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THEMATIC INSIGHTS

A world shaped by autonomous technology

Economic disruption in the transport sector – a case study

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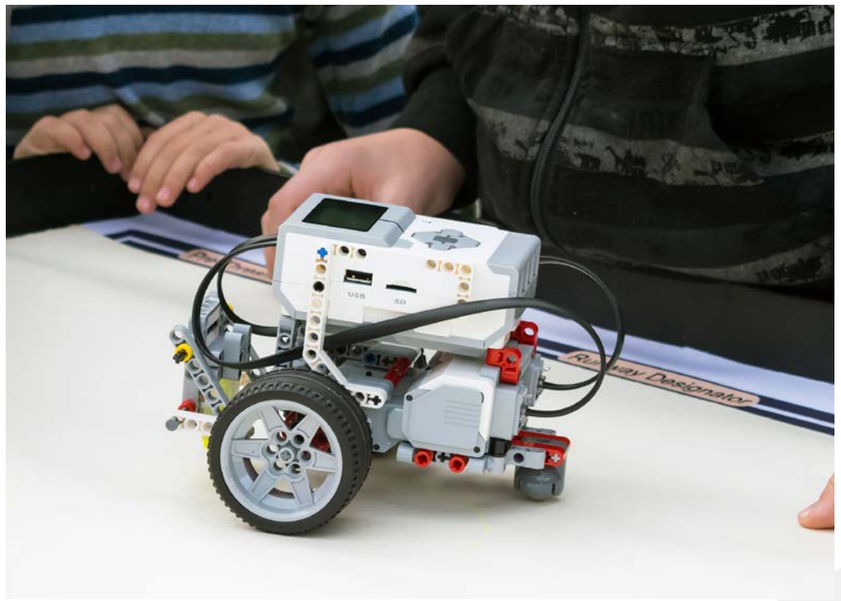
Contents

Overview

Transportation serves a fundamental economic function, and historically, transportation innovations have both foreshadowed and enabled fundamental economic transformations. In the late 1800s, the Sears' catalog could not have transformed retail without the railroad.[1] Likewise, in the 1920s, without the widespread adoption of tractors and the Model T, the agricultural workforce could not have so easily moved to the cities. Again, after the Second World War, the internationalization of business followed the jet turbine; the globalization of manufacturing necessitated standardized shipping containers; and the growth of the suburbs with their superstores supported road system expansion and widespread ownership of relatively inexpensive cars.[2]



It seems that transportation may now be entering another period of innovation. Superior economics as well as increased convenience could soon encourage widespread consumer adoption of autonomous (electric) cars. Adjusted for inflation, the total cost to own and operate a personal car has changed little since the Model T first rolled off the assembly line. In comparison, it has been estimated[3] that, at scale, autonomous taxis may cost consumers as little as USD 15 cents per kilometre. In this model, autonomous taxis allow a ten-fold increase in vehicle utilization and thus enable a huge reduction in the price of point-to-point travel alongside a significant shift in consumer behaviour. The taxi would then grow to dominate personal mobility, with associated deep economic and societal impacts. In that scenario, over the next 5-10 years, autonomous electric taxis would have a profound impact on global health and would disrupt the auto industry and associated industries.

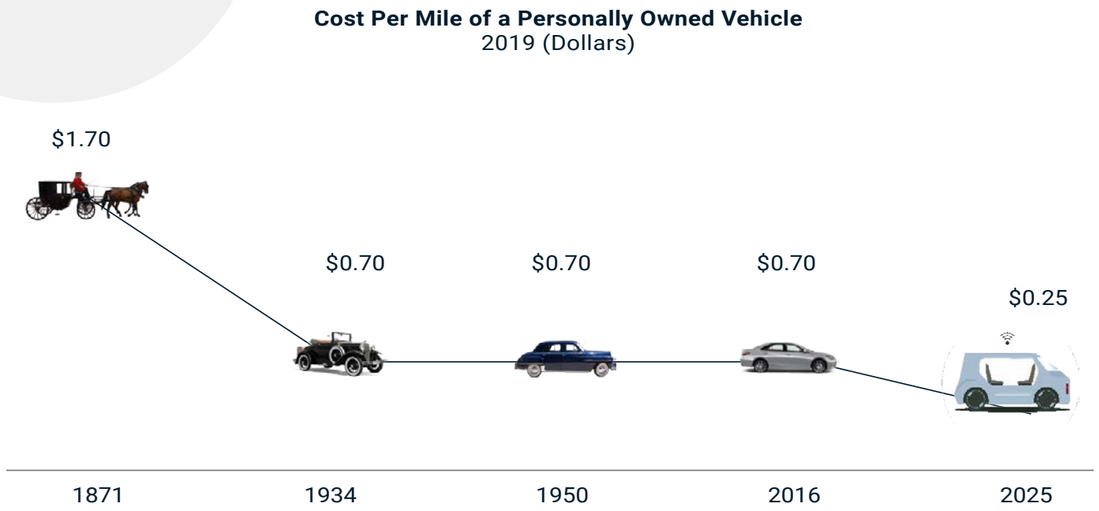
1 "History of the Sears Catalog," Sears Brands LLC, March 21 2012, Sears Archives.

