuous learning, training and improvement is the basis for a lean manufacturing success.

These technologies will help India leapfrog to gain global leadership. These advancements will help India gain a sustainable competitive advantage – increased innovative capability, cycle time reduction for product development, and hence time to market (Wong, Y. C., & Wong, K. Y. 2011).

The way to leapfrog would be to collaborate with Taiwan but there are concerns over the uninterrupted supply of water and electricity The ecosystem of water, power supply, and logistics is still a big concern for Taiwan to setup manufacturing in India. The proposed locations for semiconductor fabs are Greater Noida and Gujarat. India is on its way to build FABS (Singh T 2021).

The logistics cost in India is higher than any other developing nation and policies like LEEP are being brought to implementation to create a competitive environment.

The warehousing for inventories is getting spruced up to increase scale. The National Highways are the fastest growth in the last decade including rail networks. The Goods and Services tax regime has brought in a one window for taxation to a large extent bringing in ease of doing business for the country (Mehta 2017).

The nature of the country's polity also matters for investments. There are challenges with types of polity socialist and democratic. The socialist structure gives a stable government for a longer time than a changing elected government and hence the confidence of investors. The pitfall is like in the case of China where the decision taken by head of state is final. This can create issues on intellectual property and labour laws (Parik R 2020).

The total export of electronics goods from India in 2020 was 4.53 billion U.S. dollars and Vietnam's export, however, amounted to 76.8 billion U.S. dollars, nearly 17 times that of India while 310.87 billion U.S. dollars was from China. In comparative terms China exports were four times that of Vietnam and 68 times that of India (Jiang Jiang , Wu Ziyu 2022).

Vietnam offers ease of setting up a business as compared to India. The average time taken to start a business in Vietnam is 16 days compared to 18 days in India and the number of steps to start a business is 10 in India vs 8 in Vietnam 7. Similarly, Vietnam fares better on speedy property registration which takes 5 days on average as compared to India's 9 (Manan Silawat & Sachin Nayak 2021).

The Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme in 2015 was to encourage electric and hybrid vehicle purchase. There were many subsidies provided in this scheme.

The second phase of the FAME called FAME II was launched in 2019. The scheme had an outlay of USD 1.5 Bn. The demand aggregation, subsidy and public transport were the main areas of focus.

The sale of EVS was 2.7 times more in 2022-23 according to VAHAN, the road transport ministry and out of them more than 60% were two wheelers. But the share of the EV's was only 5.6% of the total vehicles registered. The capital cost of the EV; s driven by battery technology mainly Lithium ion which was around 30-40% of the vehicle cost.

The FAME II did not deliver in its objective of homegrown innovation and value addition during the manufacturing and assembly process. The FAME II scheme could be stopped beyond FY 2023 and industry will see a discontinuity in this policy. The government wanted to leverage its Production Linked incentive program for higher value and innovation into EV components manufacturing and promote through advanced GST reductions, fee exemptions etc.

2.4 Semiconductors

The industrial revolution coupled with the Moore's law created a completely new industry the electronics and the software industry. The semiconductors became the basic step towards creating products across domains. This industry is now more than 7 decades old and has entered every part of our lives from household appliances, power sector, automotive, defence, industrial and our telecommunications which makes it ubiquitous.

The statement data is the new oil gives the importance of data today while the underlying chips are the new steel. This is like the role steel played during the Industrial Revolution (James A Lewis 2022).

The assembly of an electronic product is the system building of electronic boards which are sub systems and each electronic could have components from a few to thousands. The component supply chain is the most critical in the cycle and any one component falling short in the process disrupts the entire production cycle. As per Accenture report 2022 in the 1980's and 1990's the development of the fabless model has helped speed innovation. The huge capital investment for the foundries and the economies of scale made it logically converge towards a supply chain with foundries specialising in manufacturing for many chips design companies while the chip design companies, or the fabless industry focussed on innovation. All the exponential rise in the smartphone industry, computing industry were an outcome of this core competencies getting distributed (Syed Alam et al 2022).

India does not figure in the above Global Value Chain of equipment, chemicals and gases for semiconductor manufacturing.

The Accenture report 2022 also cites that having design and some manufacturing which are onshore fabs helps the economy on multiple counts like the employability for skilled jobs and being resilient to trade policy and supply chain shocks.

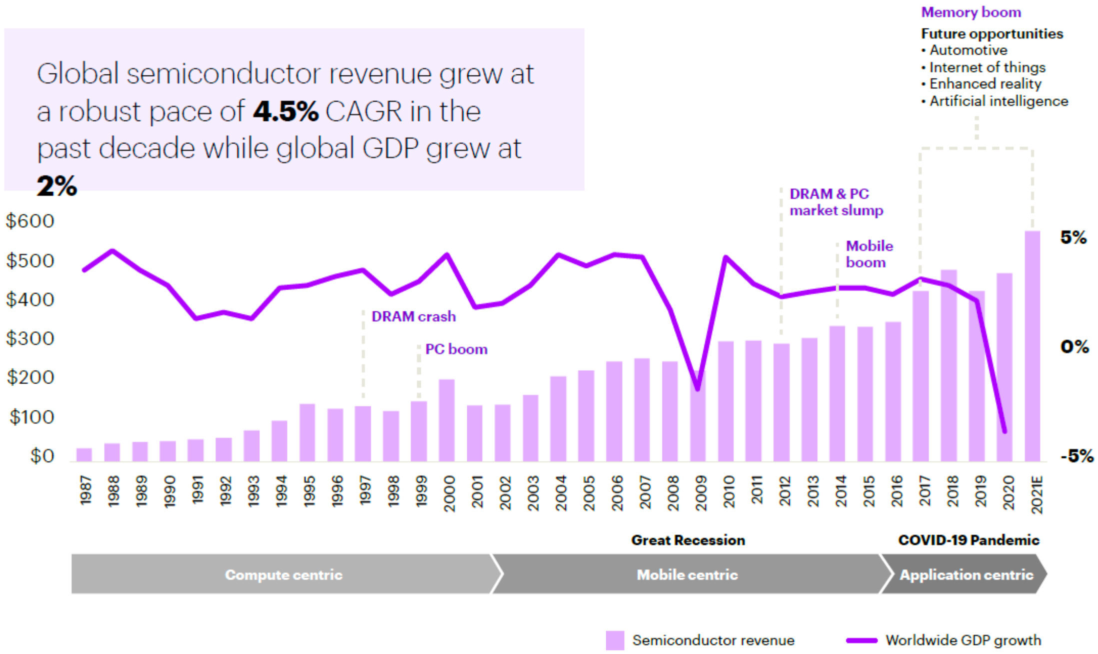


Fig.9. Semiconductor revenue against global GDP growth (Syed Alam et al 2022)

It is very evident from the above exhibit that the semiconductor growth has outperformed the worldwide GDP growth. The speed of innovation required surpassed the customer demand and with the supply chain disruptions has made it challenging.

2.4.1. Supply Chain Impact on Semiconductor Manufacturing

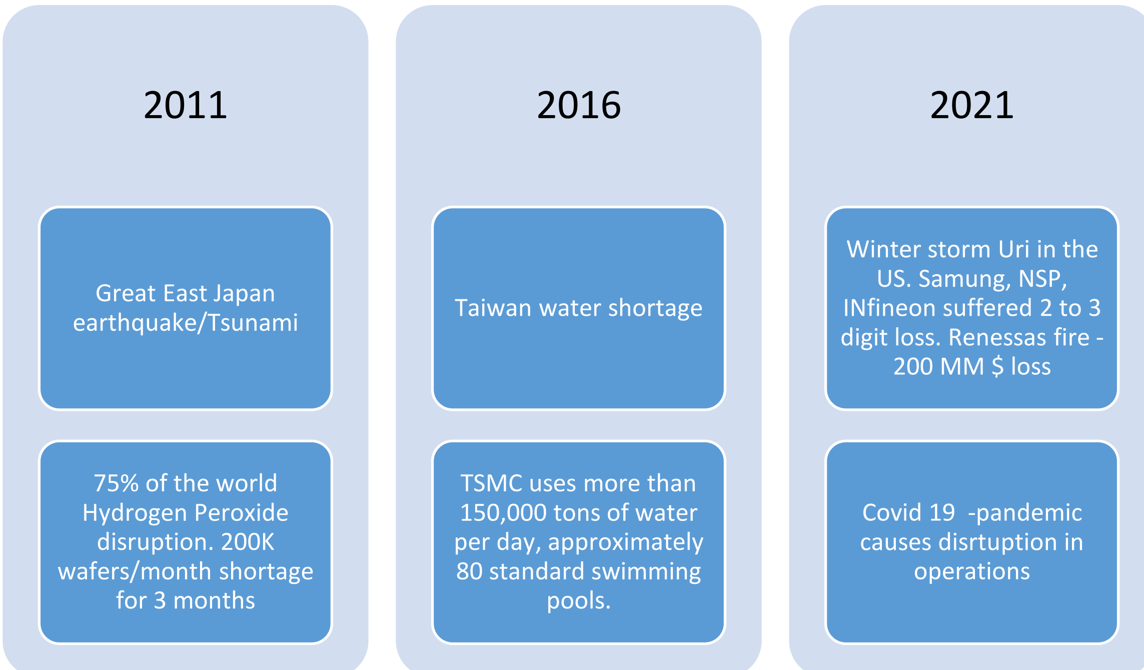


Fig.10. Collected from various sources and depicted in the exhibit.

The huge investment in the machinery, the usage of chemicals like the Hydrogen peroxide, the water usage makes it an industry with a huge barrier to entry and a huge risk unless the supply chain is not hedged.

As per the Forbes article 2021, the climate model projections with lesser typhoons and reducing spring rainfall, the supply of microchips could become rarer. Climate change is causing droughts and the TSMC is now dependent on water trucks to maintain production. The overspend on the water requirement exceeded original budget planning. The requirement of TSMC exceeds 150,000 tons of water per day and with the water scarcity the production levels are at risk and that put the world at risk (Emanuela Barbiroglio 2021 Forbes), With the large share of manufacturing in countries like Japan, China, South Korea and 60% of the share with Taiwan in the foundry market, the pandemic caused a disruption in the manufacturing cycle (Ankita Tripathi SPRF 2022).

Exhibit 5: Illustrative flows within global semiconductor value chain

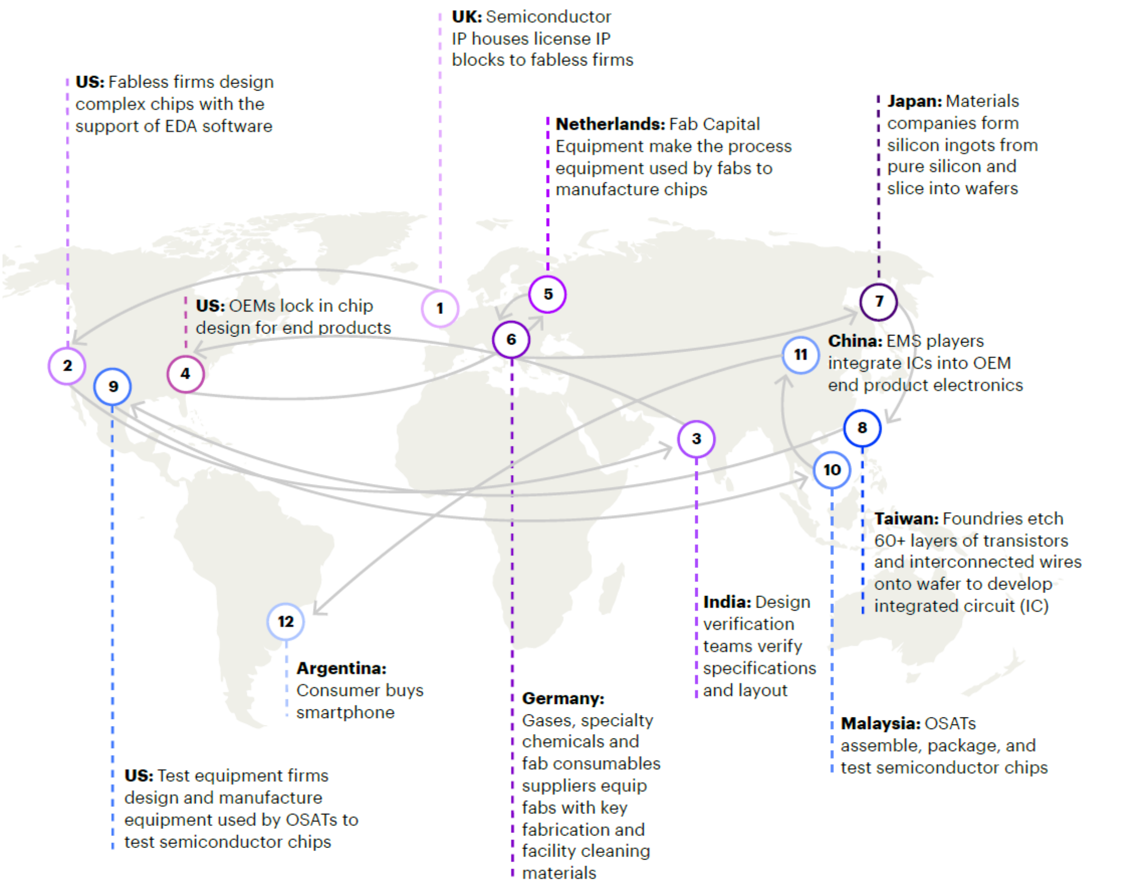


Fig.11. illustrative flows within global semiconductor value chain

(Syed Alam et al 2022 page 17)

A simplified example of a value chain flow is depicted in the exhibit 5.

The Global value chain depicted above shows the criticality to sustain the $422 billion market size and the pervasiveness of the semiconductor from telecommunication to aviation makes it more valuable than the sheer size of the number.

The Semiconductors for the world to functions is now akin to the oxygen for life sustenance.

In a country like India where there is an automobile demand and a push towards electric vehicles for sustainable technology implementation, the impact of semiconductor shortage is huge. The convention IC engine cars are getting obsolete though at a very slow pace while there is a trend to shift to electric cars. The electric vehicles have a large content of semiconductors, and the shortage is a major concern. The demand also is increasing for smartphones, computers, and various smart devices. The forecasted growth is to increase by a CAGR of 36% with the EV battery market to increase by 20% by 2026. The internet usage in India is estimated to increase to between 750 million and 800 million. The mobile phone is virtually with everyone and that could be between 650 million and 700 million by 2023 (Ankita Tripathi SPRF 2020).

The semiconductor industry is experiencing the bullwhip effect with the supply getting constrained and hence pricing going up which creates a situation where additional foundries could be required to meet the demand. The long cycle of time builds a foundry brings a situation where demand goes low, prices go down and there is an oversupply. This is particularly riskier for countries like India where capital is scarce, and risk is high considering the guaranteed returns (Nicolas Rivero 2021).

Overinvestment would be a short-term phenomenon and still better than a centrally directed investment. The demand for chips would grow but the only problem is where in the Global value chain and supply chain China be. A trustworthy and economically viable transnational supply chain through the United States, Canada, Australia, South Korea and other democracies would be the need of the hour which will leave these countries richer and stronger (James A Lewis 2022).

The demand for automotive makers shows a dip during the pandemic and hence the demand for semiconductors from automakers saw a dip. The chip makers during this period focused on the consumer electronics and gadgets like computers and mobiles. The recovery for the automotive firms was a V curve as depicted in the figure constraining the supply of raw materials and hence chip supplied unprecedently. The recent downturns in the industry mainly the 1975,1982, 1991 were due to oil shocks, the internet bubble in 1998 and the pandemic resulting in chip manufacturers cutting manufacturing which is inevitable die to the huge CAPEX and overheads. Increasing capacity needs to be complemented by process and product innovations which otherwise could be catastrophic with manufacturing investments in the wrong direction (Carter Young 2021).

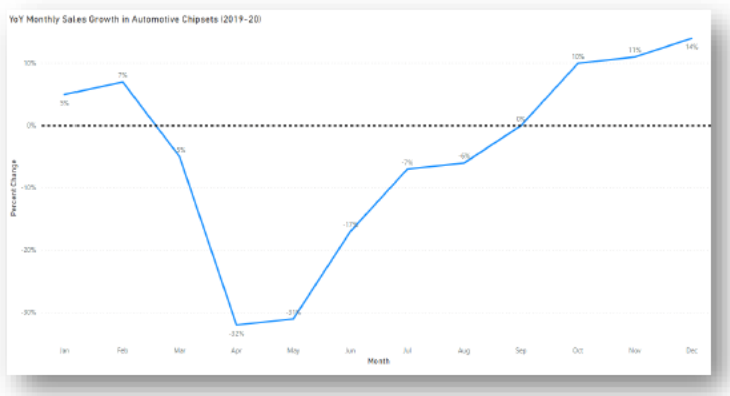


Figure 2: YoY Monthly Sales Growth in Automotive Chipsets 2019-20 (*source: World Semiconductor Trade Statistics Bluebook Sales Data. 2020-2019*) [5]

Fig.12. YoY Monthly Sales Growth in automotive Chipsets 20192020

(Carter Young 2021)

India export was a paltry \$0.296B as against the imports of \$7.29B in 2018 while the total trade was \$691 B. With this level of trade imbalance, India is spending more money than oil for semiconductors. Semiconductor manufacturing is a very mature industry though having huge barriers to entry due to massive investment requirement to the tune of \$3B to \$5B. The amount of water required and the quality of power supply required is phenomenal. India faces the capital investment challenges but also the competition from the mature semiconductor foundries in China, Korea, and the US (Rahul Shashaank Nath 2018).

The MNCs who have been in China and India created a trained work force and has created more capable workers to enable value additions on every design activity. India has now a workforce who can train personnel from parent companies. The paradox is that India with their sophisticated workforce working for MNC's have a lower revenue base than a lower skilled Chinese workforce and the key differentiator is the domestic markets and foundries in China (Fuller 2014).

One study shows that the annual energy consumption in a large semiconductor manufacturing fab may be around ~169 MWh, enough to power an Indian city. More than five million gallons of ultrapure water per day is the need of a FAB which requires at least eight million gallons of city water per day. With 20% of the world population in India, water management becomes one of the most vital requirements for the fabs (Mamidala Jagadesh Kumar 2021).

The supply chain of for semiconductors is very specialised at every step. The semiconductor types are at least 30 in variations with a very specific functional specification. There are specialised firms which have deep functional expertise in both mixed signal design and very expensive complex tools. There are various inputs that are required to the tune of 300 including raw wafers, commodity chemicals, specialty chemicals, and bulk gases and in turn require high precision equipment. There are very complex sub systems for this equipment like lithography and metrology tools. These sub-systems range from modules, lasers, mechatronics, control chips, and optics. This value chain is spread globally and the chain from source to end customer is long (Varas, A.et al April 2021).

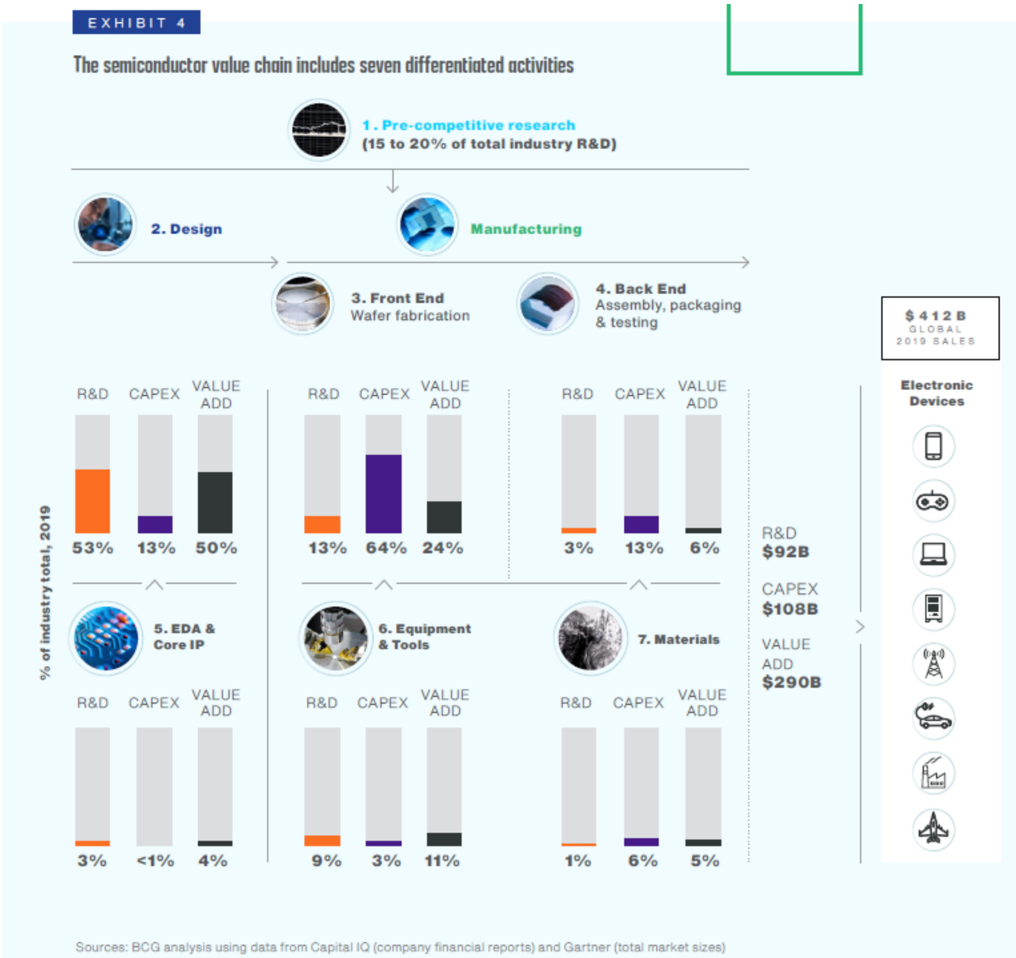


Fig.13. BCG Analysis using data from Capital IQ (Varas, A., Varadarajan, R., Royston, J., & Yinug, F. April 2021 page 13).

