

## Fundamental Perspectives: Investment Outlook for the Automotive Industry



### **How Advanced Driver-Assistance Systems, Ridesharing, and Electric Vehicles Are Driving Change Across the Industry**

We believe that today's automotive industry—more than at any other time in its history—presents ample opportunities for active managers to uncover value for their investors. In this paper, five of our global research analysts discuss how advanced driver-assistance systems, ridesharing, and electric vehicles are driving change across the industry.

**Director of Research,  
Global Equity Team**  
D.J. Neiman, CFA, Partner

**Industrials Analysts**  
Andrew J. Siepker, CFA  
Anil Daka, CFA  
Taylor Cope, CFA

**Information Technology Analyst**  
William W. Benton, CFA, Partner

**Real Assets Analysts**  
William DeAllaume, CFA







## Driving Change Across the Automotive Industry

If you were to draw up the ideal scenario for active managers looking to generate alpha, you would start by identifying a systematically important industry that presents a massive, global opportunity set. You would also want an industry that is being reshaped by multiple, interrelated disruptive forces that are shifting profit pools across the value chain, resulting in many winners and losers. To top it all off, you would want the industry to be solving problems that have broad implications for society.

In short, you would be looking for the automotive industry. We believe that today's automotive industry—more than at any other time in its history—presents ample opportunities for active managers to uncover value for their investors.

With more than 95 million vehicles sold annually around the world and an overall profit pool in excess of \$1 trillion, the automotive industry represents a massive ecosystem that involves the raw materials, industrial, technology, and consumer sectors. The most intriguing aspect of the automotive industry for active managers, however, is the importance of being able to identify which parts of the value chain—original equipment manufacturers, integrators, suppliers, and raw materials producers—will be gaining and losing profitability over the next several decades, as well as the specific companies that are well positioned to capture that value.

Three powerful trends—advanced driver-assistance systems, ridesharing, and electric vehicles—are dramatically changing the trajectory of the industry. Each of these trends creates immense threats to established players and opportunities for incumbents and new entrants alike. To excel in this environment, investors must think across sectors, have a global perspective, and focus on sustainable value creation—identifying companies that can generate excess returns on capital over time and reinvest those returns in growth projects that reinforce the company's competitive advantage.

As we will explain in this report, none of the three major trends can be viewed in isolation. They are evolving at different speeds and creating derivative effects across industries. To understand these complex dynamics, investors must think about the interconnectedness of industries. Investors also must think about how these trends are playing out differently in developed markets versus emerging markets and, more specifically, about how projections for volume growth and regulatory changes will play out in specific countries.

In addition to understanding the long-term macro trends that are reshaping the entire automotive industry, investors also must identify the characteristics of companies that have a sustainable advantage—and those that are most at risk—within the shifting pools of profitability across the value chain. Capitalizing on long-term growth opportunities in the automotive industry while navigating near-term risks requires a disciplined, bottom-up approach and the ability to delineate between shorter-term, cyclical dynamics and more enduring, structural ones.

In this report, we will show you how we are assessing the threats and opportunities facing the automotive industry and looking across sectors to identify sources of sustainable value creation on behalf of our clients.

Sincerely,

A handwritten signature in black ink, appearing to read "D.J. Neiman". The signature is fluid and cursive, with a long horizontal stroke at the end.

D.J. Neiman, CFA, Partner  
Director of Research, Global Equity Team, William Blair Investment Management



“Investors must also take into account the varying attitudes and personal connections that people have with their cars.”

## Advanced Driver-Assistance Systems

Over the last several years, safety features such as automatic emergency braking, lane-keeping assistance, and blind-spot detection have become increasingly common in new cars. Meanwhile, companies across the automotive and technology industries—from incumbent original equipment manufacturers (OEMs) to technology behemoths and start-ups—are aggressively touting their progress toward developing fully autonomous vehicles.

The development and proliferation of advanced driver-assistance systems (ADAS), and the resulting headlines, are raising many questions for investors as they think about the future of the industry, including: Is the move toward higher levels of automated driving a threat or an opportunity for OEMs, integrators, and suppliers? Will transportation eventually be viewed by consumers as a commoditized service?

For investors, the answers to questions such as these and their influence on how pools of profitability will shift across the value chain depend largely on investors’ time horizon.

### Short- and Intermediate-Term Impact: Progress Toward L2 and L3 Automation Provides a Tailwind Across the Value Chain

While many of the reports coming out of the auto industry’s epicenters of Detroit, Munich, and, more recently, Silicon Valley suggest that the advent of fully autonomous (L5) driving is right around the corner, the reality is that its arrival will occur across

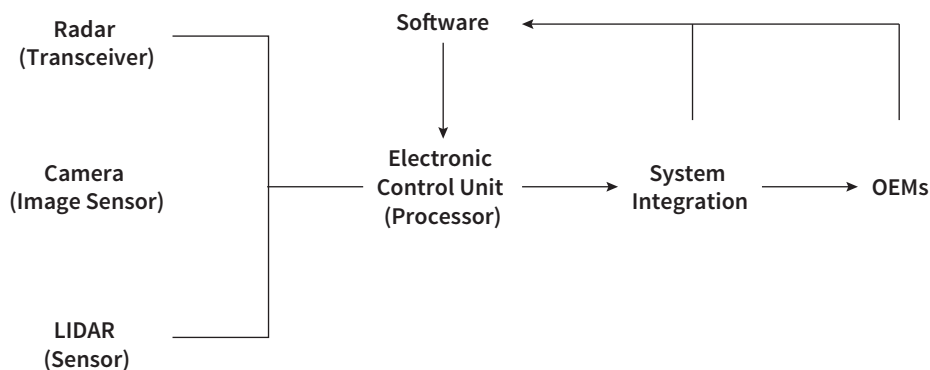
## Analyzing the Human Element of Automobiles

One factor that makes analyzing the automotive industry even more complicated—and interesting—is the “human element.” The future of the automotive industry will have profound implications for human safety and productivity, environmental sustainability, and the next phase of industrialization in China and other emerging markets.