2 "Two Prime Movers of Globalization: The History and Impact of Diesel Engines and Gas Turbines", Vaclav Smil, Cambridge, MA: MIT 2010; "Why have containers boosted trade so much?", Economist, May 22 2013; "The Interstate Highway System" Jean-Paul Rodrigue, 2016, Hofstra University

3 "A Better Understanding of ARK's Autonomous Taxi Model", Tasha Keeney, March 2019, ARK Invest.

Exhibit 1:
The price of personal mobility – 1871 to 2024E

Source: ARK Invest



More broadly, within the transport sector, robotaxis could reduce the cost of point-to point-mobility discontinuously in the US, potentially taking USD 150 billion in annual demand per annum from ride-hailing, short-haul flights and public transit.[4] If robotaxis were to dominate urban transit, then ARK, for example, estimates US auto sales to drop from 17 million units today to roughly 10 million by 2030.[5] Knock-on effects would hit traditional auto insurance (cutting total annual premiums by half) and the auto loan market (the legacy vehicle fleet, worth USD 2.6 trillion,[6] would face material write-downs). Oil demand could then peak much sooner than currently forecast as electric vehicle mileage grows.

4 ARK Investment Management LLC; "Public Transportation Facts" American Public Transportation Association, 6 Oct. 2020; "Consumer Airfare Report: Table 1 - Top 1,000 Contiguous State City-Pair Markets" US Department of Transportation.

5 Wagner, I. "U.S. Vehicle Sales 1978-2019." Statista, 16 July 2020, www.statista.com/statistics/199983/us-vehicle-sales-since-1951/.

6 ARK Invest; "2019 Used Car Industry Report" Niada.

A wave of disruption for the **auto industry and beyond**

Let us examine these arguments in more detail to better understand how autonomous electric vehicle technology could cause a wave of disruption beyond the auto industry. ARK Invest forecasts that if battery system costs were to decline as projected, the subsequent fall in electric vehicle prices would be enough to trigger mass market electronic vehicle (EV) adoption.[7] Autonomous driving systems could also boost vehicle utilization and lower the cost of transportation overall: robotaxis may cost consumers just USD 0.15 per kilometre, less than half the cost of a personal car, half the cost of a short flight, and close to many public transit modes, as shown in Exhibit 2.[8] As a result, autonomous taxis could quickly come to dominate urban personal transportation, leaving little economic need for personal vehicles. This is the driver for ARK's estimate that, for example, US auto sales fall from 14 million units today to just 10 million over the next 10 years.[9]

7 ARK Invest "Big Ideas 2019", "Big Ideas 2020"

8 Assumes short-haul flights are less than or equal to 700 miles.

9 "Bad Ideas Report: The Industries That Could Be Disrupted by Innovation", ARK Invest, October 2020; Lutz, Hannah. https://www.spglobal.com/platts/en/market-insights/latest-news/metals/010621-us-2020-auto-sales-slide-15-but-recovery-stronger-than-expected