The semiconductor manufacturing is very highly complex as it is a confluence of specialised material technology which requires advanced research, the manufacturing equipment is with specialized companies having core competencies. The software design tools, and the core IP suppliers are again a very vital part of the semiconductor research and manufacturing.

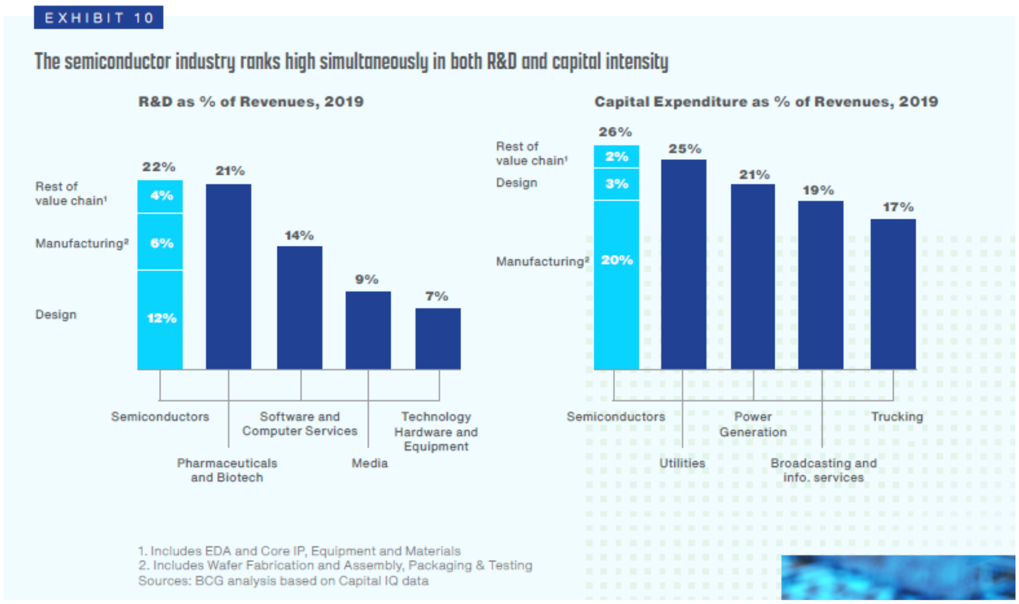


Fig.14. R&D and Capital Expenditure as % of Revenues, 2019

(Varas, A., Varadarajan, R., Royston, J., & Yinug, F. April 2021 page 13)

Semiconductor manufacturing has a high level of intensity in Research and Development. The initial investments in capital equipment are huge (See Fig 14). This level of investment is a barrier to entry for new entrants and emerging economies and creates a need for large-scale globalization and specialization.

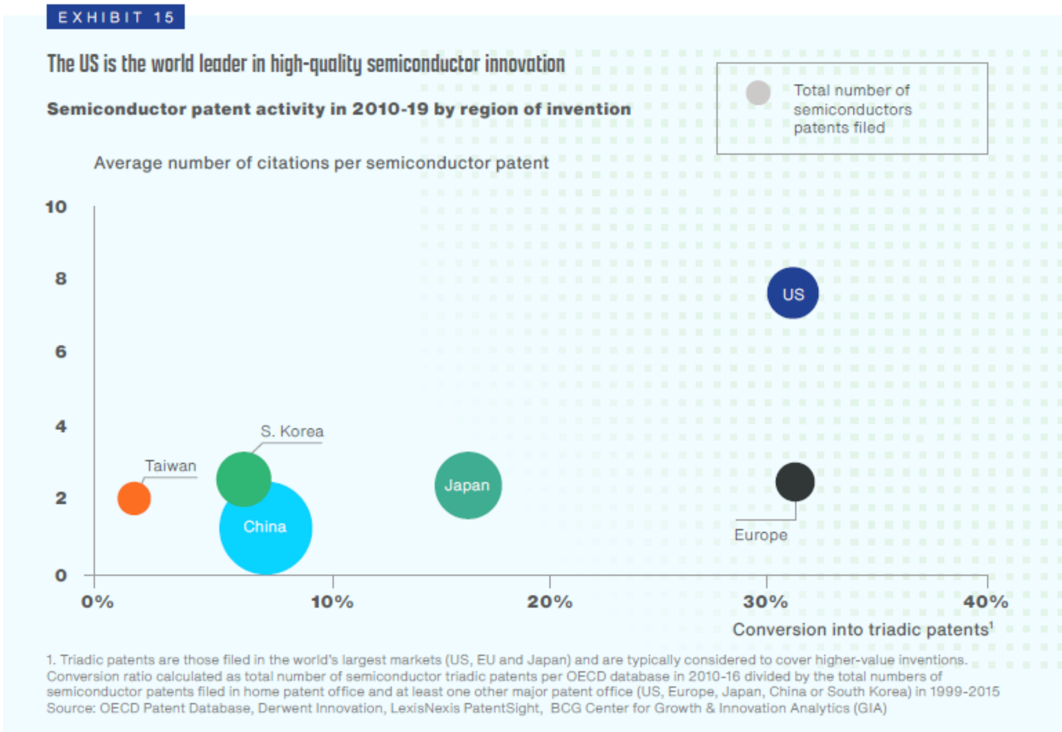


Fig.15. Semiconductor patent in 201019 by region (Avg. number citation per semiconductor patent)

(Varas, A., Varadarajan, R., Royston, J., & Yinug, F. April 2021 page 13).

As is evident, the semiconductor industry requires the largest investment in revenue to fuel research and development and also in the capital expenditure for manufacturing. The United States has the perfect web of collaboration between universities, talent, skills, and access to capital to fuel innovation. China is following suit, but the leadership still lies with the United States.

The combined revenue $188 billion of 12 largest chipmakers was equal to the top 3 companies, Intel, Samsung, and TSMC in 2020, India's imports 100% semiconductors of approx. $24 billion value. Though 30000+ chip design engineers add revenue worth $33 billion and more in 2020 our manufacturing in India is Nil (Kirtane,Pandit 2023).

India does not figure significantly in the semiconductor manufacturing cycle and with all these barriers, it requires a quantum leap in this direction.

The advantage for India is 20% of the world's semiconductor designers are in India.

Though the percentage looks large there are two critical weaknesses. The present IC design model is based on a service model and on peripheral design. Also, the design engineers have no exposure to markets and real business needs and away from core Intellectual property (Ernst 2014).

India has its unique challenges of land allocation with preapproved clearances for environment, water and power. Skilled labour is a critical factor and with the absence of this industry, it will take time to build a talent base. One of the factors is also the availability of raw material.

The most significant is also the import of cutting-edge machinery required which must be imported which also cost in dollars along with the technology. The semiconductor industry is fast changing and required process and product innovation to stay relevant and competitive. But without the semiconductor foundries India cannot dream of becoming a developed economy.

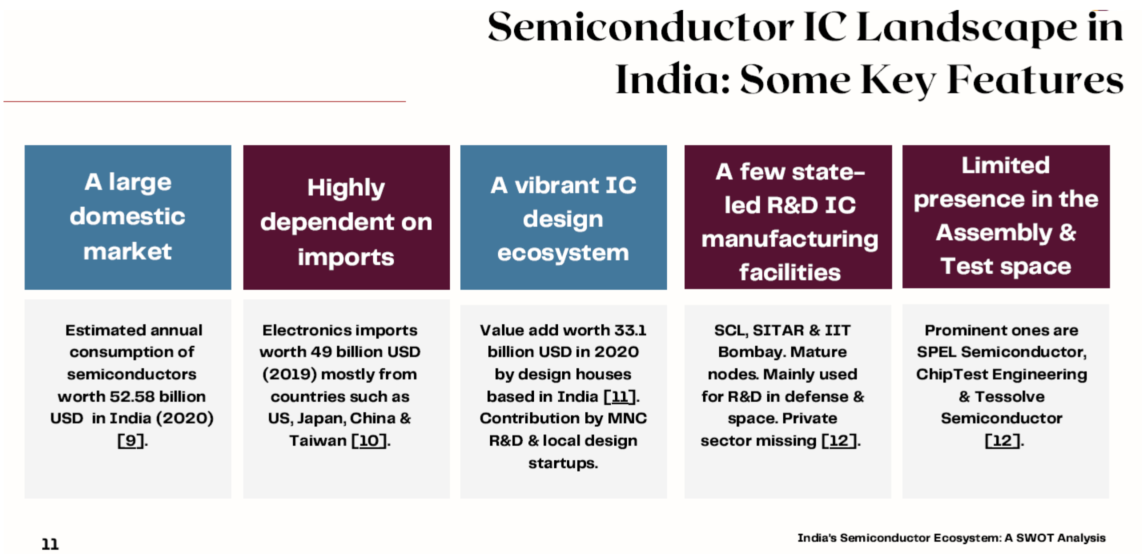


Fig. 16. Semiconductor IC Landscape in India: Some Key Features (Tripathy et al 2021)

India's semiconductor manufacturing is very minimal, and all are owned and managed by the government of India. There is some fabrication, packaging, and testing facility at the Semiconductor Laboratory (SCL). Basic 6 inch wafer processing facility is available at Society for Integrated Circuit Technology and Applied Research (SITAR) has a 6 inch wafer processing capacity. There is another lab for Nanofabrication Facility (IITBNF) at IIT Mumbai that has the ability to produce 2inch, 4inch, and 8inch silicon wafers and these are only prototyping facilities (Kirtan Pandit 2023).

The Global value chain as depicted is critical for economies to collaborate. The pandemic was a blip in the supply chain and countries like the United States now want to build FABs on shore and countries like India want to get into semiconductor manufacturing. The goal should be to have a reliable and productive supply chain and address China as a concern rather than attempting to create a self-sufficient ecosystem (James A Lewis 2022).

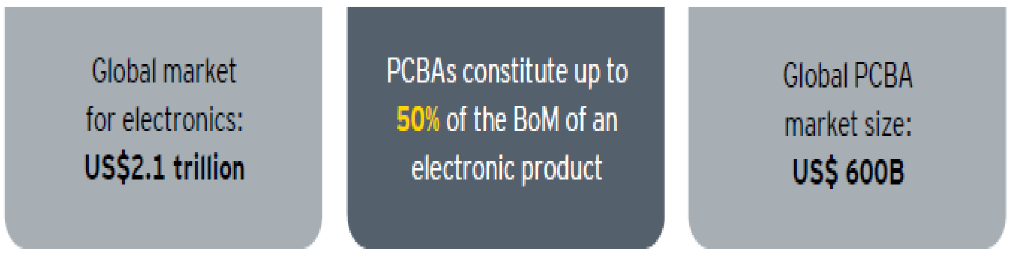
Restrictive regulations and a large dysfunctional implementation of past support policies have led to a not effective implementation in plants and machinery and technology development. India chip design capabilities for the world are disconnected with the local electronics manufacturing capabilities. Hence the local demand for electronics is largely catered by imports which are next only to the countries import of petroleum and gold (Ernst 2014).

India needs to harness her existing strengths to gain a competitive advantage and strengthen its vantage position. MeitY and Cadence Design Systems have started Fabless Chip Design Incubator Programme (FabCI) to support chip design IPR. Also, with its large talent pool across engineering colleges India can focus on building semiconductor design capabilities by working with industry and government (Sindhuja Balaji 2021).

With scarce resources in India and the high capital investment need for semiconductor manufacturing, redundancy in resources and activities should be avoided. A consolidated approach is needed to achieve the desired results in the form of a consortium keeping country interests as supreme to meet the commercial and strategic demands of the country (Kamaljeet Singh and S.V. Sharma 2018).

2.4.2 Printed Circuit Board Assembly

While we discussed the Semiconductors, a value-added component in any Bill of material for electronics is the assembly of chips. The printed circuit board assembly is typical 40% of the product bill of materials. The total US market is around $600 B for PCBA's.



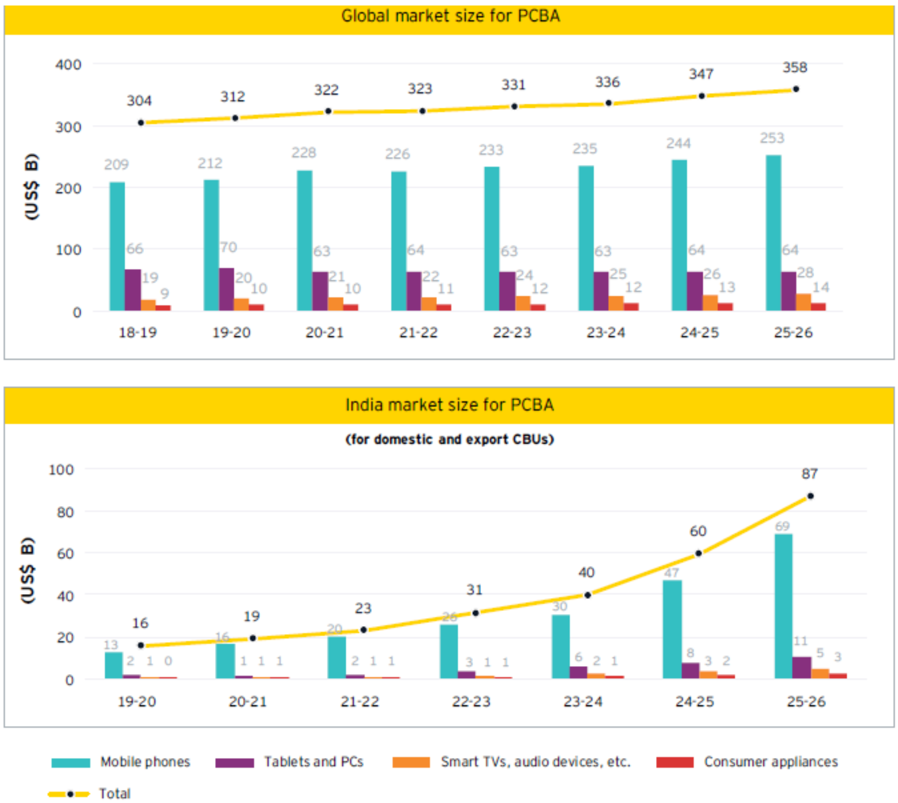
Making India the global hub for Printed Circuit Board Assembly

Fig. 17. Atmanirbhar Bharat 2020

The PCBA industry already has created a good installed base with companies like Foxconn, Flex, Wistron setting base in India.

Th disadvantage of India or steep curve to success is largely due to lack of experience in this sector, talent unavailability, infrastructure costs, domestic markets with a lack of R&D.

The global innovation index for India is now at its 57th position in 2018 to 48th in 2020. Disruptive innovations are required to meet the dynamic market conditions, urbanization needs, and environmental sustainability. India needs to Enhance research infrastructure, elevate educational standards, boost private sector and university engagement, and foster the growth of startup enterprises, and encourage startup companies (Vedachalam 2021).



Source: ICEA
Note: PCBA market size includes four product segments - mobile phones; tablets, notebooks and desktop PCs; Smart TVs, audio devices, video and music streaming devices; and Consumer appliances (washing machine, refrigerator, AC and heaters)

Fig. 18. Global and India market Size for PCBA (Atmanirbhar Bharat 2020)

For India to be a product development leader and build an export economy the primary ingredient is the semiconductor and then the Printed circuit board assembly.

One of the barriers to entry is chip manufacturing and a relatively lower barrier is the PCBA. The cost of the product is directly related to the cost of the chip. An example of a display of 2.4" is apt here. China this would cost 67 RMB and India will pay 11 RMB. This is very easy to relate on the cost-effectiveness of Indian Manufacturing which is directly related to growing economies of scale (Atmanirbhar Bharat 2020).

The role of the Government is key to enabling PCBA manufacturing in India.

The push towards creating a self sufficiency in the United States or Europe will create inefficiencies in costs and also hence give advantage to China (James A Lewis 2022).

2.5 Innovation talent and R & D

In India, there are over 900 universities, approximately 39,000 colleges, and around 10,000 standalone academic institutions. The percentage of students opting for postgraduation is a mere 12 percent and a dismal 0.5 percent opt for doctorate degrees. This is a per the Ministry of Human Resource Development, As compared to China this is only 20% and 4$ of Japan.

India is still an importer of defence technology and hence has a trade deficit unlike China which has by virtue of its increased R&D spending now have indigenous technology. India’s imports are nearly 10% of the worldwide defines exports which for a developing country is detrimental for its indigenous development effort (Vedachalam 2021).

Innovation measures can be through patents which even today companies like IBM, Microsoft, Toshiba lead the pack. Raising the countries’ ability to innovate is very complex and multifaceted. It requires attention to intellectual property law changes, simplified technology imports, salary incentives for academia, High quality universities and national labs go a long way in creating an innovation ecosystem. The environment for accessing capital like venture capital funding is vital for sustenance and growth. Very difficult but important is creating a conductive environment for social, cultural and political environment. Also the image and brand of a country matters. Example of country level branding initiatives are the Turquality drive by Turkey. Taiwan in the 1990s spent a lot of effort on branding Taiwan products. There are some companies like Mahindra and Mahindra, LG and HTC which have leverage their service quality and not only product focus. Tata Nano , Lenovo, and Wipro have demonstrated frugal innovation closer to their markets to create differentiation. Acquisitions can also help leapfrog market accessibility and innovation capabilities example arcelik, Lenovo and Tata tea. Latest are Jaguar and Land Rover by Tata (Chattopadhyay, A., Batra, R., & Ozsomer, A).

India has been famous for the Jugaad terminology. Jugaad ideally means getting around a problem and not solving it systematically and for longer term if possible. Prof Anil K Gupta in his book "Grass Roots innovation" highlights the importance of Frugal engineering and its benefits for a circular economy. The most famous example is the Indian Space Research Organisation (ISRO) mission to the Moon and Mars which cost less than $80 Million as against billions by developed countries. The innovation in today's corporate world does not take into account the environmental costs like in the case of shampoo satches, detergent or mouth fresheners which the plastic containers are all strewn around creating environmental disasters. Frugality involves affordability, circularity and durability or renewability. When products are designed accessibility, affordability, adaptability, and availability are vital.

Any innovation at an individual level needs a lot of support for adoptability and scalability. Grassroot innovations require National or federal policies and strategies.
The National Innovation Foundation (NIF) was established in in 2020 to promote grassroot innovations. The hallmark of grassroot innovation is the cradle-to-cradle approach called Circularity where everything is recyclable (Gupta, A.K. 2016).

In countries which have a large poor population like India and its neighbouring countries, the power of information, communication, and technology to change lives of poor people is immense. A new form of entrepreneurship was formulated by Dr Muhammed Yunus the father of Grameen bank where cell phones were sold to poor village ladies, and they could make rental income on services for connecting internationally from villagers. Huge focus is on artificial intelligence, robotics but there is little interest in applying technology social upliftment. The primary focus is on military and commercial purposes (Yunus, M. 2017).

While frugal engineering is of immense requirement and scalability especially in countries like India, there are some technologies for aviation, turbines, computers, and semiconductors which require global markets and economies of scale are in the order of nations. particularly great. These technologies are huge in terms of barrier to entry in terms of technology and capital costs (Porter, M. E 1980).

The product development scenario in India must be upscale in terms of scale and quality.

Sometimes Nations are built given a crisis. The pandemic got the world in a lockdown and during this time the Andhra Pradesh Medical Technology Zone got built and now it is the world's largest medical equipment manufacturing and development centre. The goal is import neutral for medical devices (Sharma, J. 2021).

3. Electric Vehicle

The Electric Vehicle (EV) represents a prime example of the integration of various subsystems, including electronics, software, electric motors, and traditional automotive components. However, despite India's prowess in electronic manufacturing and software as a service, there has been limited progress in software product development, while challenges persist in automotive parts manufacturing, with policies favouring China.

India is poised for a substantial transformation in the adoption of Electric Vehicles. Initially met with scepticism, advancements in technology are fostering greater acceptance and penetration. Crucially, government policies and incentives that support the EV ecosystem are pivotal in driving this shift. Addressing the perception of Electric Vehicles is crucial. Consumers must weigh the higher initial capital costs against the long-term benefits and sustainability goals. Articulating these trade-offs is essential in shaping attitudes towards EV ownership.

Moreover, considerations such as battery range, lifespan, speed, and overall quality specifications are paramount for consumers when considering purchasing an EV. Effective marketing and branding strategies will also play a vital role in shaping the industry's trajectory (Khurana, A et al 2019).

For Electric Vehicles (EVs) to gain significant traction in India, the establishment of battery charging stations and robust battery management facilities is imperative to address range concerns. Policies promoting green energy and incentivizing EV adoption, such as FAME (Faster Adoption and Manufacturing of Electric Vehicles) and the National Wind Solar hybrid policies, are already in place but further measures are necessary. The industry requires additional incentives to engage in this sector, either through profitability incentives or by emphasizing corporate social responsibility activities (Upadhyay, R. K. 2019).

TABLE 1. Automobile sales trends (data from the Society of Indian Automobile Manufacturers).

Category	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017
Passenger vehicles	2,629,839	2,665,015	2,503,509	2,601,236	2,789,208	3,046,727
Commercial vehicles	809,499	793,211	632,851	614,948	685,704	714,232
Three-wheelers	513,281	538,290	480,085	532,626	538,208	511,658
Two-wheelers	13,409,150	13,797,185	14,806,778	15,975,561	16,455,851	17,589,511
Total	17,361,769	17,793,701	18,423,223	19,724,371	20,468,971	21,862,128

Table.1: Automobile sales trends (Jhunjhunwala, A., Kaur, P., & Mutagekar, S. 2019).

India holds a distinctive position globally due to its diverse vehicle mix. The majority of vehicles sold annually in India are two-wheelers, followed by three-wheelers known as autorickshaws, four-wheelers, and commercial vehicles such as trucks and buses. Notably, commercial vehicles, which often carry a large number of passengers, present a significant opportunity for environmental impact through electrification.

Unlike other regions, vehicle speeds in India typically hover around 25 km/h. Consequently, vehicle system designs must accommodate this specific speed range, optimizing efficiencies accordingly. Additionally, India's climate poses unique challenges, with ambient temperatures exceeding 35 degrees Celsius in most regions and occasionally reaching up to 50 degrees Celsius. This necessitates specialized battery technology and maintenance protocols to ensure optimal performance and longevity in such adverse conditions (Jhunjhunwala, A., Kaur, P., & Mutagekar, S. 2019).