In addition to these considerations, investors must also take into account the varying attitudes and personal connections that people have with their cars. For example, in developed countries, automobiles have been an important—and, in the United States, often romanticized—part of consumers’ lifestyles for much of the past century. In emerging markets, owning a car is one of the landmark aspirational purchases of the rising middle class. These attitudes, as well as society’s views on safety regulations and the treatment of workers, will have a major influence on the adoption of new technologies and business models.

**Figure 1:**  
**The ADAS Value Chain**

As the automotive industry moves toward higher levels of autonomy, more sensors and cameras will be needed to capture information about the vehicle’s surroundings and more powerful processors and software will be needed to manage this data. While integrators face some disintermediation risk from the component manufacturers over the long term, integrators that can provide a solutions-oriented approach to managing this growing complexity should be well positioned to capture value.



Source: William Blair, as of June 2018.

**“Adoption of L2 and L3 technology should be a profitable tailwind for companies across the automotive supply chain.”**

a much longer time frame. The release of fleets of “robo-taxis,” or cars with no drivers and no steering wheels, in any widespread commercial application is likely 10 to 15 years from becoming a reality.

Major advancements in data capturing and machine learning—as well as major regulatory decisions—will need to occur before L5 can be used extensively across a range of settings. In the meantime, L5 vehicles will initially be used in very limited, geofenced situations, such as at airports to drive passengers between terminals and parking garages. These limited-use situations will enable the learning needed for more widespread application, but the expansion to less controlled settings will be much more gradual than many people currently believe.

While lower levels of ADAS may not capture the public’s imagination like fully autonomous driving, the growing adoption of L2 and L3 should certainly capture investors’ attention. Technology that enables “hands off” partial automation involving steering and acceleration (L2) and “eyes off” conditional automation in more predictable settings such as highways (L3) is already available. It is also relatively affordable and demanded by consumers.

The “active safety” features that define L2 and L3 have reached an inflection point in adoption. In addition to growing consumer demand for these features, regulators around the world are beginning to push for making this technology more common. Today, fewer than 20% of new vehicles in developed markets include automatic emergency braking systems, according to Mobileye, an Israeli company owned by Intel that creates

software, sensors, and other inputs central to ADAS. But in Europe, for example, vehicle models released after 2017 will need to include automatic emergency braking, road-edge detection, and lane-keeping assistance in the base price to achieve a four- or five-star safety rating.<sup>1</sup>

Adoption of L2 and L3 technology should be a profitable tailwind for companies across the automotive supply chain.

**OEMs:** For OEMs—the companies such as General Motors, Ford, Fiat Chrysler, and Honda that are manufacturing automobiles—L2 and L3 represent a “sweet spot” in the ADAS evolution in terms of monetizing the value created by this technology. These features provide approximately 80% of the safety benefits of full automation at only about 20% of the cost. Manufacturers have proved to be very good at knowing how to package and price these features at various trim levels in a way that captures value from the consumer. According to Berenberg research, driver and park assistance cost BMW slightly more than €950 to put into one of its 5 Series cars, and these features add about €4,000 to the car’s sticker price.

**Suppliers:** Manufacturers of sensors, cameras, processors, software, and other components that go into ADAS will benefit from the higher volume of content—and the growing complexity of that content—that will be required as the industry moves up the autonomy spectrum. Of this group, companies that create software and processors are particularly well positioned to capture value because, as ADAS becomes more complex, the systems need to process and convert higher volumes of data.

**Figure 2:  
Levels of Driving Autonomy**

Fully autonomous vehicles (L5) are grabbing headlines today, but the widespread deployment of this technology is still 10 to 15 years away. In the meantime, the growing adoption of L2 (“hands off” partial automation involving steering and acceleration) and L3 (“eyes off” conditional automation in more predictable settings) represents a pure growth story and should drive increasing profitability across the value chain.



Source: William Blair, as of June 2018.

## Is the Automotive Industry Being Disrupted?

The term “disruption” gets thrown around often to describe how ADAS, ridesharing, and electric vehicles are poised to reshape the future of the automotive industry. It is important to note, however, that what is currently happening in the automotive industry does not fit the classical definition of disruption.

Disruption typically involves incumbent players that are unable or unwilling to acknowledge the magnitude of the threat represented by the new forces. When the incumbents finally realize that they must adapt, it is too late. (Think: film companies’ response to the emergence of digital cameras.)

This is far from being the case in the automotive industry. Rather than digging in their heels, the OEMs have fully embraced the fact that their future profitability—and survival—will be largely determined by their ability to adapt to changes wrought by ADAS, ridesharing, and electric vehicles. That is why incumbents in Detroit and Munich are eagerly partnering with start-ups in Silicon Valley. What is occurring today in the automotive industry should be viewed as a significant innovation, not disruption.

Furthermore, it is important to realize that change happens in the automotive industry much slower than in other industries, for a host of reasons. Foremost among these is that OEMs have long design and production cycles. Also, the sheer size and capital intensity of the industry means that it takes a long time for significant changes to take hold. Using Tesla as an example, we estimate that every one percentage point of penetration of global vehicle sales would require an additional \$33 billion of new investment.

Moreover, Silicon Valley’s mantra of “move fast and break things” isn’t acceptable when the “things” are humans. When it comes to components, manufacturing parts that are automotive-grade requires an extraordinarily low failure rate. In terms of autonomous vehicles, consumers and policymakers will have to determine what level of accident rates is deemed acceptable. Given society’s fear of the unknown, it is clear that the rate will be significantly lower than the accident rate involving human drivers. Another aspect of the “human element” is that, relative to other products, consumers may be slower to adopt major changes to something that is as central to their lifestyles and identities as their cars.

Over the long term, however, all of these characteristics of the automotive industry are impediments to change, not insurmountable barriers. OEMs are already working to adapt their design and production cycles to the increasingly rapid pace of technological change. It is also important to note that the move toward electric powertrains could shorten production and design cycles because electric vehicles have a fraction of the number of parts and are significantly easier to assemble than vehicles with internal combustion engines.

