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Confederation of Indian Industry

Indian auto industry 2.0 – Innovation, NPD and globalisation imperatives

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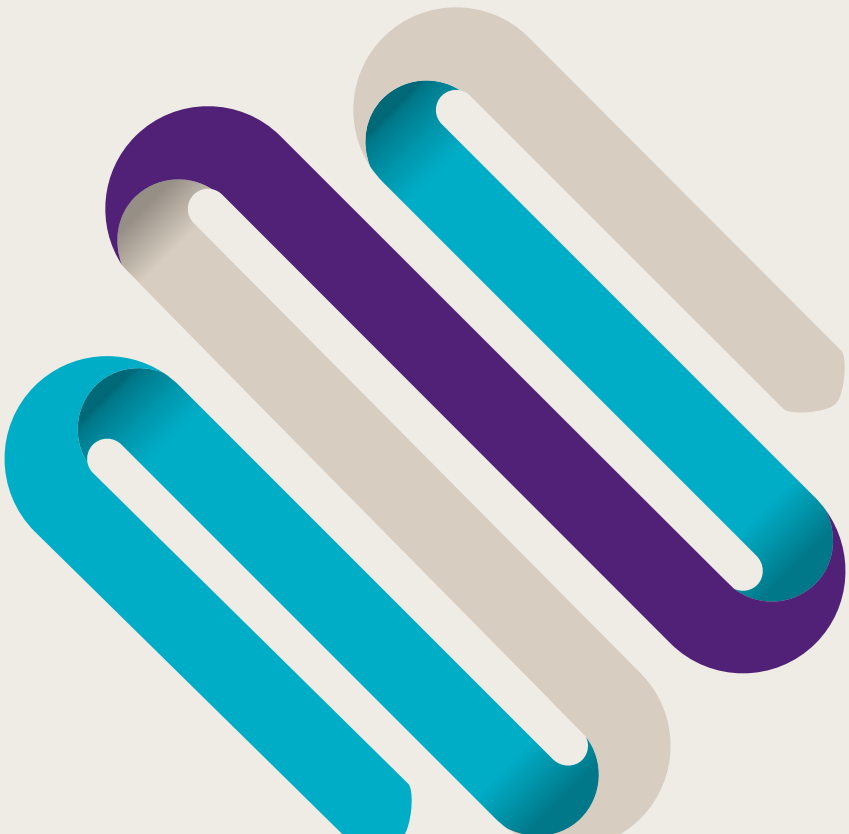


Foreword from CII

Disruptions, new product development and globalisation are changing the landscape of the auto industry. New products and new technologies are causing the shift in consumer preferences.

Technological advancements have been reshaping the manufacturing industry, including automotive manufacturing, over the last couple of years. Vehicle features that we could only imagine five years ago have now become a reality. Experiments with driverless vehicles are being conducted around the world.

The Indian automotive industry is one of the fastest-growing markets of the world, accounting for a large share in the Indian economy. The complete manufacturing ecosystem is undergoing a phenomenal shift with technological advancements happening at a fast pace. Understanding and adopting advanced manufacturing techniques are the need of the hour.

Disruptions, new product development and globalisation are changing the landscape of the auto industry. New products and new technologies are causing the shift in consumer preferences. The interesting thing to watch out for will be how fast the traditional companies will learn and adapt. The key to survive in the current age of disruption will be to develop new capabilities, adapt to changing customer needs and collaborate across the auto ecosystem.

This Conference on Future of Automotive Manufacturing - Innovation, New Product Development & Globalisation will be an ideal platform where all stakeholders from industry will get a common platform for discussion. The industry experts who will be addressing the participants will give insights into the related aspects, and relevant discussions will help get a better understanding of the changes happening in the overall automotive industry.

Shreekant Somany

Chairman, CII-Centre of Excellence for Competitiveness for SMEs and Chairman and Managing Director, Somany Ceramics Ltd

Foreword from Grant Thornton in India

As part of our interaction with industry players, we found them to be increasingly open towards testing out new business models.

It gives me great pleasure to share this CII-Grant Thornton in India knowledge paper covering important themes of innovation, new product development and globalisation. We have captured the views of both the OEMs as well as tier 1 suppliers and the shifts companies are making or expected to make in the light of the rapid changes in the automotive landscape such as multiple breakthrough technologies and changing consumer preferences as well as the regulatory environment.

Disruption is for real and also cannot be predicted with certainty. It thus will require agility on the part of the industry to ensure that India remains at the forefront of these developments. Automotive companies will be well served to invest in capabilities across innovation and new product development while increasingly embracing a global perspective. As part of our interaction with industry players, we found them to be increasingly open towards testing out new business models like evaluating R&D outsourcing apart from working with their global partners and investing in R&D centres to help meet their audacious aspirations.

For the Indian automotive industry, which is a significant contributor to India's manufacturing GDP, these developments present both a challenge and an opportunity towards ensuring that India remains an important part of the emerging supply chain.

Alok Verma
Partner
Grant Thornton India LLP

Introduction

The automotive sector, which is critical for the country to establish its manufacturing footprint, is at the cusp of transformation. Innovation is driving new technologies, leading to potential disruption, new product development and globalisation imperatives.

The following updates in the automotive ecosystem can be indicators of the future to come for the sector:

OLA launches mobility institute as a research and social innovation think tank.

The Hindu Business Line

Toyota to invest $500m in Uber in driverless car deal

BBC News

"The landscape of future mobility is going to be a varied one. It is going to straddle the very low end, which will involve transport as a commodity where people get into small pods or EVs or autonomous cars to get from point A to point B"

Anand Mahindra

India's biggest ride-hailing service Ola is driving into the UK

Quartz

India among five countries for Uber flying taxis; a drone may soon deliver your Uber Eats order

YourStory

"Would love to be in India. Some challenging government regulations, unfortunately. Deepak Ahuja, our CFO, is from India. Tesla will be there as soon as he believes we should."

@elonmusk, Twitter

ICE powertrain contributes to over 60% of the employment generation in the auto component sector, and that a switch to 100% electric could impact up to 5.6 million jobs by 2025-26

ACMA

At CES 2018, we will reveal the fully-electric subcompact SUV Niro EV Concept featuring a first-ever Human-machine interface (HMI) and an advanced new 'motion graphic' lighting system, previewing the potential ahead of these technologies for market introduction in the near future.

Kia Motors

Daimler, BMW and Audi buying Here – Car manufacturer announcing acquisition of Nokia map services.

Manager Magazine

Pittsburgh Welcomed Uber's Driverless Car Experiment. Not Anymore.

NYT

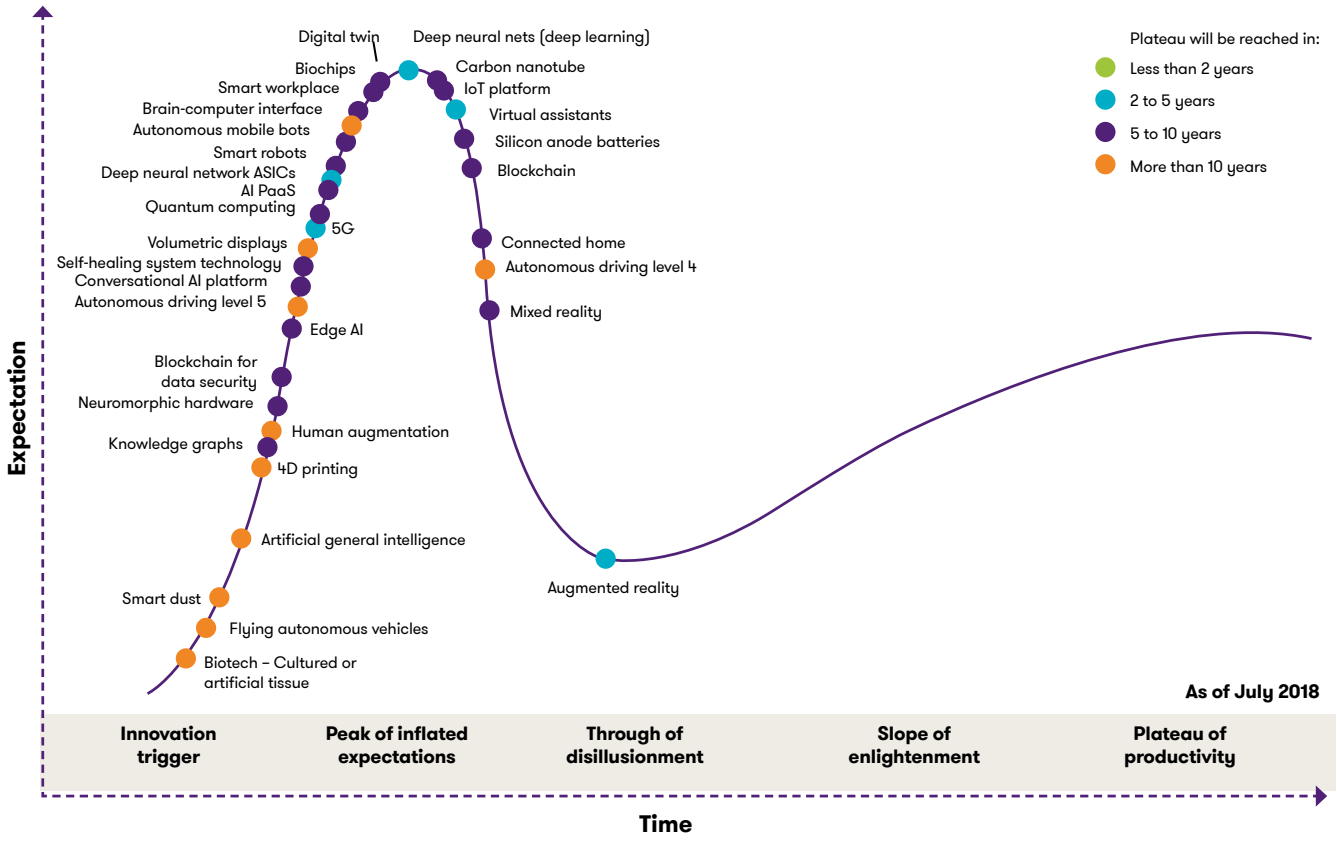
FAME 2 outlay of INR 10,000 crore over three years to support 10 lakh 2Ws, 5 lakh 3Ws, 55,000 4Ws and 7,000 buses.

Source: News articles

It is critical to read some of these signposts in the context of the Indian automotive businesses as they reveal both the opportunities as well as threats to an ecosystem where India has established its footprint. Indian auto suppliers have 25+ Deming awards, behind only Japan.

However, some of these award winners might actually be the ones getting disrupted through electric vehicle (EV) adoption (forging, gear, transmission manufacturers), thus impacting 1.5 million jobs as per ACMA. Companies are also increasingly investing in R&D and taking bets on technology that will work in the Indian context.

Hype cycle for emerging technologies, 2018



Source: Gartner (August 2018)

At the same time, Uber, for example, has announced its intent to launch Uber Flying Taxi and also shortlisted Mumbai as one of the five destinations where it would like to launch it in the next five years.

Innovation or disruption?

Automotive has long been a stable industry with a known set of competitors, predictable product development cycles and easily replicable global trends. The last time the auto industry saw disruption of this magnitude was around 100 years back. Incidentally, at that time, EVs, which had a leading market share of 38% in the US in 1900, were getting disrupted by internal combustion (IC) engines on account of a combination of starter motor innovation, range limitations of electric cars (60 miles in 1900) as also the cost of IC engine cars coming down significantly because of Ford's innovation of mass production through its Model T cars.

We are seeing a very active technology innovation landscape where several new technologies like artificial intelligence (AI), machine learning (ML), internet of things (IOT) and battery tech are at the core of the new automotive technology landscape. New individual technologies by themselves do not cause disruption as can be seen depicted in the Gartner Hype Cycle for Emerging Technologies.

What really causes disruption then?

Disruption is for real, although it cannot be timed as it is dependent on multiple factors. For example, AT&T was not able to leverage its strong patent footprint in mobile technologies as it grossly under-estimated the market size by 99%.

It then makes it important to analyse why disruption is for real. Tony Seba, a leading voice on disruption, has put together a tech disruption framework which essentially captures the essence of disruption in the automotive industry.

Technology Cost Curve

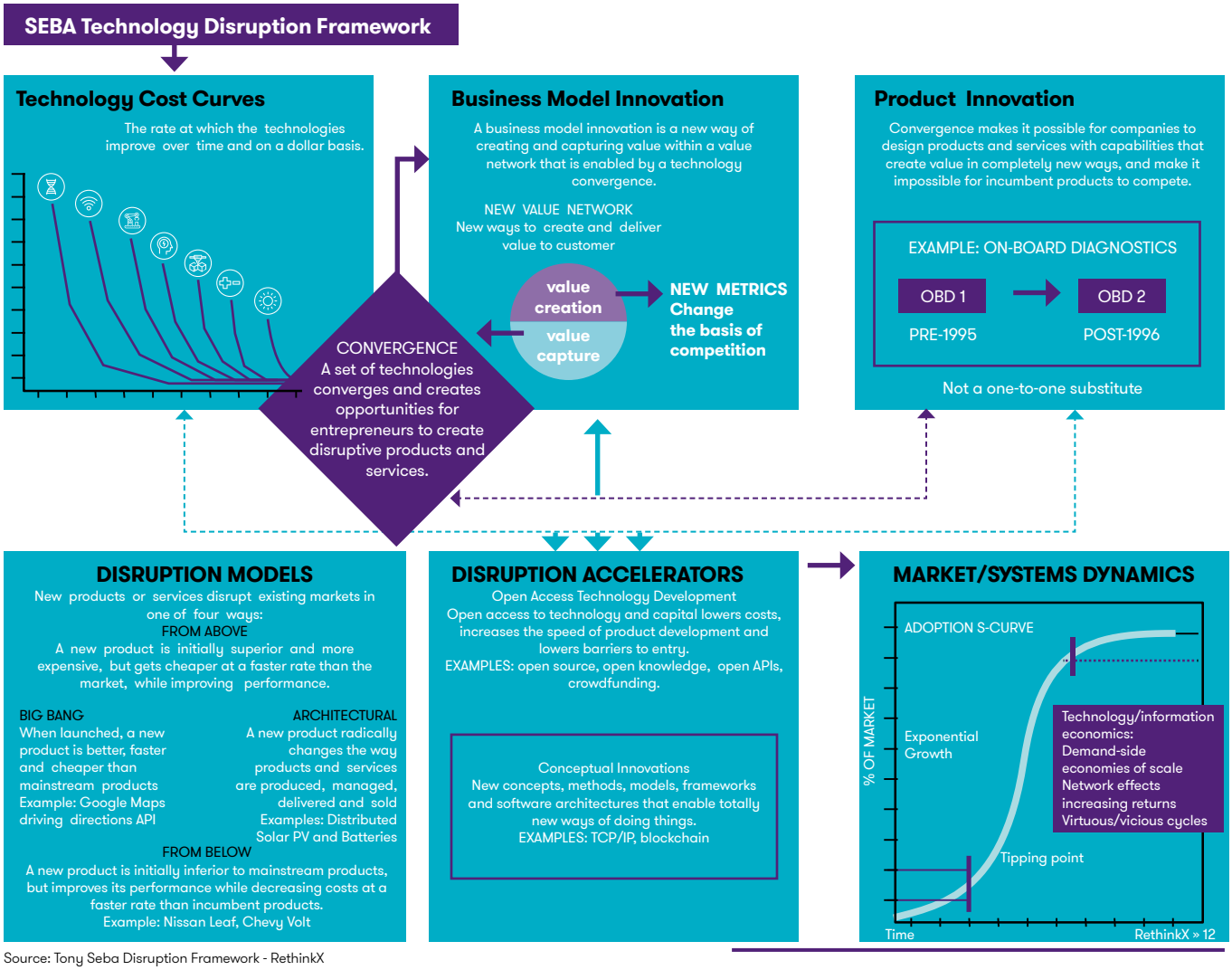
- Battery cost has come down from $1,000/kwH to $227/kwH
- Solar costs have come down 95% since the 1990s
- Cloud computing costs have come down significantly
- Mobile networks are now ubiquitous