The electric vehicle market is anticipated to theoretically decrease the trade deficit by fostering indigenization, although there is a lack of substantial data to support this claim. The crucial determinant for electric vehicle production lies in economies of scale, which are pivotal in driving down costs. This, in turn, positions India favourably to cater to both domestic demand and export markets. However, achieving economies of scale necessitates the implementation of appropriate policies, corporate initiatives promoting EV adoption, and the establishment of a robust ecosystem (Shukla, V. 2021).

Range anxiety, which refers to the apprehension that an EV may not have sufficient charge to complete a journey, is identified as a significant impediment to the widespread adoption of EVs. The concern stems from the relatively restricted range of Electric Vehicles in comparison to Internal Combustion Engine Vehicles (ICEVs)., primarily attributed to the lower energy density of lithium-ion batteries used in EVs.

Users often unfavourably compare EVs to internal combustion engine vehicles (ICEVs) due to their perceived limited range. However, research suggests that current EV models can adequately meet the daily commuting needs of most users. Factors such as driving conditions, acceleration patterns, ambient temperature, and the use of auxiliary devices significantly impact an EV's range.

Expanding the charging infrastructure by establishing a robust network of charging stations is crucial. This entails strategically locating charging points based on user behaviour and ensuring an adequate number of fast charging stations. Additionally, providing users with accurate range predictions and guidance on energy consumption optimization can help extend the effective range of EVs. Furthermore, advancements in battery technology, such as modular battery designs, offer promising solutions to combat range anxiety by facilitating easier and more cost-effective range extension.

Improvements in battery technology will gradually enhance the range of EVs and alleviate range anxiety, a comprehensive approach is essential. This includes infrastructure development, precise range estimation, and energy optimization measures, tailored to the economic conditions and market dynamics of each region. Such a strategic and adaptive approach is vital for addressing range anxiety worldwide and expediting EV adoption (Shrestha, S., Baral, B., Shah, M., Chitrakar, S., & Shrestha, B. P. 2022).

The article explores the dynamics between battery charging and battery switching for electric vehicles (EVs) and examines how consumers' anticipation of regret affects their decision-making process when choosing between conventional charging vehicles (CVs) and battery switching vehicles (SVs). It emphasizes the significant impact of anticipated regret on EV adoption rates and consumer preferences for SVs over CVs.

Understanding consumers' anticipated regret is vital in shaping the adoption rates of electric vehicles (EVs) and influencing consumer preferences. Anticipated regret plays a pivotal role in consumer behaviour, with revolutionary regret potentially hindering the adoption of EVs with battery-switching capabilities. This regret dynamic affects the market dynamics between standard EVs (CVs) and those with battery-switching capabilities (SVs). While battery charging remains cost-effective and mature, battery switching offers a significant advantage in addressing concerns such as long charging times and range anxiety. However, challenges arise for SV manufacturers in enhancing the battery-switching function due to the presence of revolutionary regret. Thus, managing anticipated regret becomes crucial for EV manufacturers in crafting effective product strategies and marketing approaches. Moreover, infrastructure development, including the availability and convenience of public charging and battery-switching stations, significantly influences consumer decisions and the broader adoption of EVs. Overall, understanding and addressing consumers' anticipated regret is key to accelerating EV adoption rates and shaping market dynamics in the electric vehicle industry (Liu, Z., Wu, Y., & Feng, J. 2023).

The development of a robust fast charging infrastructure is paramount for enhancing the convenience of electric vehicle (EV) owners and plays a pivotal role in driving the adoption of EVs. This infrastructure serves a dual function, acting both as electricity loads and potential storage units within the power grid, as discussed in the review. Moreover, there is a growing emphasis on integrating renewable energy into the charging infrastructure to minimize environmental impact and bolster sustainability efforts. Challenges encompass various technical, economic, and environmental factors that require careful consideration to ensure effective deployment and optimal performance of charging infrastructure (Mohammed, A., Saif, O., AboAdma, M., Fahmy, A., & Elazab, R. 2024).

Table 2 Charging levels of EV according to IEC 61 851-1.

From: Strategies and sustainability in fast charging station deployment for electric vehicles

Type of charging	Voltage (V)	Outlet place	Maximum power (kW)	Charging time (h)
Level I (slow charging)	120.0 US (AC)	Home	1.90	4.0–11.0
	230.0 EU (AC)		7.40	11.0–36.0
Level II (semi-fast charging)	240.0 US (AC)	Private/public	19.20	2.0–6.0
	400.0 EU (AC)		43.0	2.0–3.0
Level III (fast charging)	208.0–600.0 (DC)	Public	50.0–350.0	0.160–0.50
Level IV (ultra-fast charging)	≥ 800.0 (DC)	Public	> 400.0	Gas refueling

Table.2 EV Charging Levels according to IEC 61 8511 (Mohammed, A., Saif, O., AboAdma, M., Fahmy, A., & Elazab, R. 2024).

The crucial role of "on the go" charging in supporting the expected surge in electric vehicle (EV) adoption over the next decade. While home charging will remain predominant, convenient away from home charging is vital to accommodate the growing EV numbers. The emergence of an EV charging network mirrors traditional fuelling infrastructure dynamics, balancing cost, efficiency, and convenience. EV chargers are categorized into four levels, with varying power ratings and installation costs. Utilization is critical for efficiency, with fast chargers offering competitive overall cost to serve due to higher capacity. The Charging market is predicted to segment into convenience driven, price driven, loyalty program driven, and quality driven segments, akin to the retail gasoline market. Strategic planning and investment in charging infrastructure are crucial to meet the evolving needs of the growing EV market (Hodson, N. (n.d.)).

The popularity and practicality of EVs have been increasing, largely due to the advantages offered by lithium-based batteries. The review notes a significant increase in journal publications and citations related to lithium-based batteries in EVs, indicating growing academic and industrial interest. Despite the COVID-19 pandemic, the sale of EVs continued to increase, particularly in the Chinese market, which played a significant role in global sales.

While lithium-based batteries are the most widely used energy source for EVs, safety concerns due to potential malfunctions at high temperatures are a concern.

The critical role of lithium-based batteries in the success of EVs, highlighting their superior energy density compared to other battery technologies (Ralls, A.M.; Leong, K.; Clayton, J.2023).

According to the lithium-ion battery pack costs for electric vehicles has seen a significant decline of nearly 90% from 2008 to 2022, dropping from $1,355 per kilowatt-hour (kWh) to $153 per kWh. This reduction is attributed to advancements in battery technology and increased manufacturing volume. However, a recent report by Bloomberg NEF noted a slight increase in costs in 2022 due to rising raw material prices, although the introduction of lithium iron phosphate (LFP) technology helped mitigate this surge. Despite the uptick, LFP batteries remained approximately 20% more cost-effective than lithium nickel manganese cobalt oxide (NMC) batteries.

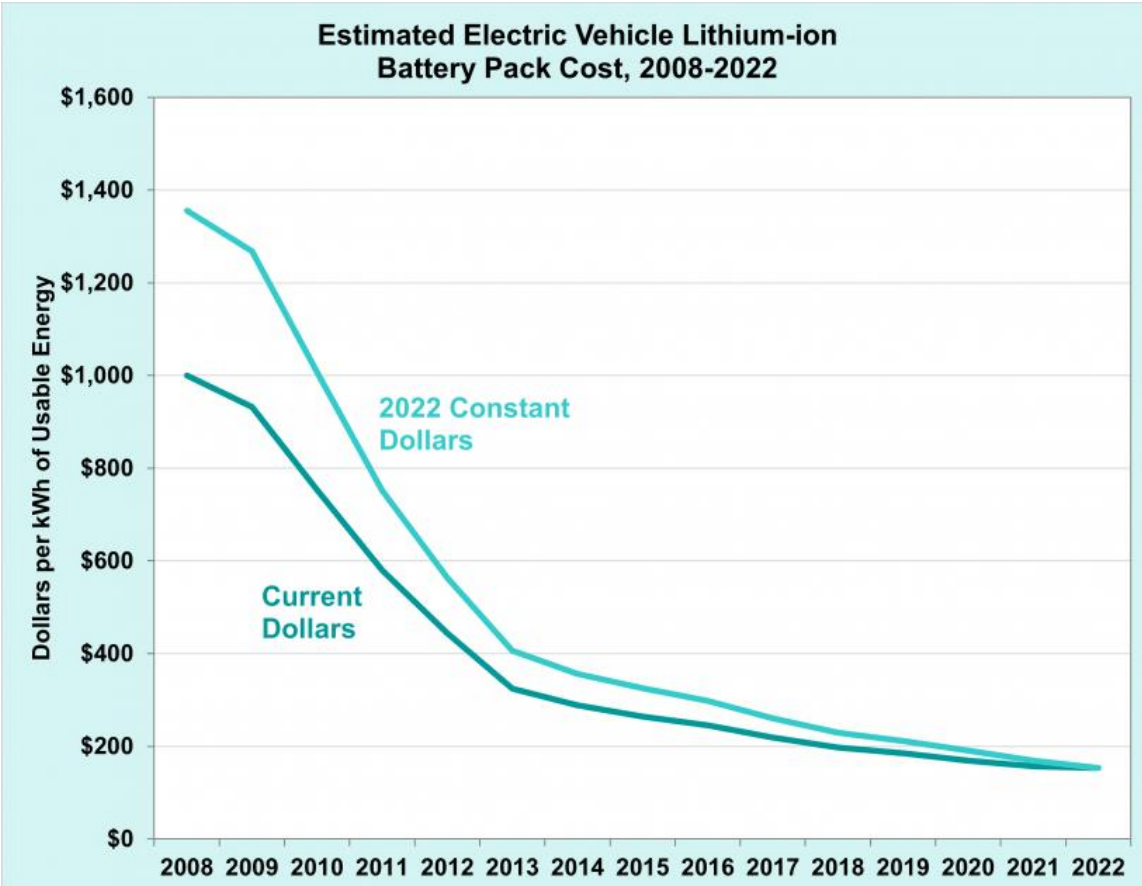


Fig. 19 Estimated electric vehicle lithium-ion battery pack cost

Source: https://www.energy.gov/eere/vehicles/articles/fotw-1272-january-9-2023-electric-vehicle-battery-pack-costs-2022-are-nearly

The EE Power article "Trends in Electric Vehicle Fast Charging" explores the evolution and future directions of fast charging technology for electric vehicles (EVs), crucial for fostering widespread EV adoption. It covers various advancements and expected trends, including a shift towards ultrafast charging methods to match traditional fuel vehicle refuelling times. The article emphasizes the increasing energy demand for EVs, particularly highlighting the anticipated growth in Level 2 and DC fast charging. It also examines the architectural evolution of ultrafast charging stations, showcasing their adaptability in handling power capacities. Battery technology improvements are deemed necessary to support fast charging, focusing on materials and electrode designs to tackle challenges such as lithium plating and thermal management. The role of power electronics in enabling faster and more efficient charging, Additionally, the ongoing support from public policies and governmental initiatives for DC fast charger deployment, amidst evolving market dynamics requiring cautious long-term supply agreements. Anticipated innovations in battery systems in 2024 are expected to prioritize improvements in energy storage density, safety, and cost-effectiveness, further advancing EV technology. Ultimately, the critical importance of fast charging in alleviating range anxiety and enhancing the adoption of EVs, requires continuous innovation in charging technology and battery performance to achieve these goals.

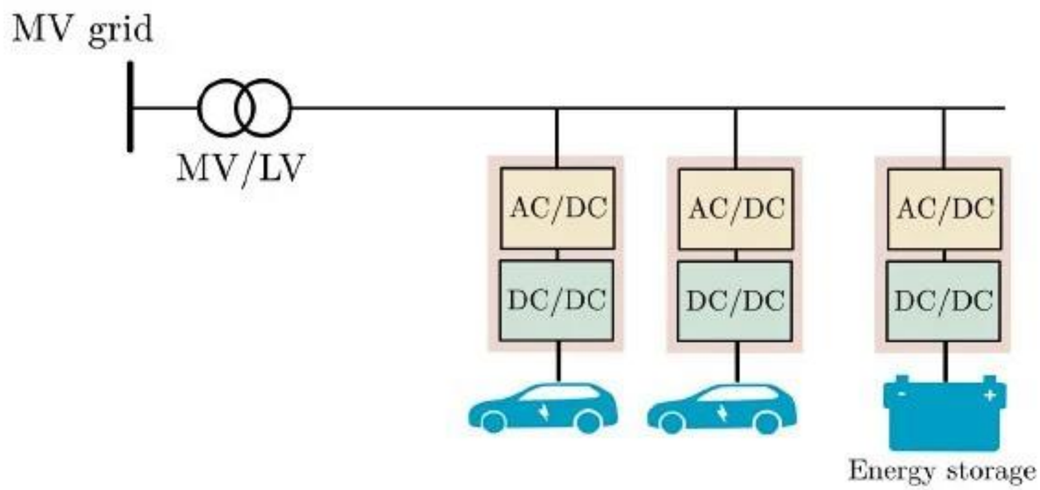


Fig. 20 Source: An AC distribution network based ultrafast charging station. Image used courtesy of IEEE Open Journal of Power Electronics

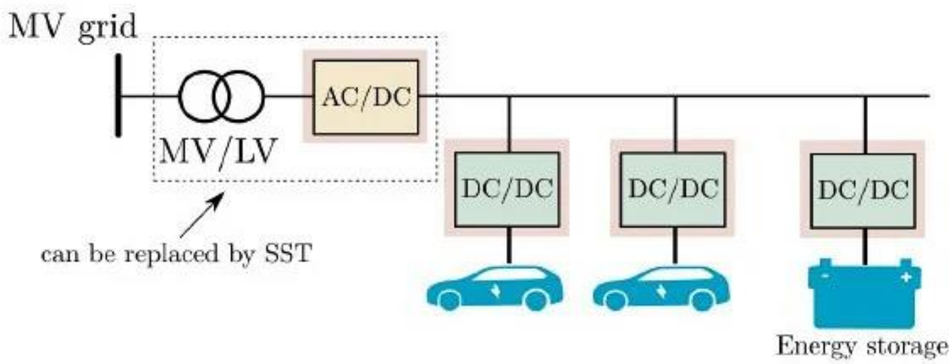


Fig. 21 Source: A DC distribution network based ultrafast charging station. Image used courtesy of IEEE Open Journal of Power Electronics

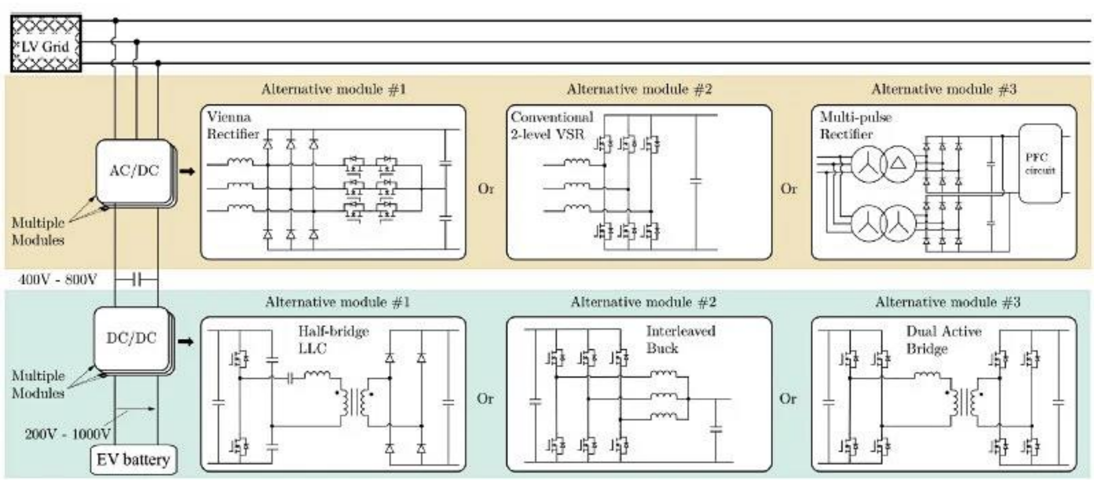


Fig. 22 Source Different power electronics topologies for DC fast charging. Image used courtesy of IEEE Open Journal of Power Electronics

The above figures 24-26 gives an overview of the complexity of Fast Charging Technology, the dependence on semiconductors and a complex power system of Grid to the vehicle. Fig 24 is the line diagram for fast charging and fig 25 also has Solid state technology. The culmination of power systems, Power electronics, renewable energy, various topologies with control system makes this a very complex Technology.

On a very innovative business model standpoint, independent of the size of the organisation, long term car rentals can give a fillip to the costs savings in terms of maintenance costs and a solution-based service. This will also help to alleviate urban problems through car renting and sharing (Bolesnikov, M et al 2018).

Companies across the world are rebranding themselves as mobility companies and looking at customers as long term rather than one-time sales (Bolesnikov, M et al 2019).

Leveraging Smart cities through the technology benefits of efficiency, commute travel, shared mode of transport through fleets and hence personal expenses could be another business remodel (Bolesnikov, M et al 2023).

4.0 Summary of the Literature Review

There is a lot of literature available in silos on R&D in India, collaborations across the globe, software services, manufacturing services, and semiconductors but what could not be found is the holistic study of building a sustainable product/product company in India. There is not as it seems from research publications available work done in identifying measures to build an indigenous product development leadership ecosystem.

As is presented above there is a lot of research done and published on manufacturing services in India lagging and all the related policies that can make us be on par with the global manufacturing world. There are elaborate and focused discussions on the barriers to innovation, high end manufacturing for semiconductors, frugal engineering and all the possible measures the government and private sector has to take to win in these markets.

The literature has pointed out the software services success and the availability of a talent pool for high end technologies, the challenges of the semiliterate population and the challenges. The disconnect between the successful software services sector with the local markets has been pointed out and also the talent not available for the local markets.

The dots of the manufacturing world, software services, policies, semiconductors, and innovation seem to be researched and good quality published literature in various research paper, articles, reports from leading consulting agencies are available.

It is evident that there is very little attempt to connect these various dots to weave in an understanding of the situation of our product development forays which requires all these dots to be well developed and connected. Unless we do product development and exports to the globe, Indian economy has a barrier to scale up.

This is also evident in the case of electric vehicles in India. The EV's with the integration of electronics, software, motor and other typical automotive parts is a challenge to build in India even when there lies huge expertise over the decades in parts manufacturing. There is a lot of literature available in silos on manufacturing challenges, adoption, and infrastructure but there is no comprehensive study on the gaps to Make in India for EV's. EV is the wave of growth in the near term and long term considering the sustainability regulations.

The recent going back and forth on the Faster adoption and manufacturing of EV's FAME policy after more than 5 years of implementation and now linking EV growth framework to the Production linked innovation scheme points out to the inconsistency in policy frameworks in India for product building.

Overall, the literature underscores the importance of addressing range anxiety, expanding charging infrastructure, advancing battery technology, and implementing viable business models to support the widespread adoption of EVs but lack in connecting the dots of software, electronics design, manufacturing, talent, infrastructure, policy incentive, regulations to build a comprehensive framework for India to be an indigenous leader in EV product development and the alleviation of dependency on Chinese imports.

The upcoming section is the methodology, techniques for data collection, analysis and methods of the study.

CHAPTER III:
METHODOLOGY

3.1 Overview of the Research Problem

The technology product development process comprises several critical phases. It begins with sourcing basic parts like semiconductors and electronic components, which are then assembled onto printed circuit boards. Software plays a significant role, ranging from embedded software on chips to creating meaningful applications for users.

Testing is a pivotal phase, including functional, reliability, and compliance testing to ensure the product meets standards and specifications. Finally, transitioning the developed product to manufacturing is crucial, ensuring scalability for local and global markets while maintaining competitive pricing and quality standards.

The goal of this research is to identify the gaps hindering India from becoming a product development capability centre. India has its excellence in pockets, encompassing software services, manufacturing capability, product design, and compliance. However, the major challenge lies in connecting these dots within its silos of excellence to establish a cohesive product development ecosystem.

For this research case, we consider the electric vehicle as the product of focus among various potentials, including electric scooters, cars, buses, or locomotives. The case specifically explores electric scooters due to their successful adoption in Far East countries, particularly China, India's neighbour. India has been striving to increase the adoption of electric vehicles, particularly electric scooters, for at least the past one and a half decades.

India possesses a wealth of talent in engineering, with renowned government colleges, deemed and private institutions nurturing skilled professionals in electric motor design, power electronics, and control systems. Additionally, established companies like Crompton Greaves, BHEL, and Siemens have decades of experience in designing, developing, and manufacturing electric motors. However, the country faces limitations in lithium material availability and battery manufacturing, impacting cost and availability despite advancements in lithium-based battery technology.

While India boasts expertise in electronics design and manufacturing, much of the electronics required for electric scooters are imported, particularly from China. Government policies such as Make in India and FAME subsidies aim to encourage local production and adoption of electric vehicles, yet the nation still struggles to independently design, manufacture, and export electric scooters. This research seeks to delve into the underlying reasons behind this disparity despite India's strengths, aiming to identify barriers and propose solutions to establish India as a leader in electric scooter production.

3.2 Operationalization of Theoretical Constructs

The research attempts to understand India’s electric scooter industry, aiming to understand the ecosystem, capabilities, barriers that define its present state and create a roadmap to achieve leadership status. With a clear focus on establishing a baseline understanding of competency levels vis-à-vis China, the research sets out to meticulously examine various dimensions of electric scooter development. The key competencies existing within Indian ecosystem for design, manufacturing of motor drives, batteries, and embedded software, are analysed. The barriers for indigenous development of these vital components are studied. The component supply challenges, the impact of lithium battery imports, and the implications of a sparse charging infrastructure are considered. The outcome of this research is to create a comprehensive framework for India to achieve indigenous product development leadership. These specific metrics, indicators, or variables will be used to operationalize the theoretical constructs mentioned:

1. **Product Development Capability:**
   - Metrics:
     - Number of electric vehicles in India and China annually.
   - Indicators:
     - Comparative growth of EVs in both countries.