Regulation may slow progress toward autonomous driving, but policymakers will eventually find workable solutions, particularly if they fear that looser regulations in another country allow that country’s companies to gain a significant head start in developing the technology. In terms of the human element, while consumers may be resistant to change given the safety concerns and lifestyle considerations, eventually consumers will change their behavior if a more valuable option exists—just like they did with commercial air travel during the last century.

**Integrators:** Companies such as Bosch, Valeo, and Continental that integrate systems and components that are built by other suppliers have a more valuable role in the value chain than many industry commentators may believe. For a vehicle to have 360-degree visibility across all lighting and weather conditions, it likely will require sensors from three or four different manufacturers, all of which have their own computing platforms. In these situations, the integrator’s ability to pull all of that data together in a usable format—and do it in a way that fits within the OEM’s design cycle and production capabilities—is extremely valuable. While the threat of disintermediation is real, integrators can mitigate this by focusing on providing solutions, rather than products. OEMs have their hands full in trying to manage the various elements of ADAS and thus are willing to invest in partners that can bring all of these pieces together.

### Long-Term Impact: Arrival of Full Autonomy (L4 and L5) Could Threaten OEMs’ Position in the Value Chain

Although the widespread deployment of L5 is still 10 to 15 years away, the day is coming when fully autonomous cars become commonplace. And when fully autonomous cars arrive, they will have the ability to dramatically shift the value chain in the automotive industry.

The adoption of L2 and L3 is a pure growth story for the industry, as OEMs are simply adding new, valuable content that consumers are willing to pay for. Adding these features doesn’t have a negative substitution effect on other parts of the value chain. But once the industry reaches L4 and then L5, it raises more difficult questions about who will be able to capture value in a fully autonomous ecosystem.

**OEMs:** The arrival of L5, together with further development of electric powertrains, could enable massive increases in ridesharing and prompt consumers to purchase a subscription service rather than own a vehicle. As we will discuss in more detail later, the net potential impact of these forces on total vehicle sales is far from clear, but it is difficult to imagine a scenario where they won’t be at least a minor headwind for OEMs. It is important to note, though, that the impact will likely be markedly different in developed markets than in emerging markets, where owning a vehicle may still be viewed as a status symbol for the growing middle class.

**Suppliers:** Achieving fully autonomous driving requires a very powerful central brain that coordinates all the inputs that the vehicle’s sensors are gathering. Thus, the shift toward L5 will be quite positive for suppliers that create semiconductors, processors, and operating systems. The semiconductor industry is focusing an increasing amount of its attention on automotive

“The day is coming when fully autonomous cars become commonplace. And when fully autonomous cars arrive, they will have the ability to dramatically shift the value chain in the automotive industry.”

end-markets, which are viewed as strong growth opportunities at a time when smartphone and personal computer demand is plateauing. Manufacturers of sensors and cameras will benefit from volume growth, but their ability to generate profits will largely be tied to the quality of their computing platforms.

**Integrators:** Integrators that can solve the problems that OEMs face in fitting a growing number of disparate systems into long-term design cycles and existing production processes will continue to be a valuable part of the value chain throughout the progression toward L5. But integrators that remain focused on simply providing products face major disintermediation risk from Tier 2 suppliers that learn how to work closely with OEMs.

## Ridesharing

The rising ubiquity of ridesharing in major metropolitan areas and its continuing expansion into lower-density towns and suburbs is forcing investors to think about how these trends will affect the size of the global vehicle fleet and the types of business models used to deliver transportation. As with the development of ADAS, the answers to these questions and their impact on the value chain will depend largely on investors' time frame.

### Concerns About Ridesharing's Impact on Fleet Size: Real but Largely Overblown

When thinking about ridesharing's net impact of the total number vehicles required to serve the world's transportation needs over the short and long term, there are many cross-currents to consider:

#### Will Transportation Become Commoditized?

Electric vehicles, ridesharing, and eventually fully autonomous vehicles all have elements that suggest that consumers may begin to view transportation as a commodity. In this scenario, consumers would make their transportation decisions based on utilitarian factors and stop viewing vehicles as essential to their lifestyle.

If OEMs shift toward a subscription-based model where individuals don't own the car, it is easy to see how the car's design and performance features would be less important. If people are purely passengers in vehicles rather than sitting behind the wheel, the vehicle's ability to handle corners smoothly is less valuable. If most new cars have an electric powertrain rather than an internal combustion engine, the speed at which the car can accelerate from 0 to 60 miles per hour stops being a differentiating factor.

While these concerns are valid and directionally true, the idea that transportation will become largely commoditized

#### Total miles driven

In terms of total miles driven, ridesharing could be a tailwind to the global fleet size. According to research by the University of California Davis Institute of Transportation Studies, ridesharing will likely contribute to an increase in the total number of miles driven in major cities.<sup>2</sup> The study found that if not for ridesharing being an option, 49% to 61% of ridesharing trips wouldn't have been made at all.

#### Substitution effect (short term)

There is a common assumption that the rise of ridesharing services is already serving as a significant headwind to vehicle sales. But according to the UC Davis study, 91% of ridesharing users said that they hadn't made any changes in their vehicle ownership. Furthermore, the study found that rather than being a substitute for vehicle ownership, ridesharing today is mostly a substitute for public transportation. For now, ridesharing serves as a viable substitute for owning a car only in dense, urban areas where ridesharing is widely available and the cost of owning a car is high.

#### Substitution effect (long term)

Over the longer term, however, the substitution effect for owning a vehicle will become greater. As ridesharing continues to lower the cost of mobility—a dynamic that will accelerate as electric powertrains gain more penetration and as fully autonomous vehicles become a reality—not owning a car, or not purchasing a second or third car, will make economic sense for a larger portion of the market, not just those who live in dense, urban areas.

is overblown. Whether purchased as a product or a service, transportation is still a consumer transaction, and premium options exist in every part of the consumer industry. People will always want to have options, and as a result, brands will always matter. There is a reason why people buy luxury watches that are no better at telling time than cheaper options. Airlines are continually developing new fare classes that allow passengers to upgrade to larger seats with more amenities. The creation of premium service levels has already occurred in the ridesharing industry, with Uber and Lyft offering black car and other tiers of service.

