

For Turkish Automotive Manufacturers Association (OSD)

Measures to be Taken Regarding the Turkish Automotive Industry's Sustainability in Export and Production Competitiveness in Light of Emerging Disruptive Automotive Technologies



Project Report | December 2019

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Executive Summary

Turkey's domestic production of Passenger Cars (PC), Light Commercial Vehicles (LCV) and Heavy Commercial Vehicles (HCV) has continuously grown to almost 1.7 million units as of 2017, rendering the automotive industry one of the biggest contributors to GDP in Turkey, the top export industry for 12 years in a row, and a key contributor to the trade balance. Additionally, its significant contributions at the national level on attracting investments, generating employment, triggering technology diffusion & spillovers, facilitating industrial clustering, enhancing SME development, facilitating integration to global value chains and therefore paving the way for economic growth imply that the automotive industry remains a core component of Turkish manufacturing and economy. In 2017, the industry produced around 1.1 million PCs in the A, B, C "value" segments, 517k LCVs and 35k trucks & buses (HCV) in 14 plants by 12 key OEMs. The export destinations of Turkey's export-oriented automotive industry are overwhelmingly concentrated on Europe, with the continent accounting for nearly 85% of exports.

Globally, demand and supply dynamics for the automotive industry are increasingly undergoing a series of structural changes. A series of demand-shaping global trends such as green growth policies, disruptive technological advancements, shifting balances in purchasing power, rapid urbanization in emerging markets, and evolving consumer behavior is creating pull and push factors that will transform the way the automotive industry operates. Among these are the set of disruptive technologies that this study has focused on, rise in connectedness, autonomous driving, shared mobility and electrification of powertrains and the accompanying move towards alternative fuel vehicles. Among these are the set of disruptive technologies that this study has focused on:

- **Connected Vehicles:** A vehicle (car, truck, bus, etc.) that is equipped with a wireless communication device. A CV uses any of the available wireless communication technologies to communicate with other cars on the road (vehicle-to-vehicle [V2V]), roadside infrastructure (vehicle-to-infrastructure [V2I]), and other travelers and the cloud.
- **Autonomous Vehicles:** A robotic vehicle that is designed to travel between destinations without a human operator. To qualify as fully autonomous, a vehicle must be able to navigate without human intervention to a predetermined destination over roads that have not been adapted for its use.*
- **Shared mobility and services:** The shared use of a vehicle, bicycle, or other mode - transportation strategy that enables users to gain short-term access to transportation modes on an "as-needed" basis. **
- **Electrification of powertrains (and the accompanying move towards alternative fuel vehicles, hybrids & xEVs):** An electric vehicle (EV) is a vehicle that is

powered, at least in part, by electricity. EV configurations include battery electric vehicles (BEVs) which are powered by 100% electric energy, various hybrid-electric vehicles (HEVs),

and plug-in hybrid electric vehicles (PHEVs).

Turkey's automotive industry must rapidly adapt to changing external conditions in order to sustain and/or increase its competitiveness in this shifting landscape: As its core export markets are undergoing structural changes, the regulatory, technological and infrastructural environment in which the Turkish automotive industry operates will also need to be upgraded to both keep up with the shifts and leverage them into new opportunities. Here, there is a number of global trends to be closely observed and international examples of transformation to be analyzed in order to develop a tailor made roadmap addressed to both the public and private stakeholders in the Turkish automotive industry.

Global trends should be closely observed and international examples of transformation analyzed in detail to develop a tailor made roadmap addressed to automotive OEMs in Turkey: A comprehensive and holistic legislative framework and incentive scheme are necessary to regulate the whole ecosystem with upward and backward integrations. The need for new legislations and incentives is not only limited to the industry itself, but also for the resources, channels and the activities in industries' periphery.



Introduction

Automotive industry has been the building stone of Turkish manufacturing industry by being the biggest exporter sector and with its contribution to employment and sectors it is connected with. The transformative impact of automotive industry on Turkey's industrial evolution can be approached from three different perspectives, export capability, employment generation and created value-add. Total exports of automotive industry in 2018 have reached \$20.9 billion, covering 12.9% of Turkey's global exports, making it the biggest exporter industry. Moreover, with consistent growth over the last decade, automotive industry has contributed 17.2% of Turkey's total export growth during the period of 2008-2018. Employment in motor vehicles sector has grown up to 158,300 in 2018 and it now consists 4.3% of total employment in manufacturing industry. Motor vehicles has also been the dynamo of the industry by contributing 34% of the employment growth in the last four years, 2014-2018. However, automotive industry as a whole, not only leads Turkey's manufacturing industry, but also develops its surrounding industries with strong input-output connections.

Thus, for every unit value-add generated by the automotive industry returns to three units of value-add as these input-output connections generate additional two units of value-add in the surrounding industries.

Automotive industry is under a compelling transformation as new digital solutions arise, artificial intelligence gets involved in transportation, emission regulations restricts further penetration of internal combustion engine (ICE) vehicles into the market and people's expectations of mobility with new generations. These disruptive changes will normalize autonomous, connected, electric cars and shared mobility in our daily lives. By 2030, 4 trillion dollar economy is expected to be generated by connected cars while electric vehicles penetrate 40% of the market and 55% of the mobility need will be satisfied with shared mobility solutions. On the other hand, autonomous cars are expected grow with a CAGR of 25% until 2035. The speed of disruption has started take effect in developed markets and it has also started to excite the developing markets but it is expected to escalate in the upcoming years

As the disruptive technologies coalesce with automotive industry, many ICT players also intervene the market with increasing competition for the profitability. As the market is expected become even more segmented with ICT players, many automotive players will have to acknowledge the competition forced by ICT players. Disruptive technologies will create a competitive edge for ICT

player in the industry by altering the value chains and the revenue structure of the industry. Today, ICT players and shared mobility providers hold less than 5% of the market's revenues and profits, but by 2030, they are expected to grab 30% share from market's revenues and almost 45% share from market's profits.

Figure 1: Four main drivers of change for the automotive industry and their magnitudes

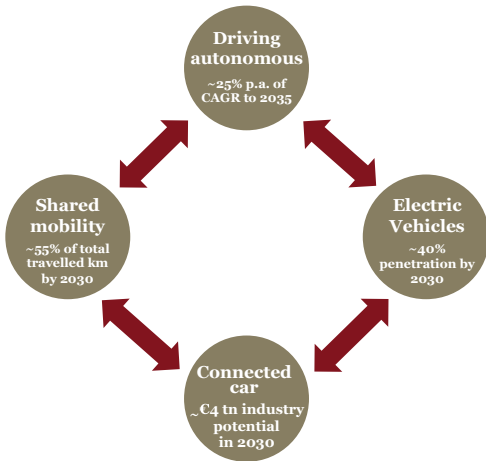


Figure 2: New car sales: Autonomous (millions, by level of automation)

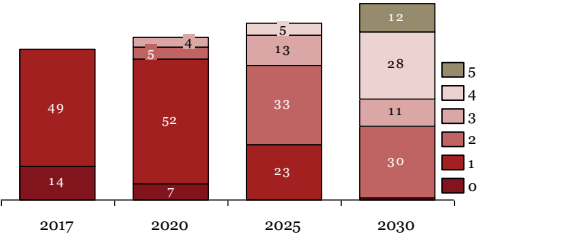


Figure 3: New car sales: ICEs and Alternative Fuel (millions, by fuel type)

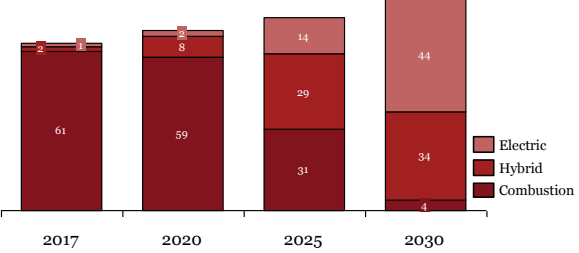
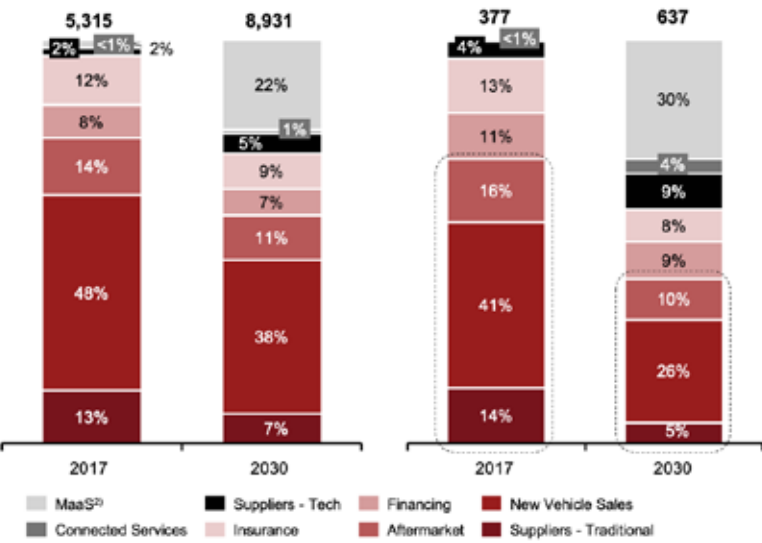


Figure 4: Revenue and Profit Distribution in Automotive Industry (in \$bn)



1) Based on S& PwC 2030 Scenario. Totals may not equal sums shown due to rounding
2) Vehicle-based mobility as a service, incl. "shared autonomous" & "shared driver-driven"
Note: consolidated view; supplier value pools not eliminated from vehicle/aftermarket/MaaS revenues to show full industry value pools
Source: PwC Autofacts, IHS, HBR, Technavio, Thomson Reuters, Oxford Economics, OEM Reports, PwC Analysis

Disruptive changes have taken effect initially in the developed markets and they are also expected to become the pioneers to lead the change in automotive industry. Sparks have already emerged in EU market in terms of the four drivers of disruption; connected cars, autonomous cars, shared mobility and electric cars. By 2025, it is expected to see evident penetration into European markets by disruptive technologies and by 2030, it can be seen that these four disruptive technologies dominate the market. On the other hand, developing markets with strong automotive

industries, including Turkey, will also be the markets susceptible to disruption. Technological transformation is catching up with these countries as well, while the most dynamic change in demand will happen in traditional segments. Automotive industries in developing markets have become key exporters of traditional autos to developed markets. Thus, in addition to the disruption in their local markets, these countries will also be the ones who will be disrupted by the demand change in their key export destinations.



