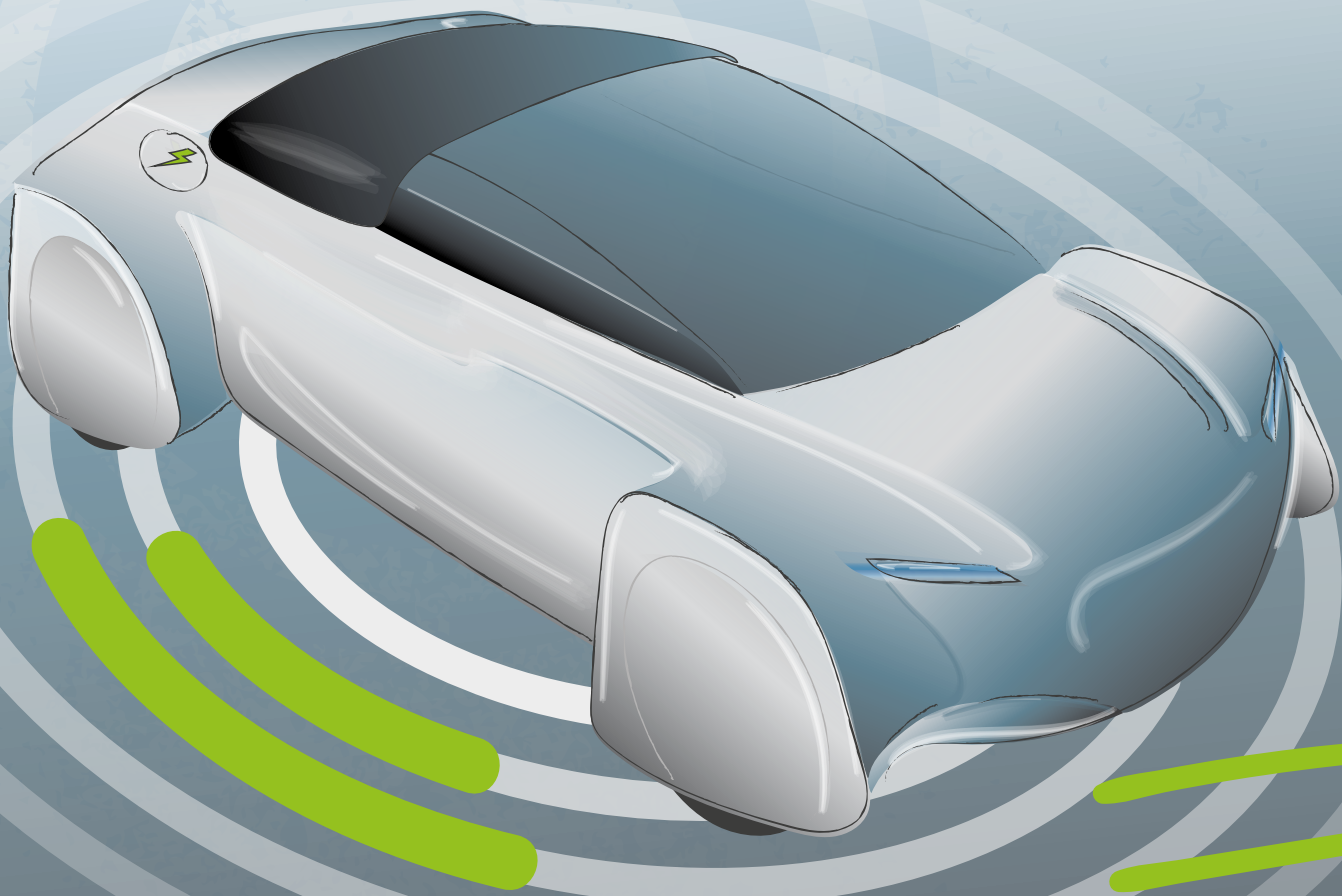


Automotive revolution – perspective towards 2030

How the convergence of disruptive
technology-driven trends could
transform the auto industry

Advanced Industries January 2016



Today's economies are dramatically changing, triggered by development in emerging markets, the accelerated rise of new technologies, sustainability policies, and changing consumer preferences around ownership. Digitization and new business models have revolutionized other industries, and automotive will be no exception. For the automotive sector, these forces are giving rise to four disruptive technology-driven trends: diverse mobility, autonomous driving, electrification, and connectivity.

Most industry players and experts agree that these four technology-driven trends will reinforce and accelerate one another, and there is general consensus that the industry is ripe for disruption. Yet although the widespread sentiment that game-changing disruption is already on the horizon, there is still no integrated perspective on how the automotive industry will look in 10 to 15 years as a result of these trends.

With this publication we aim to make the imminent changes more tangible. We start from the general consensus that the industry is transforming and go further to specify and quantify the magnitude of change. The forecasts in this study should, thus, be interpreted as a projection of the more probable assumptions across all four trends, based on our current understanding. The forecast methodology is certainly not deterministic in nature (Text box 1), but should help industry players better prepare for the uncertainty by discussing potential future scenarios (Text box 2).

Text box 1: The methodology behind “Automotive revolution – perspective towards 2030”

- Research on the future of mobility conducted in collaboration with Stanford University
- Substantial industry-wide research covering perspectives from incumbents, new entrants, start-ups, academia, as well as investment and legal firms
- Extensive executive interviews and in-depth discussions with over 30 industry experts in Asia, Europe, and the United States
- A proprietary quantitative market model integrating macroeconomic development, future mobility behavior, electric vehicle and autonomous vehicle diffusion

There are many tough, fundamental, or even existential questions that are looming for automakers and suppliers. Some commentators suggest these disruptions will mark the decline of the automotive industry. But in our view, growth in the personal mobility market will accelerate as new sources of recurring revenues supplement slowing growth from one-time vehicle sales.