Undoubtedly, the rise of electric vehicles, ridesharing, and autonomous vehicles will cause some commoditization. This will force OEMs, platform providers, and other consumer-facing players in the industry to adapt their brands and value propositions. But there will continue to be premium choices, and brands will always matter. As a result, premium OEMs are in a much better position to navigate these changes than more economy-focused ones.

“Despite questions about how ridesharing business models will evolve, it is clear that the cost of mobility will continue to decrease.”

Beyond these purely economic factors, generational attitude shifts will also cause the substitution effect to accelerate. Getting your driver’s license on your 16th birthday used to be a rite of passage for young Americans. Today, many American teenagers are either delaying getting their driver’s license or avoiding the trip to the Department of Motor Vehicles altogether. According to a study by the University of Michigan Transportation Research Institute, in 1983, 46% of 16-year-olds and 87% of 19-year-olds in the United States had their license. By 2014, these figures had dropped to 25% and 69%, respectively.<sup>3</sup> The researchers found a smaller, but still significant, decrease across all age groups between age 20 and 45. These trends suggest that millennials and other digital natives will see the value of having an asset-light personal balance sheet and will be less likely to own a vehicle than previous generations.

This dynamic, however, may weaken once more millennials start having children because family formation has always been one of the biggest drivers of purchasing a vehicle. But there are logistical challenges related to car seats, and parents most likely will be uncomfortable putting their children in vehicles driven by a stranger—or a faceless algorithm.

**Utilization rates**

To understand ridesharing’s ability to affect the total vehicle fleet size, it is essential to think about utilization rates. It is unquestionably true that owning an expensive, depreciating asset that sits in a garage at least 90% of the time is grossly inefficient. If technology companies can solve this utilization problem for vehicles in a similar fashion to how they solved it for vacation lodging or data servers, it stands to reason that the total number of vehicles needed will decrease.

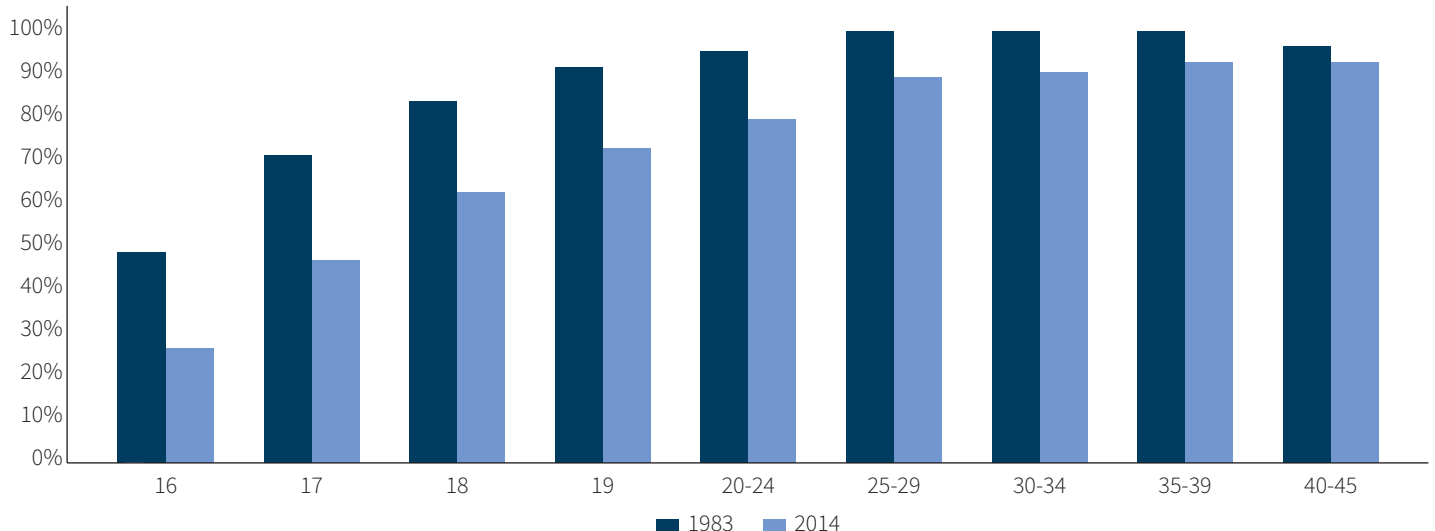
While this is directionally true, the impact of utilization improvements when it comes to vehicles will be limited by demand volatility—a.k.a., rush hour traffic. Given people’s work schedules, a large portion of the total miles driven in a given city occurs at the same times. As a result, fleet sizes need to be large enough to accommodate peak demand.

When considering all of these cross-currents, we believe that in the near term ridesharing should have a negligible impact on the total vehicle fleet size. Over the long term, however, the impact could be substantial. But we believe that the long-term impact will still be less than what many headlines currently suggest because of the natural limits to how much utilization rates can improve.

**Figure 3:  
Getting a Driver’s License: No Longer a Rite of Passage for U.S. Teens**

The percentage of Americans with a driver’s license has decreased across all age groups younger than 45 since 1983, but the decline has been particularly steep among teenagers. This, along with the growing availability of ridesharing services, suggests that many millennials will eschew vehicle ownership and opt for asset-light personal balance sheets.

**Percentage of Americans With a Driver’s License by Age Group, 1983 vs. 2014**



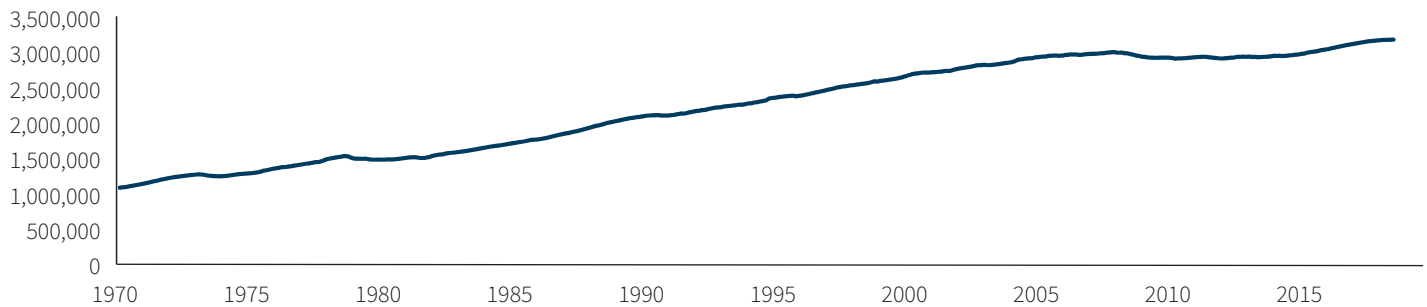
Source: William Blair, University of Michigan Transportation Research Institute, as of 2014.