Figure 5: Estimated connected services market size development, (in USD billions)

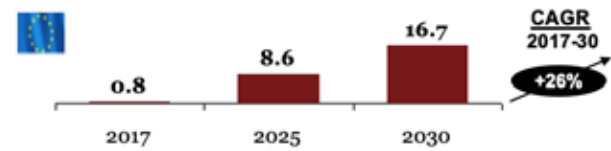


Figure 6: Estimated MaaS market size development, (in USD billions)

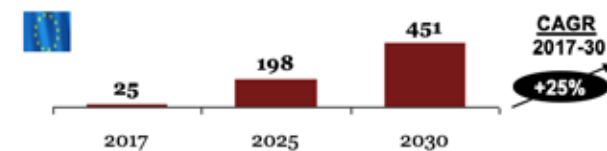


Figure 7: Estimated autonomous car sales, (in total vehicle sales, millions)

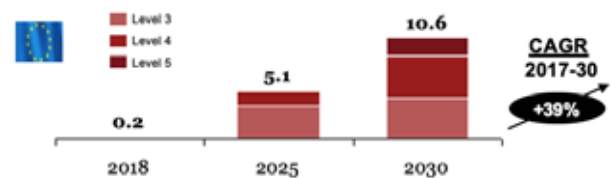
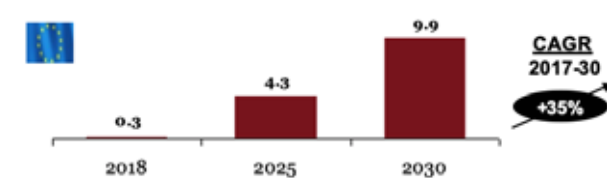


Figure 8: Estimated electric vehicle sales, (in total vehicle sales, millions)



China had been aware of the upcoming disruption in automotive industry and taken actions to control and lead the disruption in the local market as country has already been the place where electric vehicles are sold the most. Thus, along with the EU and the US, China will also be one of steering countries of disruption in automotive industry. The change in the industry will be driven by consumer preferences, economic parameters, technological progression and regulatory empowering. Facilitating actions in these four pillar will determine when and where transition to disruptive solutions will happen first.

For consumers preferences,

- Preference for vehicle ownership
- Affinity towards new modes
- Relative willingness-to-pay

For economic parameters,

- TCO for existing and new mobility alternatives (purchasing price, incentive schemes, fuel/electricity cost, write-downs, penalties, etc.)

For technological progression

- Technology enabling autonomous driving (e.g. vehicle systems, V2X infrastructure)
- Electric drive technology (e.g. powertrain, battery, charge points)

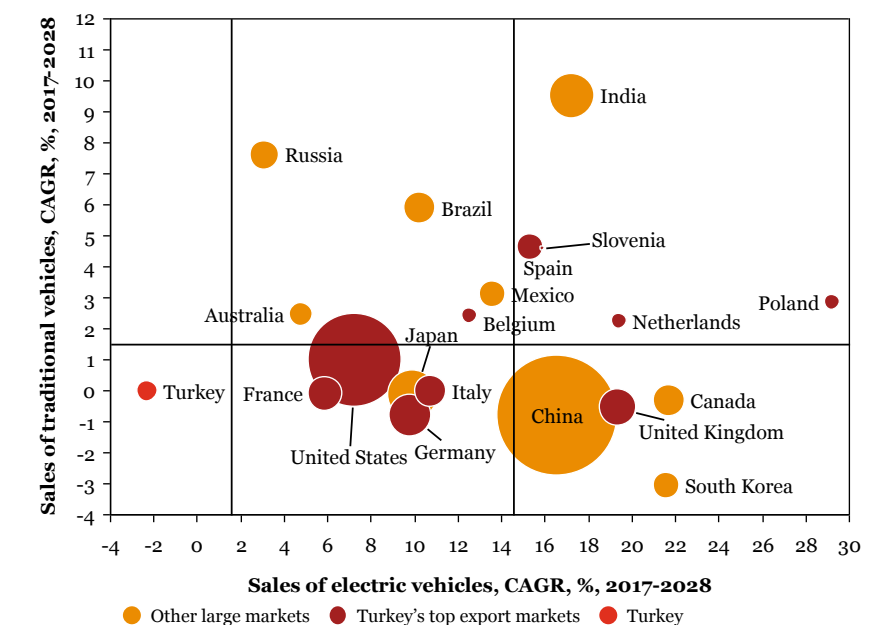
For regulation,

- Standards
- Liabilities/legislations
- Permissions / CO2 target will be the topics of discussion for a strategy design against disruptive technologies.

Sales growth of electric vehicles with respect to sales growth of ICE vehicles in domestic markets represent countries' forecast of adoption rate of electric vehicles by local customers. In comparison with its benchmark countries and top export destinations, Turkey's electric vehicle adoption rate is expected to remain slower than its peers. Electric vehicle market will grow by more than 15% CAGR in 5 of Turkey's top 10 automotive export destinations. Besides increasing electric

vehicle market, a decrease in traditional vehicles market is expected in Turkey's top 4 automotive export destinations Germany, Italy, France and UK. This demand and supply mismatch that is likely to occur in the near future can jeopardize the future of Turkish automotive industry as well. Thus, In order to maintain its current market share, Turkey should take action in order to penetrate the EV market both as OEMs and as their suppliers.

Figure 9: Market transition from traditional to electric vehicles, 2017-2028



Besides the four main drivers of disruption in automotive industry (connected, autonomous, shared, electric), body types of vehicles are also rapidly changing. Sales volume for hatchback and MPV (multi-purpose vehicle) types are in decline while SUV (sport utility vehicle) models are rapidly increasing shares in the market. Sedan models maintain their position in the both global and EU markets in terms of sales volume. For the mid-

term development of the market, the momentum of change captured in the last few years is expected to continue and SUVs are expected to be the main drivers of growth in both global and European markets. This physical change in automotive body types point that change in customer expectations have implications for the industry not only through disruptive technologies but also design and architecture.



1 Connected Vehicles

Figure 10: Global PC Sales and Forecasts by Body type, 2014-2024, by million units sold

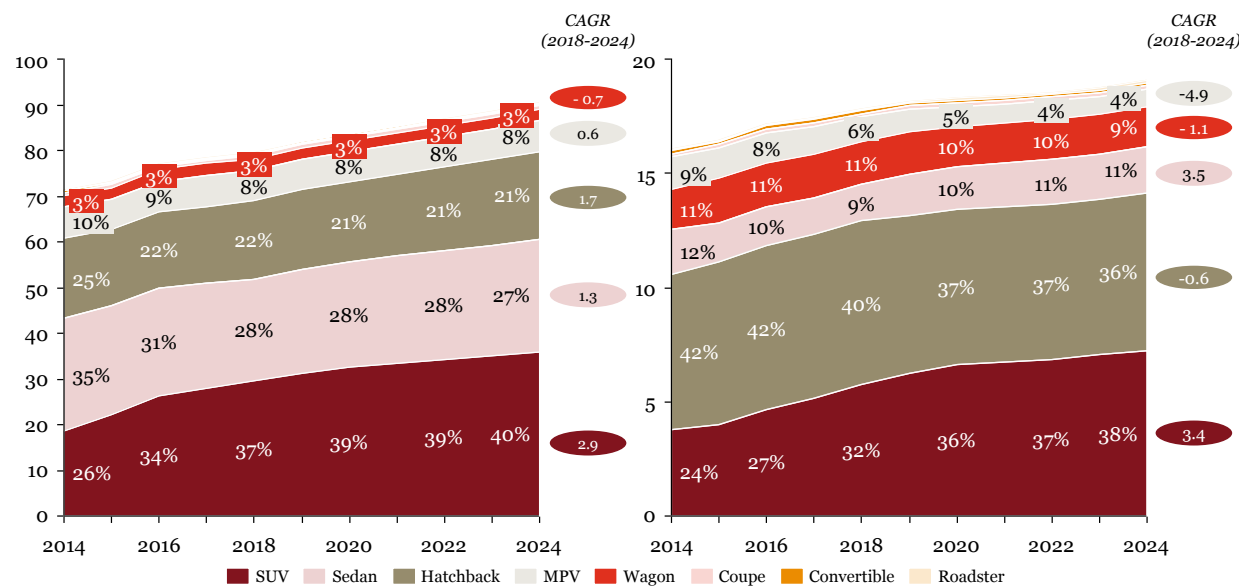
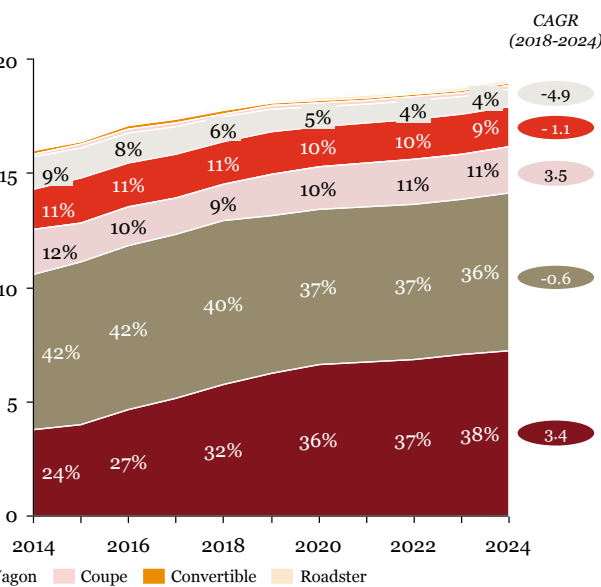


Figure 11: PC Sales and Forecasts in Europe by Body type, 2014-2024, by million units sold