Text box 2: Overview of the high-disruption vs. the low-disruption scenario

| | High | Low |
|--|---------------|------------|
| Diverse mobility | | |
| City policies discouraging private vehicles | Intensified | Steady |
| New, on-demand business models | Prevalent | Limited |
| Modal shift away from car ownership to shared mobility | Significant | Limited |
| Autonomous driving | | |
| Regulatory challenges are overcome | Fast | Gradual |
| Development of safe and reliable technical solutions | Comprehensive | Incomplete |
| Consumer acceptance and willingness to pay | Enthusiastic | Limited |
| Electrification | | |
| Battery prices continue to decline | Rapid | Protracted |
| Regulator-driven emission restrictions | Intensified | Gradual |
| Consumer demand for electrified powertrains | Widespread | Restrained |
| Connectivity | | |
| Uptake of car connectivity globally | Vast majority | Partial |
| Consumers regularly using paid content | Mainstream | Limited |

We drafted **eight key perspectives on the “2030 automotive revolution”** to provide insights into the kind of changes that are coming and how they will affect traditional OEMs and suppliers, potential new players, regulators, consumers, national car markets, and the automotive value chain.



Shifting markets and revenue pools

1. Driven by shared mobility, connectivity services, and feature upgrades, new business models could expand automotive revenue pools by ~30 percent, adding up to ~USD 1.5 trillion.
2. Despite a shift towards shared mobility, vehicle unit sales will continue to grow, but likely at a lower rate of ~2 percent p.a.



Changes in mobility behavior

3. Consumer mobility behavior is changing, leading to up to one out of ten cars sold in 2030 potentially being a shared vehicle and the subsequent rise of a market for fit-for-purpose mobility solutions.
4. City type will replace country or region as the most relevant segmentation dimension that determines mobility behavior and, thus, the speed and scope of the automotive revolution.



Diffusion of advanced technology

5. Once technological and regulatory issues have been resolved, up to 15 percent of new cars in 2030 could be fully autonomous.
6. Electrified vehicles are becoming viable and competitive; however, the speed of their adoption will vary strongly at the local level.



New competition and cooperation

7. Within a more complex and diversified mobility industry landscape, incumbent players will be forced to simultaneously compete on multiple fronts and cooperate with competitors.
8. New market entrants are expected to initially target only specific, economically attractive segments and activities along the value chain before potentially exploring further fields.

Based on our analysis of these eight perspectives, which are explained in more detail in the following four chapters, we believe incumbent players need to make fundamental and strategically vetted decisions now to shape the industry's future by preparing for uncertainty, leveraging partnerships, adapting the organization, and reshaping the value proposition.



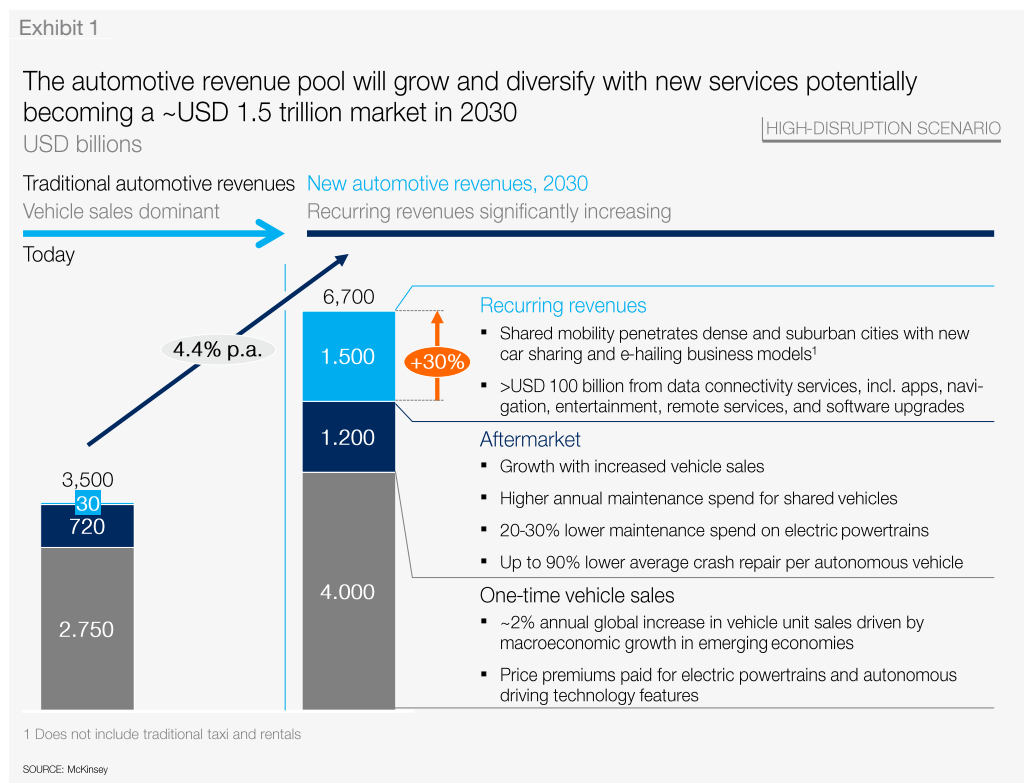
Shifting markets and revenue pools

Some commentators argue that the automotive industry is in decline; however, we contend that growth is actually accelerating, stemming from new revenue streams, including shared mobility and data connectivity services as well as continuing global macroeconomic growth in emerging economies.

1. Driven by shared mobility, connectivity services, and feature upgrades, new business models could expand automotive revenue pools by ~30 percent, adding up to ~USD 1.5 trillion

The automotive revenue pool will significantly increase and diversify towards on-demand mobility services and data-driven services. This could create up to ~USD 1.5 trillion (or 30 percent more) in additional revenue potential in 2030, compared to ~USD 5.2 trillion from traditional car sales and aftermarket products/services (up from ~USD 3.5 trillion in 2015). Together, these revenues could accelerate annual automotive industry growth to 4.4 percent (up from about 3.6 percent from 2010 to 2015).