**Figure 4:**  
**Personal Miles Traveled in the United States**

Although ridesharing will increasingly become a substitute for vehicle ownership, ridesharing's impact on total vehicle fleet size will be offset, to some degree, by an increase in the total numbers of miles driven. Total vehicle miles in the United States have increased steadily since 2014, even as ridesharing services become much more prevalent.

**Moving 12-Month Total Vehicle Miles Traveled, in Millions**



Source: William Blair, Federal Reserve Bank of St. Louis, as of June 2018.

### **Ridesharing Business Models Will Continue to Evolve as Electric Powertrains and Autonomous Driving Improve Profitability**

Competition, regulatory pressure, and the need to continually make massive investments in developing technology and entering new markets will lead to substantial operating losses for ridesharing platforms in the short and intermediate terms. Over the long term, however, advancements in autonomous driving and electric powertrains will significantly improve the profitability of these companies.

As long as human drivers are required, generating operating profits will be extremely challenging—if not impossible—for ridesharing platforms. But once widespread L5 is achieved, the equation shifts dramatically. In the meantime, ridesharing companies will be battling each other fiercely and subsidizing fares to gain market share.

It is important to appreciate the symbiotic relationship between ridesharing and electric vehicles. Ridesharing favors the use of electric vehicles, as opposed to ones with internal combustion engines. Electric vehicles have lower fuel and maintenance costs, and the fleet model that will likely be used by ridesharing companies solves most of the range issues that currently limit the widespread adoption of electric vehicles among consumers.

Questions remain about how ridesharing companies' business models will evolve as these advancements occur. We believe that the model will likely involve some combination of an asset-light platform provider and an asset-intensive but steady-return fleet manager. It is also possible that these two core services will remain completely separate, with the platform providers outsourcing all of the fleet management to avoid adding vehicles to their balance sheets. It is also possible that the OEMs, thanks to their ability to offer lower operating costs, could force some degree of backward integration among the platform providers.

### **Low-Cost Brands Are Vulnerable as the Cost of Mobility Decreases**

Despite questions about how ridesharing business models will evolve, it is clear that the cost of mobility will continue to decrease. In this landscape, OEMs offering premium brands are in a much better position to maintain their position in the value chain than low-end brands. Non-premium brands are much more vulnerable to substitution as ridesharing becomes cheaper and more prevalent. Ridesharing is an exercise in efficiency, and owners of premium vehicles have already indicated that efficiency is not high on their list of priorities when it comes to mobility.

### **The Transportation Experience: Who Captures Value as Passengers Get Access to More Content?**

Ridesharing and, eventually, the advent of autonomous cars will make mobility an increasingly passive experience, turning more drivers into passengers. As a result, people will have more time to consume entertainment, news, advertising, and other forms of content while riding in cars.

OEMs' ability to profit from this trend by turning vehicles into fully equipped mobile entertainment centers, however, will be marginal at best. Smartphones and tablets will continue to be the hubs of passengers' entertainment and information consumption. Technology related to this content simply moves too fast for OEMs to be able to keep up given their long design and production cycles. Just as maps on smartphones quickly made cars' embedded navigation systems obsolete, OEMs' attempts to stay at the cutting-edge of entertainment content would be futile.

Instead, OEMs will simply make it easier for passengers to consume content from their personal devices by adding larger screens and better speakers in the vehicle, as well as making it simpler to sync smartphones and tablets to the car. This will be a tailwind for suppliers of those components, but OEMs' ability to capture value from the enhanced "transportation experience" will be limited to their skill at including larger screens and more powerful speakers within more expensive trim levels.

“Producing electric vehicles is no longer a science question but a supply chain and manufacturing one. This leads to an even bigger question facing the automotive industry today: How quickly will electric vehicles penetrate the market?”

### ESG Lens: How Will Socially Responsible Investors Navigate the Automotive Industry’s Bumpy Road

Given the myriad ways that transportation affects our daily lives, the major forces that are reshaping the automotive industry all raise interesting questions for investors focused on environmental, social, and governance (ESG) factors.

Some of the most challenging ESG issues that investors must grapple with include:

**Implementing appropriate safety regulations for autonomous vehicles:** Improving the algorithms that guide self-driving cars requires testing them in an ever-broadening array of real-world scenarios—and learning from the mistakes that will inevitably, and tragically, occur along the way. After a March 2018 accident in Tempe, Arizona, in which an autonomous car operated by Uber killed a pedestrian, Uber quickly suspended its self-driving vehicle testing programs in Tempe and Pittsburgh. As policymakers around the world grapple with how to regulate the testing and deployment of autonomous vehicles, they must weigh the costs (i.e., accidents that occur during testing) versus the benefits (i.e., the opportunity to significantly reduce accidents caused by human error or recklessness). These policy decisions will have a meaningful impact on the growth and profitability of companies across the ADAS ecosystem.

**Analyzing ridesharing’s impact on human drivers:** Fully autonomous vehicles will someday eliminate the need for ridesharing platforms to use human drivers. In the meantime, ridesharing companies are lowering their rates to gain market share—and the strain being placed on drivers is drawing more critical attention from policymakers and consumers. A January 2017 *Bloomberg* article chronicled the plight of drivers who live outside major metropolitan areas coming to the city for days at a time to earn higher fares—and pulling into parking lots of convenience stores, hotels, and other businesses to grab a few hours of sleep between shifts.<sup>6</sup> It remains to be seen whether concern about driver welfare will affect consumers’ use of ridesharing services, but heightened scrutiny could lead to tighter regulation on driver compensation and the number of hours that drivers can work.