2. **Lithium Material Availability and Battery Technology**:

- Metrics:
    - Lithium battery cost and density YOY
- Indicators:
    - Cost per kWh of lithium-ion batteries.
    - Density increase YOY

3. **Charging Infrastructure**:

- Metrics:
    - Number of charging stations.
    - Approx number of Vehicles
- Indicators:
    - Vehicles to Charger ratio

4. **Total Cost of Ownership**:

- Metrics:
    - Cost of 2W in India and comparison with ICE
    - Cost of 3W in India and comparison with ICE
    - Cost of 4W in India and comparison with ICE
- Indicators:
    - Cost of ownership with capital expense and operational costs.
    - Perception of Indian electric scooters in global markets compared to competitors.

3.3 Research Purpose and Questions

The research aims to formulate a comprehensive framework to position India as a leader in the entire lifecycle of electric scooter development, encompassing design, engineering, manufacturing, enabling regulatory policies, and infrastructure.

Objectives:

1. To conduct a detailed review of the literature and barriers hindering product development leadership in India, particularly focusing on electric scooters.

2. To assess the current competency levels across various stages of the electric scooter product development lifecycle in comparison to successful models, such as China, including:

- Design & Development (electronics, software, motor)
- Manufacturing
- Policies
- Infrastructure

3. To identify the barriers impeding indigenous design, development, and manufacturing of electric scooters in India.

4. To delineate the key elements necessary for the formulation of a comprehensive framework for electric scooter development in India.

Significance:

The findings of this research will provide valuable insights to industry practitioners and policymakers, facilitating informed decision-making and effective policy incentivization to bolster India's position as an indigenous product development leader in electric scooter development.

3.4 Research Design

The research methodology will be based on a mixed method approach involving both qualitative analysis and quantitative analysis. The research methodology will be based on a mixed method approach involving both qualitative analysis and quantitative analysis. The qualitative analysis will be a major part of the research and the quantitative will focus on the cost factors of EV bikes in India compared to China, Trend in battery costs, and charging infrastructure availability expressed in terms of Vehicle to charger ratios.

The qualitative analysis will be a semi-structured discussion to elicit the responses to the questions for the study. The participants will be EV users and industry experts. There will be interviews with industry experts who are in this domain. The interviewees will be entrepreneurs. Senior executives in the marketing and technology functions, design development engineers, suppliers of components, and policymakers.

A SWOT – Strength, weakness, opportunities, and threat matrix will be created to have a holistic understanding of the challenges for Electric Scooter development in India. This will help in identifying the elements for the framework to position India as an indigenous product development leader in Electric Scooter product development

3.5 Population and Sample

The qualitative analysis will be a semi-structured discussion to elicit the responses to the questions for the study. There will be interviews with industry experts who are in this domain. The interviewees will be entrepreneurs. Senior executives in the marketing and technology functions, design development engineers, suppliers of components and policymakers.

3.6 Participant Selection

Participant selection is a critical aspect of any research study as it directly impacts the validity and generalizability of the findings. In this study, a total of 110 participants took part in the survey, representing a diverse range of cities and users of electric vehicles (EVs). This broad sampling approach allows for insights from a wide demographic and geographic spectrum, enhancing the richness and depth of the data collected.

Additionally, 15 senior personnel were interviewed as part of the research process. These interviews provide valuable perspectives from industry experts or key stakeholders, offering deeper insights into the topic under investigation. By including senior personnel, the study gains access to nuanced insights and expert opinions, further enriching the research findings.

Overall, the combination of survey respondents from various cities and EV users, along with interviews with senior personnel, ensures a comprehensive understanding of the research topic. This diverse participant selection approach enhances the robustness and credibility of the study's findings, contributing to its overall validity and reliability.

3.7 Instrumentation

In this research effort focused on electric vehicle (EV) usage and insights, instrumentation played a pivotal role in gathering comprehensive data from both EV users and senior personnel within the industry. The primary instrument utilized for collecting data from EV users was a carefully crafted survey, designed and administered through SurveyMonkey, a widely used online survey platform known for its user-friendly interface and robust data management capabilities.

The survey instrument was thoughtfully developed to cover a range of pertinent topics related to EV usage, including driving habits, charging preferences, satisfaction levels, and perceptions of EV technology. Through SurveyMonkey's intuitive survey creation tools, a structured questionnaire comprising both closed ended and open ended questions, allowing for quantitative analysis of responses as well as qualitative insights into participants' experiences and perspectives.

Additionally, interviews were conducted with senior personnel within the EV industry to gain expert insights and nuanced perspectives on key issues. The interview protocol, also developed, served as the guiding instrument for these discussions. It outlined a series of questions aimed at eliciting in depth responses regarding present competencies, barriers, challenges, and future outlooks.

SurveyMonkey as the digital platform for survey administration and data collection, a wide audience of EV users across diverse geographic locations were leveraged efficiently and effectively. The platform's features, such as customizable survey templates, automated data analysis tools, and real-time reporting capabilities, streamlined the research process and facilitated the collection of high quality data.

Overall, the instrumentation used in this research, including the surveys for EV users and interviews with senior personnel, enabled a comprehensive exploration of the factors influencing EV adoption challenges and perceptions.

3.8 Data Collection Procedures

1. Survey Administration for EV Users:

The survey instrument, designed using SurveyMonkey, was administered to EV users through various channels, including social media platforms. Participants were invited to voluntarily participate in the survey, with a clear explanation of the research objectives and confidentiality measures.

Upon accessing the survey link, participants were presented with the questionnaire comprising a mix of closed ended and open ended questions. Participants were encouraged to provide honest and accurate responses to the survey questions, ensuring the reliability and validity of the data collected. The survey was open for a predetermined period, allowing sufficient time for participants to complete it at their convenience.

Data collected through the survey was automatically compiled and stored securely within the SurveyMonkey platform for subsequent analysis.

2. Interview Protocol for Senior Personnel:

Senior personnel within the EV industry were identified and contacted through professional networks and relationships.

A semi-structured interview protocol was developed, outlining a series of key topics and questions to channel the interview process. Invitations for interviews were sent to selected senior personnel, detailing the research objectives, interview format, and anticipated time commitment.

Upon agreement to participate, interviews were scheduled at mutually convenient times, either in person or through virtual communication platforms.

During the interviews, there were conversation interspersed with probing questions to elicit detailed responses and insights from the participants.

Some Interviews were audio recorded with participants' consent to ensure accuracy in data capture and facilitate transcription for subsequent analysis.

Data obtained from the interviews were transcribed verbatim with tools like Google Transkriptor and stored securely for analysis, maintaining confidentiality and anonymity as per ethical guidelines.

Overall, the data collection procedures employed a combination of survey administration and semi-structured interviews to gather comprehensive insights from both EV users and senior personnel. These procedures adhered to ethical standards and best practices in research methodology, ensuring the integrity and reliability of the data collected.

3.8.1 Data Analysis

Data Analysis:

1. Survey Data Analysis for EV Users:

Upon completion of the survey period, the data collected from EV users via SurveyMonkey was exported into statistical analysis software for processing.

Qualitative data gathered from open ended questions, analysis was conducted to identify recurring patterns, themes, or categories within participants' responses.

Data visualization techniques, including charts, graphs, and tables, were employed to present the findings in a clear and visually appealing manner, facilitating interpretation and communication of results.

2. Interview Data Analysis for Senior Personnel:

Verbatim transcriptions of interviews with senior personnel were recorded and then imported into qualitative data analysis software for coding and analysis purposes.

Emergent themes from the data, was developed to systematically organize and categorize the interview transcripts., Key concepts, themes, and patterns were identified, allowing for in-depth exploration of the interview data through iterative reading and coding of the transcripts.

Based on the interviews Quotes and excerpts from the interview transcripts were selectively chosen to illustrate and support the identified themes.

The data analysis comprising of survey and interview data combining both quantitative and qualitative approaches helped gain a comprehensive understanding of EV design, manufacturing, adoption dynamics, and industry perspectives. The aim was to create a baseline of the ecosystem for EV adoption, design, and manufacturing competencies, identify barriers and understand gaps to achieve technology leadership in this domain.

3.8.2 Research Design Limitations

Research Design Limitations:

1. Sampling Bias:

The survey sample may be subject to selection bias, as the survey was administered participants through online media. The broader population away from the network may be absent in this survey and hence there may be under of EV users leading to potential biases in the findings.

2. Self Selection Bias:

It could be possible that early adopters in the survey may self select based on their interest or experience with EVs, potentially leading to an overrepresentation of enthusiasts or early adopters. These responses could lead to generalization and misrepresent the real population.

3. Response Bias:

It could be possible that inaccurate responses may lead to inaccurate representation. This is largely unlikely considering that there were interviews and the survey was very objective.

4. Limited Generalizability:

The respondents were mainly from urban population and hence may have limited generalizability beyond the specific context and sample population examined. The research focused primarily on EV users and senior personnel within the industry. This may not be easily applied to other domains or geographical regions.

5. Small Interview Sample:

Considering the availability and acceptability contribute to the interview, the number of senior personnel interviewed was limited. This was a constraint on insights obtained from industry experts. A larger sample size of interviews could provide a more comprehensive understanding of industry perspectives and challenges.

6. Subjectivity in Qualitative Analysis:

The interview responses was limited by the expertise of the industry experts and their perceptions of certain areas of experience. Hence this is subjective and open to interpretation. And also, on the researcher's perception

7. Resource Constraints:

A larger scale survey or more extensive interview sample may have provided richer insights but the available time and budget was a limitation.

Acknowledging these limitations is essential for interpreting the findings of the research accurately and for identifying areas for future research refinement and improvement. The research design was carefully articulated to address the research objectives effectively and provide valuable insights into EV ecosystem, industry perspectives and adoption challenges

3.9 Qualitative Survey:

The qualitative analysis will be a semi-structured discussion to elicit the responses to the questions for the study. There will be interviews with industry experts who are in this domain. The interviewees will be Entrepreneurs, Senior executives in the marketing and technology functions, design development engineers and suppliers of components

A Qualitative Survey is designed for Understanding Perspectives on Electric Scooter Development and Adoption in India and create a framework to achieve Technology leadership in EV development.

A SWOT – Strength, Weakness, Opportunities, and Threat matrix will be created to have a holistic understanding of the challenges for Electric Scooter development in India. This will help in identifying the elements for the framework to position India as an indigenous leader in Electric Scooter product development.

3.9.1 Introduction:

This survey is designed to understand the motivations, challenges, and preferences of individuals regarding the adoption of electric scooters in India and the interviews with industry experts to understand the competencies, barriers, and potential actions to catapult India to a leadership position in this space. The study outcome with help understand influencing adoption decisions, barriers to adoption, and perceptions of ownership, this study provides valuable insights for manufacturers, policymakers, and stakeholders in the electric vehicle industry.

3.9.2 Methodology:

A qualitative survey was conducted among electric scooter owners to gather firsthand perspectives on their decision-making processes, preferences, and experiences related to electric scooters. The survey comprised eight questions covering a range of topics, including purchase motivations, challenges, preferences for brands, technical specifications, and perceptions of the industry's manufacturing capabilities. Respondents were encouraged to provide detailed insights, allowing for a comprehensive understanding of their attitudes and behaviours toward electric scooters.

Also, interviews were conducted with industry experts based on the research questions designed to achieve the research objectives.

These interviews were conducted with industry experts to understand the competencies, barriers, and potential actions to catapult India to an indigenous capability leadership position in this space.

The data was collected through interviews recorded and transcribed. Some of them were transcribed by the interviewee. Microsoft Technology was the primary tool used such as Microsoft Word, Excel. For ease of analysis all the data was transcribed, interpreted, and summarized. Confidentiality was maintained by using an alphanumeric code beginning with the letter BL1 (for business leader), followed by a suitable number for each participant. The alphanumeric numbering began between BL1 and BL15.

The research aims to assess India's current standing compared to China across various aspects of electric scooter development and manufacturing and achieve India's ambition to be a technology leader in EV (electric scooter) industry, drawing inspiration from China's success.

3.9.2.1 Research Objective 1: Baseline Competency Levels:

To baseline competency levels and understand the current state in each area of the Product Development Lifecycle of the Electric Scooter as compared to the most successful China.

Hypothesis: The competency levels and the current state of each area in the Product Development Lifecycle of the Electric Scooter in India are not on par with those in China, suggesting that China is ahead in terms of competency and development in this field.

3.9.2.1.1 RESEARCH QUESTIONS:

1. What are the key competencies and capabilities in electric scooter design and development that currently exist in India?
2. Can Indian companies develop their own Motor drive, Batteries and Battery Electronics and other embedded software for the electric Scooter.
3. How does India's design and development competencies compare to successful countries like China?

4. What is the current state of electric scooter manufacturing in India, in terms of Technology, supply chain efficiency and Cost effectiveness?
5. How competitive is Indian manufacturing when compared to Chinese counterparts, and what are the factors determining the same?
6. What is the influence of the policy frameworks like the FAME and PLI schemes for electric scooter development and manufacturing?
7. Does the industry require policy changes for the electric scooter industry?

3.9.2.2 Research Objective 2: Barriers to Indigenous Development:

To identify the barriers to indigenously design, develop, and manufacture products in India, using the electric scooter as a case study. It investigates the challenges hindering India's indigenous electric scooter development. This includes assessing barriers related to component supply, lithium battery imports, sparse charging infrastructure, and regulatory constraints.

Hypothesis: The identification of barriers to indigenously design, develop, and manufacture products in India, with a focus on electric scooters as a case study, will reveal significant obstacles that hinder the domestic production and innovation in this specific industry.

3.9.2.1.2 RESEARCH QUESTIONS:

8. What are the major challenges faced by Indian companies for indigenous development of electric scooters locally?
9. What are the specific barriers for the component supply of sub systems like motor and electronics for electric scooter manufacturing in India?
10. What is the impact of Lithium Batteries imports to the indigenous development.?
11. What is the impact of the sparse Charging Infrastructure in India for indigenous product development.?

12. What is the impact of regulatory and policy constraints of electric scooter product development in India?

3.9.2.4 Research Objective 3: Comprehensive Framework Development:

To identify the key elements for the development of a Comprehensive Framework for Electric Scooter development in India.

The objective is to devise a comprehensive framework for India's electric scooter industry. This involves identifying hurdles to India's indigenous leadership aspirations, strategizing to overcome them, defining key framework elements, and establishing performance indicators for measuring success. The research also explores avenues for India to catch up with global leaders through collaborations and innovations.

Hypothesis: The identification of key elements for the development of a Comprehensive Framework for Electric Scooter development in India will reveal essential components and strategies necessary to facilitate the growth and sustainability of the electric scooter industry in the country. These will be the key areas to focus to position India as an indigenous leader in Electric Scooters.

3.9.2.1.3 RESEARCH QUESTIONS:

13. What are the challenges or gaps to overcome for India to become an indigenous product leader in the electric scooter industry?
14. What are the strategies to implement to overcome these challenges or gaps and achieve leadership status?
15. What should be the key elements in the comprehensive framework to foster India to achieve indigenous leadership in electric scooter product development?
16. What should be the key performance indicators to measure the success for

    India's progress to be an indigenous leader for Electric Scooters.?
17. How can India jump the experience curve and catch up with global leaders like

China in Electric Scooter potentially through collaborations and innovations.?

3.9.2.5 Survey questions

The Qualitative Survey is designed as below.

Electric Scooter Adoption Survey

1. If you own an Electric Scooter, what influenced your decision to purchase an electric scooter?

- ◯ Environmental concerns
- ◯ Cost savings on fuel
- ◯ Government incentives
- ◯ Ease of maintenance
- ◯ Other (please specify)

2. What factors would encourage you to adopt an electric scooter?

- ☐ Lower cost of ownership
- ☐ Increased charging infrastructure
- ☐ Government subsidies
- ☐ Longer battery life
- ☐ Improved performance

3. Do you find the initial cost of electric scooters affordable?

- ◯ Yes
- ◯ No

4. What are the main challenges you face in adopting an electric scooter?

- [ ] Limited range per charge
- [ ] Lack of charging infrastructure
- [ ] High initial cost
- [ ] Concerns about battery life
- [ ] Limited model options

5. Would you prefer Indian Brands or Chinese imports

- [ ] Indian
- [ ] Chinese

6. What technical specifications are important to you when considering an electric scooter? (e.g. range, speed, charging time)

- ◯ Range
- ◯ Speed
- ◯ Charging Time
- ◯ Price

7. Do you feel India has the capability to manufacture Electric Scooters - motor , controller, Batteries etc

- [ ] Yes
- [ ] No

8. Are you satisfied with the overall cost of ownership (including maintenance, charging, etc.)?

◯ Satisfied

◯ Dissatisfied

9. Are there any improvements you would like to see in electric scooter technology or infrastructure or policies to influence EV scooter adoption or enhance your experience?

Done

3.10 Quantitative analysis

Quantitative research will be required to understand the contrast between China's growth in the EV ecosystem, EVs on road, Charging infrastructure, and policies. The data in terms of market share and cost of the Electric Scooter will be collected and analysed as compared to the India story. Most of the data will be collected through secondary sources available online.

The quantitative research on the vehicle-to-charger ratio in India and China involved several steps. Initially, data was gathered from secondary sources such as government reports, industry publications, and academic studies. This data included the number of electric vehicles (EVs) and the corresponding number of charging stations in each country.

Next, analysed this data to calculate the vehicle-to-charger ratio, which indicates the number of EVs per charging station. This ratio provides insights into the availability and accessibility of charging infrastructure relative to the EV population in each country.

In parallel, the research examined battery technology advancements in terms of energy density and price. Data on battery specifications, such as kilo-watt-hour (kWh) capacity and cost per kWh, were collected and studied to track trends in battery technology development over time. Comparisons were made between India and China to identify differences in battery technology adoption and innovation.

Furthermore, the research assessed the total cost of ownership (TCO) for EVs in both countries. This involved gathering data on various cost components, including vehicle purchase price, charging costs, maintenance expenses, and government incentives or subsidies. By comparing TCO data between India and China, researchers could evaluate the overall affordability and economic feasibility of EV ownership in each market.

Overall, the quantitative research process provided valuable insights into the vehicle-to-charger ratio, battery technology advancements, and TCO of EVs in India and China, shedding light on the respective developments and challenges in the EV ecosystems of both countries.

3.11 Conclusion

Despite the inherent limitations of the research design, the study provides valuable insights into electric vehicle (EV) usage dynamics and industry perspectives. Through a combination of survey administration for EV users and interviews with senior personnel, the research explored various facets of EV adoption and industry trends, shedding light on key challenges and opportunities in the field.

The survey findings offer valuable insights into the preferences, behaviours, and perceptions of EV users, highlighting patterns and trends in EV usage across different demographic groups and geographic locations. While the sample may be subject to biases and limitations, the data collected provides a valuable snapshot of the current state of EV adoption and usage dynamics.

Interviews with senior personnel within the EV industry provided very insightful perspectives on industry competencies, barriers, and actions required.

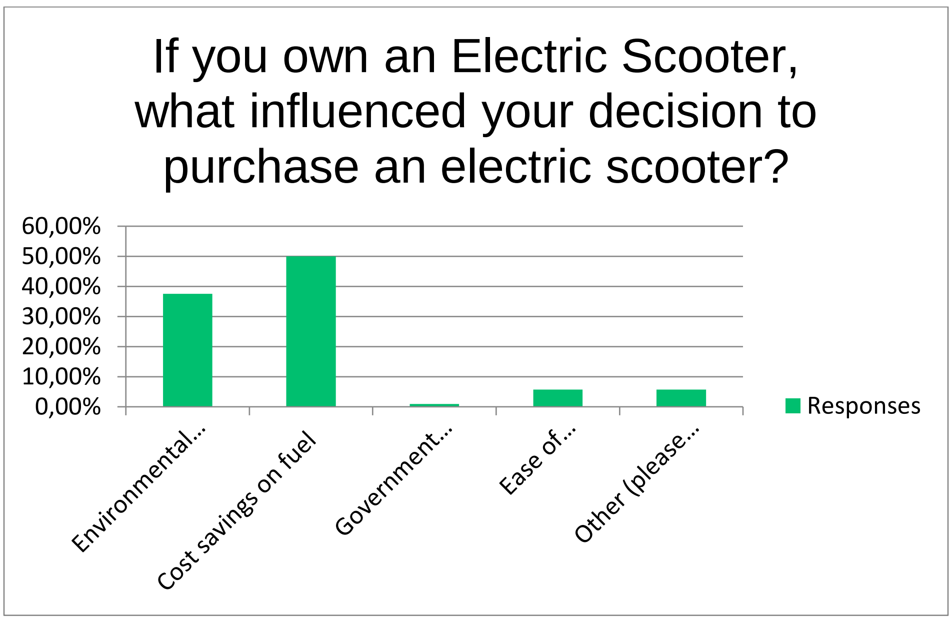
Overall, the research contributes to a deeper understanding of the complexities surrounding EV adoption and technology and production capabilities in India. By acknowledging the limitations of the research design, such as sampling biases and resource constraints, future research can build upon these findings to further explore and address the challenges hindering India's transition to a more sustainable and electric mobility landscape.