Connectivity, and later autonomous technology, will increasingly allow the car to become a platform for drivers and passengers to use their transit time for personal activities, which could include the use of novel forms of media and services. The increasing speed of innovation, especially in software-based systems, will require cars to be upgradable. As shared mobility solutions (i.e., car sharing or e-hailing) with shorter lifecycles will become more common, consumers will be constantly aware of technological advances, which will further increase demand for upgradability in privately used cars as well.

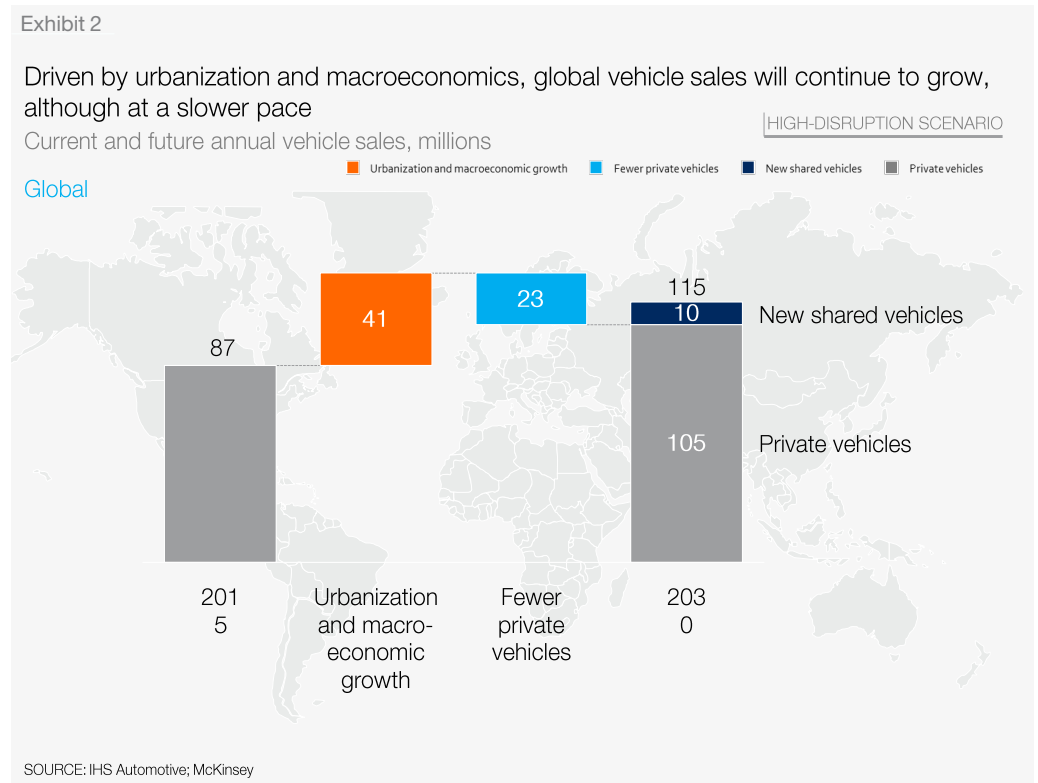


2. Despite a shift towards shared mobility, vehicle unit sales will continue to grow, but likely at a lower rate of ~2 percent p.a.

Overall global car sales will continue to grow, but the annual growth rate is expected to drop from the 3.6 percent of the last five years to ~2 percent annually by 2030. This drop will be largely driven by macroeconomic factors and the rise of new mobility services such as car sharing and e-hailing.

A detailed analysis suggests that dense areas with a large, established vehicle base are fertile ground for these new mobility services, and many cities and suburbs of Europe and North America fit this profile. New mobility services may result in a decline of private vehicle sales, but this decline is likely to be partially offset by increased sales in shared vehicles that need to be replaced more often due to higher utilization and related wear and tear.

The remaining driver of growth in global car sales is the overall positive macroeconomic development, including the rise of the global consumer middle class. As established markets are no longer expanding, growth will continue to rely on emerging economies, particularly China and India.





Changes in mobility behavior

When considering the potential for industry transformation, consumer preferences and behavior are an important starting point. We believe the disruptive technology-driven trends have the potential to fundamentally change the relationship between the consumer and the automobile.

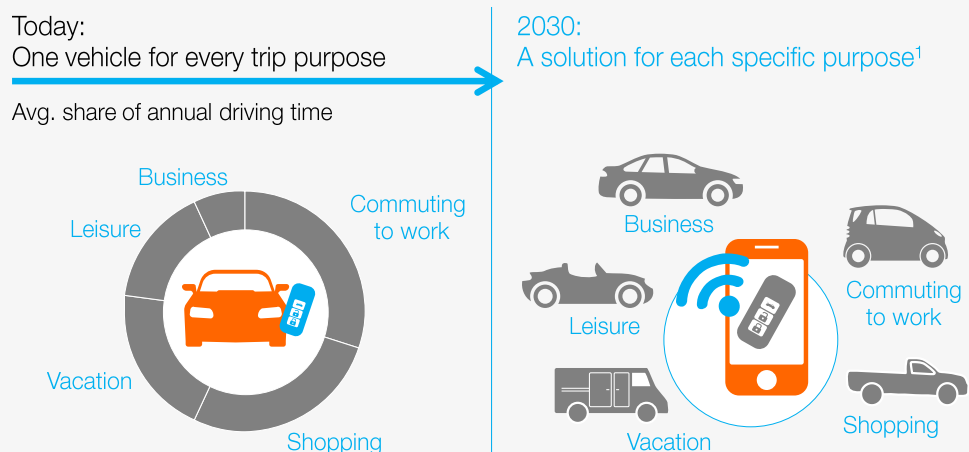
3. Consumer mobility behavior is changing, leading to up to one out of ten cars sold in 2030 potentially being a shared vehicle and the subsequent rise of a market for fit-for-purpose mobility solutions

Consumer preferences, tightening regulation, and technological breakthroughs add up to a fundamental shift in individual mobility behavior. Individuals increasingly use multiple modes of transportation to complete their journey, and goods and services are increasingly delivered to (rather than fetched by) consumers. As a result, the traditional business model of car sales will be complemented by a range of diverse on-demand mobility solutions, especially in dense urban environments that proactively discourage private car use.