Business Model Innovation

- Digital layer on top of the hardware
- Sharing economy

Product Innovation

- Frugal engineering/innovation
- AI centric
- IoT data-driven and scenario-based



Source: Tony Seba Disruption Framework - RethinkX

Companies like Tesla have taken a route to disruption over the frugal one adopted by Nissan, helping it gain more acceptance.

Multiple megatrends

Multiple megatrends colliding on one side also further boost the innovation landscape and pushes companies to find newer solutions.

Megatrend 1: Multiple breakthrough technologies

We are witnessing investments from both existing players into new technology areas and also new players like Google, Apple, Tesla, Dyson, among others, entering the automotive space. While Apple's CarPlay is an attempt to own the car infotainment through its device compatibility and integration, Google is much more ambitious with its autonomous car initiative. In a short span, Tesla has already achieved leadership status in the EV space with cutting edge innovation in battery technology, over-the-air (OTA) updates, and 300 miles EV range.

Dyson, the latest entrant into the EV space, however, has raised eyebrows among industry insiders who feel regulatory complexity around crash regulations alone will make it difficult for a Wiltshire-based vacuum cleaner company to build an EV by 2020 on the back of electric motor technology and 400 engineers devoted to the cause. Dyson being an industry outsider could trigger an EV approach which can challenge existing industry thinking and 'ways of operating' as this is something that SpaceX has achieved under Elon Musk's leadership.

These imperatives have now pushed the automotive players as well as new entrants to invest more in innovations and M&A deals. This will usher in a disruptive phase in which new players will challenge the status quo, while established automotive companies will try to retain turf with both in-house as well as acquisitive efforts.

Megatrend 2: Smart cities mission

All mega cities are developing a smart city blueprint which would focus on sustainable living through a holistic approach involving smart mobility in addition to smart care, smart buildings, renewable energy, etc. India has embarked on a smart cities mission, which is an urban renewal and retrofitting programme by the government with a mission to develop 100 cities all over the country, making them citizen-friendly and sustainable.

Smart cities: Constant enablers of smart technology

Environment	**Smart energy**	**Healthcare**	**Transportation**
Government and administration	**Education**	**Smart infrastructure**	

Megatrend 3: Climate change

Since the advent of industrialisation, global warming has always been a pivotal concern for the modern world. The UN Climate Change Conference held in Paris in 2015 raised serious concerns over the adverse consequences of increasing greenhouse gas (GHG) emissions. It was said that about 23% of the global energy-related GHG emissions are emitted from the transport sector. Further, it is anticipated that these emissions will rise 20% from the current levels by 2030 and another 30% by 2050 unless significant measures are undertaken to curb emissions.

To address this concern, it is important to limit global temperature rise to a maximum of 2 degrees Celsius. This will entail changing the trajectory of the automobile industry by including a conjunction of EVs, shared mobility and connected cars ecosystem. To achieve this goal, it was agreed as part of the Paris deliberations that at least 20% of all vehicles will have to switch to electricity and hydrogen technologies by 2030.

Multiple breakthrough technologies	• Combination of electric battery technology, smartphone and solar technology • Global and Indian auto OEMs investing in EVs, shared mobility and connected cars • Technology firms such as Google and Apple and Tier I firms such as Panasonic and Delphi also supporting OEMs • Samsung's acquisition of Harman - Auto, home, mobile and work convergence
Smart Cities mission	• 100 smart cities to be developed in India • Will involve transit-oriented development, public transport and last mile connectivity • Will pave the way for sustainable development, including shared mobility and connected car concepts
Paris Climate Change Declaration	• 23% of the world's GHG emissions come from automobiles • Need to limit global temperature rise to maximum 2 degree Celsius • 20% of global automobile population needs to shift to EVs by 2030

EVs

Disruptive trends: EVs

Global	Local	Technology	Infra and regulatory
Annual global electric car sales broke the 2016 record; crossed the 3 million mark in 2017	Government likely to cease the sale of ICE-based vehicles by 2030	As of 2017, the share of battery EVs (BEVs) was 66% and share of plug-in hybrid EV (PHEV) has increased in recent years	India to invest in adding 2,700 charging stations across metros, tier 1 cities and cities with population over 1 million
China leads the global EV market (40%) followed by USA (25%)	India accounts for less than 1% of the world's market share	Battery costs per kWh reduced by 85% in 2017 compared to 2010	Government to provide tax exemptions and rebate on the purchase of EVs under the FAME scheme
10 countries account for 95% of EV sales	EESL is procuring vehicles to be used by central government and PSUs	Battery reuse and recycling open up opportunities for other industries	Indian PSUs such as NTPC, IOCL, HPCL and DMRC are developing a public charging infrastructure
Tesla's Model 3 leads the market followed by BAIC's EC-Series and Nissan's Nissan Leaf; Tesla cuts Model 3 price to $35,000	FAME 2 to cover over three years: 2Ws: 1,000,000 3Ws: 500,000 4Ws: 55,000 Buses: 7,000	Electric motor technology options ranging from induction motors (Tesla) and permanent magnet machines (Nissan Leaf and Chevy Bolt)	FAME 2 INR 10,000 crore subsidy spanning three years covering 3W and 4W public transport and 2W private vehicles using advanced battery technology.

Source: Grant Thornton research

Driving into the future with EVs

By itself, EV is not a disruptive innovation but a new propulsion system for a traditional means of transportation. The first EV was rolled out in the 1830s and was replaced by ICE vehicles because of range concerns. As Stanford University's Tony Seba points out, "When multiple breakthrough technologies come together, the probability of a disruption improves exponentially." In the current scenario, EVs have emerged as a disruptive innovation in the automotive industry because of climate change—driven stricter emission norms, smart city imperative at both the global and India level, and battery technology innovation. In effect, EVs have become a promising alternative to ICE technology.

China is the largest EV market with 580,000 EVs sold in 2017 accounting for 40% of the global EV sales volumes, followed by USA. Globally, 95% of electric car sales are taking place in just 10 countries: China, USA, Japan, Canada and the six leading European countries. Overall, the European market stands at 150,000 vehicles with Norway having a favourable policy in terms of tax breaks and exemptions to waivers on-road tolls and ferry fees. This has resulted in several European nations having a greater than 1% overall passenger vehicle market. Though EV sales have been picking up for the last five years, the increase in unit sales can be seen in new and old companies that are proactively integrating sustainability and technology to enhance customer experience.

Tesla's Model 3 sedan was the best-selling electric car in 2018 and led the electric vehicle race with 138,000 units sold globally, ahead of China's BAIC group that sold 92,000 units of its EC series car. In 2018, total battery-powered EV sales surged by about 74% to 1.26 million.

The advent of EVs has challenged the status quo in the automotive industry and led to the gradual but steady decline of ICE vehicles as a share of total sales volume globally. For instance, Honda will discontinue production and sales of its diesel-powered vehicles in Europe, and Porsche has stopped selling diesel vehicles of its major models to focus on EVs. Companies around the world are focusing on an electrification strategy which is set to gain momentum in the next five years.

Announcements by key OEMs: Increased focus on EVs

OEM	US and Europe footprint	Announcement
Top US and Europe footprint: OEMS and their future plans		
Tesla (Model S)	US: 26,500 Europe: 3,715	0.5 million annual electric car sales by 2018; 1 million annual electric car sales by 2020
GM (Chevy Bolt)	US: 23,297	Stop Chevy Volt production by the end of first quarter of 2019; focus on all-electric Cadillac as first GM EV
Renault-Nissan (Nissan-Leaf Renault-Zoe)	US: 11,230 Europe: 15,000	Zero-emission vehicles to be 20% of sales in 2022
BMW (BMW i3)	US: 6,276 Europe: 3,958	0.1 million electric car sales in 2018 and 15%-25% of the BMW group's sales by 2025
Volkswagen (e-Golf Passat- PHEV	US: 3,534 Europe: 3,570	2-3 million annual electric car sales by 2025
Other OEMs' plans for EVs		
Chinese OEMs	All OEMs have aggressive plans to ensure that they have a credible alternative to leading EV players	4.52 million annual electric car sales by 2020
Daimler		Electrify entire Mercedes Benz portfolio by 2022
Ford		Planned investment of $1 billion by 2022 and the total number of electrified models to be 40
Honda		Two-third of the 2030 sales to be EVs (including hybrids, PHEVs, BEVs and fuel cell EVs (FCEVs))
Volvo		1 million cumulative electric car sales by 2025
Mahindra		Manufacture 36,000 electric cars by 2020
Toyota		Toyota takes 5% stake in Mazda to jointly develop EVs; the objective of 4.5 million sales of HEVs and PHEVs in 2030
Suzuki		Suzuki-Toyota JV started testing 50 EVs in India in October 2018 and will launch its first EV in India in 2020; will set up Li-ion battery plant that will be operational 2020 onwards

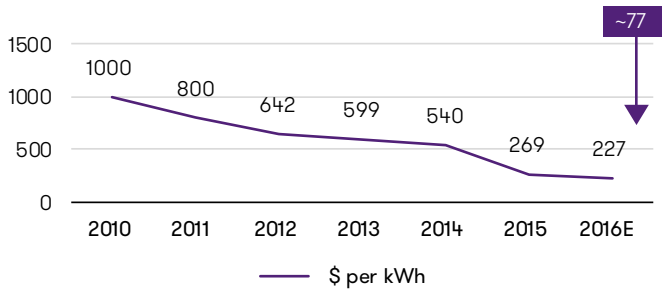
Source: Grant Thornton analysis

Even so, innovation must be sustainable and commercially viable for it to be disruptive. The reason EVs failed earlier was range anxiety — the fear that the power in the vehicle will run out before reaching a charging station or the destination.

Battery technology: Key enabler for EV resurgence

Battery technology is the biggest area of innovation from an EV standpoint. Battery cost is a critical area for disruption as it currently accounts for up to ~35%-50% of an EV's price, which makes it a significant barrier to profitability. This is despite steady improvements in terms of battery costs from above $1,000 per kilowatt-hour in 2007 to $200 per KWh in 2020 (2016: $227 per KWh). In addition to battery costs and energy storage capacity, other aspects like safety and life span are equally important. Thus, we see different OEMs putting their bets behind different battery technologies. Lithium-titanate and lithium-iron-phosphate are gaining importance. Furthermore, with the potential to outperform lithium-ion batteries on energy density and cost, battery chemistries that involve magnesium, sodium or lithium-sulphur are also being increasingly used. Hopefully, there is convergence and a gold standard technology will emerge from this initial experimentation as the technology matures.

Average battery pack price



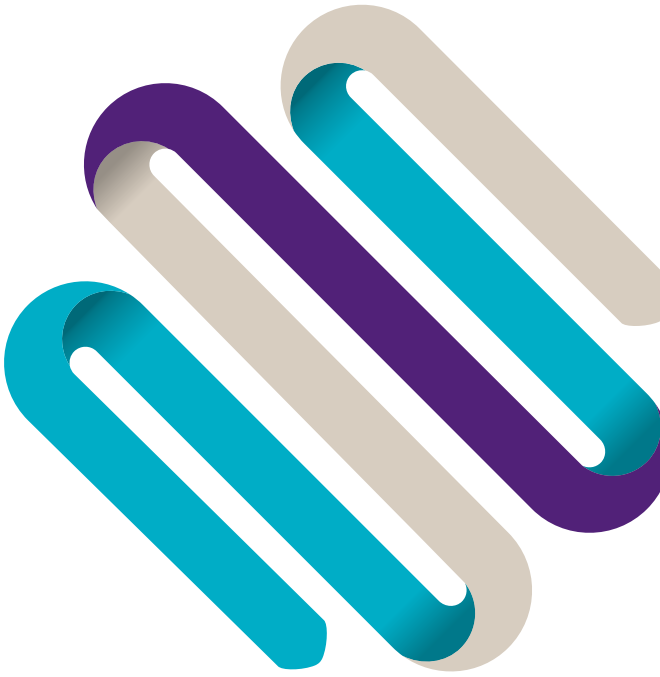
Source: McKinsey

This pre-empts the need for adequate charger and charging infrastructure. In addition, high EV cost in comparison to that of an ICE vehicle has been a deterrent in the quick adoption of EVs.

Key success factors for EVs

EVs could account for ~10% to ~50% of new vehicle car sales over the next decade.

Stricter emission regulations can indirectly boost EV sales as companies clamour to build compliant vehicles. Widely available charging infrastructure will increase convenience for customers. Lower battery cost will make EVs cheaper, attractive and affordable for customers. Consumer acceptance will increase through the elimination of concerns in terms of 'range anxiety' and costs – both short and long term.