CHAPTER IV:

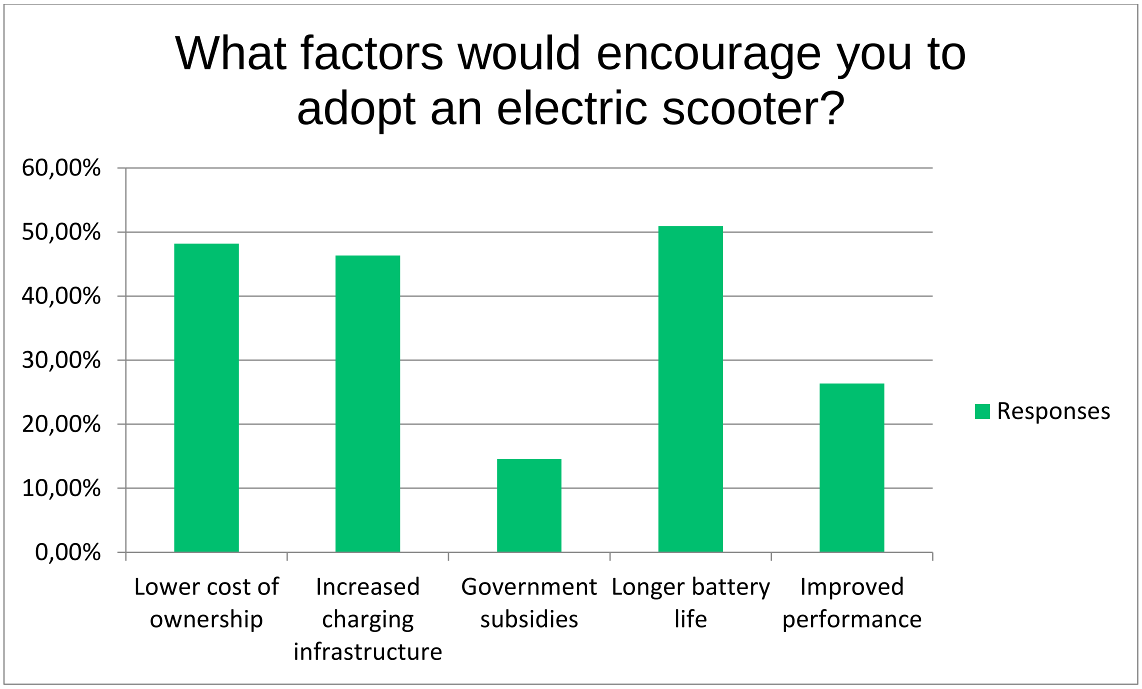
RESULTS

4.1 Qualitative analysis and data finding:

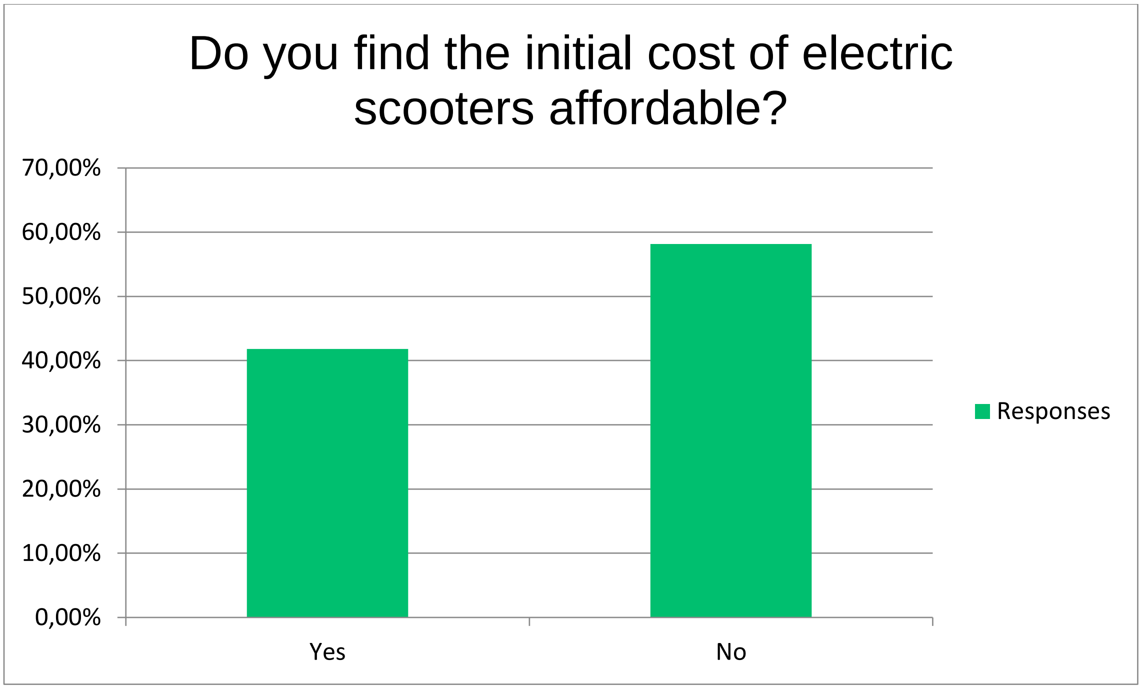
The Survey as described in 3.9.2.4 was administered and the results are as below.



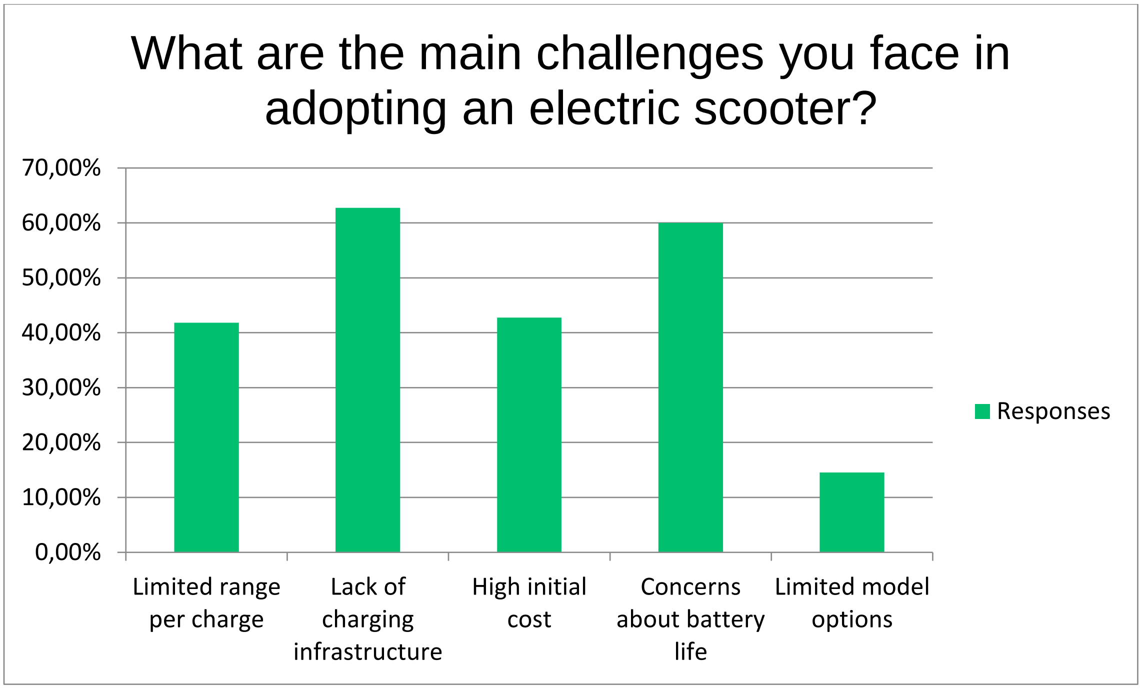
The survey results indicate that the majority of respondents who own an electric scooter were influenced by either cost savings on fuel or environmental concerns when making their purchase decision. Specifically, **50%** of respondents cited **cost savings on fuel** as a factor, while **37.5%** cited **environmental concerns**. Other factors that influenced the decision to purchase an electric scooter include ease of maintenance and government incentives.



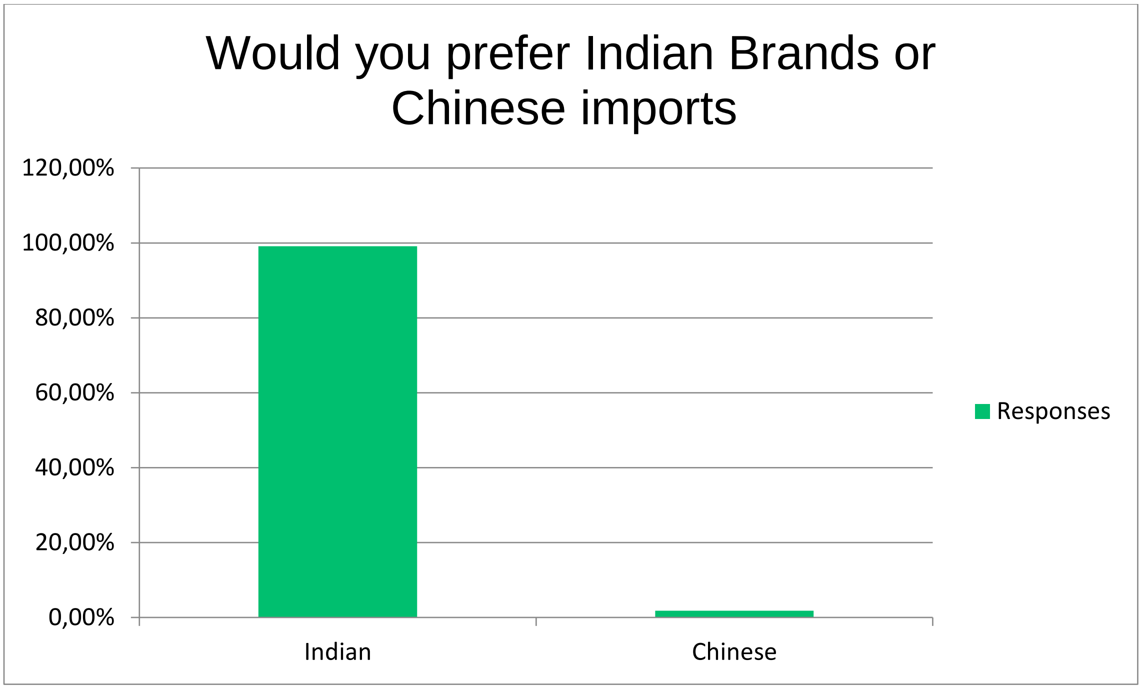
This survey question asked respondents what factors would encourage them to adopt an electric scooter. The answer choices included lower cost of ownership, increased charging infrastructure, government subsidies, longer battery life, and improved performance. Out of 110 respondents, **longer battery life** was the most commonly cited factor, with **50.91%** of respondents indicating that it would encourage them to adopt an electric scooter. **Lower cost of ownership** was the second most commonly cited factor, with **48.18%** of respondents indicating that it would encourage them to adopt an electric scooter. **Increased charging infrastructure** was the third most commonly cited factor, with **46.36%** of respondents indicating that it would encourage them to adopt an electric scooter. Government subsidies and improved performance were also mentioned as factors that would encourage adoption but to a lesser extent.



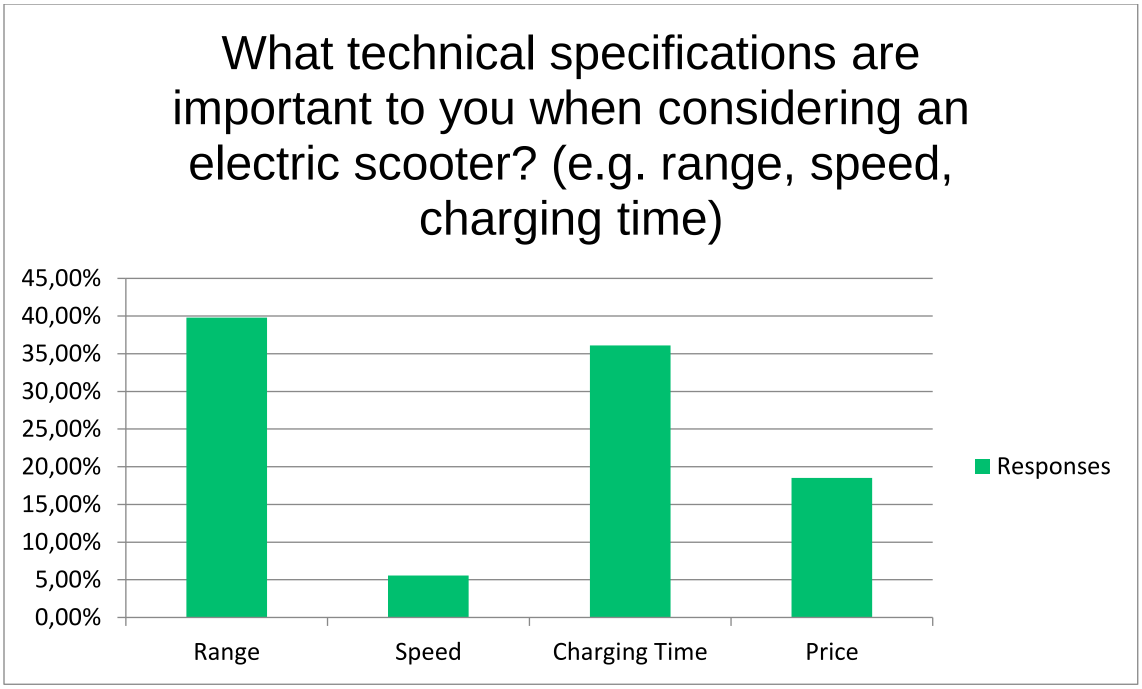
Question 3 of the survey asked respondents whether they find the initial cost of electric scooters affordable. Out of 110 respondents, 58.18% indicated that they DO NOT find the initial cost of electric scooters affordable, while 41.82% indicated that they do find it affordable. This suggests that the initial cost of electric scooters may be a barrier to adoption for some potential buyers.



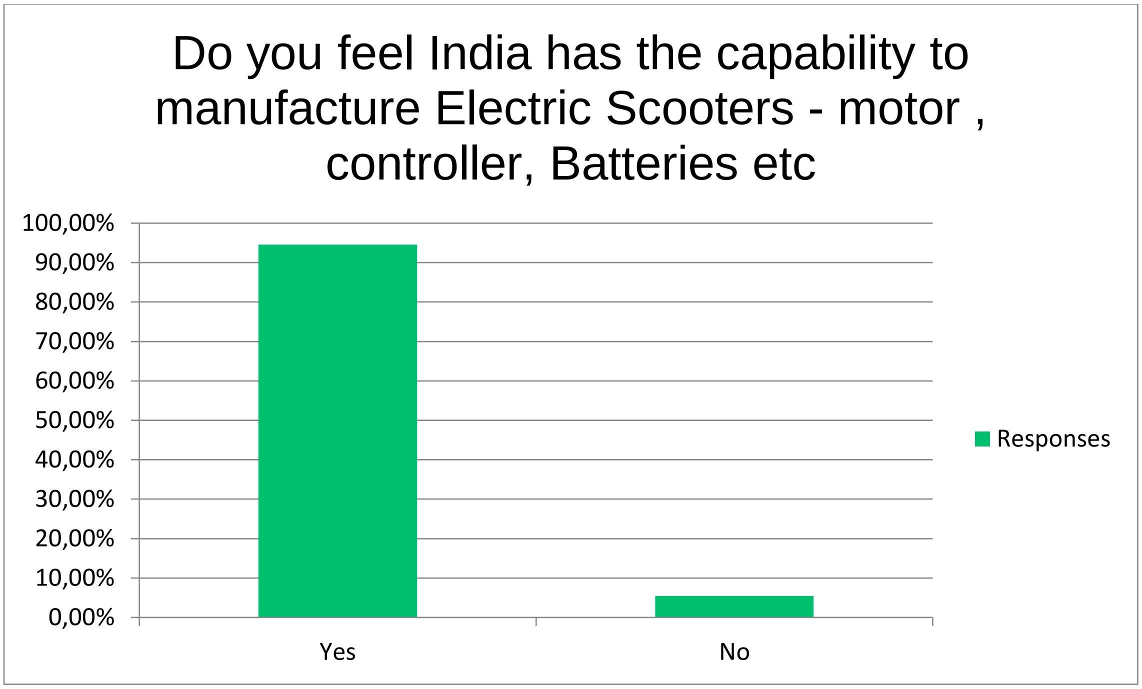
Question 4 of the survey asked respondents about the main challenges they face in adopting an electric scooter. The answer choices included limited range per charge, lack of charging infrastructure, high initial cost, concerns about battery life, and limited model options. Out of 110 respondents, the most commonly cited challenges were lack of charging infrastructure (62.73%) and concerns about battery life (60%). Limited range per charge (41.82%) and high initial cost (42.73%) were also cited as challenges by a significant number of respondents. Limited model options were the least commonly cited challenge, with only 14.55% of respondents indicating that it was a challenge for them.



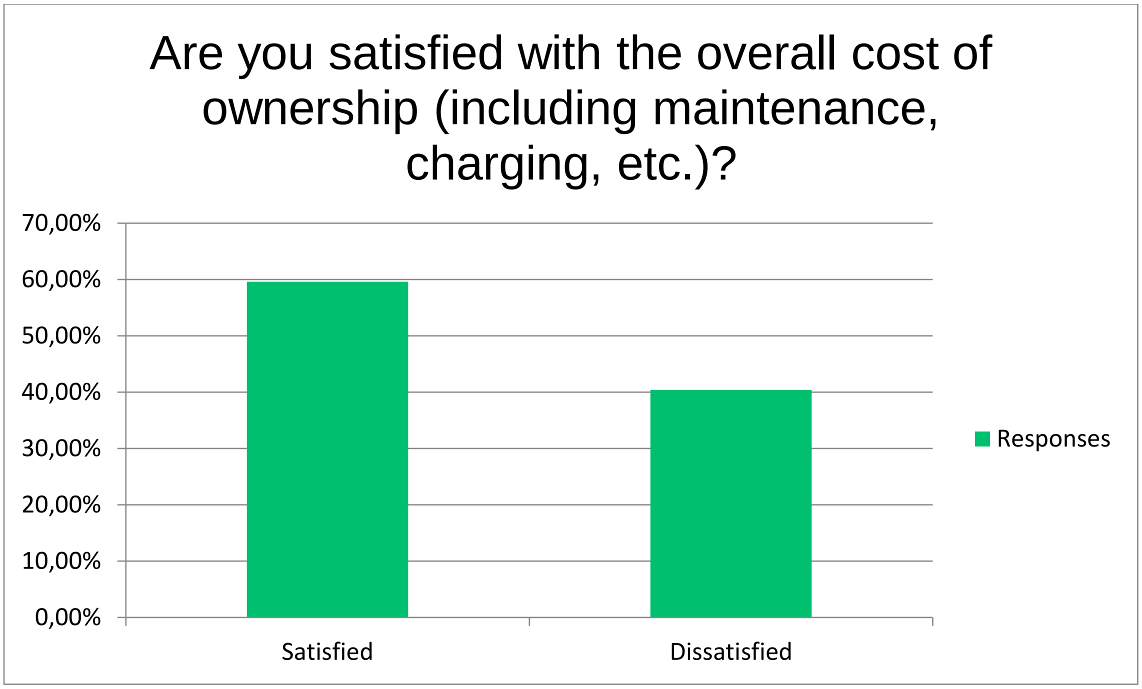
Question 5 of the survey asked respondents whether they would prefer Indian brands or Chinese imports when it comes to electric scooters. Out of 109 respondents, 99.08% indicated that they would prefer Indian brands, while only 1.83% indicated that they would prefer Chinese imports. This suggests that Indian brands are more popular among respondents than Chinese imports when it comes to electric scooters.



Question 6 of the survey asked respondents about the technical specifications that are important to them when considering an electric scooter. The answer choices included range, speed, charging time, and price. Out of 108 respondents, **Range** was the most commonly cited technical specification, with **39.81%** of respondents indicating that it was important to them. **Charging time** was the second most commonly cited technical specification, with **36.11%** of respondents indicating that it was important to them. Speed and price were the least commonly cited technical specifications, with only 5.56% and 18.52% of respondents indicating that they were important, respectively. This suggests that range and charging time are the most important technical specifications for respondents when considering an electric scooter.



Question 7 of the survey asked respondents whether they feel India has the capability to manufacture electric scooters, including motors, controllers, batteries, etc. Out of 110 respondents, **94.55%** indicated that they feel **India can manufacture** electric scooters, while only 5.45% indicated that they do not feel India has the capability. This suggests that the majority of respondents have confidence in India's ability to manufacture electric scooters.



Question 8 of the survey asked respondents whether they are satisfied with the overall cost of ownership of their electric scooter, including maintenance, charging, etc. Out of 99 respondents, **59.60%** indicated that they are **satisfied** with the **overall cost of ownership**, while 40.40% indicated that they are dissatisfied. This suggests that a significant number of respondents may feel that the cost of ownership of an electric scooter is too high. However, it is important to note that this question only applies to respondents who currently own an electric scooter, and not to those who are considering purchasing one.

Question 9 asked the respondents on their views on various facets of EV scooter products namely technologies, infrastructure and policies to influence EV scooter adoption.

The feedback in response to Question 9 emphasizes several key points for improving electric scooter technology, infrastructure, and policies:

1. Battery Efficiency and Range: Prioritize advancements in battery technology to increase range per charge and decrease charging times.

2. Charging Infrastructure: Expand charging station networks to make charging more convenient and accessible, potentially incorporating fast charging options.

3. Safety: Address safety concerns related to battery fires and ensure rigorous quality control standards.

4. Cost Reduction: Lower the initial cost of electric scooters and decrease maintenance expenses, possibly through subsidies and affordable battery replacement options.

5. Regulations and Policies: Implement supportive government policies such as subsidies, dedicated lanes, and standardized charging port requirements.

6. Environmental Concerns: Focus on environmentally friendly battery materials and proper disposal methods for used batteries.

7. Customer Service and Maintenance: Improve service quality, spare parts availability, and doorstep service options to enhance customer experience and satisfaction.

8. Infrastructure Alignment: Ensure that the growth of charging infrastructure is aligned with the increasing market for electric scooters to avoid post sales challenges.

9. Education and Awareness: Increase awareness about the benefits of electric scooters and their environmental impact to encourage adoption.

4.1.1 Summary of Survey results

The Survey results are arranged solely by percentage:

1. Brand preference:

   99.08% prefer Indian brands over Chinese imports

2. Perception of India's manufacturing capability:

   94.55% believe India can manufacture electric scooters

3. Affordability of electric scooters:

   58.18% find initial cost affordable

4. Satisfaction with overall cost of ownership:

   59.60% are satisfied (including maintenance, charging, etc.)

5. Challenges faced in adopting electric scooters:

   High initial cost: 62.73%

   Concerns about battery life: 60%

   Limited range per charge: 47%

6. Factors encouraging adoption of electric scooters:

   Longer battery life: 50.91%

   Lower cost of ownership: 48.18%

   Increased charging infrastructure: 46.36%

Improved performance: 26.36%

Government subsidies: 14.55%

7. Importance of technical specifications:

Range: 39.81%

Charging time: 36.11%

The above results are categorised as below.