Although the impacts of these rapid changes in automotive industry has just become obvious for everyone, many ex-ante strategies were built by automotive industry player in the recent years for the upcoming disruption. These strategies were reflected in the transactions made by the industry players through mergers and acquisitions. In 2017, two largest automotive-related deals in the industry were made by tech players, Intel and Samsung. Intel acquired MobilEye with a \$15.3

billion worth deal for improved drive assistance systems while Samsung acquired auto electronic manufacturer Harman for \$8.04 billion. These two deals made up 53.7% of top 20 automotive transactions in total volume. Snapshot of the market direction reveals that irrespective of engine and body types, interlinkages between the automotive and tech industries should be strengthened in order to capture technological transformation



Key Findings

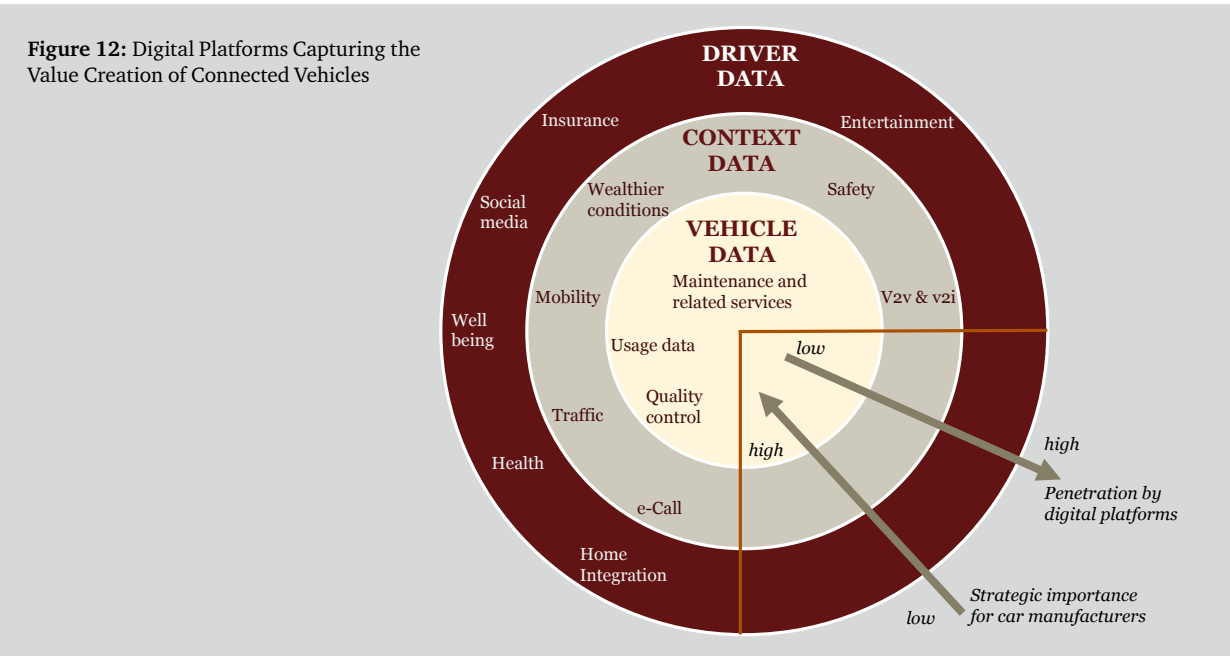
- Connected vehicles are revolutionizing the concept of motor vehicles and enhancing the driving experience
- Pervasive connectivity is a crucial step on the way to self-driving cars
- The way to build the fully connected vehicle is an interim process shaped by data-driven technologies, which will ultimately lead to the completely autonomous vehicle
- Empowering the technology-related infrastructure surrounding vehicle-to-vehicle and vehicle-to-infrastructure communications is necessary to sustainably transform the driving experience of today to that of tomorrow
- Rapidly increasing production of connected vehicles cannot be considered without regulations especially within the EU border
- Connected vehicle intelligence is moving to the cloud, driven by several benefits
- Regulations should favor OEM access to smart vehicle data as well as protection against cyber-threats, in order to develop their supply chains accordingly and provide more effective after-sales services
- Turkey's ICT indicators are in need of further development to catch up with Europe



1. Connected Vehicles

Digital services provided by automotive industry is occupying a higher proportion of all services provided in the industry. Value creation in the industry is now subject to digital platforms capturing the essence of information held in mobility systems. In this context, integration of several different information providing systems

is key for success in digitalization of automotive industry. Thus, the concept of connected vehicles arise as such integration is essential for the penetration of digital solutions in the automotive industry. In the connected vehicle ecosystem, there are three major data sources, vehicle data, context data and driver data.



- **Driver Data:** Drivers are important data providers to mobility ecosystem as each presents a different driving characteristics due to several different features. As connected vehicles capture driving characteristics during motion time, personal information obtained from drivers' social media, insurance, smart home systems and etc., enable further value creation by digital services.
- **Context Data:** This data source contain information obtained from out-of-vehicle data providers. Traffic data, weather conditions,

- vehicle-to-vehicle connections and vehicle-to-infrastructure connections are key data obtained from exterior resources. Effective utilization of context data will ultimately lead to completely autonomous vehicle.
- **Vehicle Data:** Vehicles handle the motion time data and process data obtained from exterior resources such as other vehicles and infrastructure. Besides, vehicles also provide information for maintenance and related services, and perform quality control

Digital chains between OEMs, outside technologies through data and analytics will reshuffle automotive value chain across horizontal and vertical competitors and start-ups. According to European Commission, in the long run, %30 to %40 in the automotive value chain will be captured by digital services, through digital platforms. Thus, empowering the technology-related infrastructure surrounding vehicle-to-vehicle and vehicle-to-infrastructure communications is necessary to sustainably transform the driving experience of today to that of tomorrow.

Connected vehicle intelligence is moving to the cloud, driven by several benefits. However as the data infrastructure shifts toward cloud, regulations concerning data sharing and privacy issues become more critical in terms of technological progression. Rapidly increasing production of connected vehicles cannot be considered without regulations especially within the EU border. Regulations should favor OEM access to smart vehicle data as well as protection against cyber-threats, in order to develop their supply chains accordingly and provide more effective after-sales services.

Figure 13: Turkish ICT export, import1 (2013-2017, USD bn)

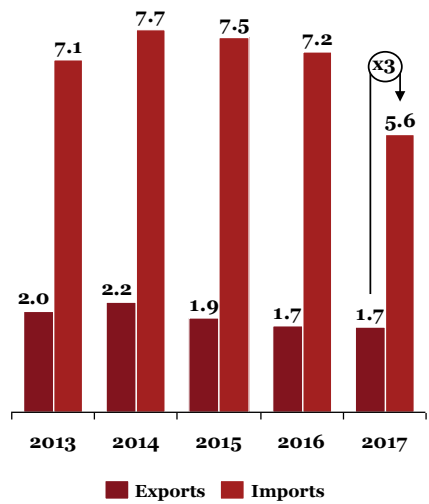
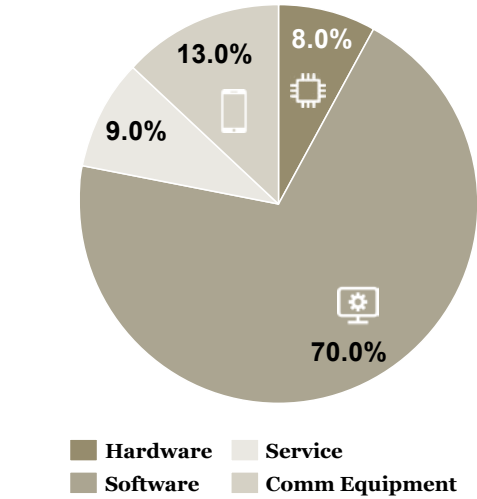


Figure 14: Share of ICT exports by sub-categories (2017)



Information and communications technology (ICT) infrastructure of countries will also be a decisive factor for penetration of connected vehicles into local markets since substantial amount of data generated in real-time by numerous vehicles on traffic will need to be transmitted and processed. While data usage per hour by HD video streaming is approximately 870 megabytes and web browsing is 15 megabytes, 25,000 megabytes of vehicle data is expected to be generated by a single connected vehicle on the traffic. Thus, ICT infrastructure is a key enabler for connected technologies in automotive industries. However, Turkey's ICT infrastructure parameters and sectoral ICT indicators are behind Turkey's European peers. According to score calculate by World Bank considering

multiple ICT related parameters, Turkey's ICT Development Index Value (IDI) is 5.69, while that of Europe is 7.35 and that of Japan is 8.1. On the other hand, ICT sector in Turkey is also import-oriented, as in 2017, imports were triple the value of exports. Yet, Turkey has considerable progression in software industries and software related exports make up 70% of Turkey's ICT exports. Thus, Turkey needs to enhance this progression with further developments in its ICT infrastructure through investments in wireless connectivity, road markings and sensors, to fully utilize connected vehicle technologies. This will also pave the way for transition to smart cities and increase the country's foreign direct investment (FDI) attractiveness.

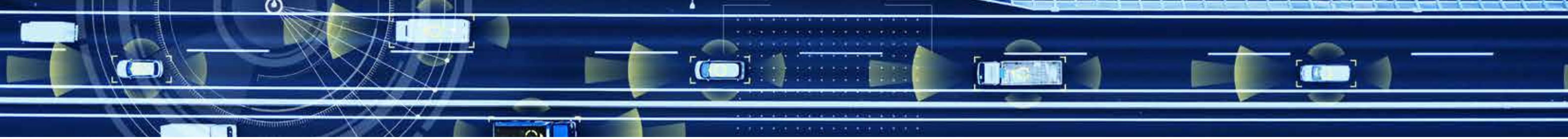
2

Autonomous Vehicles



Key Findings

- As a pioneering development in technology, autonomous driving is an ongoing process, the results and implications of which are yet to be observed. OEMs must invest and follow the developments.
- This pioneering piece of technology implies that the value chain of motor vehicles will inevitably evolve, moving away from physical products towards data-based platforms
- Transformations in the field of mobility indicate a move towards assistance and autonomous vehicle (AV) systems. Increases in the usage of data imply the need for data exchange amongst different stakeholders.
- Developments related to connected and electric vehicles, along with the rise of shared mobility lead to increased integration levels with autonomous vehicles.
- Use of autonomous vehicles is expected to pick up rapidly from 2020 onwards, experiencing a dramatic increase around 2030. A population of approximately 80 million autonomous cars is forecast for the year 2030.
- Autonomous driving technologies are expected to transform the supply chain through upstream and downstream pull & push factors.
- Establishment of robust regulatory frameworks is of grave significance for the market, with the potential for the industry to fail if otherwise. The types of regulations needed will be shaped as much by operational and ethical factors as legislations enacted.
- Rather than general industrial policies, targeted policies and regulations with a smart mobility focus will positively influence market development and FDI attractiveness in Turkey.