Shared mobility

Disruptive trends: Shared mobility

Global	Local	Technology	Infra and regulatory
Nearly $28 billion invested in shared mobility by players such as Uber, Didi and Lyft	Shared mobility accounts for 25%-30% of all rides by Ola and Uber in metros	Smartphone as a digital layer creating ease of use for shared mobility	Integration of public and private transportation
Car-sharing could reduce vehicle sales by 500,000 units worldwide by 2021	Indian market dominated by standalone applications such as OlaShare, UberPool and BlaBlaCar	Mahindra to support Ola's vision of a fleet of 1 million shared EVs in the next five years; Glyd has partnered with Cisco Systems and Vodafone Idea for in-car connectivity and content	Make stringent KYC checks for drivers
Global OEMs like GM and BMW making strong investments in shared mobility through Lyft, Zendrive, Cruise, RideCell, etc.	By 2040, Indian car ownership to increase by 775% to 175 per 1,000 people from the current 20 per 1,000 people	Ola Electric raises INR 400 crore for Its Mission: Electric Plan	Frame norms about shared mobility for the safety of passengers; more stringent data privacy and cybersecurity norms

Source: Grant Thornton analysis

Disruptive innovation in the automotive customer experience: Shared mobility

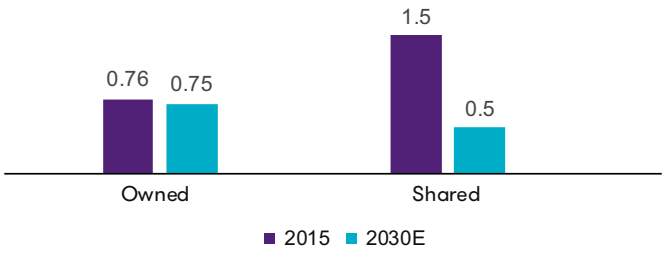
Rapid urbanisation, lack of city planning and an increase in car park sizes in major cities are leading to increased congestion and commute times across mega cities worldwide. This coupled with increased social awareness and easy-to-use platforms like Uber and Ola have made shared mobility a viable option.

Around $28 billion has been invested in shared mobility businesses alone including Uber, Didi Dache, Lyft and, closer home, Ola to develop a technology platform defined by ease of use (user experience), consumer convenience (urban consumer through initial subsidy) and driver-friendliness (with initial incentivisation).

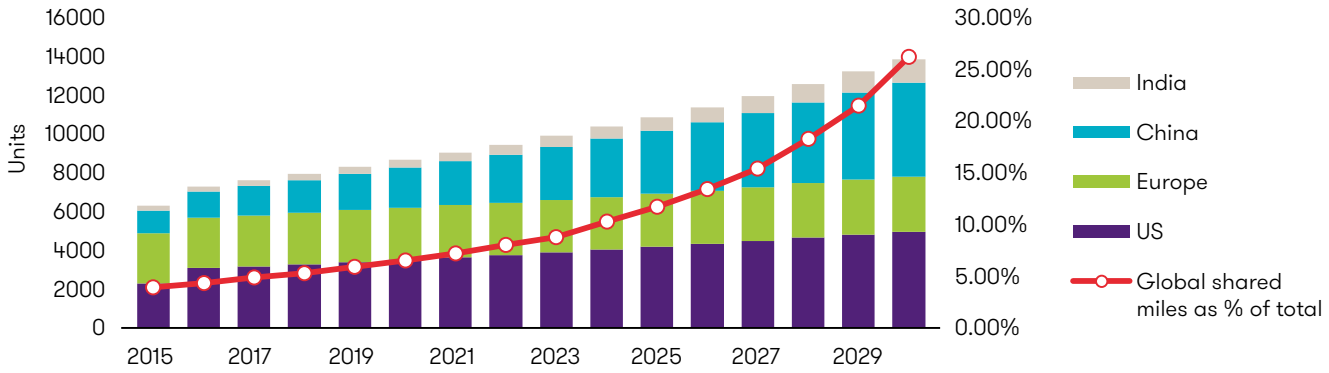
It will be key to see how developed markets react to this disruption over the medium and short term as personal mobility is central to the modern consumer needs. With shared mobility, there are early signs of this getting challenged with consumers delaying the purchase of their first cars and reduction in second car demand. There are varying estimates that a shared mobility car has the potential to reduce the new car demand by a factor of over 10-25. While automotive OEMs will need to follow these trends as there is a downward pressure on demand, there is also a potential to earn additional revenues through new business models in terms of OEMs entering into shared mobility themselves.

With the emergence of shared mobility, it is anticipated that the health of the automotive industry will be measured by total miles travelled instead of total car sales made. To that end, cars are estimated to cover 19.6+ billion miles worldwide in 2030 compared to ~10.2 billion in 2015.

Global per mile cost ($)



Source: Morgan Stanley



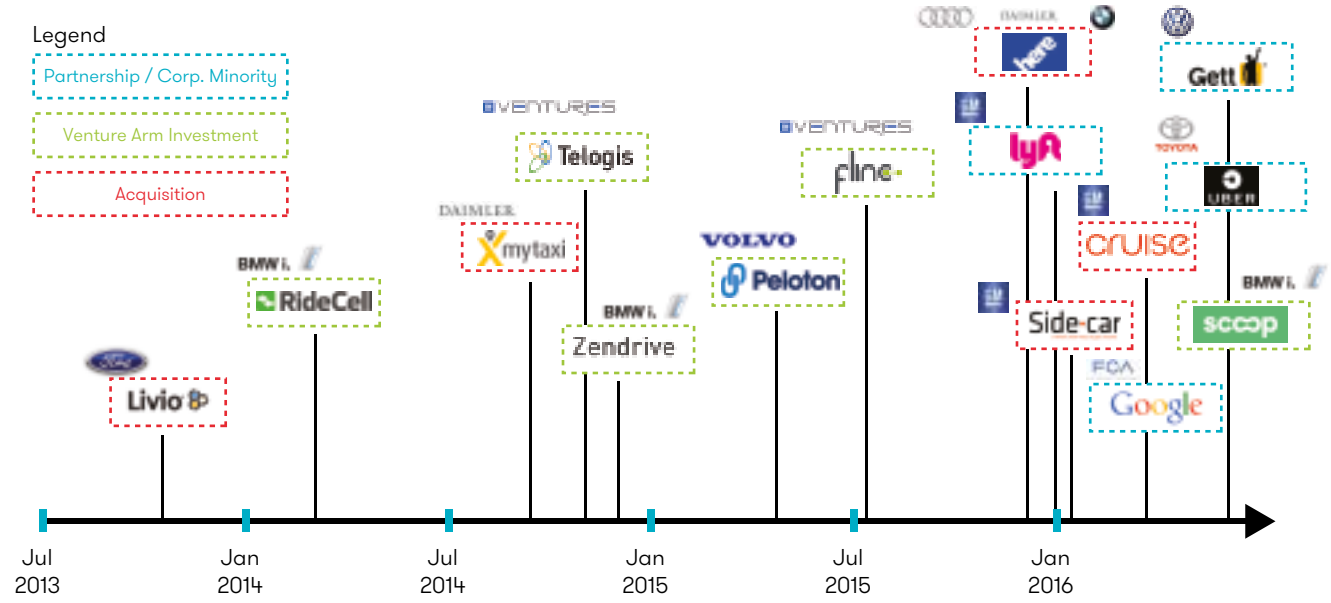
Source: Morgan Stanley

Shared cars (taxis and cars operated by ride-sharing companies) are expected to account for ~26% of total global miles travelled in 2030 as compared to 4% in 2015. The per mile cost for shared vehicles is set to fall below the per mile cost for owned vehicles by 2030.

Initiatives by key OEMs: Increased focus on shared mobility

Nearly all major OEMs have made at least one, if not multiple, investments to secure ground into next-generation transportation service networks. Toyota and Volkswagen have taken corporate minority stakes in Uber and Gett, respectively. Volvo has also secured a separate partnership with Uber. However, with the finite number of large contenders in this space, other OEMs have turned to alternative strategies. For example, Daimler is looking to assemble a European contender under its 'moovel' subsidiary, purchasing a majority stake in Hailo to augment its investments in Blacklane and the previously acquired myTaxi.

In India, the latest entrant in the shared mobility space is Mahindra through the launch of Glyd, a premium app-based taxi service offering to rival Uber and Ola on select routes in Mumbai.



Source: CB Insights

Area of disruption: Influence of car-sharing on vehicle ownership

High influx of VC money, changing consumer preferences in terms of making shared mobility easy to use, enabling network effect in terms of adoption and providing initial incentives for the development of the overall ecosystem. Based on the initial trends and star gazing into the future, it is estimated that:

- about 5.8 million people worldwide share about 86,000 vehicles
- 25% of all car-sharing members will sell a car after joining car-sharing
- 50% of all car-sharing members stop buying cars
- One car-sharing vehicle replaces ~10 ownerships

Although it is difficult to predict the impact of disruption as estimates tend to vary drastically, the following are industry estimates capturing the impact of carpooling on the automotive industry.

- Car-sharing market to reach $16.5 billion by 2024
- Various industry analysts suggest that car-sharing will reduce vehicle sales by 550,000 to 650,000 units worldwide by 2021
- Despite a shift towards shared mobility, vehicle unit sales will continue to grow but likely at a lower rate of around 2% per annum
- The automotive revenue pool will grow and diversify with new services (shared mobility, data connectivity), potentially becoming a $1.5 trillion market in 2030

While contributing towards sustainability, carpooling will have an impact on both OEMs and dealers alike. The short-term impact seen in India has given a boost to automobile sales as new business models like Uber and Ola are making it possible for drivers to go in for car ownership given the steady flow of income and sustainability. The long-term impact on new car sales will be that one shared car is expected to replace 10 new car sales. While this will have several inbuilt assumptions, one cannot step away from a volume impact. However, OEMs can compensate for the lost profit by adding revenue from car-sharing business, whereas dealers are unlikely to do so. The current dealer environment allows limited manoeuvring space to react to a changing market situation.

Companies leading the race to the future

OEMs too have started investing in their own shared mobility services. For instance, General Motor, BMW and Daimler are coming with their shared mobility services Maven, BMWi and Car2Go, respectively. In India, as previously mentioned, OEMs such as Mahindra and Maruti are partnering with Ola. While there are multiple business models in this domain, the Indian market is largely dominated by independent service providers.

Company	Details
BlaBlaCar	Launched in India in January 2015, it has successfully completed 18 million rides in 18 months.
SRIDE	Launched in November 2014, it focuses on corporate carpooling. In 2015, the company had more than 1,500 users across India.
uberPOOL	Launched in India in September 2015, 25% of Uber users in key Indian cities use Uber Pool.
OLASHARE	Launched in October 2015, it has grown 500% in terms of number of rides in one year. More than 20 million carpool rides have been pre-sold through the Share Pass subscription.
carpool by MERU	Launched in September 2015, Meru Cab provides an option to passenger for sharing their rides with people travelling in the same direction promising in return for a fixed 30% discount on estimated trip fare. The company has partnered with IOCL to promote carpooling.
ryde	Ibibo Group launched its carpooling app in April 2015. It offers both inter-city and intra-city rides.
Quick Ride	Launched in September 2015, it had more than 4,000 registered users and an average of 130 rides per day within four months of its launch.
Zify	Launched in February 2014, Zify offers both intra-city and inter-city ride-sharing. It recently expanded its presence to Europe.

Source: Grant Thornton analysis

Key success factors for shared mobility

The success of shared mobility is dependent on a shift in consumer attitude away from private car ownership to recognise the benefits of shared mobility. Private cars are underutilised at a rate of 5%, resulting in poor asset utilisation. Shared mobility allows for improved asset use efficiency and monetisation opportunities. In addition, consumers pay lesser per use of shared vehicles in comparison to the high upfront cost and maintenance costs of private vehicles.

Autonomous driving and connected cars

Disruptive trends: Autonomous driving and connected cars

Global	Local	Technology	Infra and regulatory
• Connected car market to grow at a five-year CAGR of 46% — 10× faster than the overall car market • By 2020, about 75% of cars shipped globally will have built-in internet-connection hardware	• Connected car market ecosystem in India expanding fast with players cutting across on-board diagnostic (OBD)-based connected car solutions, fleet telematics, vehicle navigation • India's connected car market expected to grow at a 60% CAGR	• Fleet telematics • Vehicle-to-vehicle communication • Driver assistance • Vehicle cybersecurity • Driver safety tools	• Telecommunication regulations • Automotive and road regulations • Privacy and data protection laws • Consumer protection laws