Consumers today use their cars as “all-purpose” vehicles, no matter if commuting alone to work or taking the whole family to the beach. In the future, they may want the flexibility to choose the best solution for a specific purpose, on demand and via their smartphones. We can already observe significant, early signs that the importance of private car ownership is declining and shared mobility is increasing. In the US, for example, the share of young people (16 to 24 years) that hold a driver’s license dropped from 76 percent in 2000 to 71 percent in 2013¹, while the number of car sharing members in North America and Germany has grown by more than 30 percent annually over the last five years.^{2,3}

Exhibit 3

Today consumers use their vehicles for all purposes; in the future, they will choose an optimal mobility solution for each specific purpose



¹ Only showing automobile based mobility, alternative options like walking, biking, and public transportation are also included in optimal mobility solutions
SOURCE: McKinsey

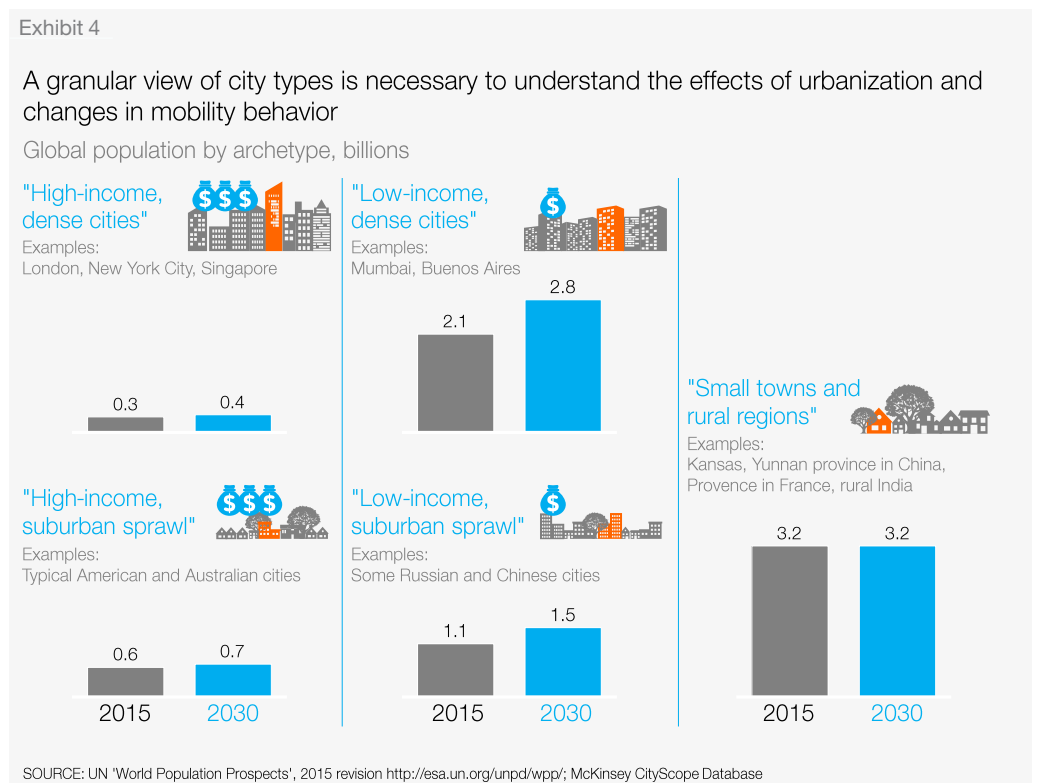
The shift to shared mobility, enabling consumers to use the optimal solution for each purpose, will lead to new segments of specialized vehicles designed for very specific needs. For example, the car parc for a vehicle specifically built for e-hailing services – i.e., designed for high

utilization, robustness, additional mileage and passenger comfort – would already be millions of units today; and this is just the beginning. As a result of this shift to diverse mobility solutions, up to one out of ten new cars sold in 2030 may likely be a shared vehicle, which could reduce private-use vehicle sales, an effect partially offset by a faster replacement rate for shared vehicles. This would mean that more than 30 percent of miles driven in new cars sold could be from shared mobility. On this trajectory, one out of three new cars sold could potentially be a shared vehicle as soon as 2050.