2. Autonomous Vehicles

The value chain of motor vehicles are evolving from offerings of hardware and products to those of value creation based on data. The way to build the fully connected vehicle is an interim process shaped by data-driven technologies, which will ultimately lead to the completely autonomous vehicle. Therefore, autonomous vehicle technology passes through different levels as connectedness of the vehicle increase along with its automation. Society of Automotive Engineers (SAE) assessed on the basis of whether human drivers or systems fulfill the specified tasks and defined five levels in vertical regarding the degree of automation and four horizontal in which major functions in a vehicle; execution of steering in terms of acceleration and deceleration, monitoring of driving environment, fallback performance of dynamic driving task, and system capability of driving modes.

Several features of autonomous driving are engaged at different levels. In general, at the first level, parking assistance systems are engaged, second step involves automated driving, third step introduces lane change assistance, fourth step is expected to bring automated hazard perception and with the addition of self-diagnostics and alert-rescue functionalities in the fifth step, a fully autonomous car will be welcomed. Currently, the level of automation in passenger cars is in between level two and level three in terms of SAE's classification. Use of autonomous vehicles is expected to pick up rapidly from 2020 onwards, experiencing a dramatic increase around 2030. A population of approximately 80 million autonomous cars is forecast for the year 2030.

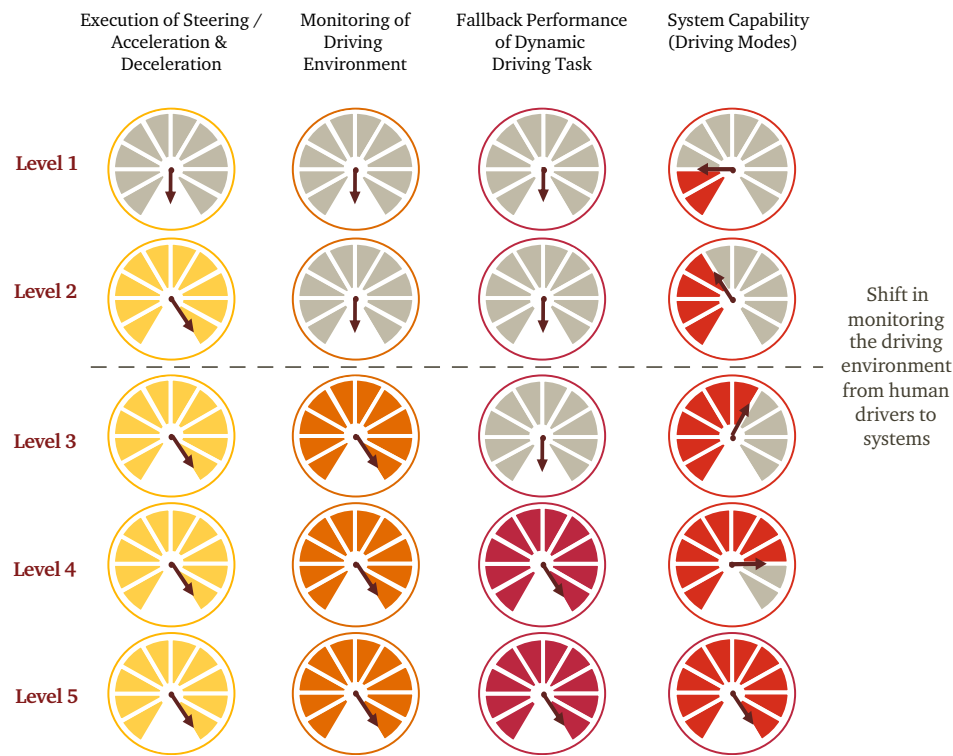
However, the developments in autonomous vehicle technology is not primarily driven by technological progression. Advantages brought by autonomous driving also create a demand-pull from the buyer side. Advantages that will be brought by autonomous vehicles can be summarized with following points,

- **Mobility of Non-Drivers:** Provision of mobility solutions for non-driving or reduced mobility groups such as the elderly, disabled, and youngsters;
- **Reduced Stress and Fatigue:** Users allowed to rest and work while travelling; reduced stress and anxiety through advanced safety features
- **Increase in Road Capacity:** Reduced congestion, automation of traffic law enforcement, and ability to drive in narrower lanes may reduce roadway costs
- **Fuel Efficiency and Sustainability:** Environment and sustainability conscious through increased fuel efficiency and reduced greenhouse gas emissions
- **Reduced Driver Costs:** Driver costs for taxis and commercial transport reduced
- **Increased Safety:** Ensure provision of safety through reduction of crash risks, resulting in lowering of costs and insurance costs; contribution to reduction of high-risk driving
- **Reduced Parking Costs:** Efficiency of self-driving features may reduce demand for parking at intended destinations, hence resulting in lower parking costs for users
- **Ability to Support Vehicle Sharing:** Technological infrastructure to facilitate car sharing and ride sharing, helping spread out and reduce vehicle ownership and general travelling costs.

As autonomous technology solutions in the industry are driven by progressions in artificial intelligence (AI) technologies, tech firms are setting eye on the revenues of the future autonomous vehicle market. Alphabet Inc., parent company of Google, is developing its own autonomous vehicle, Waymo and many tech firms like Microsoft, Apple, Intel, Huawei and etc., lead R&D studies in the field of autonomous driving. However, legacy automakers have recently started fighting back in an attempt to secure their shares of an ever-growing market. Large scale of acquisitions in the automotive industry are driven not just by technological and mobility solutions providers as legacy automakers also acquire start-ups active in fields such as autonomous driving and artificial intelligence.

Yet, transition to autonomous vehicles also require significant support from regulatory side. R&D studies in autonomous driving technologies demand infrastructural support and legislative framework which incentivize autonomous vehicle testing. Countries leading autonomous vehicle technologies have formulated strategies to enable autonomous vehicles access to public roads and dedicated pilot regions as testing beds for autonomous vehicles. Road traffic and safety regulations were redrafted to include provisions for vehicles operated by autonomous systems. In United Kingdom, Center for Connected and Autonomous Vehicles was established as part of Department of Transport and Department of Business, Energy and Industrial Strategy. The center is also designated as the regulatory body charged with establishment of standards around treatment and protection of vehicular data. However, there are also countries like Italy, Norway, Finland who have started to designate testing beds for autonomous vehicle R&D studies before enabling regulatory and policy actions take place, which imply that countries may prefer to test out autonomous vehicles prior to regulating them.

Figure 15 :
SAE Framework
with dimensions to
assess level of automation





3

Shared Mobility

Figure 15: Availability of Access to Public Roads for Autonomous Vehicles

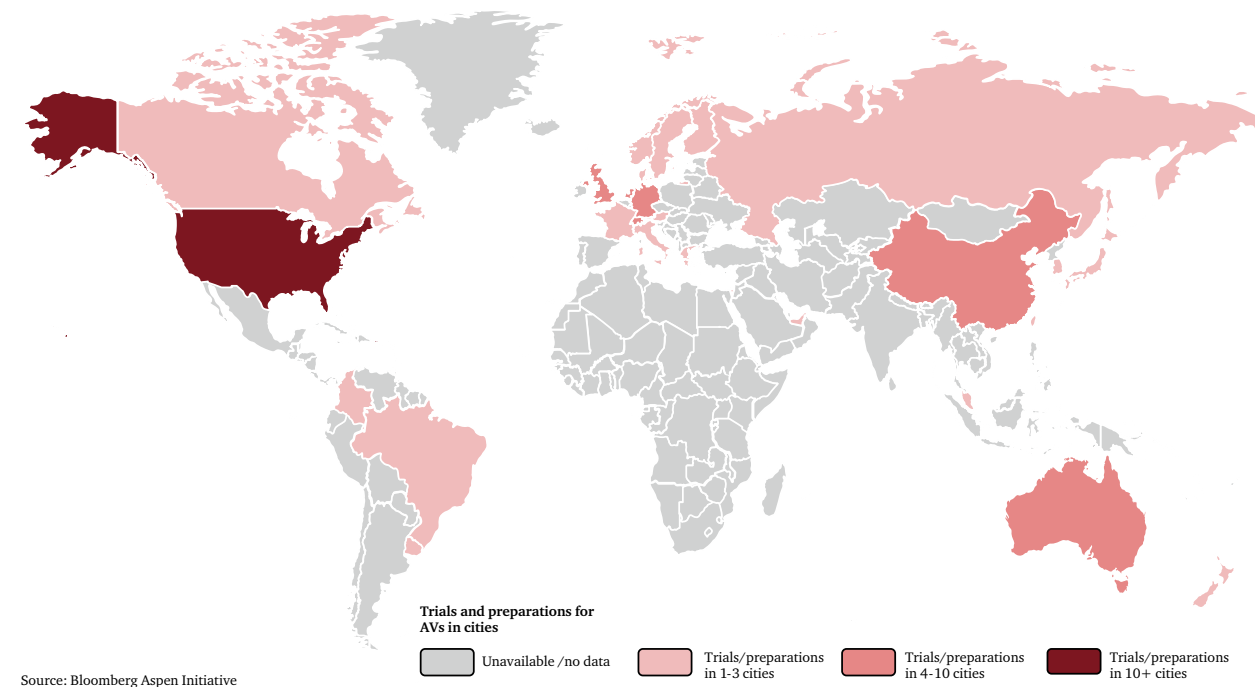
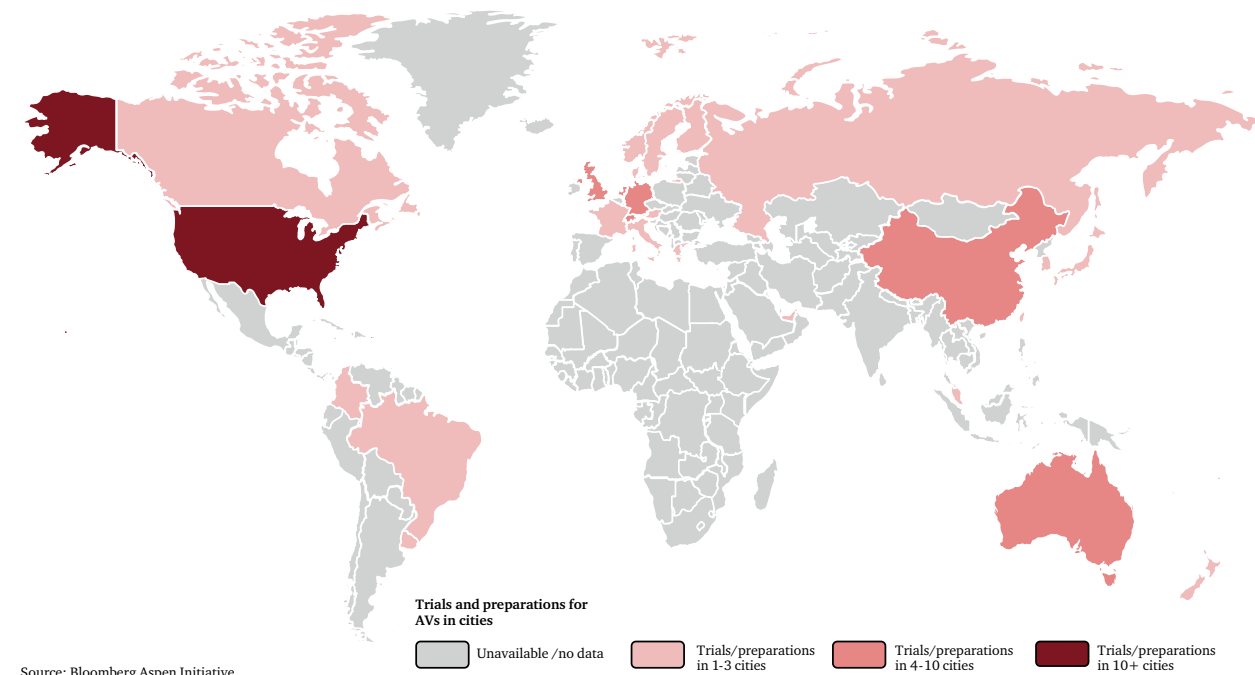