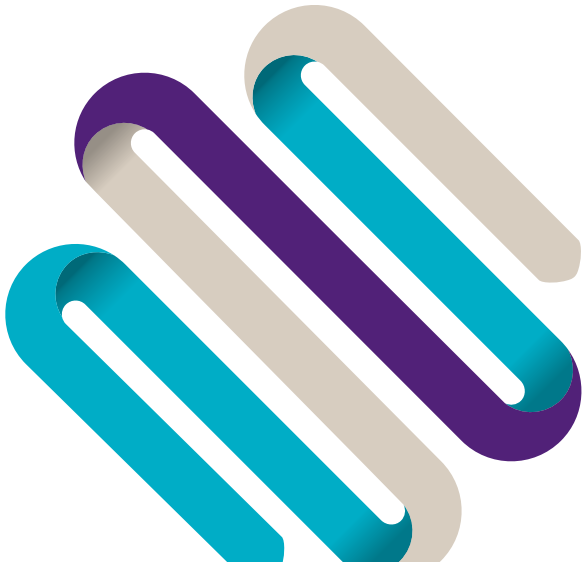
Source: Grant Thornton analysis

Levels of autonomous driving

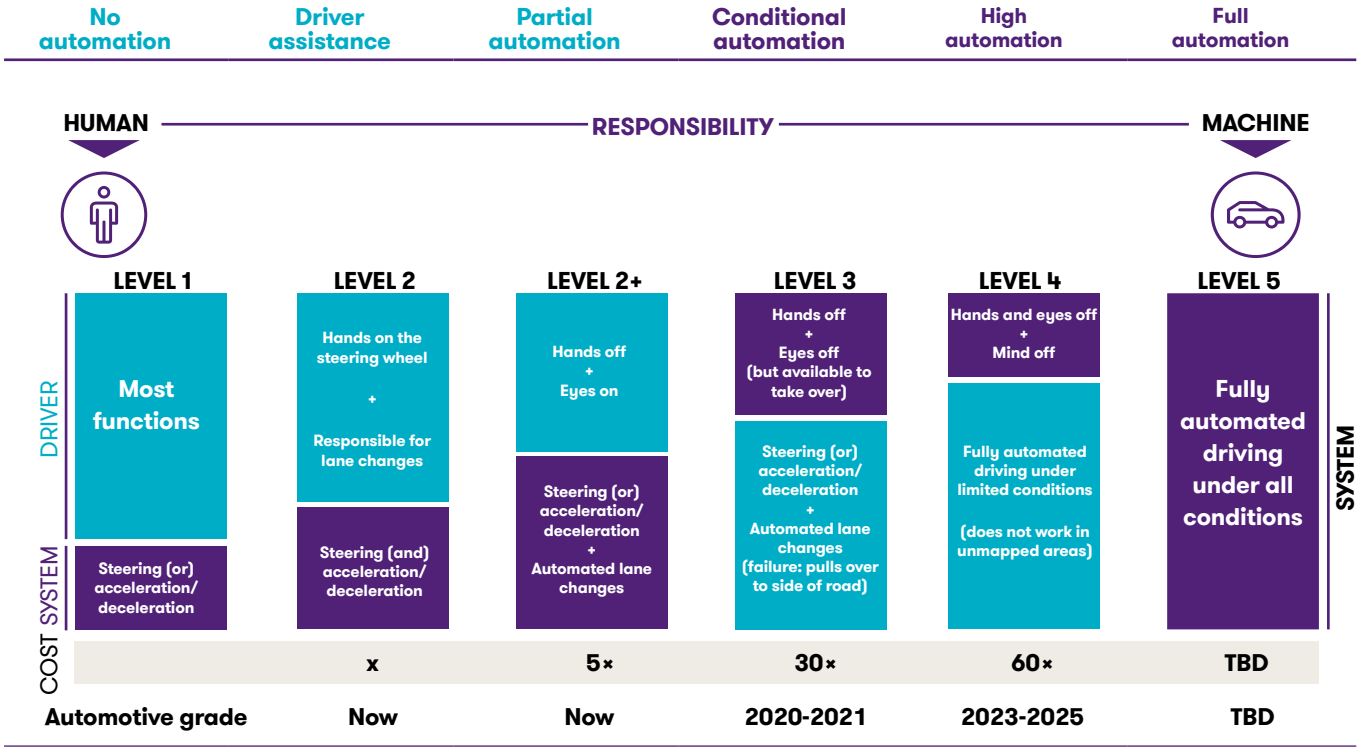
The journey that started towards providing convenience to the vehicle owner has now transformed into a race to eliminate human intervention in driving. A new car owner who moves from a connected home environment where, for example, the smartphone is integrated into the home music infrastructure to a smart vehicle environment will have high expectations of receiving the same, or higher, levels of connectedness in terms of vehicle features, infotainment, etc. OEMs are now moving towards the development of vehicles that can not only provide a number of features but also interact with each other as well as with the external environment and humans. The final intent would be to provide all the current features plus a plethora of new features as an exhaustive package. The consumer touch point could either be through an embedded system in the car or an external wireless device such as a smartphone, tablet or watch. This journey will eventually enable the automobile industry to develop autonomous cars.

To capture this journey in a defined manner, organisations such as the Society of Automotive Engineers (SAE) International, German Federal Highway Research Institute (BASt) and the National Highway Traffic Safety Administration (NHTSA) have defined six levels of autonomous driving. Of these, we have already achieved the first three, while the fourth and fifth are not distant from reality. It is interesting to watch non-traditional players from the software domain (Alphabet, Apple, etc.) and tier Is (Delphi Bosch, etc.) competing head to head against the established global OEMs to reach level 4.

The diagram below summarises the nuances of various levels of autonomous driving models with cost and time-to-market aspects and relevant examples.



Levels of autonomous driving

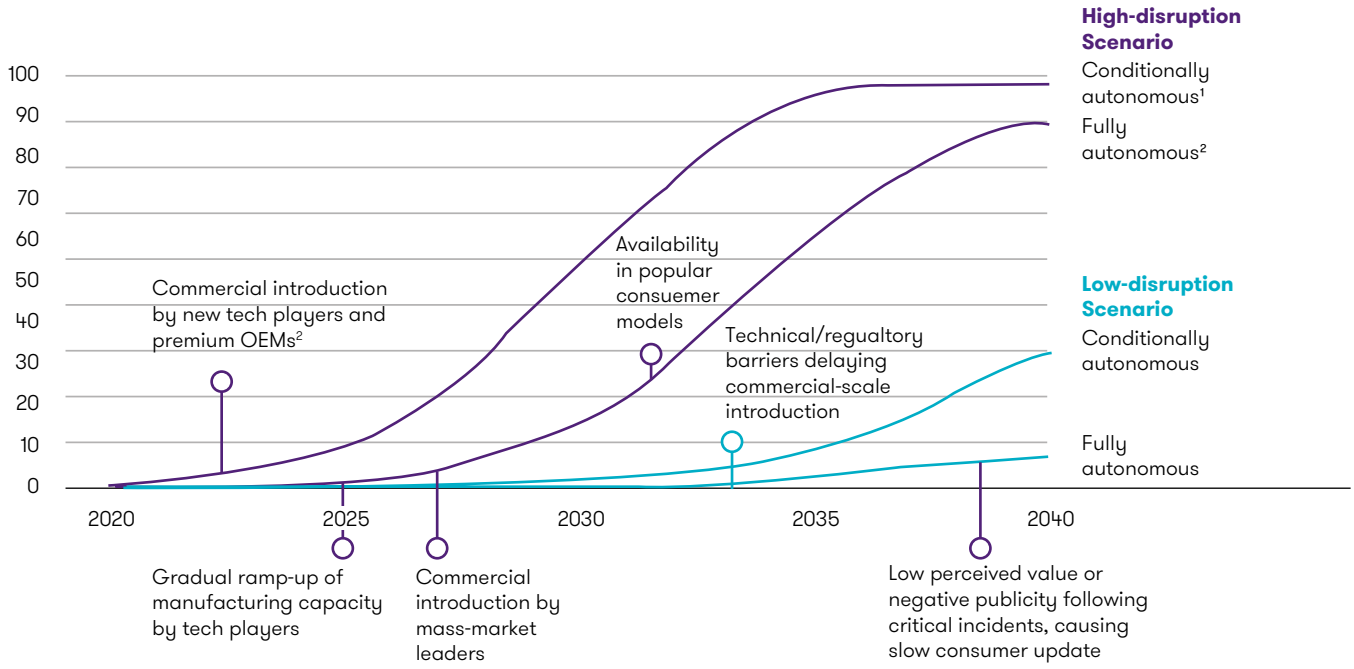


All cars	Any car with adaptive cruise control or lane-keep technology is at least a level 1 vehicle	Any car with advanced driver assistance system (ADAS), eg General Motors Super Cruise, Mercedes-Benz Distronic Plus, Nissan ProPilot Assist and Tesla Autopilot	Alphabet (2013), Audi A8 (awaiting legal approval for Audi AI Traffic Jam Pilot)	All cars in testing phase: Google Waymo, GM Cruise (Chevrolet Bolt-based vehicles)	None (in concept or testing phase) Traditional: GM, BMW Non-traditional: Alphabet, Apple JV: Volvo-Uber

Source: Grant Thornton Analysis

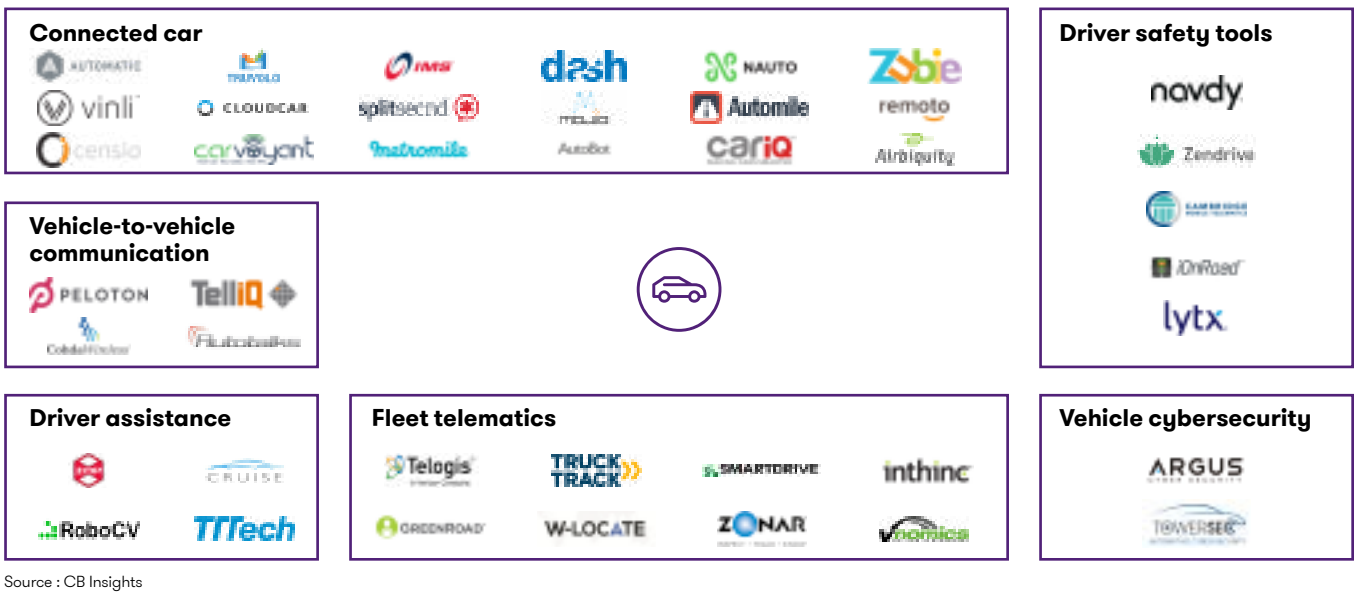
Based on the stages above of automation and the current levels of automation, one can predict the potential market share these autonomous vehicles could capture by 2040. The chart depicted below provides highlights of the rate of adoption of level 3 and 5 autonomous vehicles under optimistic and conservative scenarios along key milestones and barriers.

New vehicle market share of autonomous vehicles (%)



Source: Morgan Stanley

Global scenario: Innovation across the automotive landscape



Source : CB Insights

Volvo's self-driving car venture gets the nod to test on Swedish roads

In January 2019, Volvo Cars' joint venture won the approval to begin hands-free testing of its software for self-driving cars on Swedish highways. Securing permissions had become tougher after a deadly accident involving a self-driving car that Uber was testing using its own software in a Volvo vehicle.

A software by Zenuity (formed by Volvo and Veoneer in 2017) for Level 4 autonomous driving — the second highest level — would be tested in a Volvo car by trained drivers with their hands off the steering wheel at a maximum speed of 80 kmph. Zenuity has already been running some tests in Sweden after Volvo last year won permission to test cars with self-driving features, but with the requirement that drivers keep at least one hand on the wheel at all times and cars do not exceed 60 kmph. These real-life tests are essential for gathering important data and test functions and generate a strong proof-point for the progress of Zenuity's self-driving capabilities.

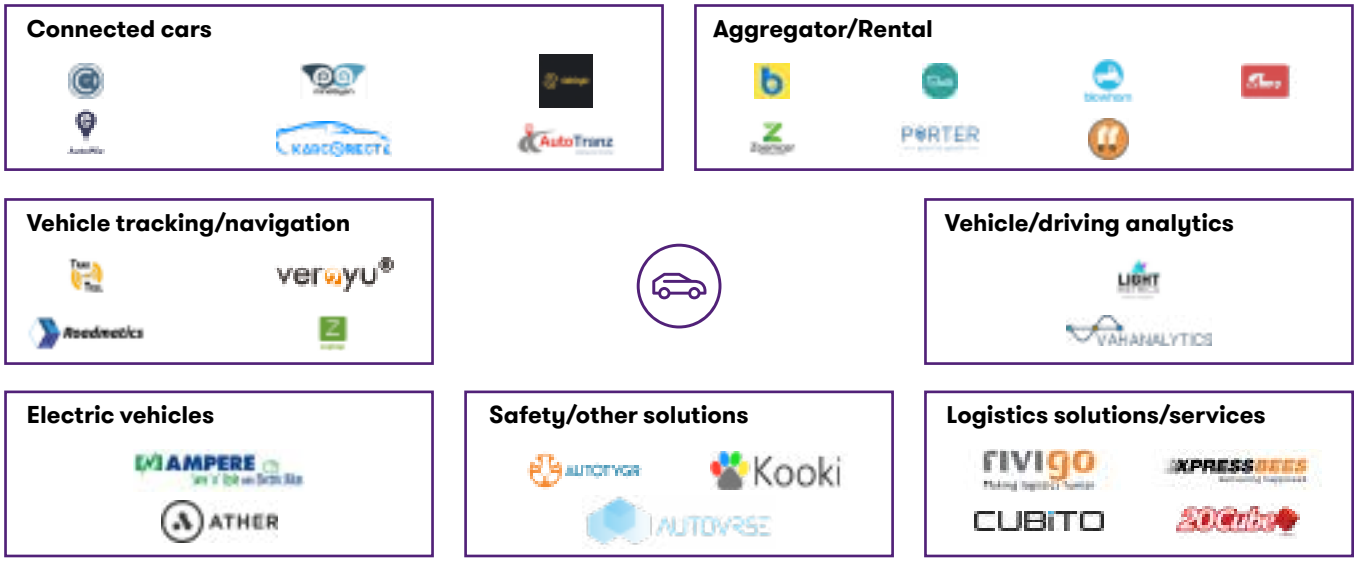
US companies are currently leading the pack, with Google's Waymo last year winning the first approval to test cars without safety drivers on Californian public roads. General Motors' Cruise has said it is ready to deploy a self-driving car with no manual controls, while Germany's BMW and Audi have also secured licences to test their vehicles. The venture is striving to keep up with larger rivals in the race to develop self-driving vehicles.

Volvo has its own goals of delivering self-driving cars sometime after 2021 and deriving a third of its sales from fully autonomous cars by 2025. In 2017, it also formed a venture with Baidu to use the Chinese company's autonomous driving software Apollo to develop a level 4 car.