**Sourcing cobalt from the Democratic Republic of Congo:** Cobalt is a critical component of the cathodes that determine the performance and stability of electric vehicle batteries. More than half of the world’s cobalt, however, is mined in the Democratic Republic of Congo, a country with a history of violent conflicts, corruption, and political oppression. The mining is often performed in hazardous conditions, and many of the laborers are children. Investors must weigh the environmental benefits of reduced carbon dioxide emissions against the humanitarian and political concerns related to how cobalt is produced.

## Electric Vehicles

The impact of ADAS and ridesharing on investment opportunities across the value chain depends largely on an investor’s time horizon. But with electric vehicles, investors don’t need to look past the next few years to see how the development and adoption of electric powertrains is creating threats to incumbents and opportunities for new entrants.

Most OEMs are fully committed to developing lines of electric vehicles over the next decade. Governments around the world are pushing the automotive industry in this direction through a combination of tighter emissions standards and subsidies. Most importantly, the automotive industry already has a proof concept in Tesla that mass production of electric vehicles can be commercially viable.

Producing electric vehicles is no longer a science question but a supply chain and manufacturing one. This leads to an even bigger question facing the automotive industry today: How quickly will electric vehicles penetrate the market?

We believe that by 2030, electric vehicles will represent between 15% and 30% of global vehicle sales, with significantly higher penetration rates in China because of government mandates. The years of 2020 to 2025 should be a critical period in determining the trajectory of electric vehicle penetration. During this period, many OEMs will be introducing full lines of electric vehicles across various price points. This period will also see continued improvements in battery range and reductions in costs.

The rate at which electric vehicle penetration occurs is a function of several questions, all of which are interrelated:

### How quickly will battery costs decrease?

Manufacturing vehicles powered by internal combustion engines is an inherently inflationary exercise. Because of rising regulatory standards, heightened consumer expectations, and competitive pressures, OEMs are continually trying to make internal combustion engines more fuel-efficient, more powerful, and more environmentally friendly. Accomplishing these often-competing goals—and squeezing more electronics and other content into the same amount of space under the car’s hood—is an incredibly demanding, and expensive, engineering challenge.

Manufacturing electric vehicles, on the other hand, is largely deflationary. When thinking about the cost of electric vehicles, one should start with batteries and the related electrical systems, which are the largest input costs for electric vehicles. Batteries benefit from economies of scale, which results in a virtuous cycle for consumers. As more consumers buy electric vehicles, more batteries will be produced. As more batteries are produced, the

“Once the average sticker price for electric vehicles becomes lower than internal combustion engine vehicles, consumer adoption of electric vehicles will reach an inflection point.”

cost per kilowatt hour (kwh) goes down. As the cost per kwh goes down, electric vehicles get cheaper and more consumers convert away from internal combustion engines.

Battery costs are currently near \$200/kwh and should approach \$100/kwh by 2025. In addition to economies of scale, these cost decreases will be driven by improvements in battery chemistry, as battery manufacturers develop batteries that use lower ratios of cobalt and higher ratios of nickel. This thrifting out of cobalt, however, is creating some questions about battery stability and safety that will need to be managed.

Once the average sticker price for electric vehicles becomes lower than internal combustion engine vehicles, consumer adoption of electric vehicles will reach an inflection point. We project these prices to reach parity by 2025, but it could be sooner because the overall cost of electric vehicles continues to decrease faster than previous projections. Also, if you think about lifetime ownership costs and factor in fuel and maintenance, the cost comparison shifts further in favor of electric vehicles.

#### Can the supply chain keep up with production demands?

The greatest impediment to electric vehicle penetration isn't consumer attitudes but constraints related to raw materials and manufacturing infrastructure. Across the automotive supply chain, companies will need to drastically expand and adjust their capabilities to meet the coming demand for electric vehicles.

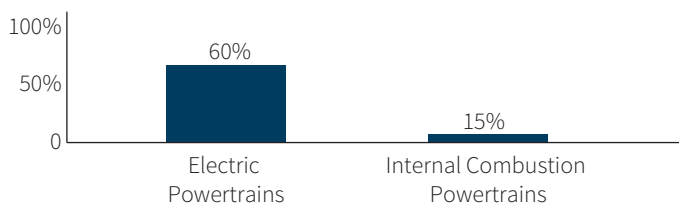
To meet demand projections for 2026, production of the four main raw material inputs for batteries—lithium, cobalt, nickel, and graphite anode—will need to increase by factors ranging from 2x to 8x. The resulting higher prices for these inputs, particularly with lithium and cobalt, will certainly be a headwind to lower battery costs. But rising materials costs won't overwhelm the aforementioned savings from economies of scale and chemistry improvements.

Currently, the four major battery manufacturers supplying the automotive industry, all of which are located in Japan or South Korea, are struggling to keep up with the growing demand. More plants will come online over the next decade, and new manufacturers will emerge. China will be the biggest wild card in the growth of the battery manufacturing industry. OEMs likely won't trust Chinese battery manufacturers in the early stages, as a result of quality and reliability concerns. But, over time, China could quickly move up the learning curve and become a major force in battery production—just as it did with the production of solar panels.

**Figure 5:**  
**Deflationary Dynamics: Electric Vehicles vs. Internal Combustion Engines**

The production of batteries, electric motors, and the related power-management systems is deflationary—it gets cheaper as volumes increase and as the technology improves. These components account for roughly 60% of an electric vehicle's cost, versus only about 15% of the cost of an internal combustion engine. As electric vehicle production increases, the cost curve will increasingly bend in favor of owning an electric vehicle.

#### Estimated Percentage of Vehicle Cost Represented by Deflationary Inputs



Source: William Blair estimates, as of June 2018.

#### Will Electric Vehicles Define the Trajectory of China's Industrialization?

If you want to understand the next phase of China's industrialization, it is important to think about the growth of the electric vehicle industry. As China looks to evolve from a heavy industrial economy to one that relies more on technology and innovation, the production of electric vehicles, and batteries in particular, could play a major role in this transformation.