Costs of ownership including Buying cost, operational costs and largely related to **Battery** as it is the most expensive.

- 58.18% find initial cost affordable
- 59.60% are satisfied (including maintenance, charging, etc)
- High initial cost: 62.73%
- Concerns about battery life: 60%
- Longer battery life: 50.91%
- Lower cost of ownership: 48.18%

Limited Range, Charging Infrastructure, and Charging Time which ultimately relates to Charging Infrastructure and Battery Technology.

- Limited range per charge: 47%
- Increased charging infrastructure: 46.36%
- Range: 39.81%
- Charging time: 36.11%

4.1.2 Interview summary

The seventeen research questions in 3.9.2.1.1 to 3.9.2.1.3 were asked in the interview with the senior industry experts. The interview participants were corporate engineering and Finance managers, entrepreneurs, and distributors.

	BL	**Research Objective 1**	**Research Objective 2**	**Research Objective 3**	**Time**
1	BL1	We have design competencies best in the world. Lack in manufacturing practices, economies of scale, lack of semiconductor companies	Semiconductors, Lithium-ion cells, and rare earth magnets all have to be imported from China. Charging infra, Manufacturing competences	High initial cost, safety concerns, charging infra, low penetration in masses due cost, R&D support by government, collaborations with universities, innovation in batteries and charging	40
2	BL2	Good design competencies, Manufacturing capacity getting ramped up, favourable policies getting implemented. Need better charging infra, interoperability, standardization	Policy ambiguities, incentivize manufacturers and increase the cost of conventional vehicles. Policies should be transparent, easily accessible, and benefit the common man. Charging infra is key. Magnets monopoly of China and hence risk	Focus on being independent from China for rare earth, and lithium. For example, have a dedicated ministry. Exports, reduced dependency, increased charging infra	50

3	BL3	Has good indigenisation ability. Need long-term sustenance with FAME policy. Dependency on imports from China makes things expensive.	Huge dependency on imports, challenges to indigenization. No IP in charging infra,	Collaborations for fast ramp up, access to capital, large scale manufacturing	60
4	BL4	India is competent in manufacturing motors, electronics, and software but China is far ahead in scale. Gov should benefit MSMEs and present schemes benefit large players.	Test facilities upgradation. Not easy to match Chinese prices. charging infra a challenge but we should consider swapping. Ambiguity in regulations and standards	Maintaining quality, and export numbers. Import dependency reduction, MSME funding	30
5	BL5	China has ramped up through domestic demand and experiential learning from design to manufacturing. Favourable policies help and also the	Dependency on China for raw materials, circular economy from raw materials to waste management, charging infra	Charging infra, low cost, range, reliability-safety, partner with leading brands, consortium of all industry players	30

		availability of raw materials.	inadequate, battery handling		
6	BL6	Good design competencies but lack in quality and scale of manufacturing. Policy incentives and concepts like green zones required	Lithium-ion battery import, charging infra, policies not favourable.	Localisation, boost EV scooter plan, strategic tie-ups- startup with large manufacturers, rate of EV adoption	30
7	BL7	India has a design competency for electronics and motors. will need policy changes and time to reach China level.	We are decades behind China and hence will take time but not impossible. Policies will have a large influence on the outcome. Also, Talent attrition to the west. Also reduces the cost of development, testing, and overall cost 8of dev. Charging infra is a big barrier.	Strategy comprising reduced imports, policies, charging infra	40

8	BL8	Design competencies are prevalent and manufacturing is ramping up example -Ola.	Sparse charging infra, dependency on China for magnets and batteries.	Focus on costs, self-reliability by alternate tech without magnets, for example, charging infra.	30
9	BL9	We have design competencies, but not to the level of owning IP. Policies need to be more favourable.	Supply chain dependency on imports, sparse charging infra,	Indigenous battery tech, performance, cost competitive, create EV clusters, Higher adoption, localization.	40
10	BL10	Good in design but services, need Product dev mindset. Hae all competencies in India for design	Charging infra and dependency on battery imports	Charging infra, battery technology. Have large exports, the right product definition, and develop indigenous tech.	50
11	BL11	We have design competencies but cannot match Chinese experience.	Fame and PLI schemes are good for large players and product-related. No funding for design and R&D	Focus on R&D funding and collaborate.	30
12	BL12	India has all the required design competencies and has companies like	Dependency on imports Li-ion, charging infra,	Safety – temp dependency, regulations, cost, ease of charging, safety	50

		Ather, Hero, and others. China has immense government backing and that is the gap.	cost of certification.	measures, and retail financing. Reliability against IC engine.	
13	BL13	India has the skills but not harnessed for product development. Remuneration for services is too high for talent to be available for products.	Support in terms of startup funding, ease of loans for MSME at lower interests.	Create special zones for EV's, have equal remuneration for services and products. Support startups and localization.	15
14	BL14	India lags behind China in all facets of design to localisation.	Government support – infrastructure and awareness on Cost benefit. Availability of raw material is a barrier.	Costs will be the cheapest in terms of initial cost and also running cost. That will bring revolution in EV.	25
15	BL15	Indian companies lag behind Chinese companies mainly semiconductors, lack of clear	Fluctuating policies, supply chain issues and varying taxation, huge certification costs.	Incentives at both ends of the development cycle- R&D, design till certification. Reduce taxation on raw material imports.	15

		regulations and policies.			

Based on the interviews below is the summary for the research objective questions.

1) Baseline Competency Levels:
    a. Largely India has a design competency in power train design and also mechanicals. The experience in product development needs to be developed as the electric scooter is a nascent industry compared to China. Also manufacturing competency and scale is the concern.
2) Barriers to Indigenous Development:
    a. The barriers are largely the availability of lithium-ion, and rare earth magnets as raw materials and Semiconductors for product development. Also, the charging infrastructure is a concern along with the policy ambiguity. The funding is largely available for large production houses but does not encourage Research and development.
3) Comprehensive Framework Development
    a. The framework for indigenous leadership has to be based on supply chain risk alleviation through innovation, alternate materials, product development intellectual property. Focus on costs and hence make the EV available cheaper, build charging infrastructure, and collaborate between startups and large corporations. Also educating the population and building reliable safe vehicles are important. Policies favouring the retail segment, startups, and R&D funding will help.

4.1.3 Results

The survey results summarized above and the interview results were leveraged to understand the research objectives. The examination of the results yielded the below understanding.

4.1.2.1 Research Objective 1: Baseline Competency Levels:

The research seeks to understand India's existing competencies in electric scooter design, manufacturing, and technology development. It compares these with China's achievements, analysing the impact of policies like FAME and PLI.

The data offers insights into the present competencies and perceptions regarding electric scooters in India:

- India's competency in electric scooter design, manufacturing, and technology development is compared with China's achievements, analysing policies like FAME and PLI.
- Insights indicate a preference for Indian brands, showcasing trust in domestic manufacturing capabilities.
- The majority believe in India's ability to manufacture electric scooters, indicating confidence in the country's infrastructure.
- While initial costs are supposed to be affordable, challenges include concerns about battery life and limited range per charge.
- Factors encouraging adoption include longer battery life, lower ownership costs, and improved charging infrastructure.
- Importance is placed on technical specifications like range and charging time, indicating areas for improvement.
- India exhibits expertise in mechanical and electronic design but lags behind China in motor design and battery technology. Lacks Intellectual property creation and product development expertise.
- Strong foundation exists in BLDC motor design, motor drives, and battery management systems but lacks holistic product development expertise.
- R&D centres and startups contribute to electric scooter design and development.
- Government policies support EV sales but more focus on MSMEs and backend manufacturing is needed.
- Challenges include cost competitiveness compared to China and barriers in policymaking and cost constraints.

India has the potential to develop indigenous companies capable of designing and manufacturing electric scooters with the right infrastructure, policy support, and investments.

The competency levels and the current state of each area in the Product Development Lifecycle of the Electric Scooter in India are not on par with those in China, suggesting that China is ahead in terms of competency and development in this field.

4.1.2.2 Research Objective 2: Barriers to Indigenous Development:

It investigates the challenges impeding India's indigenous electric scooter development. This includes assessing barriers related to component supply, lithium battery imports, scant charging infrastructure, and regulatory constraints.

KEY BARRIERS TO INDIGENOUS DEVELOPMENT:

Cost Challenges and Dependency on Imports:

- Core technology and components lack local cost competitiveness, especially lithium-ion batteries.
- Limited charging infrastructure and dependency on China for sourcing components.
- Emphasis on technical specifications for local indigenous development is a must for product development and engineering competency to build cost-competitive products.

Policy and Regulatory Constraints:

- The ambiguous policies and regulations are an impediment for businesses to thrive.
- Need for transparent and supportive policies to incentivize manufacturers and consumers.

Supply Chain Challenges:

- Import requirements are a challenge for manufacturing and cost competitiveness.
- Limited charging infrastructure deters EV adoption.

R&D and Innovation Gap:

- Lag in EV technology R&D compared to China, with limited local innovation in charging products and battery manufacturing.

Infrastructure:

- Sparse charging infrastructure impacts EV growth, necessitating clear standards and reduced dependence on subsidies.
- Longer battery life, lower ownership cost, and improved charging infrastructure are very vital for meeting consumer demands.

Addressing these barriers requires government support, investment in R&D, building a robust supply chain, and developing the necessary Charging infrastructure for electric scooter adoption in India.

4.1.2.3 Research Objective 3: Comprehensive Framework Development:

The results provide valuable insights that can contribute to the development of a Comprehensive Framework for the electric scooter industry in India:

Brand Preference and Perception of Manufacturing Capability:

- A high preference for Indian brands and belief in manufacturing capability establish trust and confidence. This makes it imperative to incentivize local design, R&D, and manufacturing.

Affordability and Satisfaction with Cost:

- Understanding consumer perceptions shapes pricing strategies and financial incentives. Capital cost to be more affordable for the larger population. Supply chain is a very crucial factor for EVs considering important vital items like rare earth magnets, lithium cells and semiconductors have no choice but to be imported.

Challenges Faced in Adoption:

- Identifying challenges like high initial cost and limited range per charge creates opportunities for improvement.

Factors Encouraging Adoption:

- Recognition of factors like longer battery life and energy density would help. Charging infrastructure is required to be made very accessible.

Policy and Regulatory Constraints:

- The policies should encourage supply chain mitigation through government support for local R&D and design through incentives. Most of the funding are for large production houses and also through subsidies for distributors.
- Need for transparent and supportive policies to incentivize manufacturers and consumers.

Importance of Technical Specifications:

- The indigenization of the EV scooter will require technical specifications that are for local markets and environments. The R&D, design to certification should be incentivized for local market growth.

A Comprehensive Framework for Electric Scooter Development in India was formulated, encompassing strategies for addressing challenges, leveraging strengths, and fostering growth in the industry. The framework would outline policies, incentives, regulations, and initiatives, enablers aimed at promoting indigenous development, enhancing competitiveness, and achieving sustainable growth in the electric scooter sector.

4.1.4 Strength Weakness Opportunity Threat.

Based on the Survey results and the interviews the SWOT was created.

	SWOT
S	➢ Strong Brand Preference: 99.08% prefer Indian brands, providing a competitive edge for domestic manufacturers. ➢ Perception of Manufacturing Capability: 94.55% believe in India's capacity to produce electric scooters, highlighting confidence in the domestic industry.

	➢ Factors Encouraging Adoption: Longer battery life, lower ownership costs, and improved charging infrastructure incentivize adoption. ➢ Satisfaction with Cost of Ownership: 59.60% express satisfaction, indicating positive consumer experiences.
W	➢ Affordability Concerns: 58.18% find initial costs unaffordable, hindering widespread adoption. ➢ Adoption Challenges: High initial costs, battery life concerns, and limited range are barriers to entry.
O	➢ Addressing Affordability: Introduce pricing schemes and subsidies to make electric scooters more accessible. ➢ Government Support: Leveraging subsidies and incentives to promote adoption. ➢ Technological Advancements: Innovations in battery tech and charging infrastructure can enhance competitiveness.
T	➢ Competition from Imports: Threat from Chinese imports despite brand preference for Indian products. ➢ Infrastructure Limitations: Challenges in charging infrastructure and range pose barriers to adoption. ➢ Market Volatility: Regulatory changes and economic factors could disrupt market stability.

Table – 3 Strength weakness opportunity threat Explanation

4.2 Addressing the swot outcome.

4.2.1 Addressing Affordability and Adoption Challenges:

Financial Incentives: Introduce targeted subsidies, tax breaks, or incentives to reduce the upfront cost of electric scooters and encourage adoption.

Financing Options: Collaborate with financial institutions to offer affordable financing options such as low-interest loans or installment plans.

Pricing Schemes: Implement innovative pricing schemes or leasing programs to make electric scooters more accessible to a wider consumer base.

4.2.2 Government Support and Policy Advocacy:

Policy Reforms: Advocate for favourable policy reforms to streamline regulations, reduce import duties on EV components, and promote indigenous manufacturing.

Infrastructure Investment: Collaborate with the government to develop a comprehensive EV infrastructure plan, including charging stations and battery-swapping facilities.

Incentive Programs: Work with government agencies to introduce incentive programs for manufacturers and consumers, encouraging investment and adoption of EVs.

4.2.3 Technological Advancements and Innovation:

R&D Investment: Allocate resources towards research and development to improve battery technology, increase energy efficiency, and reduce manufacturing costs.

Partnerships: Nurture partnerships with research institutions and technology companies to accelerate innovation in EV components and charging infrastructure.

Indigenous Solutions: Focus on developing indigenous solutions to overcome infrastructure limitations and enhance the performance of electric scooters.

4.2.4 Mitigating Competition from Imports:

Brand Differentiation: Differentiate Indian electric scooters through branding, design, and features tailored to local preferences and needs. This would also be required considering environmental factors like temperature and humidity, road conditions, and population density.

Quality Assurance: Emphasize the superior quality, reliability, and aftersales service of domestic products compared to imports.

Trade Policies: Collaborate with government agencies to impose tariffs or import restrictions on the import of components and products to create fair competition for domestic manufacturers.

4.2.5 Overcoming Infrastructure Limitations:

Infrastructure Expansion: Partner with utility companies and local governments to expand the network of charging infrastructure, prioritizing high-traffic areas and urban centres.

Innovative Solutions: Invest in research and development to develop innovative charging solutions, such as wireless charging technology and Battery swapping.

Alternative Options: Explore alternative charging options, such as solar-powered charging stations or battery-swapping services, to address range anxiety and infrastructure limitations.

4.2.6 Navigating Market Volatility:

Diversification: Diversify product offerings to cater to different market segments and mitigate the impact of regulatory changes or economic downturns. Reduce import requirements and build domestic capability.

India can leverage its strengths, and, leverage opportunities, to emerge as an indigenous leader in the electric vehicle industry.

4.3 Quantitative analysis data and findings

Quantitative research will be required to understand the contrast between China's growth in the EV ecosystem, the Number of EVs on the road, Charging infrastructure, and policies. The data in terms of market share and cost of the Electric Scooter will be collected and analysed as compared to the India story. Most of the data will be collected through secondary sources available online.

4.3.1 China Scenario (Charging piles)

From an EV ecosystem, considering the Charging infrastructure is vital for EV adoption. A comparison was drawn between Charging infrastructure in China and India.

Charging infrastructure

The table provides data on the "Vehicle to Charger Ratio" for electric vehicles (EVs) in China over several years:

In 2018, there were 6 EVs for every public charging pile available.

This ratio remained the same in 2019, despite the increase in both EVs on the road and the number of charging piles.

Similarly, the ratio remained constant at 6 in 2020.

In 2021, the ratio improved slightly to 7 EVs per charging pile, indicating a proportional increase in charging infrastructure relative to the growing EV population.

By 2022, the ratio increased to 9 EVs per charging pile, suggesting a slower deployment of charging infrastructure compared to the rapid increase in the number of EVs on the road.

In 2023, the ratio decreased to 8 EVs per charging pile, indicating a more favourable ratio compared to 2022 but still suggesting room for further improvement in charging infrastructure development.

The ratio of Electric Vehicles in China to the number of Charging structure is very impressive and this is the basic requirement for adoption of EV’s in any markets.

The below table illustrates the increase of charging stations over the years which include public charging stations and also private infrastructure.

Number of charging piles in China (000)				
	2017	2018	2019	2020
Number of public charging piles ('000)	214	300	516	807
AC	86	190	301	498
DC	61	110	215	309
AC/DC combo	66	0.5	0.5	0.5
Number of private charging piles ('000)	232	477	703	874
Total	446	777	1,219	1,681

Table 4 Number of charging piles in China- KPMG China (2021).

China Vehicles to Charger Ratio

	EVs on road	million	Number of charge piles	Vehicle to public charger ratio
2018	1500000	1.50	270000.00	6
2019	3000000	3.00	510000.00	6
2020	5000000	5.00	810000.00	6
2021	8492561	8.49	1150000.00	7
2022	15366014	15.37	1760000.00	9
2023	20738937	20.74	2610000.00	8
~Evs on road		20.74		

Table -5 China vehicle to charger ratio

Source: https://www.statista.com/statistics/993121/china-public-electric-vehicle-charging-station-

4.3.2 India scenario (Charging Piles)

The "Vehicle to Charger Ratio" in India is a metric used to assess the availability of charging infrastructure for electric vehicles (EVs) relative to the number of EVs on the road. It provides insights into the adequacy of charging facilities to meet the growing demand for electric mobility. Here's an analysis based on the data provided:

In 2018, there were 5164 EVs for every public charging pile available.

By 2019, this ratio improved significantly to 832 EVs per charging pile.

In 2020, the ratio further decreased to 1183 EVs per charging pile.

The year 2021 saw a slight increase in the ratio to 642 EVs per charging pile, indicating more charging infrastructure deployment but also a significant increase in the number of EVs on the road.

India Vehicle to charger ratio

By 2022, the ratio improved drastically to 149 EVs per charging pile, reflecting a substantial increase in charging infrastructure relative to the growing EV population.

In 2023, although the number of EVs continued to increase, the ratio further improved to 248 EVs per charging pile.

Overall, the data suggests a positive trend of decreasing vehicle-to-charger ratios over the years, indicating an increasing availability of charging infrastructure to support the growing adoption of electric vehicles in India. However, continued efforts are necessary to ensure that the charging infrastructure keeps pace with the rising demand for EVs to facilitate their widespread adoption.

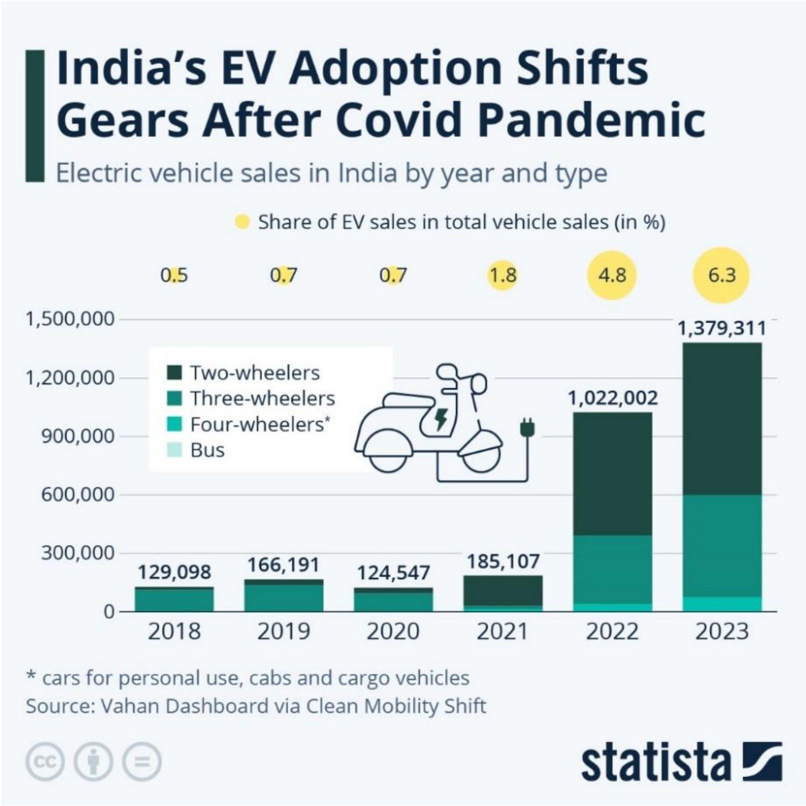


Fig. 23 India's EV Adoption shifts gears after covid pandemic.

Source: https://www.statista.com/chart/31486/electric-vehicle-sales-in-india-by-year-and-type/

Vehicle to Charger Ratio in India

	EV's on road	million	No of charge piles	Vehicle to public charger ratio
2018	129098	0.13	25	5164
2019	295289	0.30	355	832
2020	419836	0.42	355	1183
2021	604943	0.60	942	642
2022	1626945	1.63	10900	149
2023	3006256	3.01	12146	248

Table 6: Vehicle to Charger Ratio in India. Source: (https://systemschangelab.org/transport/transition-zero-carbon-cars-trucks-and-buses#indicator-319)

The comparison of the vehicle-to-charger ratio:

1. Scale of EV Market:

China's EV market is substantially larger than India's. By 2023, China had over 20 million EVs on the road, whereas India had around 3 million EVs.

2. Charging Infrastructure:

China has made more substantial investments in charging infrastructure, evident from the significantly higher number of charge piles compared to India. This investment reflects the scale of China's EV market and its commitment to supporting electric mobility.

3. Vehicle to Charger Ratio Trends:

In India, the vehicle-to-charger ratio has shown fluctuations over the years, with improvements observed from 2018 to 2022 before a slight increase in 2023. Despite the improvements, there's a need for continued investment in charging infrastructure to support the growing EV market. The ratio ranged from 149 to 248 EVs per public charger by 2023.

In contrast, China has maintained a relatively stable vehicle-to-charger ratio, ranging from 6 to 9 over the years. This suggests that China's charging infrastructure has been keeping pace with the growth of its EV market, albeit with some fluctuations.