- As an example of AI in autonomous vehicles, Flux Auto is developing a modular self-driving technology for new and existing commercial vehicles. This is done through features like AI assisting with cruise control, lane keeping, and collision avoidance.
- ATImotors designs autonomous all-electric cargo vehicles, with a major focus on customers outside India. The device Driveri has intelligent and situationally aware cameras that connect the devices over a global network.
- Auro Robotics is working on autonomous shuttles currently in a campus trial stage, at the University of Santa Clara. Two separate models of their shuttles are being developed depending on the needs of the area, with vehicles that can either follow a closed loop route with predefined stops or be called on-demand to pick and drop at user defined location.

The Indian scenario: Innovation across the automotive landscape

The Indian scenario: Innovation across the automotive landscape



Source: Grant Thornton research

Investments are being made by global companies, Indian OEMs, Indian tech firms and, most notably, by various Indian start-ups:

Global tier 1/start-ups	Bosch	India is one of the three locations of Bosch Center for Artificial Intelligence (BCAI): Around 18,000 of Bosch's 31,000 associates in India work in research and development (R&D). This underlines India's importance for the Bosch Group's global network as more and more innovations are coming out of the country. India also plays a significant role when it comes to AI. According to Bosch Group CEO Volkmar Denner, "Most of the products in the near future will be linked to artificial intelligence. These products will either possess that intelligence themselves, or AI will play a key role in their development or manufacture". In 2017, the company invested EUR 300 million in its BCAI across three continents – one of the main locations being in Bengaluru, India – along with centres in Sunnyvale, USA, and Renningen, Germany. Bosch in India has also partnered with IIT-Madras (IIT-M) and set up a Robert Bosch Centre for Data Science and Artificial Intelligence at IIT-M with a fund of INR 4 crore per year for five years. It will set a precedent in the way big data is used to improve the company's problem-solving capability in the industry. At the same time, the collaboration will result in shared outcomes for the benefit of society.
	Autolabs	German start-up German Autolabs is putting its digital driving assistant 'Chris' into Indian cars starting next year. It is a voice-controlled digital assistant that allows drivers to make phone calls, send messages, listen to music and get navigation guides without ever touching their smartphones. Chris is attached to the windscreen like a navigation device and paired with the mobile phone via bluetooth so every vehicle turns into a connected car with high-end features. The full proactive digital assistant understands simple gestures and displays relevant information on a colour screen.

Indian OEMs		Development of autonomous vehicles in India is being spearheaded by key local automakers, such as Mahindra & Mahindra and Tata Motors. For example, Minda iConnect and Microsoft India recently announced a strategic collaboration to locally develop connected vehicle technologies and enhanced driving experiences. There are currently more than 25 R&D centres within the Indian auto sector, which accounts for about 10% of domestic R&D expenditure. The government wants to halve India's dependence on oil imports by 2030, as well as reduce carbon emissions as a part of its commitment to the Paris Agreement.
Indian tech firms	Hi-Tech Robotics Systemz	Novus-Drive is a completely autonomous electric vehicle by Hi-Tech Robotic Systemz. It lets passengers manage destinations and utilise cloud-based intelligence for a fleet management system. It also offers core competencies in ML, sensor fusion, computer vision technologies, motion planning and control, amongst others.
	TCS	A number of companies in India have taken a step to change India's perspective of self-driving technology at a global level. For example, Tata is willing to invest in this field, TCS is developing self-driving Nano, Infosys is working on a self-driving rickshaw and Tech Mahindra has reported interest in working on an autonomous driving system.
	Omnipresent Robot	OmniPresent Robot is one of India's leading robotics manufacturer, which manufactures drones for industrial inspections, as well as driverless cars.
	Tata Elxsi	Tata Elxsi, a design firm part of the Tata Group, is currently seeking permission from authorities in Bengaluru to road-test an autonomous car.
Indian start-ups		Ola has raised $1.1 billion to invest in AI and ML capabilities. Swaayatt Robots is developing on-road and off-road self-driving technology that is designed for use in India's extremely difficult traffic scenarios and unstructured environmental conditions by enabling self-driving vehicles to perceive their environments using off-the-shelf cameras. Intuition Systems is a Bengaluru-based AI startup that is foraying into the automotive industry focused on developing urban commuter automobiles, currently named 'Project-Puli', under the brand name Kat Motors. The vehicle will be intelligent, semi-autonomous, electric and hybrid, pollution free, cost-effective and reliable and exclusively designed to serve crowded Indian and Asian cities. It will be powered by an AI platform called 'Ive', which is an extension of its proprietary AI platform used for the payments and point of sale (POS) industry. The first vehicle will be introduced by 2020, and simultaneously the feasibility of efficient, autonomous airborne consumer transportation vehicles will be tested to take the load off Indian roads. SeDriCa is an autonomous ground vehicle by IIT Bombay's Innovation Cell, which plans to use global positioning system (GPS)/inertial navigation system (INS), light detection and ranging (LiDAR) and stereo cameras to gather information about the immediate environment at different ranges. Another project Aerodrive, by the Indian start-up Fisheyebox, is aimed at making low-tech cars loaded with cameras, sensors and antennae, as well as voice recognition software that allows control of the car by voice command.

Indian OEMs and tier 1 suppliers are also fairly active on both the acquisition and alliance fronts as is evident from the recent activity of Mahindra & Mahindra, Bharat Forge, JBM, etc., in the new auto-tech space:

Acquisitions and investments

Date	Investor	Target	Deal value ($ million)	Stake (%)	Rationale
February 2018	Mahindra & Mahindra	Zoomcar	40	16%	To enter the shared mobility space
February 2018	Bharat Forge	Tork Motors	5	45%	To leverage Tork Motor's knowledge in EV powertrain and access to technologies in the personal e-mobility space
February 2018	Mahindra & Mahindra	Carnot Technologies	1	23%	To develop IT solutions for its products leveraging Carnot Technologies' CarSense, a smart car device which can be plugged into the OBD port of the car
June 2018	Bharat Forge	Tevva	14	35%	To focus on EV powertrain solutions for India and worldwide which can be extended for the development of commercial vehicles

Source : Grant Thornton analysis

Joint ventures

Date	Joint Venture	Rationale
March 2018	Mahindra and Ford	Manufacturing of connected vehicle projects, electric battery vehicles, development of compact sports utility vehicles, B-segment electric SUVs and power trains
February 2018	Mahindra and LG Chem	LG Chem will develop a unique cell exclusively for Indian application and will also supply Li-ion cells based on Nickel-Manganese-Cobalt (NMC) chemistry with high energy density
November 2017	Toyota and Suzuki	Suzuki will produce EVs for the Indian market and will supply to Toyota as well, while Toyota will provide technical support.
September 2017	Suzuki Motor (50%), Toshiba (40%) and Denso (10%)	With an initial investment of INR 11.8 billion, the JV between the companies will be focused on the production of automotive lithium-ion battery packs in India
July 2016	JBM Auto and Solaris Bus & Coach	The JV is for the engineering, designing and developing of fully electric and hybrid buses in India

Source : Grant Thornton analysis

New product development imperatives

In these times of technological disruption and fast-paced and dynamic business environment, successful breakthrough of new product is of utmost importance for survival and success of the existing players in the market. In the automotive industry, these changing dynamics have had the most direct impact on the new product development (NPD) cycles that the players experience. Automotive companies have traditionally been used to predictable NPD cycles which have been fine-tuned over the last few decades of functioning. However, there are several factors which are impacting the overall NPD cycles, which are listed below:

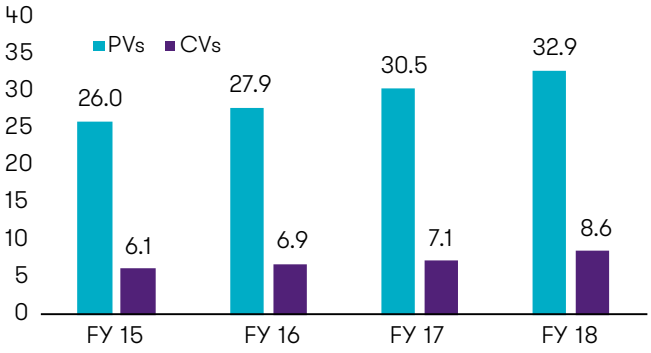
Technology-led	**New technology adoption**	Electrification of cars and the emergence of 'connected cars' have paved the way for NPD by unlocking multiple opportunities for NPD. For example, automakers are exploring various alternatives for the existing Li-ion battery packs in EVs like graphene-based battery packs, battery swapping mechanism, etc.
	New players in the auto ecosystem	Entry of new players in the domain has increased the already fierce competition with new players combining their existing capabilities with their vision for innovation to add new dimensions to the product portfolio. For example, Apple and Google offer infotainment products, CarPlay and Google Android Auto respectively. Google has also ventured into the development of autonomous car technology and vehicle prototypes.
OEM-led	**Change in OEM expectations**	Auto manufacturers are gradually shifting their process outsourcing strategy to OEMs from the 'build-to-print' model to the 'design-for-manufacturing' (DFM) model, which allows them to transfer responsibility partly and shrink overhead costs resulting in increased focus on their core competencies.
	Alliances towards sharing of platform to generate economies of scale	Auto manufacturers are forming strategic alliances to benefit from the synergy created by combining their specialised capabilities in shared vehicle platforms. Ford India and Mahindra & Mahindra have established a partnership to share vehicle architecture, electric powertrains and common sourcing and leverage each other's distribution network. Nissan and Renault have extended their alliance to become a leader in electrification and build on its current competitive position.
Business model-led	**IOT-led product development**	IOT has acted an enabler for various disruptions in the auto industry like connected mobility, vehicle-to-vehicle (V2V) communication and vehicle-to-everything (V2X), leading to a need for the development of various integrated and centralised devices which will be relaying information between each other.
	Bundling software and hardware could lead to new ways for product updates	The modifiability of a product throughout its lifecycle to enable its continuous development has developed a potential to alter product strategies of auto manufacturers. As functionalities can be modified and activated by updating software, a manufacturer can continue to sell additional features of a product throughout its lifetime. For example, Tesla has led this change through remote OTA updates for Tesla cars.

Source: Grant Thornton analysis

Changing consumer preferences

India is already the fourth largest automobile market in the world globally, contributing nearly 12 million vehicles (excluding two- and three-wheelers) in 2017-18. Sales grew by 9.5% yoy in FY 18 and are expected to grow further, which has led to auto companies trying to understand the Indian consumers' needs and designing the appropriate models for the Indian consumer. Automotive car manufacturers across the spectrum are now spending the requisite time and money to understand the Indian consumer psyche better.

Car Sales in India (Units in Lacs)



Source: SIAM

The automotive market (passenger as well as commercial segment) is among the most competitive markets globally. In India, for example, there are about 20 major OEMs (domestic and international) offering multiple variants of models to the consumers.

With a rapidly changing landscape (from a design as well as technology perspective), it is imperative for the OEMs to be agile and be able to address changing market needs with respect to product as well as channels. Changing customer profiles and evolving needs driven by increased penetration of technology have brought about changes in expectations and preferences of customers. Differing expectations of mobility and disruptions of ownership models will change OEM engagement with customers, and this shift in buying behaviour presents opportunities as well as challenges for OEMs. Market research suggests that today, customers demand real-time satisfaction, transparency, control, convenience and uniqueness in both product and experience.

Auto manufacturers are now extending their selling channels from offline to online modes by enabling ordering of vehicles online by selecting amongst the different variants. This is primarily to enhance the buying experience for customers by offering more flexible and transparent customer solutions that meet their expectations. Auto makers Jaguar Land Rover and BMW India have launched online sales channels where customers can compare specifications, use the car configurator, view financing options and payment methods, choose preferred dealership, book a test drive and get instant consultation before finalising the purchase of a vehicle. Recently, Hyundai opened bookings online for the Santro, and it received a positive response.

The increasing proliferation of various technological developments has led to rapid digitisation, bringing about a need for products cutting across dimensions by integrating mobility and connectivity, thereby leveraging technology to integrate with the consumers' lifestyles. This suggests that going forward, the lines between humans and machines and between goods and services will blur as connectivity and data are used interchangeably and freely.

Changing customer profiles suggest that an average consumer today is more tech-savvy and product research oriented. Multiple social media platforms and widely followed trade journalists, providing tons of data, feedback and reviews on any product, have given rise to an 'empowered' customer, all at a click of a button. Market research suggests that nearly 50% of auto buyers typically consult at least one social media platform prior to purchase.

Having a vocal potential customer base can act as an advantage with many consumers discussing their experiences, thoughts and opinions on products across platforms. The ability to tap this data and analyse it for targeted marketing could present a huge opportunity for auto manufacturers.

Changing Consumer Preferences

Megatrends	+	Improved consumer insights	=	NPD impact
Population overflow Collaborative transport approaches; changing operating models of ownership		**Changing mix of buyers** By 2020, ~40% of new car buyers will be millennials/Gen Y		**Changing business models** Gen Y is interested in owning/leasing but feel owning a car is not necessary
Generational views Gen Y is more interested in operating models that ease mobility & connectivity		**Increasing proliferation of Tech.** Gen Y are conversant with trends and technology like AI, IoT, AR, ML etc.		**Driving a new engine** Gen Y aspire to drive new-engine car, and are willing to pay a premium for it
Connected tech. & data generation Consumers now integrate technology & lifestyle, which can generate tons of data		**Intelligent and informed consumer** Average consumer today is more tech-savvy and product research oriented		**Autonomous cars** Increasing interest in emerging markets for higher levels of autonomy in cars
Sustainability concerns OEMs being challenged to develop fuel-efficient engines & alternative powertrains		**Market insight, brand recall** Imperative for OEMs to not just focus sales volume but understand the reasons		**Attractive features** Autonomous way to identify other vehicles on road & steer away from them

Source: Grant Thornton analysis

Emerging trends in R&D to drive NPD

The automotive industry is the largest contributor to the aggregate global R&D spend, accounting for nearly 16%, at ~$130 billion, and is growing annually at 6%-7%. Top 5 global auto R&D spenders together contribute ~40% of this quantum.