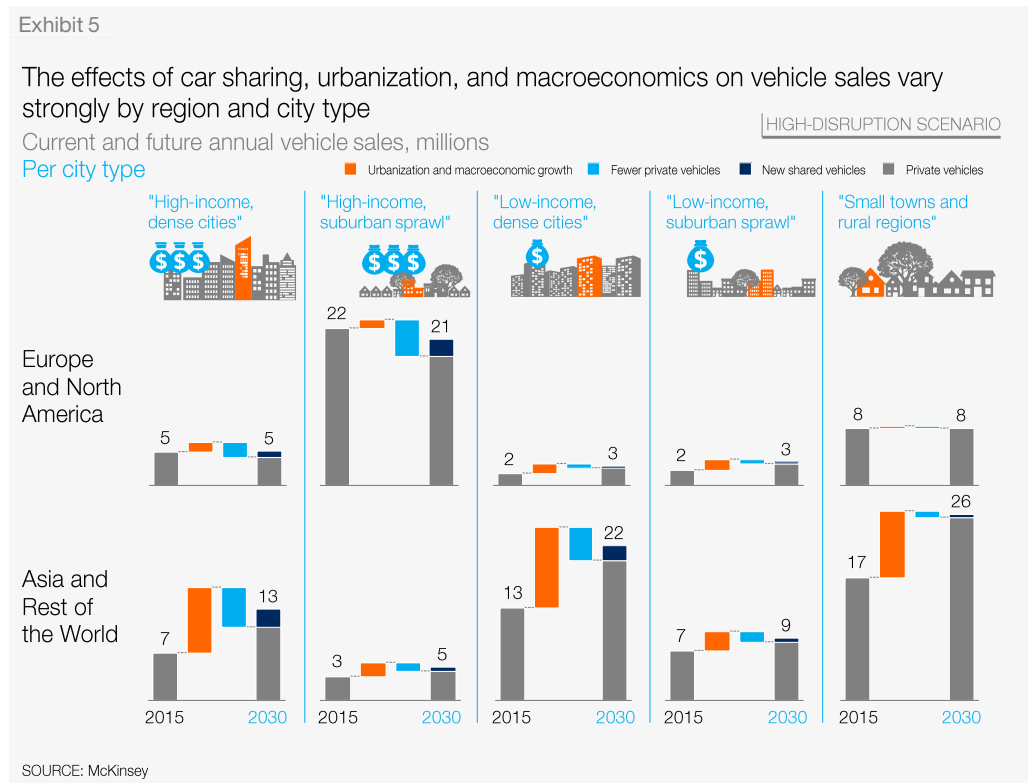
4. City type will replace country or region as the most relevant segmentation dimension that determines mobility behavior and, thus, the speed and scope of the automotive revolution

Understanding where future business opportunities lie requires a more granular view of mobility markets than ever before. Specifically, it is necessary to segment these markets by city types based primarily on their population density, economic development, and prosperity. Population levels are growing most significantly in low-income cities, while higher income cities remain relatively stable.

Across those segments, consumer preferences, policy and regulation, as well as the availability and price of new business models will strongly diverge. In megacities such as London or Shanghai, for example, congestion fees, a lack of parking, traffic jams, etc. mean car ownership is more of a burden for many, and shared mobility presents a competitive value proposition. Such cities also provide sufficient scale for new mobility business models. By contrast, in rural areas, where low density creates a barrier to scale, private car usage will remain the preferred means of transport.



Similarly, penetration of autonomous technology and electric powertrains would most likely be led in dense high-income cities which have a well-established car base, increasing regulatory pressure against vehicle emissions, and where the cost of technology features represents a lower proportion of income.



The type of city will thus become the key indicator for mobility behavior and car sales, replacing the traditional regional perspective on the mobility market. By 2030, the car market in New York City will likely have more in common with the market in Shanghai than with that of Kansas.



Diffusion of advanced technology

Autonomous technology and electrified powertrains are generating plenty of interest and we see strong long-term potential; however, the extent of diffusion over the next 15 years will depend on overcoming a wide range of barriers.

5. Once technological and regulatory issues have been resolved, up to 15 percent of new cars sold in 2030 could be fully autonomous

Fully autonomous vehicles (AVs) are unlikely to be commercially available before 2020. Meanwhile, advanced driver assistance systems (ADAS) will play a crucial role in preparing regulators, consumers, and corporations for the medium-term reality of cars taking over control from drivers.

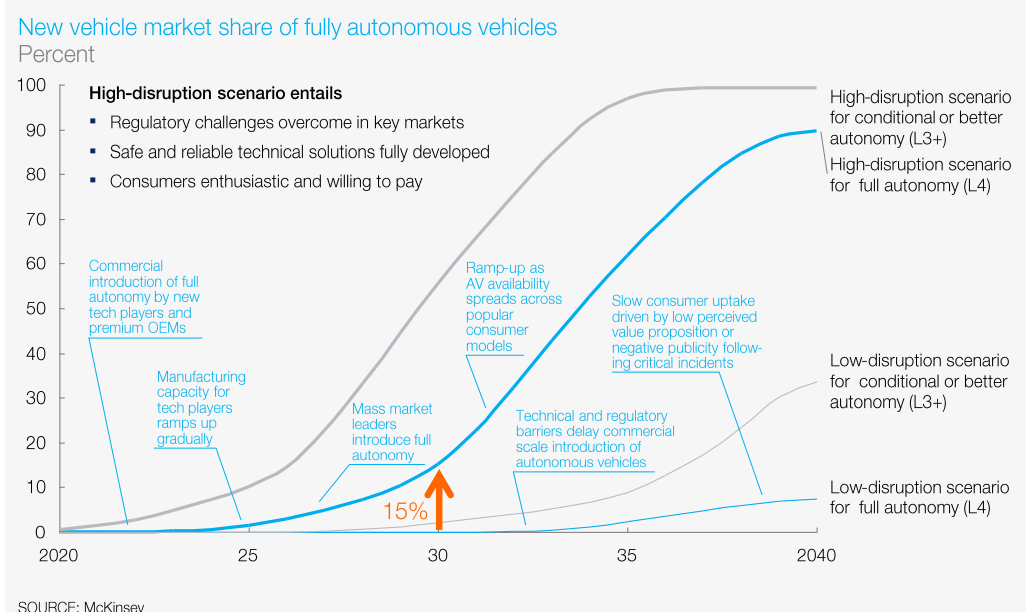
The market introduction of ADAS has shown that the primary challenges impeding faster market penetration are pricing, consumer understanding, and safety/security issues. The technological challenges are not insignificant, and will likely drive the delay between conditionally autonomous cars which allow the driver to cede control in certain situations (Level 3 according to the National Highway Traffic Safety Administration (NHTSA)), and fully autonomous cars, which require no driver intervention for the entire trip (Level 4 NHTSA). Tech players and start-ups will likely play an important role in achieving this level of technical complexity.