With internal combustion engines, China will have difficulty matching the engineering expertise developed by suppliers and OEMs in Germany, Japan, and the United States. But with electric vehicles and batteries, the barriers to entry are much lower and the learning curve is less steep. This creates an opportunity for Chinese companies to become significant players in the automotive industry. In addition to accelerating the next phase of China's industrialization, the growing adoption of electric vehicles will contribute to solving China's pollution problems.

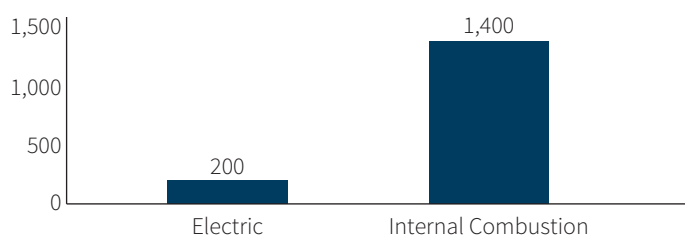


“The four major battery manufacturers supplying the automotive industry, all of which are located in Japan or South Korea, are struggling to keep up with the growing demand.”

**Figure 6:**  
**Fewer Parts = Less Complexity**

Assembling electric vehicles is less demanding from an engineering perspective than building vehicles powered by internal combustion engines. This is largely a function of the number of parts that go into each type of powertrain.

#### Estimated Number of Parts in the Powertrain



Source: William Blair, Friedrich Ebert Stiftung, “The Future of the German Automotive Industry,” as of 2015.

#### Which new entrants will emerge?

Building electric vehicles is a fundamentally different—and in most ways, less complex—engineering process than building cars powered by internal combustion engines. According to research by the Friedrich Ebert Stiftung, a German think tank, the powertrain of an internal combustion engine vehicle has approximately seven times more parts than the powertrain of an electric vehicle.<sup>4</sup> The engineering that goes into designing and continually improving internal combustion engines requires an immense amount of institutional knowledge. As a result, incumbent OEMs have a nearly insurmountable advantage over new entrants when it comes to internal combustion engines.

From OEMs’ perspective, building electric vehicles is more an exercise in supply chain management and assembly than precision engineering. Much of the most technically demanding engineering is done by the battery manufacturers, as well as by the companies creating the software and processors that manage the power stack and serve as the powertrain’s central nervous system.

As a result of these smaller competitive advantages, the shift toward electric vehicles creates opportunities for new entrants to emerge across the automotive supply chain. In addition to bending the cost curve lower, these new players could accelerate the pace of innovation and, ultimately, make electric vehicles more appealing to consumers.

#### How will the industry address consumers’ “range anxiety?”

Another one of the biggest hurdles to electric vehicle penetration is consumers’ concerns about running out of electricity in the

middle of a trip. The newest electric vehicles have ranges of approximately 300 miles per charge. While this significantly exceeds the daily range needs of a vast majority of drivers, the fear of running low and not being able to find a nearby charging station is a major impediment to consumer adoption.

The solution to overcoming this range anxiety is likely a combination of three factors: 1) educating consumers about how much range they actually need on a daily basis; 2) putting larger batteries in vehicles; and 3) building out a more extensive infrastructure of charging stations. The idea that charging stations will need to be as plentiful as gas stations are today is overstated; most charging will be done overnight in the vehicle owner’s garage. Adding more super-charging stations along highways and expressways, however, will go a long way toward easing consumers’ concerns about running out of electricity on long trips.

#### Can appealing models be created at all price points?

Currently, electric vehicles are gaining significant penetration only among luxury vehicle consumers. The growth of the electric vehicle market will be limited until appealing models are created for the mass market. This dynamic is in its early stages and it will accelerate over the next several years as OEMs around the world are preparing to introduce full lineups of electric vehicles at varying price points. Furthermore, these vehicles will be designed for mainstream consumers, not consumers who fancy themselves as early adopters.

#### Electric Vehicles’ Impact on the Value Chain

Across the automotive supply chain, the continuing shift toward electric powertrains will have a dramatic influence on the industry’s profitability. In evaluating the investment risks and opportunities facing OEMs, suppliers, integrators, and raw materials producers, one must delineate between transitory, short-term forces and longer-term changes that create opportunities for sustainable value creation.

**OEMs:** *The growing importance of electric vehicles creates near-term headwinds to OEMs’ profitability and jeopardizes their position in the value chain over the long term.*

OEMs are at a challenging time in their evolution, as they are being pulled in multiple directions. They have to climb a steep learning curve when it comes to electric vehicles while simultaneously making continuous improvement to internal combustion engines to meet increasing fuel economy and emissions standards. The investments being made to ramp up electric vehicle capabilities are hurting OEMs’ profitability, and the need to manage supply chains for two different types of powertrains is adding complexity to OEMs’ business models.

“Over the longer term, the shift toward electric vehicles could put OEMs’ position in the value chain somewhat at risk.”

Over the longer term, the shift toward electric vehicles could put OEMs’ position in the value chain somewhat at risk. Currently, a large part of the value that OEMs bring to the process is their engineering expertise in designing and assembling internal combustion engines, as well as managing the supply chain. Managing the supply chain will remain a vital part of OEMs’ value proposition regardless of whether they are sourcing gear boxes and drive shafts for internal combustion engines or cobalt and power-management systems for electric vehicles. But the ability to design and assemble high-performance powertrains is much less of a differentiator with electric vehicles than with internal combustion engines. Therefore, premium OEMs that have built their brands around perfecting internal combustion engines may have to look for new ways to validate that differentiation in consumers’ eyes.

**Suppliers:** *The shift to electric vehicles, and OEMs’ outsourcing of many of the most technically demanding engineering functions, should strengthen suppliers’ position in the value chain.*

With electric vehicles, much of the most valuable engineering work occurs at the supplier level. This is especially true for battery manufacturers and the makers of the processors, operating systems, and other components that are essential to managing the power stack.