Total R&D Spend in the Auto Industry	$130 billion
Top 5 spenders	**Spend**
Volkswagen	$14.5 billion
Daimler	$9.6 billion
Toyota Motors	$9.5 billion
Robert Bosch	$8 billion
Ford Motors	$8 billion

Source: Zinnov Zones 2018

Key imperatives for increased R&D for auto NPD

The time to market in the auto industry has dramatically reduced to less than two years in recent times (almost ~70% auto manufacturers agree to this). This clearly indicates one key aspect, viz, the auto product development cycle is steadily inching towards that of consumer electronics.

The key reasons for a faster time to market are urgent need to address market demand, supply chain efficiencies and technological advancement. Further, key attributes for shorter product development cycles include consolidation of vehicle platforms, convergence of automotive and consumer electronics, and expanded manufacturing capabilities.

Parameter	Description
Increased proliferation of SKUs	New, emerging technologies are increasing SKUs/platforms but are also creating gaps between desired and actual outcome due to difficulties in building, maintaining and sustaining these platforms, constraining the OEMs.
Quicker time to market	Urgency for faster time to market is due to increased competition. OEMs are looking for generic platforms that create agile systems resulting in efficiency, scalability and sustainability.
Rapid digitisation	Extensive proliferation of new-age technology is leading to rapid digitisation, thereby creating a need for end-to-end engineering services, customer-centric design and, consequently, increasing R&D potential.
Industrial automation	The use of automation is increasing (due to the need for improved efficiencies and challenges in replacing legacy engineering workforce).
Requirement for specialised knowledge	The proliferation of technical knowledge is resulting in ever-increasing customer demands – hence the need for niche sub-segments to bring out key nuances.
Pressure for higher margins	Increasing margin pressures on MNCs are leading to a shift of smaller R&D modules to low-cost countries (eg through offshore R&D centres, techno-commercial contracts, joint ventures, etc.)

Source: Grant Thornton analysis

Key challenges in reducing automotive product development cycles

Although companies of all sizes are experiencing shortened automotive product development cycles, it also appears that they are having issues keeping up with the changes. Regardless, there are challenges all companies face in compressing their product development cycles, with testing, supply chain and manufacturing taking the top three spots.

If automotive industry trends from the last five years are any indication, product development cycles are expected to shorten even further. In fact, two out of three automotive manufacturers believe their go-to-market cycles will get faster in the next five years. This means automotive manufacturers must be proactive to solve the challenges they are facing in compressing their go-to-market timelines.

Through the convergence of consumer electronics and automotive technology, the industry has been flooded with new entrants over the last decade. In the entire automotive ecosystem, it is the tier 1 suppliers who seem to be the most affected by this than automotive OEMs. Over 50% of the tier 1 suppliers believe that they would play a pivotal role in driving transformation technology through NPD.

There is an urgent need to marry consumer expectations with the potential solutions from within the industry to bridge the existing gap in demand and supply. From the perspective of R&D and new product development, we understand that the following factors are expected to play a pivotal role in determining the way ahead for NPD through increased proliferation of R&D in the automotive sector, and that these specific avenues would play a crucial role in times to come.

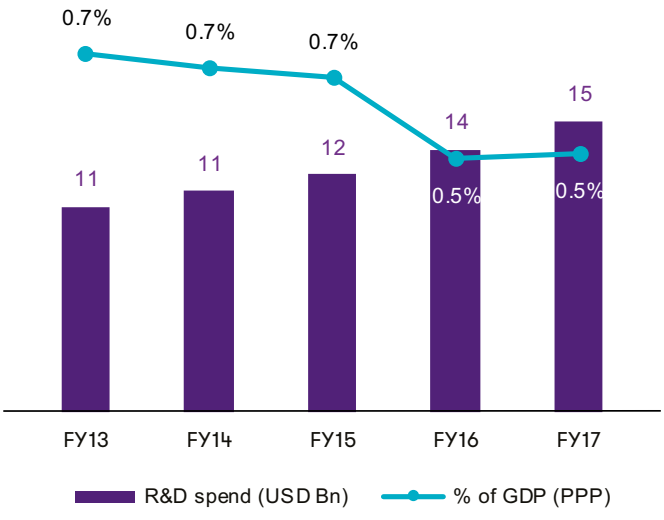
Parameter	Description
Autonomous, connected and shared mobility	During 2015-2025, the top 10 global OEMs are expected to spend cumulatively ~$230 billion on autonomous and connected technologies. Asian OEMs are focusing on in-house R&D, while European and American OEMs are more focused on outsourcing R&D and collaborating through partnerships and acquisitions in this segment. The key emerging areas are Sensors/semiconductors and autonomous solutions (computer hardware, software, V2X connectivity, testing and validation) Connected technologies primarily include telematics, user-interface technologies, back-end and cybersecurity, gesture/voice recognition and parking and mobility optimisation.
Emergence of hybrid and electric cars	During 2015-2025, the top 10 global OEMs are expected to spend cumulatively ~$116 billion on electrification technologies with a focus on battery technology and charging infrastructure, primarily due to the urgent need to comply with stringent carbon emission norms and enable smart mobility solutions including shared vehicle solutions. EVs and HEVs are expected to account for ~30% of all vehicles globally by 2025 from ~1.3% in 2017, growing at a CAGR of ~27%.
Increasing spend on electronics and focus on vehicular weight reduction	It is estimated that a 10% reduction in a car's weight can boost its mileage by 6%-8%; vehicular weight reduction R&D is primarily being done in chassis, powertrain, body and other exterior components that account for ~80% of the weight of an average vehicle.

Source: Grant Thornton analysis

Indian R&D landscape

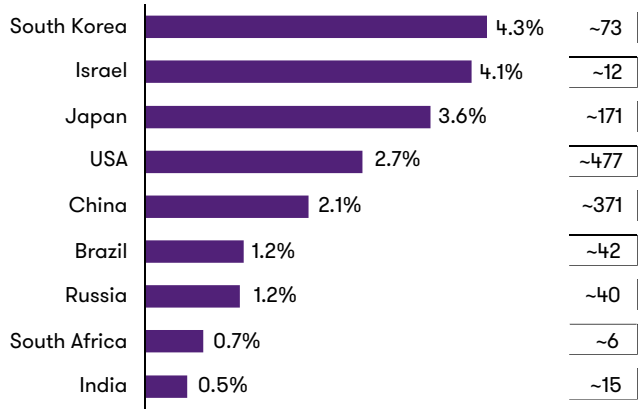
R&D spend in India has grown by ~40% in the last five years; However, India's R&D spend is significantly lower than other major countries in actual and/or percentage GDP terms. Public R&D spend (~60%) exceeds private R&D spend (~35%) and university R&D spend (~5%) in India. A major part of the private R&D spend is in the auto sector. With ~150 researchers per million inhabitants, India severely lags behind the world average of ~3,500.

R&D expenditure in India



Source: UNESCO

R&D spend (% of GDP, $b)



R&D outsourcing trends

An emerging trend observed in the automotive sector (among other segments as well) is the increase in outsourcing of certain core and non-core R&D activities. However, the majority of the outsourced R&D comprises non-core R&D activities:

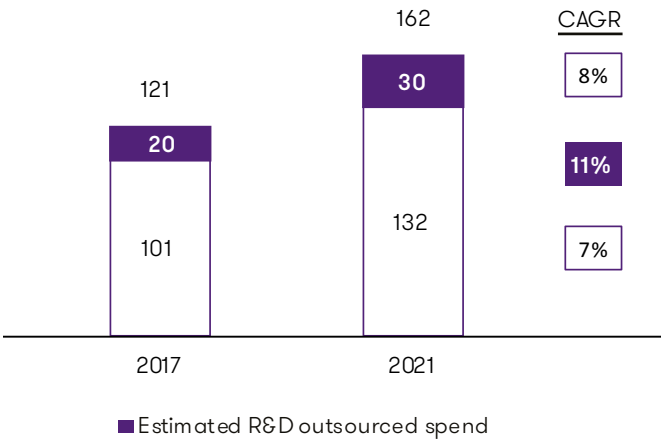
Drivers to R&D outsourcing essentially are:

- Access to specialised skillset
- Need to solve a critical design challenge within a specified timeframe
- Need for a shorter time to market
- Extending product lifecycles

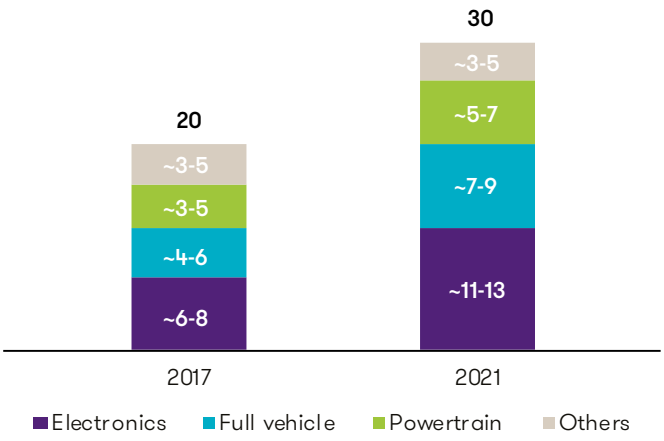
Some indicative trends across the auto sector are as follows:

- Electronic vehicles: Electronics, vehicle body and powertrain are expected to be key drivers for R&D outsourcing. In 2017, these cumulatively comprised of ~ 80% of all outsourced R&D, and it is estimated that by 2021, this share would have grown to 88%.
- New tech areas: Development of products for electrification or manufacturing connected cars, autonomous vehicles, etc. is expected to be a key growth driver for automotive R&D outsourcing.
- Lighter vehicle body: Use of composites and plastic components for the car body as a substitute of metal has emerged as a key trend, which has led to an increase in R&D outsourcing.

Global R&D spend in automotive ($ billion)



Estimated split of outsourced R&D spend ($ billion)



Source: Grant Thornton Analysis

Powergear R&D Services

Startup pioneering R&D outsourcing services

- Powergear R&D Services provides end-to-end R&D services across multiple sectors by leveraging its diverse technical experience in fundamental and applied research and state-of-the-art R&D labs and manufacturing facilities. It has filed multiple patent disclosures over the years.
- It has technological expertise in power electronics, embedded systems, micro-electro-mechanical systems (MEMS), optics, material science and electromagnetics amongst others.
- Its key markets are automotive, energy, aviation, industrial, consumer electronics, biotechnology and medical devices.

Business intelligence

Identify customer needs, map IP whitespace, make recommendations to R&D team

Product Initiation (Evaluate market leader)

- Industry trend analysis
- Market research
- Customer requirement
- Competition analysis

Fundamental innovation

Generate IP and new research concepts based on fundamental and applied research

Research phase (Demonstrate the concept)

- Concept development, pre-NPI
- Benchtop experiments
- IP analysis, disclosures
- Down-select working concept

NPI – Global/ India focus

Develop/adapt products based on global customer needs, features and price

NPI phase (Concept to production)

- Analysis of design and systems
- Prototype testing and sampling
- Freeze specifications
- Customise and manufacture products

Select work

- Development of sensor unit for healthcare
- Development of arc proof protection panel
- Development of compact protection and control panel
- Development of EV technologies
- Development of smart telemetry unit
- Development of smart energy meters
- Development of smart solar heater

Source: Grant Thornton analysis

Industry 4.0: Impact on NPD

Industry 4.0, which includes cyber systems, IoT, cloud computing and is designed to automate manufacturing technologies, refers to the seamless integration of physical objects into the information network. The idea is to have an intelligent real-time, horizontal and vertical integration of machines and human workers with information and communication systems. A 'smart factory', as per Industry 4.0, creates a virtual replica of the real world to take decentralised and quicker, automated decisions in real time.

The following are a few major changes that the fourth industrial revolution can bring to the automotive industry:

Flexible manufacturing setups	In order to cope with the rapidly changing customer expectations, it is imperative that auto manufacturers have manufacturing setups that are agile and have the ability to shift production from one type of vehicle to another. Automakers need to focus on interchangeable processes and platforms as producing one model cannot sustain an entire factory anymore. It is observed that globally, consumers are shifting rapidly away from traditional sedans in favour of crossovers and SUVs. Such shift in consumer preferences coupled with other market and trade uncertainties which are changing product lifetimes indicate the significance of flexible manufacturing factories to auto manufacturers In the global market, Nissan, Honda Motors and Toyota Motors have been the best at flexible manufacturing according to industry experts.
Virtual prototyping	Auto manufacturers are aiming to move away from using physical prototypes to using virtual fabrication and assembly tools, which is followed by the testing of products in various simulated environments using virtual reality. The existing usage of computer-aided design (CAD) and computer-aided engineering (CAE) systems serves as a good foundation to transition to virtual prototyping, under which one test a car which has been built on a computer rather than one being designed on a computer. Making design reviews more efficient helps to reduce **the time necessary to produce a prototype and the number** of prototypes needed for a vehicle's development. These savings in time and costs associated with NPD are enabling manufacturers to be nimble and more effective in their product strategies. Global players like Seat, Volkswagen, Ford and Renault have already employed such virtual prototyping techniques to their benefit.
3D printing	To stay competitive in a market that is perpetually shrinking the time to market, auto manufacturers need to meet and break new release schedules in their product development cycles. They are resorting to employing 3D printing for rapid prototyping as well as for production of vehicle parts made of high-performance materials. The recent advances in additive manufacturing have resulted in smaller lead times, newer designs and reduction in overall costs, thereby paving the way for novel ways of conceiving and producing motor vehicles. Creating physical prototypes with 3D printing is part of an iterative, agile design and manufacturing process. 3D printing also delivers ultra-high precision parts and superior surface finishes in about 10% of the time it takes to make a traditional casting pattern. This means engineers have the flexibility to print and test multiple gating configurations to ensure the very best investment casts can be made. With a high precision 3D printing process, the parts produced will reflect the CAD data provided, resulting in high-quality. 3D printing for automotive can enable rapid iteration and facilitate complex design, factors that lead to cost reduction and increased speed.

NPD strategy roadmap

To optimise the entire NPD process, it is imperative first to understand the strategic vision and goals that one strives to achieve and at the same time correctly recognise the requisite capability systems and then map these capabilities with the goals. Most NPD goals are associated with developing products that best fit the consumer requirements and minimising the time to market

There are multiple approaches for developing a strategy roadmap that successfully optimises the NPD process. One such approach is to estimate the technological maturity of a business unit or its critical technology elements. This can be done by assessing the technology readiness level (TRL), which examines programme concepts, technology requirements and demonstrated technology capabilities. The use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology. TRLs are classified into nine levels, with the ninth level indicating highest technological maturity. This scale helps categorise development stages, which is helpful to define project scope, progress, timelines, and resource requirements.