Figure 17: Trials and preparations for autonomous vehicles, number of cities per country



Key Findings

- Shared mobility network consists of various and interconnected stakeholders, service providers and beneficiaries.
- Shared mobility is expected to create a chain reaction in a way to affect interconnected parameters such as vehicle mileage and new car sales.
- Smart mobility services will be critical in the development of smart city solutions for new urbanization models and sustainable planning.
- Alternatives for mobility will expand and diversify swiftly, with several different local players expected to emerge all over the world to fulfill the expectations of modern consumers.
- Along with the implications of the global megatrends, shared mobility will transform the dynamics of the automotive industry.

3. Shared Mobility

While automotive OEMs are significantly disrupted by new digital solutions provided by tech players and structure of the industry change with technology driven revolution on the supply side, customers' perception of mobility also change with declining interest in vehicle ownership. Therefore, demand to shared mobility solution increase with new generation. To crown it all, traditional shared mobility solutions like

taxi, bus, subway and even hitchhiking, are also disrupted by digital solutions. This leads to expansion and diversification of mobility services and several different service providers emerge all over the world to fulfill the expectations of modern consumers. Thus, today's shared mobility ecosystem is highly diversified and segmented.

Table 1: Classification of Shared Mobility Ecosystem

	Active Mobility				Passive Mobility				
	Car Sharing				Ride Hailing			Ride Sharing	Public Transport
	Station based	Free Floating	Corporate	P2P	Taxi	Private Hire	P2P		
Description	Short-term ride, vehicles picked up and returned to specified parking spots	One way rides, vehicles picked up and parked in area of operations	Company car pools accessible to employees of one or more companies	Sharing of personal cars with others	Official taxi brokered to customer	Licensed limousines or vans	Offering rides according to customer demand	Person offering seats in his car to others on a personal trip	Local network of buses, rail and etc.
Driver	Registered customers	Registered customers	Employees of companies	Peers (private persons)	Licensed taxi driver	Licensed driver	Usually self-employed unlicensed drivers	Private person	Professional employees
Owner	Car Sharing company	Car Sharing company	Car Sharing company	Private person	Taxi company	Private hire company	Private persons (mostly drivers)	Private person	Cities, Municipalities
Customer Interface	Website/app or car sharing company	Website/app or car sharing company	Administrator	Website/app or service provider	Website/app or service provider	Website/app or private hire company	Website/app or service provider	Website/app or service provider	Shops, website, apps, ticket machines
Examples	Flinkster, TeiAuto	DriveNow, Car2Go	AlphaCity	Website/app or service provider	Mytaxi	Blacklane, myDriver	Uber, Lyft, Ola	BlaBlaCar, MiFaZ	MVG, BVG, Metro

On the other hand, although perception of mobility has started to change with modern consumers, people are still looking for the best possible option to cover the distance between point A and B, regarding their changing preferences. Thus, as digital solutions enable

so, different classes of shared mobility can be grouped in one single platform. Although such platform differentiates in each city due to changing dynamics of public transportation at local level, this comprehensive approach to mobility is called Mobility as a Service (MaaS).

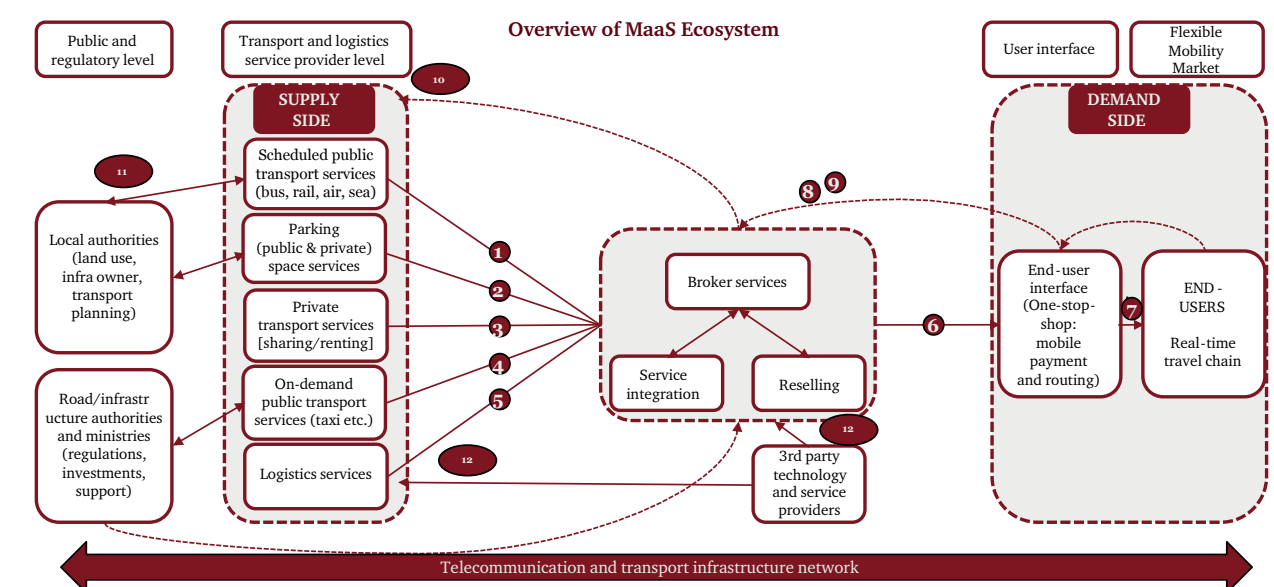
The key concept behind MaaS is to offer travelers mobility solutions based on their travel needs, combining different modes of transportation if needed. MaaS promises reduced usage of private cars, reduced emissions, enhanced urban planning, sustainable low-carbon mobility, multi-modal one stop shop and fit-for-purpose service planning. In addition, different payment methods are offered with the concept.

- Pay per usage: A mobility service directory helps in finding the smartest mobility option for the single journey (for occasional users, and ad-hoc and exceptional needs)
- Monthly computer package: Single Access point to multimodal service base that allows and attracts end-users to find the most suitable and valuable public services (trains, buses, trams and sufficient amount of taxi) for their regular everyday needs (prepaid monthly fee)

- All-in-one package: Highly customized travel solutions for users with varying travel needs. Includes tailored amount of public transport, car sharing, rental car and taxis (Monthly fee + pay per usage)

Istanbul Card is an early example of MaaS application but currently it only gathers public transportation options in the city with only pay-per-usage method. However, for further adaptation of private mobility services require enabling regulations and legislations. Incumbents of all mobility service providers should be recognized and actively engaged with the comprehensive mobility system.