4. Implications:

The larger number of EVs on the road in China necessitates a more extensive charging infrastructure network to meet the demand, driving the need for continuous expansion and optimization. Despite the larger number of EVs, the vehicle-to-charger ratio has remained relatively stable.

While India's EV market is smaller, there's still a need for significant infrastructure development to support the increasing adoption of electric vehicles. The fluctuations in the vehicle-to-charger ratio highlight the importance of consistent investment and planning in charging infrastructure to maintain an optimal ratio and accommodate the growing EV market.

4.3.3 Battery Technology – Prices and Energy density.

The cost of battery storage (USD/KWH) has shown a significant decline over the years, from 780 in 2013 to 139 in 2023. There's an indication of a continuous decrease in cost, with fluctuations in the percentage decrease.

Energy density (Watt hr/litre) has generally increased from 140 in 2013 to 693 in 2023, with fluctuations along the way.

Overall, the data suggests a notable trend of decreasing costs and increasing energy density in battery storage technology over the years. An estimated cost of 61 USD/KWH is projected for 2030.

The data on battery storage cost (USD/KWH) and energy density (Watt hr/litre) can significantly benefit the electric vehicle (EV) industry in several ways:

1. Cost Reduction for EVs: The declining trend in battery storage costs indicates a positive direction for the EV industry. Lower battery costs translate to reduced manufacturing costs for EVs, making them more affordable for consumers. This affordability can stimulate higher demand for EVs, leading to increased market penetration and adoption.

2. Extended Range and Performance: The increasing energy density of batteries means that EVs can store more energy in the same volume of battery, thereby extending their range and improving performance. EVs with higher energy density batteries can travel longer distances on a single charge, alleviating range anxiety and enhancing the overall driving experience. This improvement in range and performance can make EVs more appealing to a wider range of consumers.

3. Technology Advancements: The continuous innovation and improvement in battery technology, as evidenced by the data, drive the development of more efficient and sustainable energy storage solutions. This progress benefits not only the EV industry but also other sectors reliant on battery technology, such as renewable energy storage and portable electronics.

4. Market Competitiveness: As battery costs decrease and energy density increases, EV manufacturers can gain a competitive edge by offering vehicles with better performance, longer range, and lower prices. This competition within the EV market can spur further innovation and drive continuous improvement in battery technology and EV development.

The battery density and costs of batteries converging is a force multiplier for EV growth and adoption.

The current evolution of battery technology is being examined with a focus on achieving higher energy densities concurrent with reductions in prices. The data pertaining to this analysis is presented as follows:

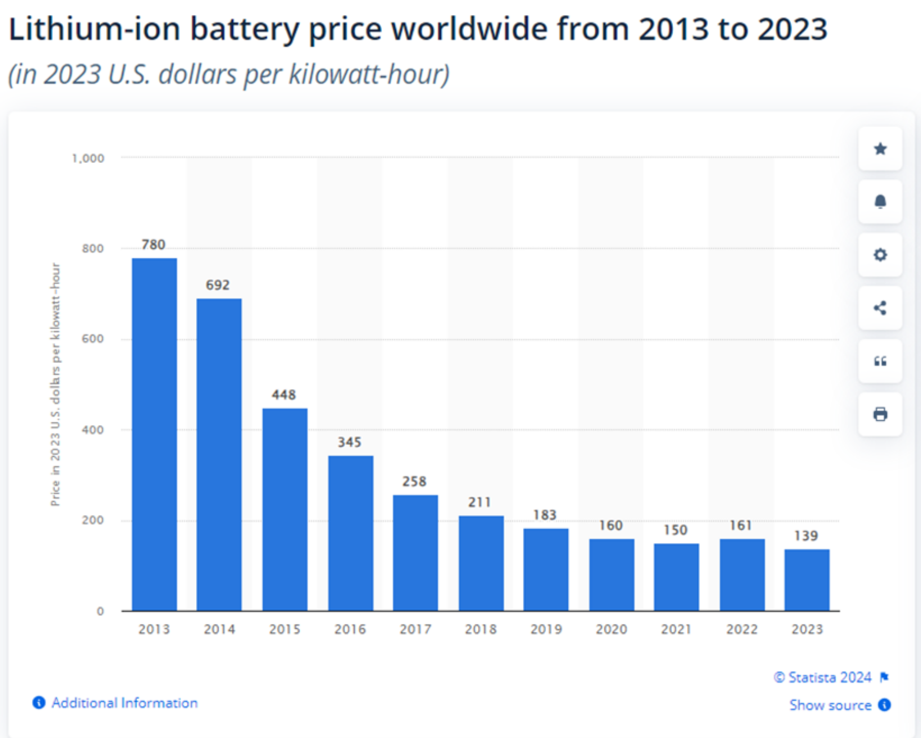


Fig. 24 Lithium-ion battery price worldwide from 2013 to 2023

Source: https://www.statista.com/statistics/883118/global-lithium-ion-battery-pack-costs

Year	USD/KWH	% decrease
2013	780	
2014	692	11.28
2015	448	35.26
2016	345	22.99
2017	258	25.22
2018	211	18.22
2019	183	13.27
2020	160	12.57
2021	150	6.25
2022	161	7.33
2023	139	13.66
202429	?	?
Estimated 2030	61	

Table – 7 Lithium batteries Price decrease YOY derived from Fig 24

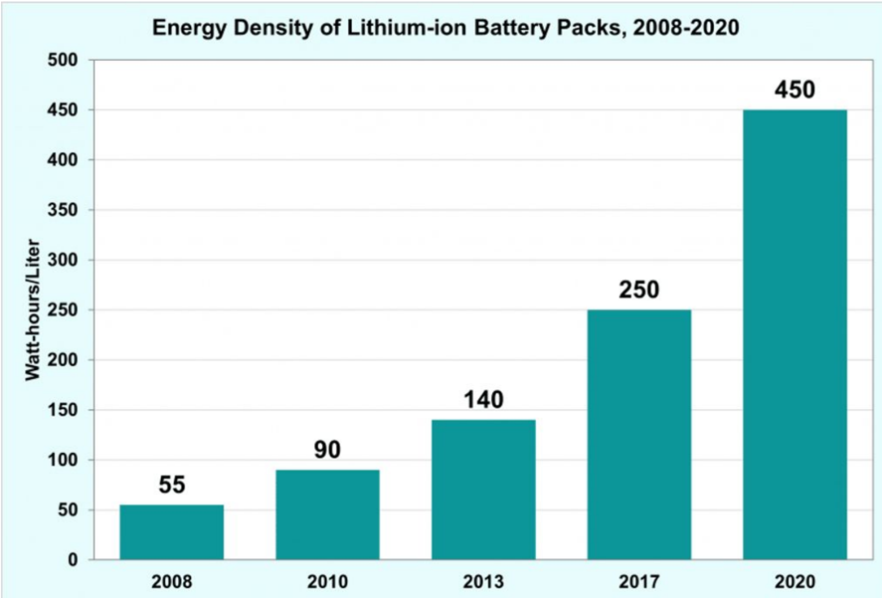


Fig. 25 Energy Density of Lithium-ion Battery Packs

Source:https://insideevs.com/news/581729/volumetricenergydensityevbatteriesgrowth/

Year	**USD/KWH**	**% Decrease**	**Watt hr/litre**
2013	780		140
2014	692	11.28	
2015	448	35.26	
2016	345	22.99	
2017	258	25.22	250
2018	211	18.22	

2019	183	13.27	
2020	160	12.57	450
2021	150	6.25	
2022	161	7.33	
2023	139	13.66	693
202429	?	?	
Estimated 2030	61		

Table 8: Price decrease and density increase derived from Fig 24 and 25

4.3.4 Comparative costs:

In January 2020, the Finance Ministry proposed several changes in customs duties related to electric vehicles. The increase in customs duty on completely built units of electric vehicles was from 25% to 40%. Similarly, the import duty on semi-knocked down (SKD) forms of electric passenger vehicles was doubled to 30%. The import of electric two-wheelers, buses, and trucks in the same form was 25% customs duty, up from the current 15%. With the strategy to increase domestic production, there were trade barriers through duties. This transition would create a cost differential of a few percentages as India still has to import battery cells and rare earther magnets from China even though China's product capacity is multiple times of India leading to cost differentials.

4.3.5 TCO – Total cost of ownership

TCO analysis for different vehicle segments – ICE vs Electric vehicles:[7]

	Upfront cost differential	Expected time for TCO parity (with subsidy)	Expected time for TCO parity (without subsidy)
2W	1.0 – 1.5x	Already there	Already there
3W	0.9 – 1.5x	Already there	Already there
4W - Personal	2 – 2.5x	2025	2030
4W - Commercial	2 – 2.5x	2022	2025
SRTUs	3.0x	2024	2030

Based on an analysis of key enablers for consideration and inflection points, KPMG in India has arrived at EV penetration estimates (as a percentage of ICE sales) for different vehicle segments in 2025 and 2030:

Fig. 26 TCO Analysis for different vehicle segments ICE vs Electric vehicle (KPMG LLP. 2020).

The anticipated rate of electric vehicle (EV) adoption across various segments is contingent upon several factors, including achieving total cost of ownership (TCO) parity and the availability of subsidies.

1. Segmented Adoption: The uptake of electric vehicles is projected to differ among various segments, such as 2-wheelers, 3-wheelers, and 4-wheelers, owing to factors like specific usage scenarios and subsidy incentives. Notably, 3-wheelers are anticipated to embrace electrification more swiftly, possibly due to advantageous subsidies and tailored utilization.

2. TCO Parity: TCO parity signifies the interval where the overall expenses associated with owning and operating an electric vehicle equate to or become lower than those of a traditional internal combustion engine vehicle. While TCO parity has already been achieved for 2-wheelers, it is forecasted to materialize for 4-wheelers post-2025.

Consequently, the competitiveness of electric 4-wheelers with conventional vehicles will take some time to materialize.

3. Fleet Cabs and Other Segments: Sectors involving fleet operations, such as taxi services, are also poised to adopt electric vehicles, likely driven by factors like reduced operational costs and environmental advantages. This segment may mirror the adoption trajectory of 3-wheelers, albeit at a distinct pace.

The adoption of electric vehicles is shaped by a myriad of elements encompassing economic factors, governmental policies, infrastructure development, and consumer inclinations.

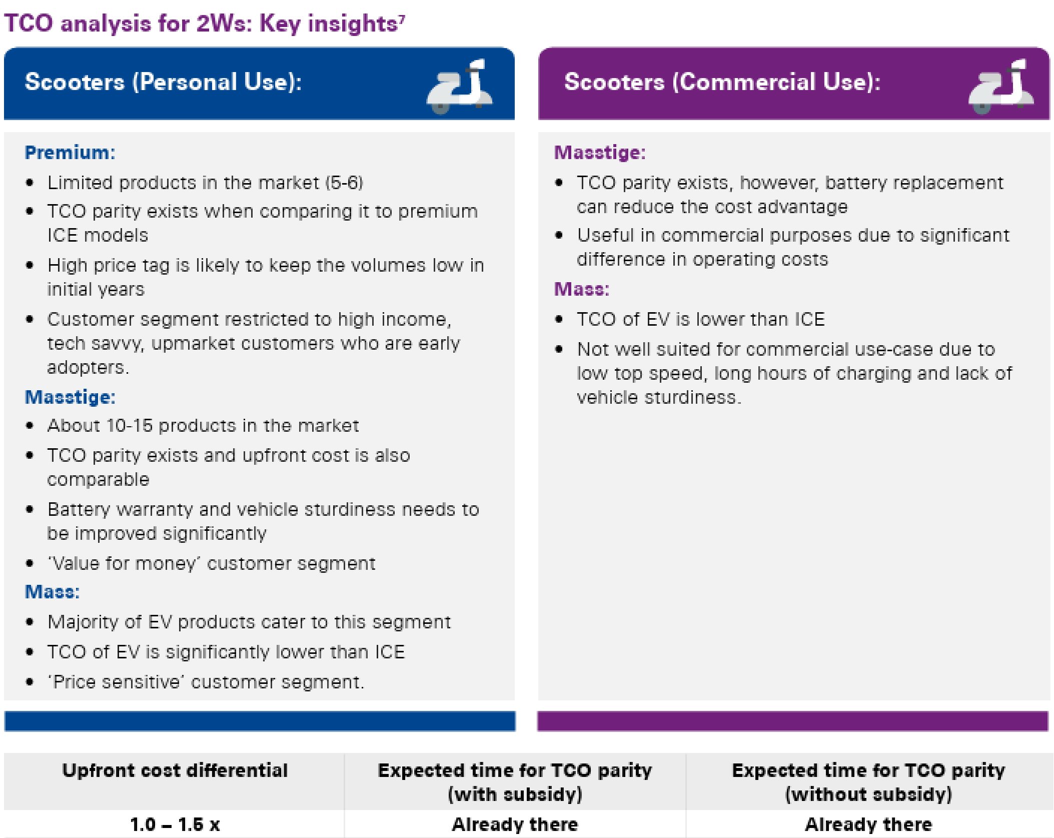


Fig. 27 TCO Analysis for 2ws: Key insights (KPMG LLP. 2020).

The data provided underscores the considerable potential for the uptake of electric vehicles (EVs) within India's two-wheeler segment, which represents a substantial portion of the automotive market.

1. Market Scale: Two-wheelers constitute a vast majority, accounting for up to 81% of total automotive sales in India as of FY20. This expansive market offers a significant opportunity for the integration of electric two-wheelers.

2. Entrepreneurial Ventures: Numerous technology startups have entered this sector, introducing electric two-wheelers tailored for personal transportation and last-mile delivery services. These ventures not only manufacture electric vehicles, but also establish charging infrastructure, creating a comprehensive ecosystem to support electric mobility.

3. Practical Applications: Electric two-wheelers fulfill essential roles such as the last-mile delivery of lightweight goods and short-distance passenger transportation. These specific applications align well with the capabilities of electric two-wheelers, rendering them appealing choices for both businesses and individuals.

Overall, the union of market scale, entrepreneurial innovation, and custom-made applications presents a promising outlook for the adoption of electric two-wheelers in India. With ongoing investments in infrastructure and technology, this segment stands poised for substantial growth in the realm of electric mobility.

The analysis of factors driving the adoption of electric three-wheelers (e3Ws) within India's three-wheeler segment, primarily serving as a last-mile transportation solution for intracity travel, is as follows:

1. Last-Mile Connectivity: Three-wheelers play a pivotal role in providing last-mile connectivity within urban areas. They are preferred for short-distance travel and manoeuvring through narrow city streets, thus creating an indispensable component of urban transportation networks.

2. Product Diversity and Affordability: The availability of various product variants in the e3W segment caters to a wide array of user requirements and preferences. Furthermore, electric three-wheelers offer advantages such as total cost of ownership (TCO) parity and lower operational expenses compared to traditional ICE counterparts. This affordability is a very important criterion for cost-effectiveness within this segment.

3. Economic Opportunities: The transition to e3Ws presents substantial economic prospects for industry stakeholders. A combination of appropriate market strategies and making investments in research, development, and infrastructure, manufacturers and other participants can leverage the rising demand for electric three-wheelers.

The merger of last-mile connectivity necessities, affordability, and the economic viability of e3Ws makes this segment appealing for industry stakeholders. The increasing scale brings in competition hence reducing prices, economies of scale and creates an ecosystem of design, manufacturing, supply chain, and consumers.

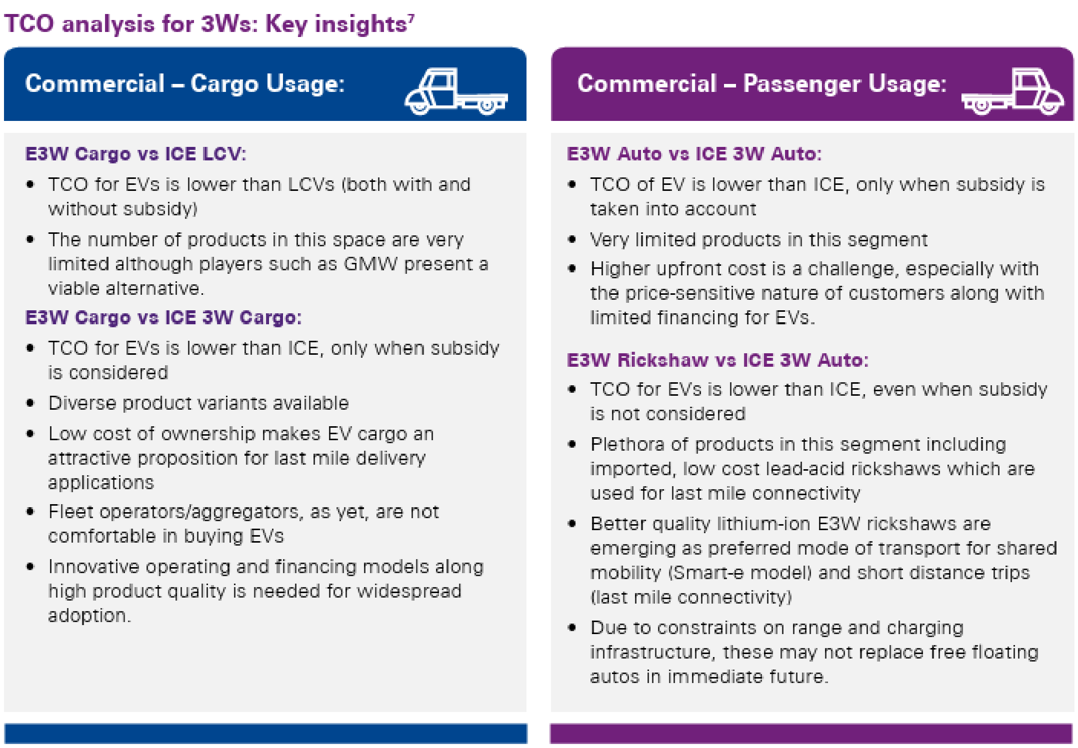


Fig. 28 TCO Analysis for 3Ws: Key Insights

Source: KPMG LLP (2020). Shifting gears: the evolving electric vehicle landscape in India. KPMG International

4.4 FRAMEWORK FOR BUILDING INDIA'S INDIGENOUS TECHNOLOGY PRODUCT DEVELOPMENT LEADERSHIP

4.4.1 Gap/Opportunity: Addressing Affordability: Introduce pricing schemes and subsidies to make electric scooters more accessible.

Status:

For 2-wheelers, TCO parity already exists. A large part of the Indian population looks for low upfront costs and ease of maintenance which includes charging infrastructure and fast charging times, while for 4-wheelers, it's expected to be achieved beyond 2025. The increase in demand in all segments will cater to economies of scale.

Call to action:

- ✓ Financial Incentives: Offer subsidies and tax breaks to lower the upfront cost of electric vehicles.
- ✓ Financing Options for startups and localization: Introduce attractive financing terms to make electric vehicles indigenisation more accessible at all value chain cycles. R&D to Manufacturing.
- ✓ Infrastructure Development: Invest in charging stations to enhance convenience and address range anxiety. This will require subsidies from government to Charging station provides through tax breaks and lower manufacturing costs through land availability, land rentals and subsidies electricity.
- ✓ Regulatory Support: Implement emissions standards and zero-emission vehicle mandates and create pollution-free zones to boost electric vehicle adoption.

- ✓ R&D Funding: Allocate resources to research battery technology and improve electric vehicle power train design and efficiency. Accelerate cell manufacturing in India through subsidies Capital costs of machinery and transfer of technology.
- ✓ Fleet Electrification: Provide incentives for fleet operators to transition to electric vehicles.

4.4.2 Gap/Opportunity: Technological Advancements: Charging infrastructure can enhance competitiveness.

Status:

Vehicle to charging ratio is one charging station for more than 150 EV's in India. China is 1 station for ~6.

Call to action:

- ✓ Government Funding: Allocate funds and provide incentives to increase charging station development and installation at a very fast pace Also facilitate the availability of high-power requirements for charging infrastructure.
- ✓ Public Public-private partnerships: Foster collaborations to speed up deployment and share costs. Charging infrastructure requires collaboration between utilities, real estate and charging station providers.
- ✓ Clear Regulations: Establish unambiguous rules to facilitate quicker installation and ensure interoperability in charging methods and standards. There should be a standard interface between the charging ports and all vehicles across players.
- ✓ Targeted Deployment: Prioritize high-demand areas like cities and highways for charging stations. Busy city to city corridors to have charging stations.
- ✓ Fast Charging Focus: Implement fast charging networks for convenience and range confidence. This will require collaboration between charging station providers, and utilities.
- ✓ Awareness Campaigns: Educate the public on EV benefits and charging availability.
- ✓ Research Investment: Support R&D for advanced charging technologies.

- ✓ Grid Integration: Develop smart grid solutions to manage/schedule EV charging impact effectively.
- ✓ Incentivize Adoption: Reduced fees and parking privileges to encourage EV use.

4.4.3 Gap/Opportunity: Innovations in battery technology.

Status:

Battery technology has evolved in the last decade. Energy density and pricing in 2013 was 780 $/KWhr and 140 Whr/Ltr. Today it is 139 $/KWhr and 693 Whr/Ltr

Call to action:

- ✓ Cost Reduction for EVs: Lower battery costs translate to reduced manufacturing costs for EVs, making them more affordable for consumers. Establish battery cell making factories in India leveraging global technologies available.
- ✓ Extended Range and Performance: Higher density lower prices help extend their range and improve performance. Single charge with the higher densities allowing more energy in less volume and also price reduction to accommodate for battery power will be a force multiplier.
- ✓ Technology Advancements: The continuous innovation and improvement in battery technology, as evidenced by the data, drive the development of more efficient and sustainable energy storage solutions.
- ✓ Market Competitiveness: EV manufacturers can gain a competitive edge by offering vehicles with better performance, longer range, and lower prices. This competition within the EV market can spur further innovation and drive continuous improvement in battery technology and EV development.

4.4.4 Gap/Opportunity: Government Support: Introduce favourable unambiguous policies to encourage EV development across value chain- R&D, design, Manufacturing, subsidies at distribution and retail segments. Infrastructure development and localization incentives for fast charging.