All the levels demonstrate a milestone in the development project where significant activities are performed. While it is possible that some stages are not applicable for certain projects, most R&D projects are likely to pass through each level.

TRL	Level description	Technology readiness for NPD
TRL 1	Concept evaluation	• Evaluation of basic principles and translation of scientific research into applied research and development • Conducting paper studies, scientific experiments and performance predictions
TRL 2	Technology evaluation	• Undertaking application-specific simulations/experiments and refining performance predictions • Making a high-level assessment of manufacturing opportunities
TRL 3	Proof-of-concept research	• Identification of critical functionalities and validation of prediction at various component/sub-system level without integration • Identification of basic manufacturing implications and material assessment
TRL 4	Early-stage prototype development	• Validation of components/subsystem in the laboratory or test house environment • Determining interactions with relevant vehicle systems • Determining manufacturing concepts, ability and viability • Identifying processes and determining supply chain requirements
TRL 5	Late-stage prototype development	• Testing with equipment that can simulate and validate all system specifications within a laboratory, test house or test track setting with integrated components • Demonstration of the viability of the technology by performance results and establishment of confidence to select it for new vehicle programme consideration
TRL 6	Simulated environment pilot	• Demonstration of a model or prototype of the technology system or subsystem as part of a vehicle that can simulate and validate all system specifications within a test house, test track or similar operational environment • Validation of technology for a specific vehicle class by performance results
TRL 7	Operational environment demonstration	• Demonstration of multiple prototypes in an operational, on-vehicle environment. • Determination of ultimate performance characteristics and limit testing • The technology performs as required and is found suitable to be incorporated into specific vehicle platform development programmes • Capability exists to produce prototype components in a production-relevant environment.
TRL 8	Final testing and evaluation	• Completion of test and demonstration phases to customer's satisfaction • Technology has proven to work in its final form and under expected conditions • Validation and confirmation of performance
TRL 9	Successful deployment	• Application of the technology in its final form and under real-world conditions. • The success of real-world performance of the technology • The launch of the vehicle or product into the marketplace • Scale up/down technology is in development for other vehicle classes

For a company to be successful in its NPD strategy, it will need a judicious mix of in-house and external capabilities that it needs to leverage to achieve its Big Hairy Audacious Goals (BHAG).

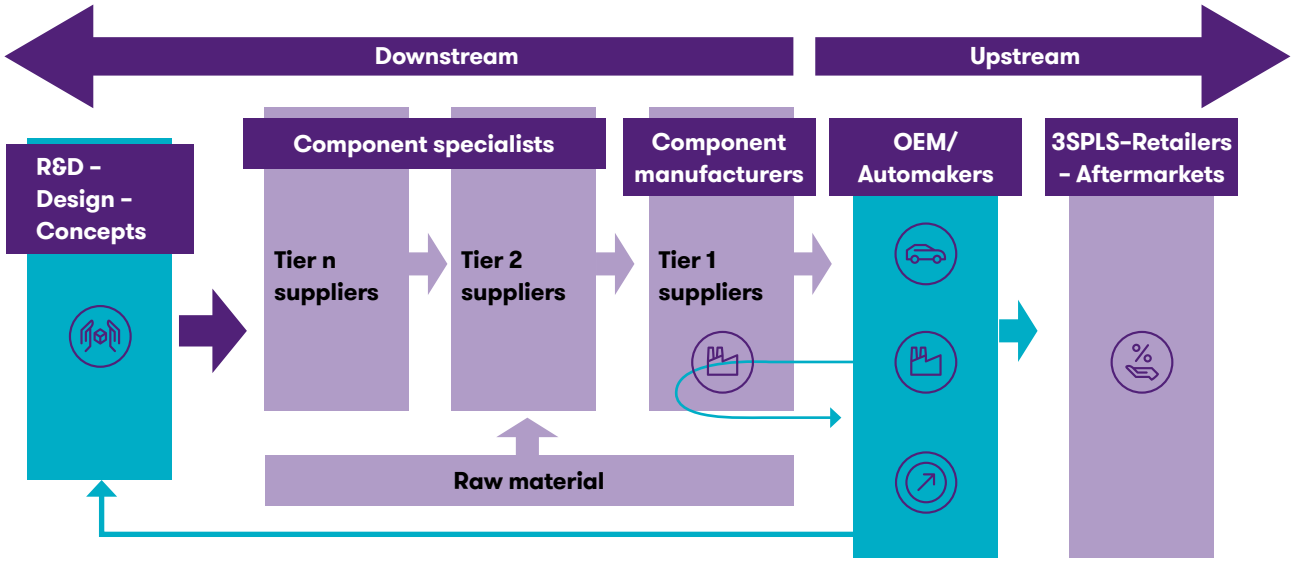
Globalisation imperative

Globalisation is in transition with declining trade intensity in goods, growing trade in services, less labour cost arbitrage, more knowledge intensity, intra-regional trade, growing awareness about climate change and the need to limit global temperature rise to a maximum 2 degree Celsius (Paris Climate Change Declaration). The global automotive sector is moving towards a critical junction which would determine its future growth roadmap. Macro-economic parameters and their subsequent impact on consumer demand have been determining the direction in which the auto sector has been moving. However, in the last few years, technological transformation has changed the way consumers demand.

These new technological interventions have disrupted auto manufacturing processes and given rise to new business models. The most interesting part of the auto journey has been the emergence of new and innovative companies ranging from carmaker Tesla to Ola, Uber and Lyft, which are primarily car-sharing platforms.

Globalisation, coupled with technology breakthroughs, has driven companies' entry into new markets, new and global customers, integrating into global supply chains and, most importantly, gaining technology and innovation expertise.

Interlinkages in the global automotive supply chain



Adapted from Veloso and Kumar (2002) and Stureon et, al (2009).

Globalisation opportunities

	R&D design	Tier 1 suppliers	OEMs	Retailers
Global	New technology tie-ups	Hi-tech player through JV partnerships	Global platforms (Nissan-Renault)	Auto aftermarket players and generic manufacturers
Regional	Hyundai and Mercedes R&D centres	India – SAARC Hungary – Europe Mexico – NAFTA	Toyota-Suzuki for EVs	US aftermarket model - NAPA
Local	Emerging markets (consumer preferences)	Indigenisation (95% of Kwid's components were sourced locally)	Mahindra (Muscular image) OLA, GLYD (shared mobility strategy)	Disintermediation of TVS

The auto industry is extremely concentrated with few nations and companies dominating production. However, the value chain is highly complex primarily due to a growing set of players, interconnected sectors, functions and activities located in separate geographies. Although few companies lead auto production, their supply chain activities (assembly, production, design, testing, R&D and innovation) are present in many locations. Many auto makers with base in OECD nations produce a large percentage of their cars in the developing and emerging nations. For example, Volkswagen and GM produced ~40% of their cars in developing nations in 2017.

The auto value chain has changed with time from being vertically integrated to a highly complex and dispersed production network. In this new network, companies function as tier 1 and 2 suppliers whose supplies are used to make the final automobile product after the OEM has designed the product. Overseas value added in the country's export as a percent of its gross exports tells us the value that is exported due to imports. This is an indication that the international network of production is highly integrated.

Consumption design and demand for value-added vehicles in each country offer additional points of view into the dynamics of the value chain. Brazil, China, Indonesia and Japan, owing to their strong domestic suppliers, are nations where value additions come from domestic companies.

SEZ to create capabilities The most preferred way to create capabilities for new countries	• Costa Rica, Morocco, Dominican Republican and Colombia have emphasised that their SEZs can link the domestic industry to the global auto supply chain. • Dominican Republican SEZ is set to attract domestic and overseas manufacturing companies with special focus on technologically sensitive sectors. • Integrated industrial platforms in Morocco (Tanger and Casablanca) are training specialised workers to develop a global supply chain. • The Grand Project Renault with a capacity of ~3,40,000 vehicles/year is a step towards putting Morocco on the radar of global investors.
Well-managed programmes	• Productive linkage automotive sector in Brazil was envisioned in 2014 with the main intention of providing targeted training to the auto suppliers, who would in turn amplify their manufacturing and innovation skill set. • Proexport Columbia is the governing body for increasing investments, exports and business opportunities between local auto suppliers and overseas companies.
New consumer preferences and association with emerging markets	• Many countries want to gain from the consumer inclination towards light vehicles and increased demand from emerging middle-income groups in developing nations. • Korea has already specified that its OEMs are benefitting from the increased demand from emerging economies like China and India. • Mexico has already manufactured many light vehicles for the US market and hence has a good understanding of expectations from priority markets. • Uruguay had signed the trade agreement with Brazil in 2008 owing to which it was able to strengthen its supply base and respond quickly to changes in the industry. • Maruti has been Suzuki's global growth driver. India would be the prime driver of Suzuki's growth with an estimated production of 2 million by 2020. India's contribution to Suzuki's global car sales is expected to go up from 40% to ~60% by then.

Toyota: A global success exemplar

- Toyota has been able to hold on to the title as the world's most valuable car brand for the sixth year in a row, while Mercedes-Benz passed BMW to finish at the second position for the first time in the annual ranking. Tesla, meanwhile, increased its brand value 60% to get within striking distance of Audi.
- Toyota's brand value increased 5% to nearly $30 billion because of strong demand for its SUVs in Europe and the USA and because of the automaker's consistency.
- The company boasts of internal operations in North America, Latin America, Europe (Germany, France, UK, Italy), Africa, Asia (Thailand, India and Indonesia) and the Middle East.
- It is considered to be a pioneer in reducing production costs and increasing vehicle quality by adopting principles like just in time (JIT) and lean production systems.

Successful strategy in Indonesia

- Toyota first began selling cars in Indonesia in 1971 and began producing them in 1977
- Toyota entered the market via a joint venture with Astra Motor.
- From 2008 to 2012, sales more than doubled from 199,000 units to 409,000 units.
- Four of the top 10 best-selling cars in Indonesia are Toyotas, with the Toyota Avanza taking the clear lead.
- The success of Toyota in Indonesia can be attributed to its 'innovative international multi-purpose vehicle' strategy launched in 2003.
- Specifically, Toyota designed and produced cars in Indonesia to meet the needs of the local market.
- Toyota launched its second auto plant in Indonesia in March 2013 at an investment of $340 million.

Policy and programme initiatives: India's response to global trends

Auto manufacturing in India started in the 1950s, before which cars were mostly imported from England. Economic liberalisation and 100% FDI in the automobile sector gave the right impetus to the auto industry. Since then, companies like Maruti, Mahindra, Bajaj Auto and Hero Motor Corp Ltd have achieved leadership status in their respective domains. Many international players have established manufacturing base, JVs and operations in India. More recently, industry players like PSA Peugeot, Kia Motors, Acura and Lexus have been trying to establish a base in India.

Manufacturing as a percentage of GDP for countries like China, Malaysia and Thailand is in the range of 35%-40%. However, for India the same percentage is relatively lower at 15%, with a 40% contribution from the auto sector.

The Indian auto industry will have to act as a catalyst for economic growth primarily because of its ability to support other manufacturing segments like electronics, plastics, chemicals, steel, aluminium, auto components, etc. apart from creating employment. The auto segment also aids the services sector, which consists of IT, insurance, logistics and transportation, etc. The government of India to be globally competitive has launched several programmes and policies which share a common vision of increased growth of vehicles and leadership status.

Some of the major programmes/policies are as follows:

Automotive Mission Plan (AMP) 2006-2026: Ensuring world class auto manufacturing hub

What is it: In 2006, the government of India launched an AMP, a 10-year roadmap for promoting growth, achieving technological competence and maturity, and accomplishing the status of world-class automotive manufacturing hub with well-evolved forward and backward linkages for sustainable automotive growth.

Focus: The AMP 2006-2016 envisaged a roadmap with growth-oriented targets to achieve the annual turnover to $145 billion. Apart from becoming a major "destination of choice in the world for the automotive engineering and design", the AMP 2006-2016 visualised output accounting for more than 10% of GDP and providing additional employment to 25 million people by 2016.

Achievement

Parameter	Target	Achieved
Combined production of vehicles	192 million units	142 million units
Total production for commercial vehicles	6.7 million units	7.1 million units
Sale of passenger vehicles	27.75 million units	27.91 million units
Jobs created	25 million	32 million
Contribution to GDP	10%	7.2%

Automotive Mission Plan (2016-2026)

What is it: The present AMP 2016-2026 is focused on strategies for enhanced automotive growth, contribution to GDP, minimising carbon footprints and attaining high level of technological competence and maturity. The AMP 2016-26 is being executed with better planning, time-targeted strategies in coordination with all stakeholders to meet the growth and export targets.

Parameter	Target
Revenue	$260 billion to $300 billion
Total production for commercial vehicles	2.0 - 3.9 million units
Sale of passenger vehicles	9.4 - 13.4 million units
Sale of 2-wheelers	50.6 - 55.5 million
Jobs created	65 million
Contribution to GDP	12%
Exports	35%-40% of overall output

In addition, the AMP 2026 envisaged end-of-life policy of vehicles, universalisation of BS-IV norms and upgrade to BS-V/VI emission norms. Currently, the BS-IV norms are being implemented across the country from 1 April 2017 and BS-VI norms (leapfrogging) are to be adopted by April 2020 as notified on 16 September 2016 by the Ministry of Road Transport and Highways.

National Electric Mobility Mission Plan (NEMMP) 2020: Addressing climate change and energy security needs

What is it: NEMMP 2020 was launched in 2013 to promote EVs and HEVs, to enhance the domestic manufacturing capabilities and to ensure ecological and energy security. The NEMMP envisages strategies to achieve the objective of efficient, environmentally friendly, affordable EVs by 2020.

Focus

Parameter	Target (2020)
Production	6-7 million units/year with a full range of EVs (xEVs)
Fuel savings	2.2 – 2.5 million tons
CO2 emissions	1.3% to 1.5%
R&D spend, including automotive testing	INR 13,000 crore – INR 14,000 crore

However, the allocation was restricted to INR 795 crore to support a two-year (2015-16 and 2016-17) Phase I of the project called the FAME Scheme. The total expenditure of Phase I was INR 219 crore.