Figure 18: Overview of Mobility as a Service (MaaS) Ecosystem



4

Electric Vehicles



Key Findings

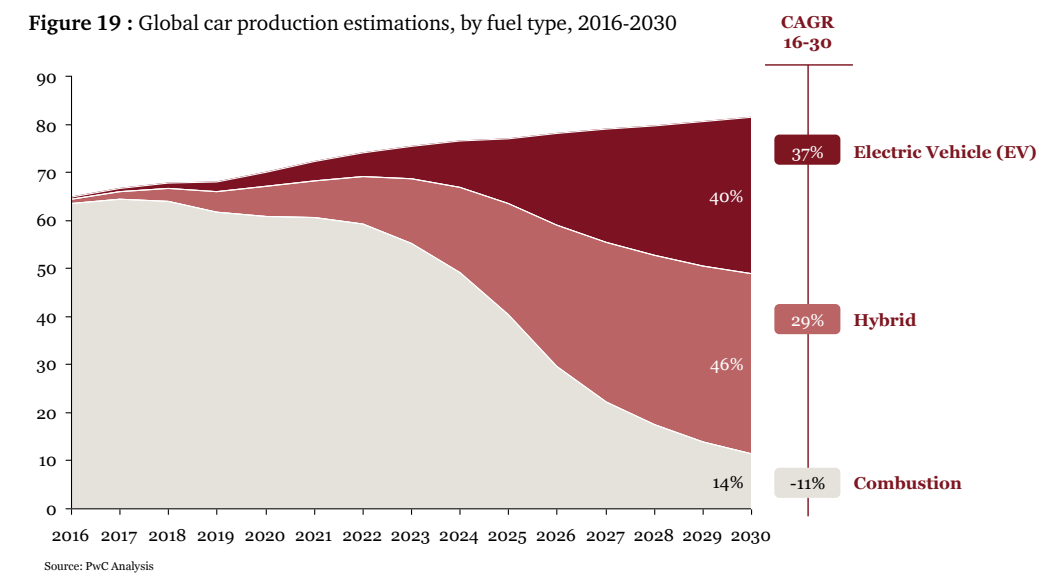
- The rise of EVs has been mainly driven by state incentives and regulations based on environmental concerns. Beyond this, availability of cost competitive powertrain, batteries legislation, infrastructure, and public perception will be the main drivers of transformation towards EVs.
- Powertrains and batteries will significantly change toward the full development of EVs.
- The trend of declining prices for lithium-ion batteries is estimated to render BEVs cost-competitive compared to ICEs.
- Turkey's powertrain portfolio will remain dominated by ICEs despite the shifting European landscape. Also, Turkey's share in region's light hybrid vehicle production will remain behind multiple East European competitors.
- Although EVs will not substantially increase nationwide electricity demand, they may pose a threat for local grid lines as per network management.

4. Electric Vehicles

Electric vehicle revolution also alter the value chain strategies of automotive industry players as a whole since the new generation vehicles have a whole different value chain. Battery is the heart of electric vehicles and it is the main source of the disruption in the vehicle. Raw materials include Aluminum, Nickel, Manganese, Graphite, Cobalt and Lithium while majority of the providers are located in Africa, Far East, Oceania and South America. Even the location change of raw material supply routes means significant

operational restructuring for automotive industry. Moreover, know-how required to build a powering mechanism for a vehicle is also changing. Major suppliers in different steps of the battery value chain, such as electrode providers, cell assemblers and battery packagers are also clustered in Far East, China and Japan. Thus, adaptation to these new value chains are of critical importance for automotive industry players.

Figure 19 : Global car production estimations, by fuel type, 2016-2030



Battery value chain is broadly composed of 5 steps, resource, processed product, electrode, cell and packaging. The most value added step of the value chain is the last step, battery packaging with 40% of value created in battery production belongs to packaging. On the other hand, processing of raw materials for making of electrodes and building of battery cells from

these electrodes are also high value added steps of the value chain. While proximity to resources is an important parameter for processing of the raw materials, industrial know-how and manufacturing related (product integration, group integrity and etc.) parameters have higher importance.

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Figure 20: Raw-Material Suppliers and Transport Network Risks on EV Battery Value Chain

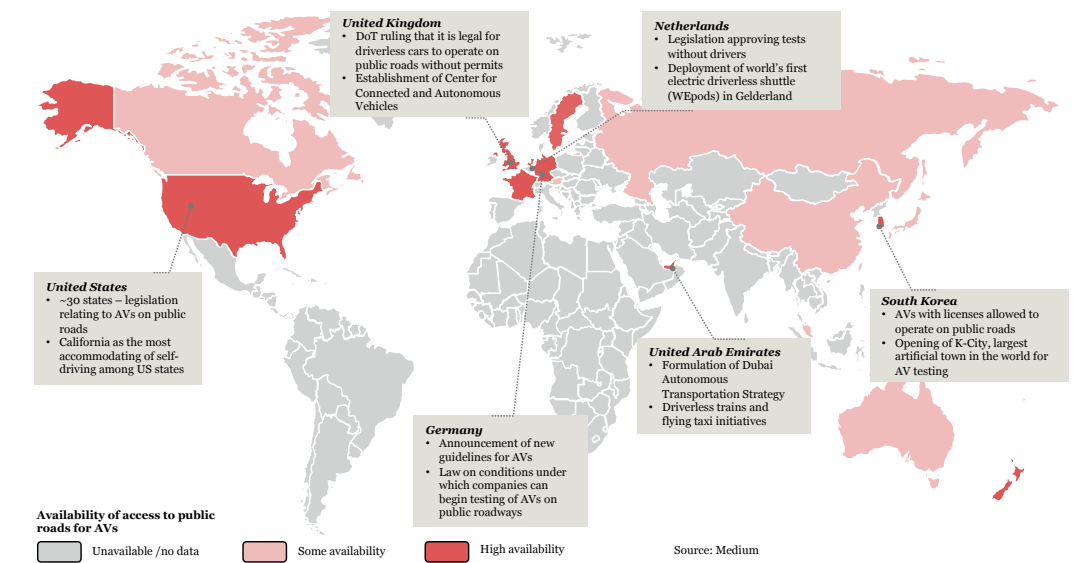
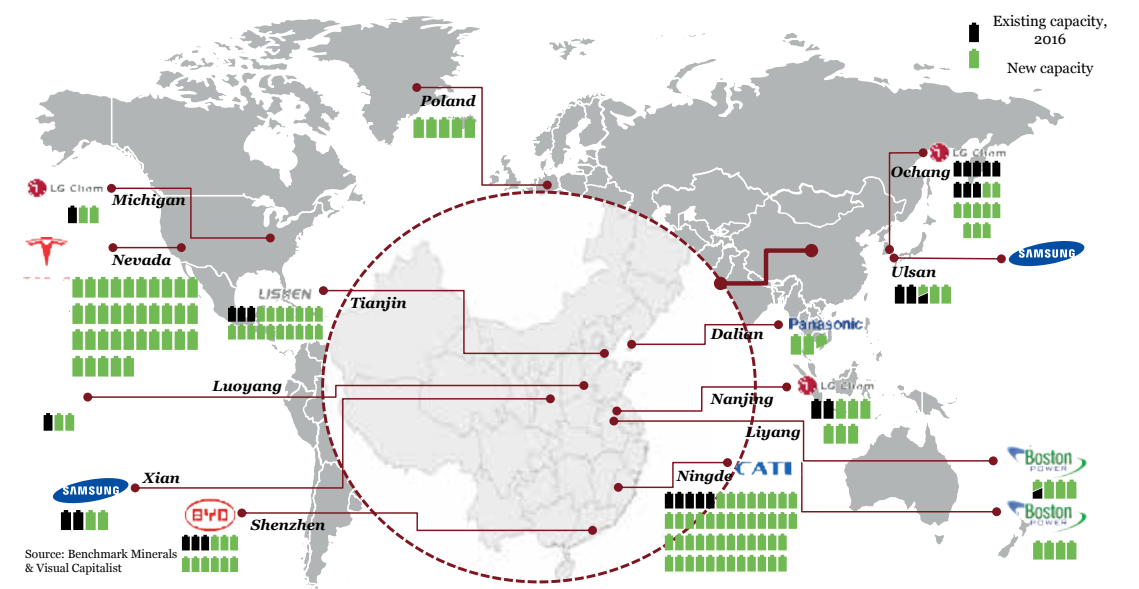


Figure 21: Lithium-ion Mega Factories and Their Capacities

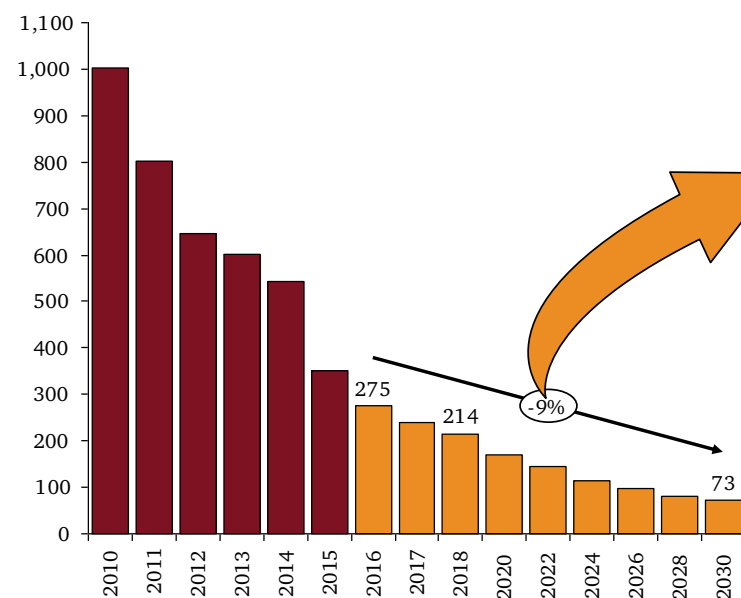




Searching for alternatives to internal combustion engine vehicles are not new in automotive industry as many have been familiar with the idea of electric vehicles but there had been obstacles ahead of progression. The most basic problem was related to cost of battery production. Due to significant additional cost burden of batteries, ICE vehicles have maintained their competitive advantage in the market for a very long time. Yet, automotive industry players and battery producers have continued R&D activities to decrease cost of battery production with technological advancement. Indeed, battery

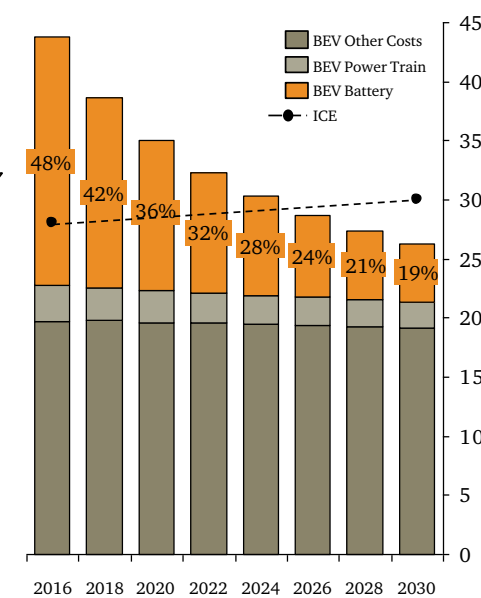
prices have started to decline rapidly after 2010 and the controversy for electric vehicles has become a vivid topic. Before 2016, battery costs would make up more than 50% of total production costs an electric vehicle but as of now, the share of battery in total costs has declined to 40% levels. This leads to growing competitive power for electric vehicles against ICE vehicles in the market. By 2025, production costs of equivalent electric and ICE vehicles are expected to equalize. Towards the end of 2020s, relative cost advantage of electric vehicle will start to sweep ICE vehicles out from the market.