Regulation and consumer acceptance represent additional hurdles for autonomous vehicles. However, once these challenges are addressed, autonomous vehicles present a tremendous value offering for consumers (e.g., ability to work while commuting, convenience of using social media, or resting while traveling).

A progressive scenario could see ~50 percent of passenger vehicles sold in 2030 being highly autonomous and ~15 percent being fully autonomous.

Exhibit 6

Subject to progress on the technical, infrastructure, and regulatory challenges, up to 15% of all new vehicles sold in 2030 could be fully autonomous



6. Electrified vehicles are becoming viable and competitive; however, the speed of their adoption will vary strongly at the local level

Stricter emission regulations, lower battery costs, widely available charging stations, and increasing consumer acceptance will create new and strong momentum for penetration of electrified vehicles (hybrid, plug-in, battery electric, and fuel cell) in the coming years. The speed of adoption will be determined by the interaction of consumer pull (partially driven by total cost of ownership) and regulatory push, which will vary strongly at the regional and local level.

Hence, in 2030, the share of electrified vehicles could range from 10 to 50 percent of new vehicle sales. Adoption rates will be highest in developed, dense cities with strict emission regulations and consumer incentives (tax breaks, special parking and driving privileges, discounted electricity pricing, etc.). Sales penetration will be slower in small towns and rural areas with lower levels of charging infrastructure and higher dependency on driving range.

Through continuous improvements in battery technology and cost, those local differences will become less pronounced, and electrified vehicles are expected to gain more and more market share from conventional vehicles (Text box 3). With battery costs potentially decreasing to USD 150 to 200 per kWh over the next decade, electrified vehicles will achieve cost competitiveness with conventional vehicles, creating the most significant catalyst for market penetration. Advances in charging technology, range, and awareness will further improve the customer value proposition. At the same time, it is important to note that electrified vehicles include a large portion of hybrid electrics, which means that even beyond 2030 the internal combustion engine will remain very relevant.

Text box 3: Why now? – reasons for the imminent disruption

Although the four trends have been observed for years, they are only now positioned to disrupt because consumers, technology, and governments are finally ready.

| Trend | Current and future enabling forces | Triggered by |
|--------------------|---|--|
| Electrification | <ul style="list-style-type: none"> Desirable products Battery technology/cost (<USD 200/kWh, 2020) Charging stations (1,200% global increase, 2014-20) Emission/efficiency regulation (EU 95 g_{CO2}/km, 2021; US 54.5 mpg, 2025, CA 15% ZEV 2025) | <ul style="list-style-type: none"> Regulation/urban design Technology/business model Consumer preferences |
| Connectivity | <ul style="list-style-type: none"> Connected lifestyle extending to the car Vehicle safety communication mandate (US vehicle-to-vehicle, expected by 2020) Communication network growing (5G, 2020) Tech giants and start-ups discover the remaining piece in connected world | |
| Autonomous driving | <ul style="list-style-type: none"> Sensor and processing solutions Communication/legal infrastructure (currently 4 states in the US, more expected) Public demonstrations of autonomous driving show benefit Tech giants and start-ups discover automated cars "interesting playground" | |
| Diverse mobility | <ul style="list-style-type: none"> Consumers prefer access over ownership (600% global car sharing revenue increase, 2013-20) Smartphone makes scheduling convenient Incentives for corporations and consumers Urban congestion (30% of traffic for parking) Shared mobility providers offer trendy products | |



New competition and cooperation

While growth in the revenue pool may be accelerating, the traditional industry boundaries are shifting, changing the rules of the game.

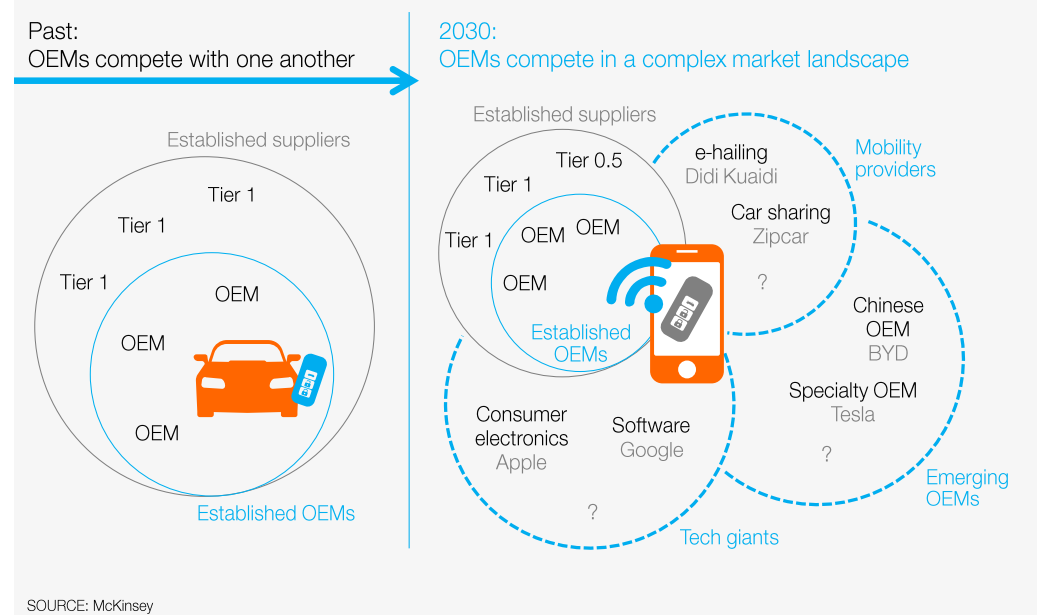
7. Within a more complex and diversified mobility industry landscape, incumbent players will be forced to simultaneously compete on multiple fronts and cooperate with competitors

While markets such as mobile handsets have recently experienced significant disruption, the automotive industry has not seen fundamental change in recent decades. For example, over the last 15 years, only 2 new players have appeared on the list of the top 15 automotive OEMs, compared to 10 new players in the handset industry.^{4,5}

A paradigm shift to mobility as a service, along with new entrants, will inevitably force traditional car manufacturers to compete on multiple fronts. Mobility providers (e.g., Didi Kuaidi, Uber, Zipcar), tech giants (e.g., Apple, Google), and emerging OEMs (e.g., BYD, Tesla) increase the complexity of the industry's competitive landscape.