Impact

- Companies like M&M, Tata Motors, Maruti Suzuki, Ashok Leyland, Hyundai, Tata Motors, Hero Motors Corp, TVS Motors Company and Honda Motor Cycle & Scooters are at various stages of developing the various types of EVs.
- Recently, the Indian Space Research Organisation (ISRO) has signed an MoU with BHEL to set up a production plant of low-cost Li-ion batteries for EVs.
- Other public-sector undertakings like NTPC and Power Grid Corporation are foraying into the business of setting up of charging infrastructure (charging stations) for promoting clean energy transportation in the country.
- Other private companies Like Tata Power and JSW Energy are also in the process of entering into the business of electric mobility related infrastructure.

Faster Adoption and Manufacturing of (Hybrid&) Electric Vehicles: Addressing global EV adoption trends

What is it: In April 2015, the government of India (Ministry of Heavy Industries) launched a scheme FAME India with a budget of INR 795 crore for the first phase (2015-16 and 2016-17) of the scheme.

Focus

- Phase I of the scheme ended in March 2017 but was extended to 30 September 2017.
- The aim is to create a market for HEVs and EVs across all segments – cars, motorbikes, buses and commercial vehicles.
- The scheme intends to encourage the development of indigenous technology and R&D capabilities so that the whole range of hybrid and electric components can be manufactured in India.
- FAME 2 through its INR 10,000 crore outlay over three years aims to provide a lot of momentum to the faster adoption of EVs and creation of charging infrastructure while supporting advanced battery technologies. FAME 2'a emphasis is on electrification of public transport including shared transport. While for 2Ws, the emphasis will be on private ownership, 3W and 4W incentive support will be mainly applicable for vehicles used for public transport or registered commercial purposes. It plans to support 10 lakh electric 2Ws, 5 lakh 3Ws, 55,000 4Ws and 7,000 buses.

The National Automotive Testing R&D Infrastructure Project (NATRiP): Provide R&D infra at par with global levels

What is it: The government has initiated a flagship project NATRiP which was approved by the Cabinet Committee on Economic Affairs (CCEA) in July 2005 to create a testing, validation and R&D infrastructure. It involves an investment of INR 1,718 crore for setting up seven auto testing facilities at seven locations across India by 2011. The NATRiP project is being implemented under the overall control and supervision of the Ministry of Heavy Industries and Public Enterprises (MoHI&PE).

Focus

- Its focus is to develop infrastructure for world-class automotive testing with the objective of helping the Indian automobile industry adopt and implement global standards for safety, emissions and performance.
- The NATRiP Implementation Society (NATIS) was set up. The total cost of the project was INR 2,288 crore up to December 2014.
- A revised outlay of INR 3,727 crore was approved by the Cabinet in July 2016 for a duration starting from 1 January 2015 till December 2017.

Achievements

Under the NATRiP, the following centres have so far been set up to carry out the testing and certification for emission standards, vehicle safety and performance:

- Automotive Research Association of India (ARAI), Pune
- National Automotive Test Tracks (NATRAX), Indore
- Vehicle Research and Development Establishment (VRDE, an organisation under the MoD, Ahmednagar
- International Centre for Automotive Technology (ICAT), Manesar
- National Institute for Automotive Inspection, Maintenance and Training (NIAIMT), Silchar
- National Center for Vehicle Research & Safety (NCVRS), Raebareli
- Global Automotive Research Center (GARC), Chennai.

New Green Urban Transport Scheme (GUTS), 2017: Improving public transport

What is it: It is a new scheme conceptualised by the government for improving and upgrading the public transport in urban areas along the low carbon pathway.

Focus

The scheme aims to:

- reduce the carbon footprint and promote low carbon sustainable public transport systems
- help provide a sustainable framework for funding urban mobility projects with minimum recourse to budgetary support by encouraging innovative financing of projects
- create non-motorised transport (NMT) infrastructure, adopt intelligent transport systems, increase access to public transport, and encourage the use of clean technologies and participation of private sector
- promote NMT, public bike sharing, bus rapid transit (BRT) systems, intelligent transport systems (ITS), urban freight management etc.

Parameter	Target (2020)
Cost allocated to the scheme	INR 70,000 crore
Cities identified	103 (Phase I)
Financial arrangement	10% - Urban local bodies (ULBs) 30% - Centre 30% - State 30% – Other agencies
Target cities (initial)	Population of 5 lakh and above

Smart Cities Programme: Enabling adoption of sustainable auto technologies

What is it: The government launched the Smart Cities Mission on 25 June 2015 to promote sustainable and inclusive cities that provide core infrastructure, clean environment, low carbon transportation which is affordable and sustainable and give a decent quality of life to its citizens.

Focus

- The Smart Cities Mission for the development of 100 smart cities provides for an outlay of INR 48,000 crore.
- Atal Mission for Rejuvenation and Urban Transformation (AMRUT) of 500 cities provides for an outlays of INR 50,000 crore respectively with the objective of making our cities more liveable besides driving economic growth.
- The NITI Aayog has formulated a three-year action plan providing convergence of major programmes like AMRUT and Smart Cities Mission and promotion of low carbon transport.
- The Smart Cities scheme comprised of three phases. The first phase covers 20 cities, the second phase covers 40 cities, and the rest of the cities are covered in the third phase.
- Under the programme, each selected city will be given INR 500 crore over a period of five years by the Centre.
- The automobile sector has immense opportunity to contribute to low carbon and affordable transportation in developing the smart cities.

Leapfrogging to Bharat Stage (BS)-VI norms: Making India suppliers ready for developed markets

What is it:

- Bharat Stage emission norms were first introduced in 1991-92 to improve the air quality of towns and cities. Each phase/stage has a limit on the pollutants released in the atmosphere.
- In 2000-01, BS-II was put into action in Chennai, Mumbai, Kolkata and Delhi while BS-I was made compulsory in the rest of the country.
- During April 2010, BS-III standards were put into action across India and BS-IV was implemented in 13 cities.
- BS-IV standards were to roll out by 2017, BS-V by 2020 and BS-VI by 2024. However, because of the exponential increase in pollution levels, the government decided to implement BS-VI, and in the process skipped the BS-V norms, by 2020.

Impact

- This leapfrog to BS-VI will reduce particulate matter emission by 82% and in NOx emissions by ~70% in diesel cars.
- This leapfrog of advanced norms is a crucial step for the country since it is a participant to the Conference of Parties.
- As per the agreement, India has to reduce its carbon print by ~35% from the 2005 values.
- Although environmentalists have welcomed this step, auto firms, auto parts makers and oil firms will be spending close to INR 80,000 crore to INR 90,000 crore to adhere to BS-VI norms.

100% EVs (public) and 40% EVs (private): Accelerating shift of mobility

What is it: The NITI Aayog launched a report titled 'India Leaps Ahead: Transformational Mobility Solutions for All' on 12 May 2017 for a complete transformation of mobility to 100% EVs in the public sector and 40% in the private sector by 2030.

Focus

- It will involve a shift of mobility by adopting a new and sustainable model for clean, cost-effective, efficient transportation that is safe, job oriented, least energy intensive (reduced oil import bill) and has a minimum adverse impact on the environment and human health.
- The report envisages a three-phased roadmap for electric mobility up to 2032.
- The **1st phase (2017-19)** will focus on institutional capacity building and aggregating interoperable transport data (ITD) with enabling mobility solutions.
- The **2nd phase (2020-23)** will focus on the development of markets, infrastructure and production capabilities in tandem with innovative business models.
- In the **last phase (2024-32),** the costs of EVs would come down significantly and economies of scale would be achieved.

Impact

- It will lead to a drastic cut by 64% in energy demand and 37% in carbon emission by 2030-32.
- The shift will save nearly INR 3.85 lakh crore by 2032 in diesel and petrol cost and save one giga ton of carbon emissions between 2017 and 2032.
- Further, the levy of GST at the rate of 43% on hybrid cars and 12%on EVs makes it clear that the government is clearly promoting EVs.
- There are indications that demand for making zero GST rate for EVs is under the active consideration of the government to achieve the target of 100% EVs by 2030 in the public sector.

Globalisation imperative: Conclusion

The growth of the automobile sector during 2006-16 has been impressive despite a slowdown phase during the implementation of the current phase of AMP. AMP 2016-26 with better planning and execution and improved economic growth will address the shortfalls of the previous AMP. It will be key to see how the industry and the government tackle the opportunities as well as challenges of globalisation, although trends across regulatory, technology and smart cities can be observed which are closely aligned to global developments:

Regulatory impact

- FAME 2 will push greater EV footprint to help the adoption of EVs through advancement of battery technologies and creation of charging infrastructure. Universalisation of EVs in the country by 2030 for low carbon economy and transport is gaining momentum through the NITI Aayog.
- The decision of the government to leapfrog to BS-VI norms for all types of vehicles from April 2020 will reduce emissions and bring diesel vehicles and gasoline vehicles at par in terms of emissions. The proposal of having a single authority for technical regulations for the industry will further boost the manufacturing environment for vehicles as the regulations would be more inclusive from the diverse viewpoints of safety, emissions and fuel efficiency, which can often be contradictory to each other.

Technology convergence

- Technological advancement in the automotive space in India is fast and is seeing the emergence of ITS-enabled vehicles, which provide useful information like congestion, fuel consumption, emissions, accident-prone areas, traffic flow, etc.
- Recent advances in the convergence of technologies (telematics) like telecommunication, vehicle technologies and ITS are further revolutionising the performance of vehicles in terms of safety, driving, communication, storage of information for records and analysis of information for rectification and amendments.

Smart city trends

- Low carbon transportation will encourage healthy competition among peers, R&D for innovation, advancement of technology and compliance with the national and international technical regulations to stay relevant and competitive.
- Focus on rural demand and low cost and robust vehicles will lead automotive growth, economic development and job creation in rural areas, which is a priority for the government.
- Urbanisation, smart cities, availability of raw material, cost-effective capital, changing lifestyle, etc. provide a conducive business environment and will foster new avenues of growth, establishing completely new ventures and start-ups.

Glossary

Electric vehicles (EVs)

Internal combustion (IC)

Artificial intelligence (AI)

Machine learning (ML)

Internet of things (IOT)

Over-the-air (OTA)

Greenhouse gas (GHG)

Battery EVs (BEVs)

Plug-in hybrid EV (PHEV)

Fuel cell EVs (FCEVs)

On-board diagnostic (OBD)

Society of Automotive Engineers (SAE)

National Highway Traffic Safety Administration (NHTSA)

Advanced driver assistance system (ADAS)

Research and development (R&D)

Bosch Center for Artificial intelligence (BCAI)

Point of sale (POS)

Global positioning system (GPS)

Inertial navigation system (INS)

Light detection and ranging (LiDAR)

Nickel-Manganese-Cobalt (NMC)

Design-for-manufacturing (DFM)

Vehicle-to-vehicle (V2V)

Vehicle-to-everything (V2X)

Micro-electro-mechanical systems (MEMS)

Computer-aided design (CAD)

Computer-aided engineering (CAE)

Technology readiness level (TRL)

Big Hairy Audacious Goals (BHAG)

Just in time (JIT)

Indian Space Research Organisation (ISRO)

Faster Adoption and Manufacturing of (Hybrid&) Electric Vehicles (FAME)

National Automotive Testing R&D Infrastructure Project (NATRiP)

Cabinet Committee on Economic Affairs (CCEA)

NATRiP Implementation Society (NATIS)

Ministry of Heavy Industries and Public Enterprises (MoHI&PE)

Automotive Research Association of India (ARAI), Pune

National Automotive Test Tracks (NATRAX)

Vehicle Research and Development Establishment (VRDE)

International Centre for Automotive Technology (ICAT)

National Institute for Automotive Inspection, Maintenance and Training (NIAIMT)

National Center for Vehicle Research & Safety (NCVRS)

Global Automotive Research Center (GARC)

Green Urban Transport Scheme (GUTS)

Non-motorised transport (NMT)

Bus rapid transit (BRT)

Intelligent transport systems (ITS)

Urban local bodies (ULBs)

Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

Bharat Stage (BS)

Interoperable transport data (ITD)

About CII

Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, playing a proactive role in India's development process. Founded in 1895, India's premier business association has around 9000 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 300,000 enterprises from around 265 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, healthcare, education, livelihood, diversity management, skill development, empowerment of women, and water, to name a few.

As a developmental institution working towards India's overall growth with a special focus on India@75 in 2022, the CII theme for 2018-19, **India RISE : Responsible. Inclusive. Sustainable. Entrepreneurial** emphasizes Industry's role in partnering Government to accelerate India's growth and development. The focus will be on key enablers such as job creation; skill development; financing growth; promoting next gen manufacturing; sustainability; corporate social responsibility and governance and transparency. With 65 offices, including 9 Centres of Excellence, in India, and 11 overseas offices in Australia, Bahrain, China, Egypt, France, Germany, Iran, Singapore, South Africa, UK, and USA, as well as institutional partnerships with 355 counterpart organizations in 126 countries, CII serves as a reference point for Indian industry and the international business community.

Centre of Excellence
for Competitiveness for SMEs

The CII - Centre of Excellence for Competitiveness for over a decade dedicated its services for building competence of India SMEs. With a national footprint, this Centre acts as a single point of reference for SME development in India

This Centre strives to accelerate SME economic engine through its bouquet of services in manufacturing excellence, human resources, energy, corrosion and cost management. SMEs are assisted in improving their business performance and enhance their productivity, innovativeness and overall competitiveness. The services are rendered pan-India both through open houses as well as in-house training programmes. Long-term assignments, which include demonstrating and leading by examples on the shop floor are conducted both for individual enterprises and clusters.

The Centre's forte is the cluster approach. Aimed at facilitating mutual learning, this approach was pioneered by CII about 17 years ago. Till date,about 3,000 SMEs have been impacted through formation of about 250 clusters.

About Grant Thornton in India

Grant Thornton in India is a member of Grant Thornton International Ltd. It has over 3,000 people across 15 offices around the country, including major metros. Grant Thornton in India is at the forefront of helping reshape the values in our profession and in the process help shape a more vibrant Indian economy. Grant Thornton in India aims to be the most promoted firm in providing robust compliance services to dynamic Indian global companies, and to help them navigate the challenges of growth as they globalise. Firm's proactive teams, led by accessible and approachable partners, use insights, experience and instinct to understand complex issues for privately owned, publicly listed and public sector clients, and help them find growth solutions.

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MUMBAI
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