Figure 22: Lithium-ion battery prices, USD/kWh 2010-2030



Source: Bloomberg New Energy Finance, PwC analysis

Figure 23: Medium Segment BEV and ICE pre-tax prices, USA market, 2010-2030 (thousand USD, %)



As cost will remain a major concern for development of electric vehicles, several other parameter will have important roles to determine the transition to electric vehicles in domestic markets.

- **Public Perception:** Today, most electric vehicle users are corporations and early-adopters of technology. Still, majority perceives ICE vehicles as best usable option in the market. However, this perception will naturally change along with other facilitating parameters for electric vehicle penetration taking effect.

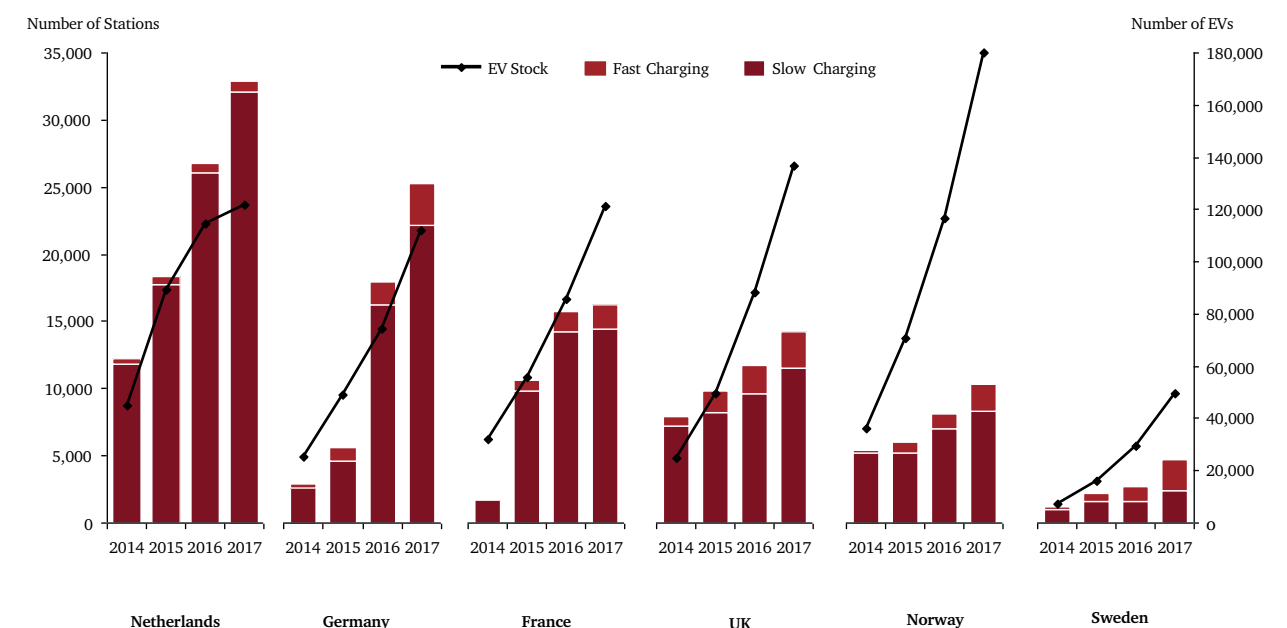
- **Infrastructure:** Although developed markets such as the US and the EU have started to make investments for the preparation of their road and charging infrastructure towards electric vehicle transformation, electric vehicle charging infrastructure is still weak. Yet, with cumulative effect of the investments, charging infrastructure will become more sufficient in the near future.
- **Legislation:** Damage done by ICE vehicles to atmosphere and nature due to CO2 emissions has been an important concern for regulators who would like to increase the quality of life in their societies. Thus, developed markets have gradually put further restrictions for CO2 emission limits in order. These restrictions will be key for pushing electric vehicles into market in spite of ICE vehicles' cost advantage.

Among these parameter, legislations have the highest capacity to create suitable conditions for electric vehicle penetration in the short term. Later on, following infrastructure investments

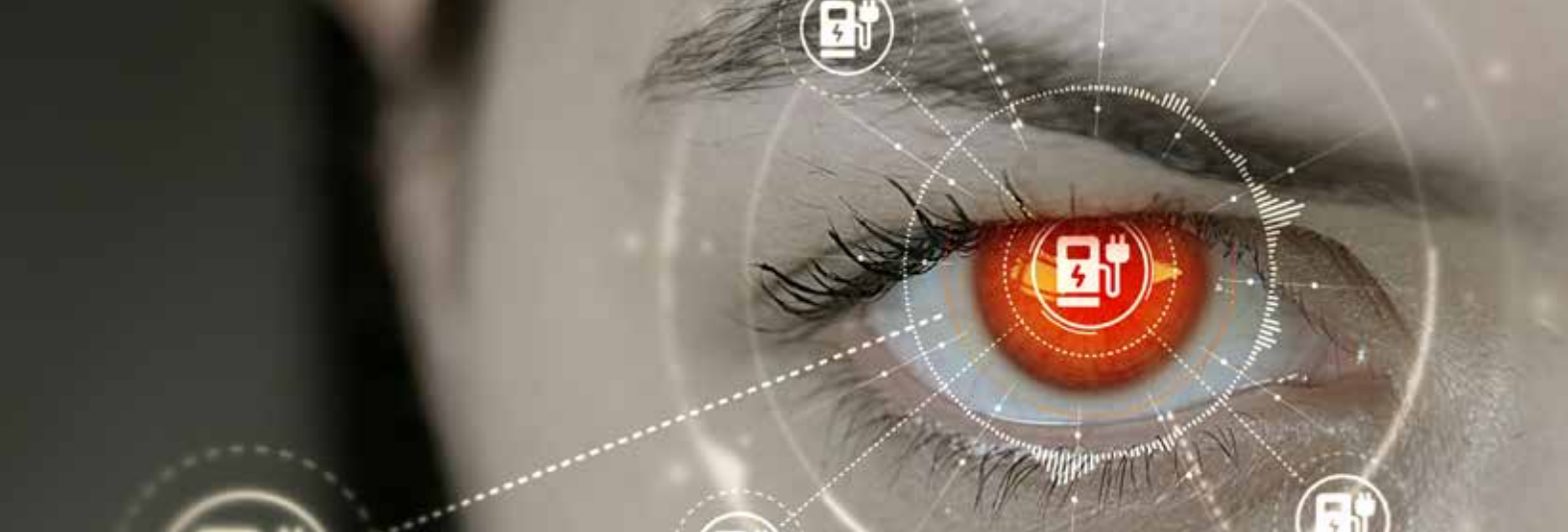
and increasing cost competitiveness of electric vehicles, public perception is expected to change on the behalf of electric vehicles. Thus, in order for Turkey to achieve a successful transformation towards electric vehicles, it should initially focus on the levers of legislation and infrastructure.

Facilitating impact of infrastructure investment for penetration of electric vehicles into domestic markets can be observed with different cases in the EU countries. For all best performer countries in the EU, in terms of transition to electric vehicles, it can be seen that the trend of number of electric vehicle charging stations and electric vehicle stock have moved in correlation. Norway who has put many legislation for electric vehicle penetration and made significant investments in her charging infrastructure, has now the highest share of electric vehicles in new vehicle sales. On the other hand, Netherlands who has the highest electric vehicle charging stations density in the EU, have managed to generate better electric vehicle sales than the EU's most populated country, Germany.

Figure 24: Charging Stations and Electric Car Stock (PHEV + BEV) in Europe's Top 6 Charging Station Market



Source :IEA



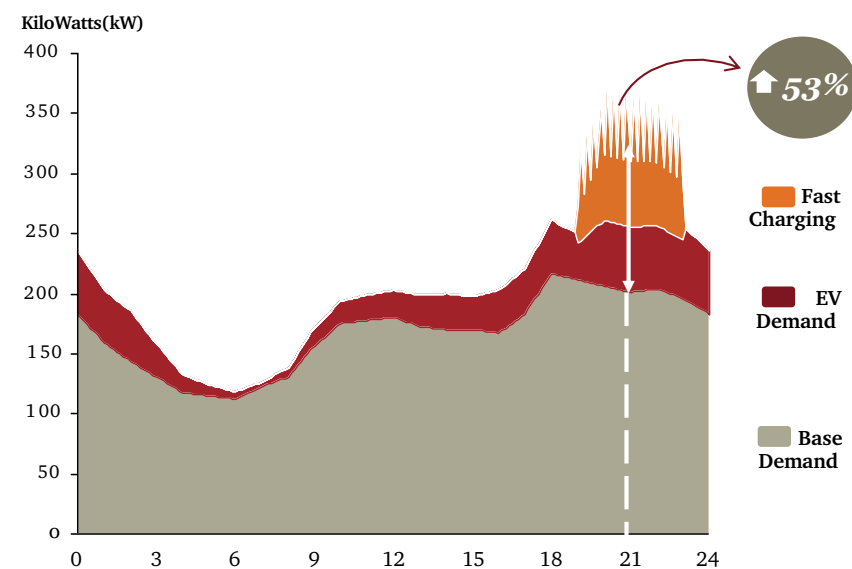
5

Policy Recommendations

Yet, investments for charging stations is more sophisticated than it seems. There are more parameters to consider than the number of charging stations to be built. Regarding the expectation of increasing electric vehicle penetration to urban areas, in some part of the city, electric load curves can be significantly affected by additional demand generated by charging stations. If 20% of home-chargers become fast-charging stations (which loads

more electric energy to grids), peak loads may increase by 54% increase during evening hours which can pose a great risk for grids and lead to power outages. Considering the fact that the cost of mass power outages in dense industrial zones of Eastern Marmara during the last days of 2016 were estimated to be around 150 million Dollars, charging station investments for electric vehicles should be made with due diligence.