Exhibit 7

Increasing complexity of the competitive landscape for individual mobility will force OEMs to compete on multiple fronts

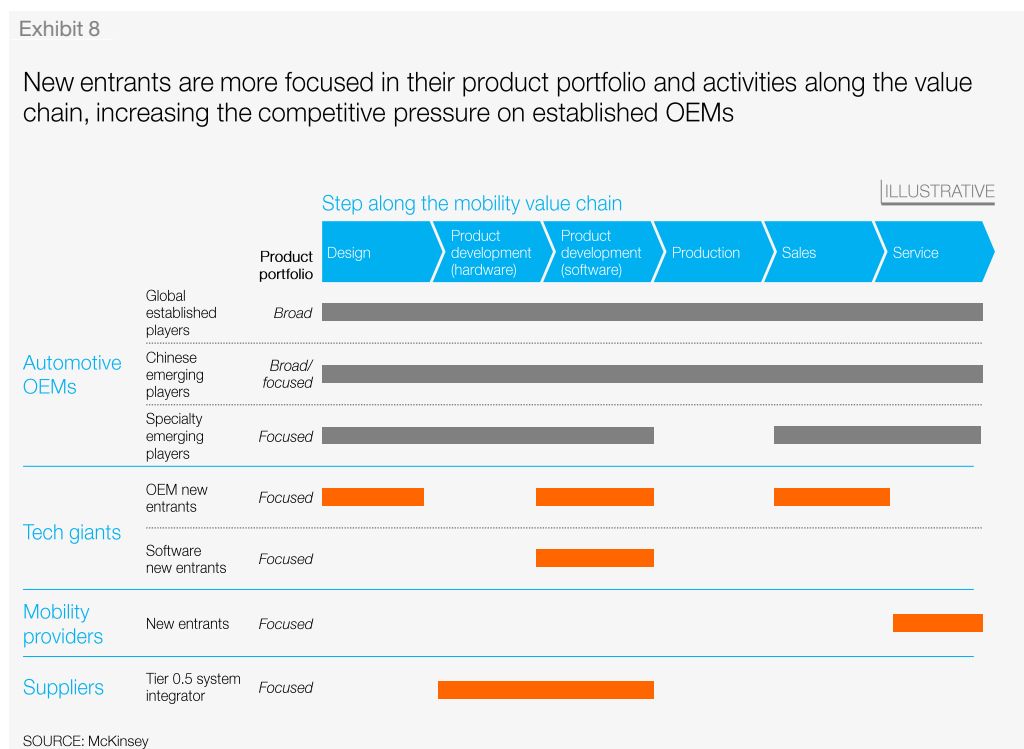


While emerging manufacturers take a share of new vehicle sales, established suppliers will increasingly capture a larger portion of the vehicle's total value. As tier 0.5 suppliers move to provide more complete vehicle sub-systems, they will even establish their own touch points with the end consumer to further capture aftersales mobility spend. Traditional automotive players, who are under continuous pressure to reduce costs and become more capital efficient, will feel the squeeze. This will likely lead to shifting market positions in the evolving automotive and mobility industries and may even lead to consolidation or new forms of partnerships among incumbent players.

In another game-changing development, software competence is increasingly becoming one of the most important differentiating factors for the industry. The program code for the modern car has approximately as many object instructions as an aerospace flight control system. Software will be used to deliver a wider range of features and services, including mobility services, advanced safety, location-based services, in-vehicle content, and remote analytics. Partnerships across technologies and services will grow the user base and reduce costs leading to increased value for consumers. These partnerships also serve to solidify rising connectivity ecosystems. Automakers need to be strategic about which parts of the connectivity ecosystem they control in order to profit from connectivity and keep the vehicle itself from becoming a commoditized content platform. However, as cars are increasingly integrated into the connected world, automakers will have no choice but to participate in the new mobility ecosystems that emerge as a result of technological and consumer trends.

8. New market entrants are expected to initially target only specific, economically attractive segments and activities along the value chain before potentially exploring further fields

Diverging markets will open opportunities for new players, who will initially focus on a few selected steps along the value chain and target only specific, economically attractive market segments – and may expand from there. While Tesla, Google, Apple, Baidu, and Uber currently generate significant interest, we believe that they represent just the tip of the iceberg. Many more new players are likely to enter the market, especially start-ups and cash-rich high-tech companies. These new entrants from outside the industry are also wielding more influence with consumers and regulators (i.e., generating interest around new mobility forms and lobbying for favorable regulation of new technologies). Similarly, some Chinese car manufacturers, with impressive sales growth recently, might play an important role globally by leveraging the ongoing disruptions and leapfrogging established competitors.





Moving forward: How automotive players should align their strategic priorities

Total revenues from personal mobility will accelerate by 2030, but shifting markets and new technologies ensure that future automotive growth will be more granular than in the past. Growth across the traditional markets and segments is no longer a given. Automotive OEMs will need to capture growth from a variety of sources such as mobility in dense cities and recurring, post-sale revenue streams. With the emergence of non-traditional revenue channels, ownership of the mobility value chain has the potential for disruption.