Status: India

FAMEII Overview:

Released in 2019 with a budget of USD 1.2 billion, extended until 2024.

Changes from FAME I:

Exclusion of older technologies like lead acid batteries and mild hybrid vehicles.

Eligibility of strong hybrid systems and plugin hybrids limited to electric four-wheelers.

Specified maximum exactor price for eligible EVs.

Enhanced safety and technical standards.

Extended coverage to the entire country, not just urban areas.

Concerns with FAMEII:

- ✓ Focus on charging infrastructure, public transport support, and domestic manufacturing.
- ✓ Localization Norms:
- ✓ Requirements under Phased Manufacturing Program (PMP) guidelines.
- ✓ Challenges with defining domestic value addition.
- ✓ Import reliance, especially for EV batteries.
- ✓ Compliance Issues:
- ✓ OEMs found noncompliant with localization norms.
- ✓ Practical constraints for OEMs in meeting norms.
- ✓ Delayed Incentives for Domestic Manufacturing:
- ✓ Production-linked incentives (PLI) schemes introduced.
- ✓ Challenges in achieving economies of scale compared to China.
- ✓ Inadequate Incentives for Charging Infrastructure:
- ✓ Only 10% of incentives for charging infrastructure.

- ✓ Lack of sufficient public charging stations.
- ✓ Insufficient Focus on R&D:
- ✓ Lack of emphasis on research and development.
- ✓ India's low expenditure on R&D compared to other countries.
- ✓ Lack of Attention to E4Ws and Commercial EVs. This will help scale.
- ✓ Shift of funds towards E2Ws, neglecting E4Ws.
- ✓ Exclusion of heavy-duty commercial vehicles from FAMEII.
- ✓ Abrupt Policy Changes:
- ✓ Reduction in subsidies and caps leading to price hikes.
- ✓ Other Concerns:
- ✓ Lack of incentives for certain types of EVs.
- ✓ Unutilized funds under FAMEII.
- ✓ Future Considerations:
- ✓ Addressing obstacles faced in previous phases for upcoming EV incentives.

Status: China

China has implemented various policies and initiatives aimed at promoting the adoption and manufacturing of electric vehicles. These include:

- ✓ New Energy Vehicle (NEV) Subsidies: China offers subsidies and incentives to both consumers and manufacturers of electric vehicles through its NEV subsidy program. These subsidies are designed to make electric vehicles more affordable for consumers and encourage manufacturers to produce more electric vehicles.

- ✓ Zero Emission Vehicle (ZEV) Credit System: China has implemented a ZEV credit system, similar to California's ZEV program, which requires automakers to obtain a certain number of credits for producing electric vehicles. Automakers failing to meet the credit requirements face fines or restrictions on their business operations in China.

- ✓ Regulatory Measures: China has implemented various regulatory measures to encourage the adoption of electric vehicles, including restrictions on the sale of internal combustion engine vehicles in certain cities, preferential treatment for electric vehicles in license plate lotteries, and exemptions from certain restrictions on vehicle purchases.

- ✓ Infrastructure Development: China has made significant investments in charging infrastructure to support the growing electric vehicle market. The government has set targets for the number of public charging stations and battery swap facilities to ensure that drivers have convenient access to charging facilities.

- ✓ Industrial Policies: China has implemented industrial policies to support domestic electric vehicle manufacturers and promote innovation in electric vehicle technology. These policies include subsidies for research and development, as well as support for domestic battery manufacturing.

Call to action:

- ✓ Extension and Expansion of FAME India Scheme:

  Consider extending and expanding the program to provide more significant financial incentives.

  Increase accessibility of electric vehicles to a larger population, especially in rural households

- ✓ Expansion of Charging Infrastructure:

  Develop a larger and more reliable network of charging infrastructure, especially in rural areas, to reduce range anxiety and promote EV adoption. This will require government intervention for localisation incentives, utilities collaboration, availability of grid and electrical distribution network.

- ✓ Promotion of Uniform Battery Technology, vehicle interface for charging and Charging Infrastructure:

Promote uniformity in battery technology and charging infrastructure to increase adoption incentives and alleviate range anxiety and ensure interoperability between electric car models.

- ✓ Public Awareness Campaigns:

  Create public education highlighting the financial and environmental advantages of electric vehicles to encourage increased adoption.

- ✓ Collaboration for Technology Advancement:

  Foster cooperation between government, industry, and research institutes to expedite EV technology advancement, making electric vehicles more efficient and affordable.

- ✓ Maintenance of Favourable Regulatory Framework:

  Ensure a favourable and stable regulatory framework, including long-term regulations and incentives, to guarantee continued growth in the electric vehicle industry. All these should be independent of the governments in place.

CHAPTER V:

DISCUSSION

5.1 Discussion of Results

The research underscores several key aspects crucial for building India's technology leadership in product development, focussed in the electric vehicle (EV) sector. The emphasis on addressing affordability through pricing schemes and subsidies for electric scooters especially in a market where two-wheelers dominate highlights the importance of making EVs accessible to a wider population. The discussion on the status and recommendations for each gap/opportunity, considering factors of technological advancements in charging infrastructure, innovations in battery technology, and government support, highlights the multipronged approach necessary for fostering EV adoption and industry growth. China's comprehensive policies, regulatory support, and collaborative efforts across government, industry, and research sectors are a benchmark for India's advancement in EV technology and infrastructure. The identified gaps in the existing FAME II scheme and the necessity for extension, and improvements therein bring out the importance of continuous evaluation and adaptation of policies to address evolving challenges and opportunities in the EV ecosystem. The research provides valuable insights into the current landscape and actionable strategies for India. The Framework creates a practical strategy for India to build its leadership in technology product development in the domain of electric mobility.

5.2 Discussion of Research Objective One Questions

The research objective of baseline competency levels in electric scooter design, manufacturing, and technology development provides valuable insights into India's current standing compared to China, while also evaluating into the impact of key policies like FAME (Faster Adoption and Manufacture of Electric Vehicles) and PLI (Production Linked Incentive). India's competencies and perceptions regarding electric scooters are studied leading to informed discussions and strategic decisions towards creating a framework for technology leadership.

The electric scooter landscape in India is largely influenced by Consumer perceptions. The preference for domestic brands over Chinese imports indicates a positive sentiment towards the Make in India initiative. The further adoption and market growth will be driven by Consumer perceptions.

India has a huge strength in Mechanical Design but there is still a gap in competency for ebike manufacturing ebikes. Motor design and battery technology is lagging in India compared to China while electronics design competency is good. .

Innovation and Growth is characterised by the research and development functions in startups in the electric scooter space. Indigenous product development is very prevalent with major manufacturers and startups leveraging inhouse capabilities for escooter design and development.

Policy frameworks such as government subsidies and schemes support EV sales in India. However, there is a need for a more targeted focus on Micro, Small, and Medium Enterprises (MSMEs) and backend manufacturing to strengthen the entire ecosystem. Challenges related to cost competitiveness against China persist, but India possesses the necessary talent and capabilities, which can be further accentuated by focussed and stable policymaking and cost reductions.

Concerted efforts in infrastructure development, policy support, and strategic investments will be required and Initiatives to develop local solutions for critical components like motor drives, batteries, and embedded software need to accelerated, to build self reliance in electric scooter manufacturing.

Leveraging existing strengths and building local design-manufacturing, India can position itself as a key player in the global electric mobility market, driving innovation, local design and manufacturing, and cost-effectiveness.

5.2 Discussion of Research Objective Two Question

The second research objective focuses on identifying barriers to indigenous development in the electric scooter industry in India. The findings highlight several key challenges that need to be addressed to foster local innovation, manufacturing, and adoption of electric scooters.

The significant barriers are mainly the Cost and import dependencies across the the value chain of electric powertrain technology and components. India is hugely reliant on Chinese imports, especially for critical components like Li-ion batteries and electronic components. This makes it imperative for domestic manufacturing capabilities to enhance cost competitiveness and reduce dependency on imports.

Stable, unambiguous and favourable regulations are essential to incentivize manufacturers and consumers, promote investment, and create an enabling ecosystem for the electric scooter industry to grow.

The lack of India's R&D and innovation in the field of power electronics compared to China is a critical barrier. This is a barrier to local innovation in the power train and charging infrastructure.

A Multifaceted approach to policy reforms, investments in infrastructure and R&D, and collaboration between government, industry, and academia will be the need of the hour. The challenges overcome will enable India to unlock the full potential of its electric scooter industry, technological advancement in the transportation sector achieve leadership status.

5.3 Discussion of Research Objective Three Questions

The third research objective focuses on the development of a comprehensive framework to address the challenges and capitalize on the opportunities in the electric scooter industry in India. The identified key elements provide a roadmap for enhancing domestic manufacturing capabilities, promoting innovation, and fostering sustainable growth in the sector.

Indigenization of EV subcomponents emerge as a critical element of the framework which will reduce imports. Domestic manufacturing capabilities for key components such as batteries, electronic components, and powertrains is imperative and India can enhance its cost competitiveness and reduce reliance on imports, thereby achieving an indigenous product development leadership position.

The Government's encouragement through funding startups in this space, Research and Development funding, and Government support for large-scale manufacturing is essential for accelerating the growth of the electric scooter industry. Incentives such as subsidies, tax breaks, and financial assistance can encourage private sector participation and spur the development of manufacturing infrastructure and supply chains.

The Charging infrastructure plays a pivotal role in electric vehicle adoption. The Chinese model of less than ten EV’s per charging station can be taken as a benchmark to create an infrastructure in India. This is imperative to reduce range anxiety, encourage adoption of EV’s in India, and reach the tipping point to increase volumes of EV sales.

In conclusion, the development of a comprehensive framework for the electric scooter industry in India requires a holistic approach encompassing manufacturing, infrastructure, technology, policy, and collaboration. By addressing these key elements, India can leverage the full potential of its electric scooter industry, technological innovation, and environmental sustainability to achieve technology Leadership in this space.

Chapter VI:
SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

The research is focused on the electric scooter industry in India, aiming to evaluate its current state, identify barriers to indigenous development, and develop a comprehensive framework for advancement. Three main objectives considered for the work are baseline competency levels, barriers to indigenous development, and comprehensive framework development.

At the onset, the study evaluates India's competencies in electric scooter design, manufacturing, and technology development, compared to China's status. Through a mixed methodology analysis, it appears that India possesses prominent strengths in mechanical and electronic design, infrastructure, and research and development (R&D) capabilities. These strengths are particularly evident in the presence of a capable workforce, a solid foundation in BLDC motor design and battery management systems, and ongoing R&D efforts by major manufacturers and startups. However, challenges persist, notably in supply chain areas such as cost competitiveness and import dependency, particularly for critical components like Lithium ion batteries and electronic components. Despite these challenges, there is a positive perception of domestic brands among consumers, signalling confidence in Indian manufacturing capabilities.

The other aspects on barriers are including cost and import dependency, policy constraints, supply chain issues, R&D gaps, and market challenges. crucial components like batteries and electronic components have to be imported from China considering that China is the only country for Lithium and India has no semiconductor factories. Policy ambiguity and the lack of supportive regulations hinder the growth of electric scooters compared to traditional internal combustion engine (ICE) scooters. Infrastructure gaps, such as the limited availability of charging infrastructure, pose huge challenges to EV adoption and product development. DC fast charging which is vital for EV adoption and vitality is non existing in India in terms of development and manufacturing. These barriers collectively become force multipliers as barriers in the scaling up of indigenous electric scooter manufacturing and adoption in India.

The research outcome proposes a comprehensive framework to address the identified barriers and promote indigenous development in the electric scooter industry. This framework encompasses several key elements, including reducing import dependency through the indigenization of EV subcomponents, government support for large-scale manufacturing and capital access, charging infrastructure development, enhanced expertise and technology development, policy and regulatory measures, and collaboration and strategic tie-ups.

The research provides a comprehensive understanding of the electric scooter industry in India, highlighting its strengths, challenges, and opportunities. With the identified barriers and implementation of the proposed framework, India can achieve leadership status as a key player in the indigenous electric scooter market, driving economic growth, technological innovation, and environmental sustainability in the process.

6.2 Implications

The implications of the research findings and proposed framework for the electric scooter industry in India are multifaceted and far-reaching:

1. Policy Reforms: The research highlights the urgent need for policy reforms and unambiguity in regulations to support the growth of the electric scooter industry. The development of supportive regulations that incentivize domestic manufacturing, investment in infrastructure, and technological innovation must be prioritized.

2. Investment and Financing: Policymakers and financial institutions must get-together to provide financial incentives, subsidies, and loans to electric scooter manufacturers, startups and also the consumers through banking institutions.

3. Infrastructure Development: Infrastructure development is critical for supporting the widespread adoption of electric scooters. Governments, along with private sector partners, should prioritize investment in charging infrastructure and the establishment of integrated

EV clusters at all major hubs like petrol stations, hotels, Malls, and other clusters. A concoction of easily available charging station network alongside strategically located support for EV service and maintenance hubs can alleviate range anxiety among consumers.

4. Research and Development: Universities, research organizations, and corporations must collaborate to develop specialized skills in power train, battery technology, and software development. Innovation, improve product quality, and maintain competitiveness in the global market can be enhanced with this collaboration

5. Collaboration and Partnerships: Collaboration and strategic tie ups with product owners and industry partners are vital for driving innovation and refining products to meet market demands. Companies should explore opportunities for mergers and acquisitions (M&A), joint ventures, and technology partnerships to access resources, expertise, and technologies. Collaborative efforts can accelerate R&D, reduce time to market, and enhance the competitiveness of electric scooters.

Overall, the implications of the research findings and proposed framework highlight the need of collaborative efforts by governments, industry stakeholders, and financial institutions to harness the full potential of the electric scooter industry in India. Focussing on the identified challenges and leveraging the opportunities presented, India can achieve leadership status in electric mobility, driving innovation, Technology Leadership, economic development, and environmental sustainability.

6.4 Recommendations for Future Research

Based on the findings and implications of the research on the electric scooter industry in India, several recommendations for further research can be suggested:

1. Technological Innovation: It will be useful to understand the requirements of the power train and Battery technology for Indian conditions. This alongside innovation in the global arena localized to local conditions will help/research has to be carried out on alternate Motor technologies to reduce import dependency of

Lithium based batteries and also alternate motor technologies to reduce magnet dependency for BLDC motors. Internet connectivity will be also important for management of EV’s and predictive maintenance.

2. Policy Analysis: A detailed policy analysis of past impacts and effectiveness and future predictions in supporting the growth of the electric scooter industry will help. Research on policy frameworks, incentives, and regulatory barriers with the use of AI and other technologies can accelerate growth through faster decision-making/

3. Supply Chain and Logistics: The dependency on Chinese imports for power train and battery components should be studied and risk mitigation should be created. These should be converted to opportunities to create local manufacturing and technology development institutions. A creative logistics for maintenance of EV’s and range anxiety alleviation can be explored.

6.4 Conclusion

The competency levels research in the electric scooter industry in India has highlighted significant strengths in mechanical and electronic design. The huge positive consumer sentiment towards domestic brands reflects confidence in India's manufacturing capabilities – MAKE in INDIA initiative. Alongside these positives, there is a huge barrier due to import dependency. Ambiguous policy regulations are a barrier to further industry growth.

The identified barriers to indigenous development need urgent action to overcome these hurdles. Policy reforms must be prioritized to provide clarity, stability, and support for the industry, facilitating investment and innovation. Infrastructure development mainly for Charging including Fast charging is vital. Investments in charging infrastructure and manufacturing facilities to enable scalable cost-effective production will help electric scooter adoption. supply chain constraints for battery technology and electronic components are very important to achieve leadership status in this domain//

The comprehensive framework proposed articulates a strategic roadmap for overcoming these challenges and converting them to opportunities. The key areas of focus are reducing import dependency, enhancing charging infrastructure, fostering innovation, implementing stable favourable policies, and encouraging collaboration.

In summary, the research objective findings provide a comprehensive understanding of the electric scooter industry's current landscape in India. The identified barriers are converted to opportunities and a comprehensive framework is created. India's emergence as a leader in the electric mobility sector for indigenous product development, driving innovation, sustainability, and economic development will be based on the execution of the identified framework call to action.

APPENDIX A

RESEARCH SURVEY COVER LETTER

Dear friend, Research title “FRAMEWORK FOR BUILDING INDIA’S INDIGENOUS TECHNOLOGY PRODUCT DEVELOPMENT LEADERSHIP “

” Research guide/mentor – Dr. Minja Bolesnikov PhD (SSBM Geneva Switzerland) I am Mahesh Patil, Doctorate (DBA) scholar and an Entrepreneur Cofounder of “SPARKONNECT TECHNOLOGIES PRIVATE LIMITED” I am doing research in the field of India’s Product Development Leadership and various perspectives around it.

I am reaching out to you regarding an important research study titled "FRAMEWORK FOR BUILDING INDIA’S INDIGENOUS TECHNOLOGY PRODUCT DEVELOPMENT LEADERSHIP."

Your input is crucial in helping us understand the current landscape of technology product development in India and identifying opportunities for growth and innovation. The survey will cover various aspects related to technology product development, including competencies, challenges, policies, and opportunities. Your responses will remain confidential and will be used solely for research purposes.

Your insights will help inform strategies and initiatives aimed at strengthening India's position as a leader in technology product development.

Your time and input are highly valued, and we assure you that your responses will be treated with the utmost confidentiality.

Thank you for your time and consideration.

Sincerely,

Mahesh Patil

APPENDIX B
INFORMED CONSENT

I,………………………………agree to be interviewed for the research which will be conducted by Mahesh Patil, a doctorate student at Swiss School of Business and Management, Geneva, Switzerland. I certified that I have been told of the confidentiality of information collected for this research and anonymity of my participation; that I have been given satisfactory answers to my queries related to research procedure and other concern matters; and that I have been informed that I am free to withdraw my consent or discontinue participation in the research or activity at any time without prejudice. I agree to participate in one or more electronically recorded interviews for this research. I understand that such interviews and related materials will be kept completely anonymous and that the results of this study may be published in any form that may serve its best. I agree that any information obtained from this research may be used in any way thought best for these studies. …………………………. Interviewee ……………………… Date

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APPENDIX A

RESEARCH SURVEY COVER LETTER

Dear friend, Research title “FRAMEWORK FOR BUILDING INDIA’S INDIGENOUS TECHNOLOGY PRODUCT DEVELOPMENT LEADERSHIP “

” Research guide/mentor – Dr. Minja Bolesnikov PhD (SSBM Geneva Switzerland) I am Mahesh Patil, Doctorate (DBA) scholar and an Entrepreneur Cofounder of “SPARKONNECT TECHNOLOGIES PRIVATE LIMITED” I am doing research in the field of India’s Product Development Leadership and various perspectives around it.

I am reaching out to you regarding an important research study titled "FRAMEWORK FOR BUILDING INDIA’S INDIGENOUS TECHNOLOGY PRODUCT DEVELOPMENT LEADERSHIP."

Your input is crucial in helping us understand the current landscape of technology product development in India and identifying opportunities for growth and innovation. The survey will cover various aspects related to technology product development, including competencies, challenges, policies, and opportunities. Your responses will remain confidential and will be used solely for research purposes.

Your insights will help inform strategies and initiatives aimed at strengthening India's position as a leader in technology product development.

Your time and input are highly valued, and we assure you that your responses will be treated with the utmost confidentiality.

Thank you for your time and consideration.

Sincerely,

Mahesh Patil

APPENDIX B
INFORMED CONSENT

I,……………………………………agree to be interviewed for the research which will be conducted by Mahesh Patil, a doctorate student at Swiss School of Business and Management, Geneva, Switzerland. I certified that I have been told of the confidentiality of information collected for this research and anonymity of my participation; that I have been given satisfactory answers to my queries related to research procedure and other concern matters; and that I have been informed that I am free to withdraw my consent or discontinue participation in the research or activity at any time without prejudice. I agree to participate in one or more electronically recorded interviews for this research. I understand that such interviews and related materials will be kept completely anonymous and that the results of this study may be published in any form that may serve its best. I agree that any information obtained from this research may be used in any way thought best for these studies. …………………………. Interviewee ……………………… Date

APPENDIX C
INTERVIEW GUIDE

Interview "FRAMEWORK FOR BUILDING INDIA'S INDIGENOUS TECHNOLOGY PRODUCT DEVELOPMENT LEADERSHIP."

The interviews will begin with introductions and an overview of the topic. Prior to that the questionnaire was sent to get familiarised with the topic and expectations on time for the interview.

A. I will advise the participants I am sensitive to their time and thank them for agreeing to participate in the study.

B. I will remind the participants of the recorded interview and the conversation we are about to have will remain strictly confidential.

C. I will turn on the recorder and will announce the participant's identifying code as well as the date and time of the interview.

D. The interview will last approximately 30 minutes to obtain responses from seventeen interview questions and follow-up questions.

E. I will also explain the concept and plan for member checking by contacting participants with transcribed data and request verification of the accuracy of collected information as soon as possible.

F. After confirming answers recorded to the participants' satisfaction; the interview will conclude with a sincere thank you for participating in the study.

APPENDIX D

Background information of research participants

BL	Age	Business type	Educational background	Job category	Working experience	Interview Time(min)
BL1	55-60	Technology	Masters	Senior Management	35	40
BL2	45-50	Technology	Bachelors	Senior Management	25	50
BL3	45-50	Entrepreneur	Bachelors	Founder	30	60
BL4	55-65	Entrepreneur	Masters	Founder	35	30
BL5	45-50	Technology	Masters	Senior Management	28	30
BL6	30-40	Sourcing	Doctorate	Management	20	30
BL7	45-50	Technology	Bachelors	Senior management	25	40
BL8	55-65	Technology	Masters	Senior management	40	30
BL9	45-50	Technology	Bachelors	Senior Management	25	40
BL10	50-55	Marketing	Bachelors	Senior Management	30	50
BL11	60-65	Marketing	Masters	Senior Management	40	30

BL12	45-50	Technology	Bachelors	Principal Engineer	25	50
BL13	40-50	Entrepreneur	Bachelors	Founder	25	30
BL14	45-50	Finance	Chartered Accountant	Senior Management	25	30
SBL15	30-40	Entrepreneur	Masters	Founder	15	50