Over the next decade, the demand for batteries will significantly exceed global production capabilities. According to Benchmark Mineral Intelligence, global battery demand is projected to exceed supply by nearly 30% by 2026.<sup>5</sup> This bottleneck will give battery manufacturers that have earned OEMs’ trust increased pricing power and volume growth. Over the longer term, though, China’s entrance into battery production could alleviate this supply-demand imbalance and negate incumbent battery manufacturers’ pricing power.

### Performance Is More Than Propulsion

The shift to electric vehicles raises questions about premium OEMs’ ability to capture value in a world where every electric vehicle can accelerate from 0 to 60 miles per hour in three seconds and where powertrain durability is much less of an issue than with internal combustion engines.

It is important to remember, however, that consumer perception of a vehicle’s performance encompasses much more than just acceleration. Premium OEMs will still have ample opportunities to differentiate their vehicles through interior and exterior design features, as well as through suspension, braking, and electronics. The OEMs’ skill at marketing and distributing their vehicles will remain as important as ever.

### Electric Vehicles’ Impact on Oil Markets

The outlook for oil demand is not as dire as one might think given the projections for rapid electric vehicle penetration over the next several decades. The shift from internal combustion engines to electric vehicles will certainly be a headwind to global oil demand, but it should limit oil demand by only a few percentage points by 2030. Vehicle fleets are expected to grow steadily in emerging markets, and most consumers in these countries likely won’t be able to afford electric vehicles. Increased air travel, trucking traffic, and demand for plastics are other factors that will mitigate electric vehicles’ impact on oil demand.

In addition to the shift toward fully electric vehicles, the increasing electrification of internal combustion engines is creating additional demand for suppliers of components for hybrid vehicles. Before Volkswagen’s “Dieselgate” scandal, diesel engines were thought to be a major part of the solution for reducing carbon dioxide emissions, especially in Europe. The fallout from that scandal, however, has significantly shifted regulators’ mindsets about diesel and put more focus on hybrid gasoline-powered internal combustion engines.

**Integrators:** *As OEMs try to manage electric and internal combustion engines supply chains simultaneously, solutions-oriented integrators have more opportunity to add value.*

OEMs certainly have their hands full as they try to enter the electric vehicle arena while continuing to improve their internal combustion engine capabilities. Beyond simply representing a second supply chain that needs to be managed, producing electric vehicles requires higher levels of outsourcing and new expertise in quality control and production scheduling. As a result, integrators will enjoy new opportunities to add value for OEMs by offering expertise and solutions rather than just products.

**Raw materials producers:** *Surging battery demand has created investable bottlenecks across the supply chain.*

The growth in battery demand has caused the entire supply chain to become tight. This is especially true for the four main raw materials that go into batteries for electric vehicles: lithium, cobalt, nickel, and graphite anode. As noted previously, global production for all of these materials will need to increase by 2x to 8x by 2026 to meet demand projections. Chemistry advancements, as well as ESG concerns, could cause cobalt to be thrifted out of batteries eventually, but it is uncertain how quickly and to what degree this substitution for higher levels of nickel can occur.

“These forces ... call for an investment approach that combines disciplined, bottom-up analysis with an integrated, cross-sector understanding of the macro environment.”

## Implications for Portfolio Positioning

When thinking about the three major trends shaping the automotive industry—ADAS, ridesharing, and electric vehicles—and what they mean for portfolio positioning, delineating between short- and long-term implications is paramount. In addition to time horizon, we believe investors also need to incorporate the following factors into their portfolio strategies:

### 1. Sustainable value creation vs. transitory opportunities

For growth investors, it is important to delineate between shifts that provide opportunities for companies to generate excess returns on capital on a sustainable basis versus opportunities that will prove more transitory. The electric vehicle supply chain provides examples of both. In the short term, supply shortages will boost profitability for nearly all raw materials producers and battery manufacturers. But soaring prices, as well as ESG concerns and chemistry improvements, may cause demand for cobalt, for example, to decline eventually. Innovative battery manufacturers with strong reliability track records, as well as companies that build processors and software to manage the power stack, on the other hand, should have highly defensible positions in the value chain.

### 2. Developed markets vs. emerging markets

The growth opportunities related to ADAS, ridesharing, and electric vehicles will play out very differently in developed markets than in emerging markets. Vehicle sales in the United States and Europe are expected to plateau or slightly decline over the next several years. But in emerging markets, the rise of the middle class represents a strong secular growth story for OEMs and suppliers. Given consumers' limited incomes in those countries, the penetration of electric vehicles in emerging markets will depend on how quickly the costs of battery-powered vehicles decline relative to ones powered by internal combustion engines. Also, cultural differences may cause adoption rates for electric vehicles and ridesharing to vary in emerging markets versus developed markets.

### 3. Growth vs. substitution effects

When determining long-term portfolio positioning in the automotive industry, it is critical to determine whether the trends you are investing in represent true growth dynamics that are increasing the size of the pie, as opposed to substitution dynamics that are essentially a zero-sum game in the long run. With ADAS, L2 and L3 technology represents a pure growth story for OEMs, as these features provide new safety benefits that consumers are willing to pay for. Once full autonomy (L5) arrives, however, it will usher in a new era of ridesharing, one that is likely to cut into total vehicle sales.

### 4. Isolated developments vs. grand unified theory

Individually, ADAS, ridesharing, and electric vehicles would each make a meaningful impact on the future of the automotive industry. But to truly understand the industry's long-term trajectory, you cannot think about these trends in isolation. You must assess the coevolution that is occurring. Widespread deployment of ridesharing platforms that use fleets of robo-taxis with electric powertrains will radically affect the industry's value chain—but this won't occur until L5 technology significantly improves and battery costs decline. While the advent of fully autonomous, electric taxi fleets is further in the future than many of today's headlines suggest, its ability to reshape the automotive industry is profound.

These forces, and their combined ability to reshape the value chain in the automotive industry, call for an investment approach that combines disciplined, bottom-up analysis with an integrated, cross-sector understanding of the macro environment. This will create ample opportunities for active managers to generate alpha by investing in companies that are well positioned to create innovative solutions for the world's evolving transportation needs. ■

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