This also means that automotive incumbents cannot predict the future of the industry with certainty. They can, however, make strategic moves now to shape the industry's evolution. In order to get ahead of the inevitable disruption, incumbent players should implement a four-pronged strategic approach.

Prepare for uncertainty: Success in 2030 will require automotive players to anticipate market trends sooner and to explore new mobility business models as well as their economical and consumer viability. In order to do that, they need to proactively analyze consumer preferences and be aware that there are more similarities across city types than across regions. They also need to pay close attention to the changing demographics in key markets, especially the increasing urbanization and the volatility of the emerging economies, which make it difficult to predict sales volumes beyond 2020 in markets like China. A sophisticated level of scenario planning and agility is required to identify and scale new, attractive business models.

Leverage partnerships: With the industry evolving from competition among individual players towards new competitive interactions, but also partnerships and open, scalable ecosystems, OEMs, suppliers, and service providers need to form partnerships across and beyond the industry. They need to benefit jointly from sharing the costs of electric and autonomous vehicle technology and the necessary infrastructure. Those partnerships should also engage governments to develop regulation and architectures for new mobility solutions together. This also extends to joint efforts in public outreach for consumer education on the benefits and challenges of new technologies. However, despite collaborative efforts, OEMs in particular need to maintain control over their individual value creation and success in the emerging ecosystems.

Adapt the organization: As the entire industry is undergoing transformational changes driven by the four key trends, players must adapt their organizations to facilitate greater internal collaboration. Internal processes need to reflect that software is the key enabler for innovation and new business models. This requires strategic decisions regarding how to acquire the necessary expertise and whether this will be built up internally through hiring or outsourced to external vendors. A two-speed R&D model is needed to catch up with short-term market trends and enable lifecycle product upgrades. This has to cover the needs of hardware's longer lifecycle as well as the shorter lifecycle requirements of software and business development.

Reshape the value proposition: To retain their share of the automotive profit pool, OEMs need to find the right strategy for differentiating their products and services, which largely means evolving their value proposition from “hardware provider” to “integrated mobility service provider.” Product differentiation should be pursued through a digital end-to-end user experience with a customer focus similar to software companies keeping products attractive throughout the lifecycle. Given the trend towards centrally operated fleets of shared vehicles, OEMs also need to further strengthen B2B sales and large-scale aftermarket services for those businesses.

The future of the automotive industry presents many challenges but also many new opportunities. To become a driver of change and benefit from the disruption that new players will bring, our four priorities highlight that incumbent players need to make fundamental and strategically vetted decisions now. The automotive industry is far from a state of decline; in fact, we believe its biggest moments are still to come.

End notes

- ¹ Sivak, M., 'Has motorization in the US peaked?', University of Michigan Transportation Research Institute, June 2013
- ² 'Carsharing expands rapidly into new towns and communities', Bundesverband CarSharing e. V., March 2015
- ³ Shaheen, S., Cohen, A., 'Innovative Mobility Car Sharing Outlook', Transportation Sustainability Research Center – University Of California, Berkeley, July 2015
- ⁴ 'Light Vehicles Sales Forecast', IHS Automotive, October 2015
- ⁵ Oh, W., 'Global Handset Shipments by Vendor by Quarter: 2000 to 2016', Strategy Analytics, June 2015

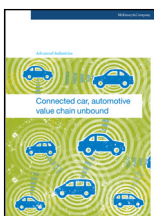
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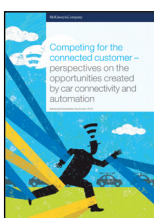
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Further information on the underlying disruptive automotive trends can be found in other recent McKinsey publications:



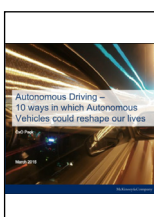
Connected car, automotive value chain unbound 2014

The “connected car” will shape the future of the auto industry, but there are many questions: Are consumers going to pay for it? How will it impact the underlying revenue and profit pools? In addition, what will determine who will benefit from changes in automotive profit pools? These are the questions addressed by the project, which has conducted significant primary market research with 2,000 car buyers across four geographies and has built a proprietary feature-level market model to create a quantified understanding of value chain dynamics.



Perspectives on the opportunities created by car connectivity and automation 2015

As customers’ expectations for in-vehicle connectivity features grow – along with their willingness to pay – so will the value pool that’s being created. This report addresses which players along the automotive value chain will reap the rewards based on an extensive consumer survey, and provides a map for success.



10 ways autonomous driving could redefine the automotive world 2015

Autonomous vehicles (AVs) represent a major innovation for the automotive industry, but high levels of uncertainty currently surround the deployment of the technology. In an effort to look beyond today’s rapidly changing predictions on AV penetration, we interviewed more than 30 experts across Europe, the United States, and Asia and combined these findings with our insights to arrive at ten thought-provoking implications that the technology could have on our world.



Urban mobility at a tipping point 2015

Solving the mobility challenge will require bold, coordinated actions. Technological advances and commercialization, funding, intelligent policies, and business-model innovation will be needed to realize productivity improvements while creating more sustainable environments in our cities. We have developed a framework to help stakeholders understand underlying forces and how they interact; on this basis, they can begin to design and implement the appropriate responses.



Sustainable mobility (working title) forthcoming

New powertrain technologies like optimized, low-emission ICE (e.g., downsized cylinder counts), hybrid, and full electric vehicles will have a significant impact on the current business of automotive manufacturers and suppliers. McKinsey is developing a renewed in-depth perspective on the adoption of these technologies in a soon forthcoming publication, examining total cost of ownership, regulation, customer preferences, and infrastructure readiness to determine potential scenarios for the future powertrain landscape.

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