Figure 25: Average Electric Load Curve in Turkey with fast charging station spikes (kW)



*Annual consumption of 5 megawatts per household is assumed (8 megawatts for US households)

** Daily mileage of 50kms with Nissan Leaf (24kWh) is assumed

*** During the evening peak hours, it is assumed that 20% of home charging events are performed by fast charging stations which can charge vehicles in 15 minutes



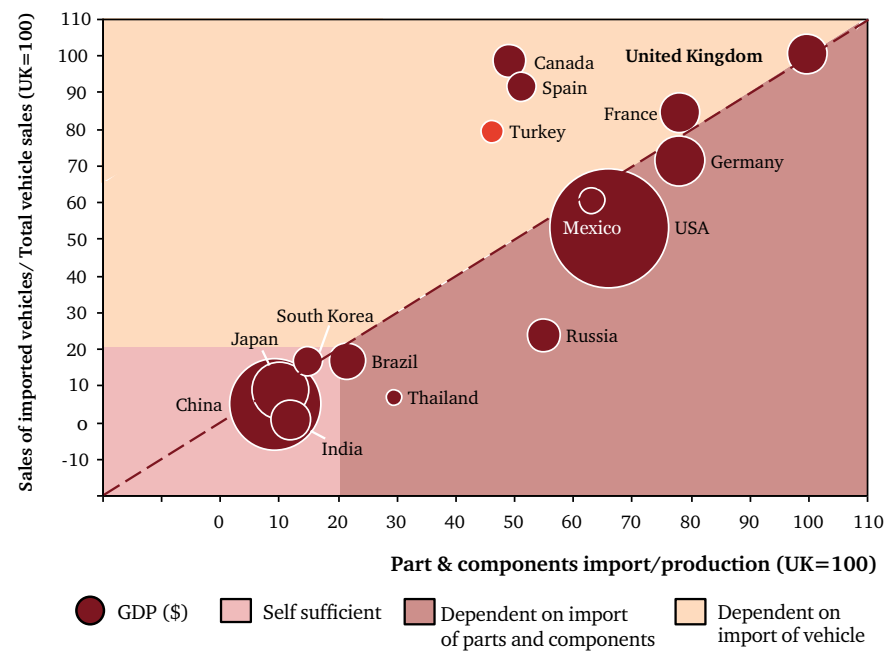


5. Policy Recommendations

In the global value chains of well-established industries, it is not easy to satisfy all demand of the industry with local capabilities. Few countries, Asian economies and Brazil, apply self-sufficiency strategies in global automotive value chains while majority of developed countries and Turkey's export destination countries are well-adapted to global value chains. Thus, aligning

with global value chains, in particular with value chains of its export destinations, will be the key guiding policy for Turkey's disruptive technology strategies in automotive industry. On the other hand, Turkey should also determine the sub-sectors to focus on localization and sub-sectors to integrate deeper with global value chains.

Figure 26: GVC indicators in automotive industry and parts & components for selected countries









From the industrial production perspective, disruptive technologies fundamentally alter the parts and components that are used as input for the production of vehicles, it is important to have an understanding of which producers will be affected by the change and this should be the reference point of strategy and localization discussions. In this context, there should be two main strategic priorities.

- Directing firms to new sub-components or to components that will continue to be used by taking their investment needs, current production characteristics and capabilities
- Investing in or attracting investment on new sub-components that Turkey would probably be competitive according to current capabilities

In order to maintain and increase the performance regarding the value added in the future, parts and components sectors should be ready for the changes in the supply and value chains of automotive industry. These parts and components are key for Turkey's created value in automotive industry and linkages between such local producers and major OEMs should be strengthened. Besides, since disruption is a reality also for automotive suppliers, a transformation strategy that can respond to the changing automotive supply and value chains should be designed and implemented.

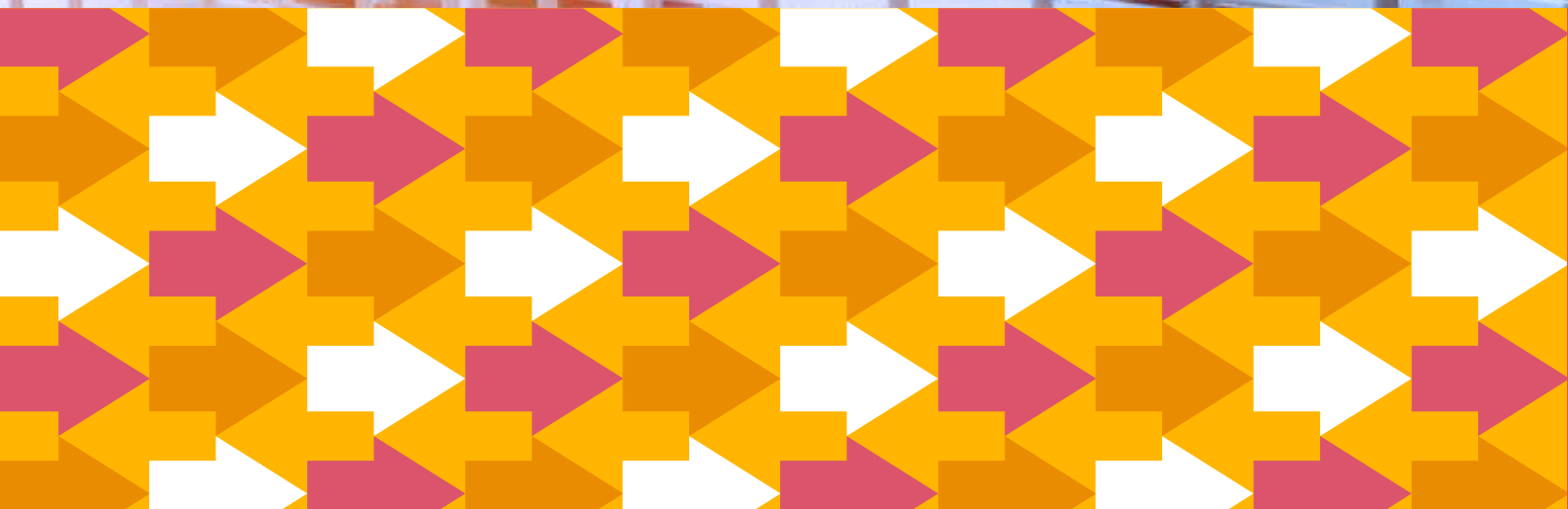
In this context, applicable for many manufacturing industries, three guiding elements which emphasize on upgrading of production facilities, adapting to changing demand dynamics and strategic FDI attraction. These three guiding elements should be the main principles of policy designs in five pillars, restructuring of the industry, legislative foundations, infrastructure planning, labor force and skill set, and innovation ecosystem. The policies falling under this matrix of strategies and implementation channels are demonstrated in the table below.

Table 2: Policy Recommendations Framework for Disruptive Technologies in Automotive Industry

	 Manufacturing Capabilities and Restructuring Automotive Industry	 Legislative Foundation Setting	 Reorientation of Infrastructure Policy Towards Smart Cities	 Initiatives for Employment and Skills	 Fostering Innovation Ecosystem
Production focus	<ul style="list-style-type: none">Software and Parts ProductionLi-Ion Battery Packaging and AssemblyIncentives for Next-Gen Vehicle Production	<ul style="list-style-type: none">Data Processing Rights and ServicesCybersecurityEV Subsidies to OEM's		<ul style="list-style-type: none">New Employment OpportunitiesEducation System Transformation	<ul style="list-style-type: none">Smart Mobility team up with OEMsCreation of Test Centers
Demand focus	<ul style="list-style-type: none">Driving Domestic and Export Demand	<ul style="list-style-type: none">Data Processing Rights and ServicesCybersecurity	<ul style="list-style-type: none">Master Urban Plan and Strategy Paper for Urban Planning		
FDI focus	<ul style="list-style-type: none">FDI Attraction in Automotive Industry	<ul style="list-style-type: none">EV Subsidies to OEM's		<ul style="list-style-type: none">Education System Transformation	<ul style="list-style-type: none">Creation of Test Centers
 <div>• Evidence Based Decision Making • Policy Impact Assessment</div>					

6

Concluding Remarks





6. Concluding Remarks

As the biggest exporting industry, employing more than 150,000 people and also indirectly significantly contributing to overall economy through its input-output relationships with many other industries, automotive industry is at the heart of Turkey's manufacturing industries.

Today, global automotive industry is facing a major transformation, led by disruptive technologies and changing consumer needs. Disruption in automotive industry is analyzed under CASE framework, which represents first letters of connected vehicles, autonomous vehicles, share mobility and electric vehicles. Each wave of disruption stresses conventional automotive strategies but it also creates significant opportunities in the field, in particular for technology providers.

However, disruptive technologies will not have the same effect all over the world. Automotive industries in developed economies, like the US and EU countries, and in world's manufacturing hub, China, will be the coasts where the waves of disruption will first hit. However, considering the fact that almost 85% of Turkey's automotive

exports are made to EU countries, Turkey should be one of leading countries in responding to disruptive changes in automotive industry otherwise Turkey's production portfolio will experience a significant mismatch with the demand in its major export destinations. Thus, the key take away from this study is that Turkey should identify industrial strategies to restructure automotive production portfolio, establish new investment attraction plans in disruptive technology and design local policies not only to catch up with its export destinations but also to stimulate demand in the local market.

As PwC, we help governments and business understand how big economic, demographic, social, and environmental changes affect them, by setting out scenarios that identify growth opportunities as well as the risks and potential measures. On behalf of PwC Turkey and Automotive Manufacturers Association, we would like to re-emphasize our pleasure in delivering this project, which will hopefully provide valuable insights on mechanisms, implications and future of Automotive Industry in Turkey.