Exhibit 2:
Modes of transportation price per mile

Source: ARK Invest

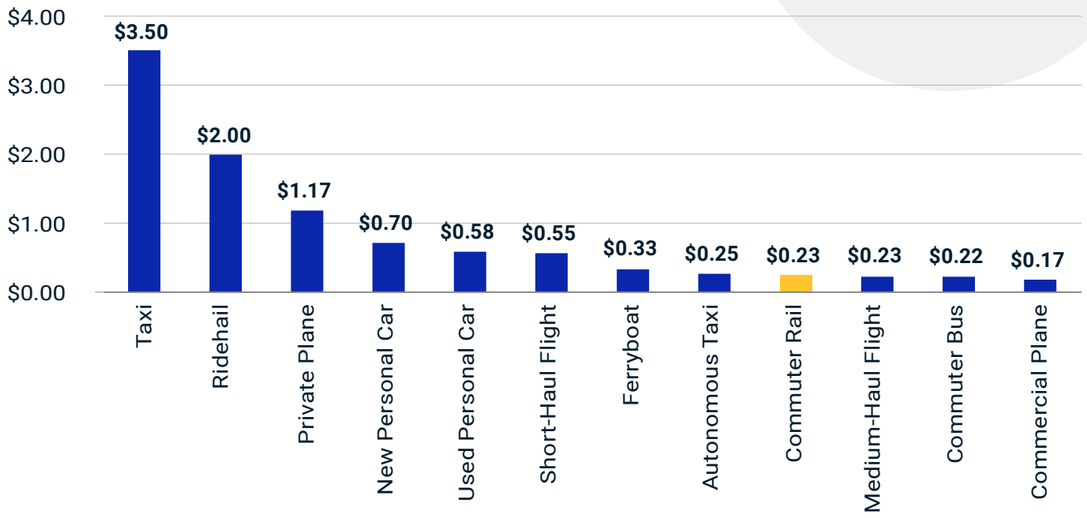
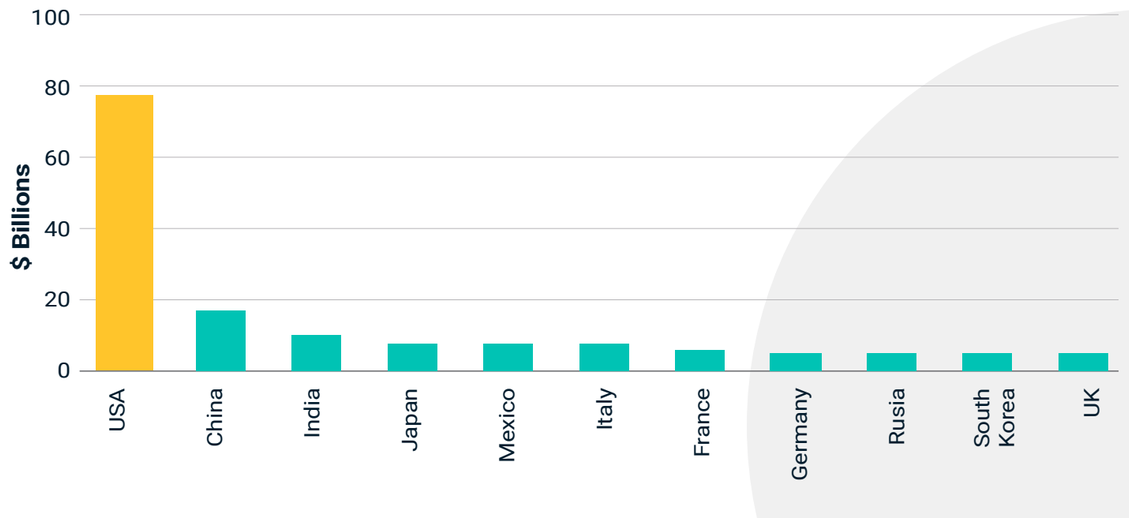


Exhibit 3:
Annual Economic Loss From Auto Deaths By Country

Source: ARK Invest



If consumers shift in this way from personal cars, then loan service could reduce and defaults rise on auto loans. The risks to auto loans would have a knock-on effect for the asset-backed securities derived from the pool of liabilities, which could undermine the prevalent purchase models in the global auto ecosystem. The familiar finance plan-based rotation into new models would break down in such a scenario with a sharp reduction in the residual value of internal combustion engine (ICE) used-vehicles. Loans totalling USD 1.2 trillion support roughly USD 2.6 trillion in vehicles on US roads today, with the balance of USD 1.4 trillion on consumer "balance sheets".[10] Both consumers and lenders would need to write down these assets, causing corporate stress and undermining wealth effects in consumption.

Auto insurance rates could also fall. According to ARK Invest, robotaxis would not only be less expensive than personal transportation, but also safer (accident rates forecast to drop by more than 80%). The majority of the US car accident fatalities are young people. The economic impact of this tragic loss of life is therefore huge: at least USD 77 billion per year in lost economic contributions.[11] This amount is equal to the entire GDP of New Hampshire.

Every year automobiles claim more than 1.2 million lives globally at an economic cost of hundreds of billions of dollars.[12] This immediate direct public health gain would be bolstered by the reduction in urban pollution and carbon emissions.

ARK estimates that roughly 57% of all automotive miles traveled in the US will be autonomous in the next 10 to 12 years and that non-autonomous miles traveled will drop by nearly 40%.[13] As shown in the figure below, traditional auto premiums (excluding autonomous vehicles) could drop roughly 55% from an expected peak of USD 266 billion in 2023 to $122 billion by 2030. Moreover, customer and profit erosion would likely be uneven - young drivers who pay the highest premiums (even with dash cams and blackbox discounts) would likely become early adopters of autonomous technology.[14]

10 ARK Invest; "Motor Vehicle Loans Owned and Securitized, Outstanding." FRED, 7 Oct. 2020,

11 "Mobility As-A-Service: Why Self-Driving Cars Could Change Everything," ARK Invest, Tasha Keeney, October 2017

12 Calculated by ARK Invest using data from the National Highway Traffic Safety Administration, WHO, Worldbank and Wolfram Alpha, see "Mobility As-A-Service: Why Self-Driving Cars Could Change Everything," ARK Invest, Tasha Keeney, October 2017

13 "Auto Insurers Should Fear: Autonomous Driving Networks Are Near!", ARK Invest, Nicholas Grous, May 2019.

14 "Bad Ideas Report: The Industries That Could Be Disrupted by Innovation", ARK Invest, October 2020

Exhibit 4:
Total US Auto Premiums Collected (Inflation Adjusted)

Source: ARK Invest

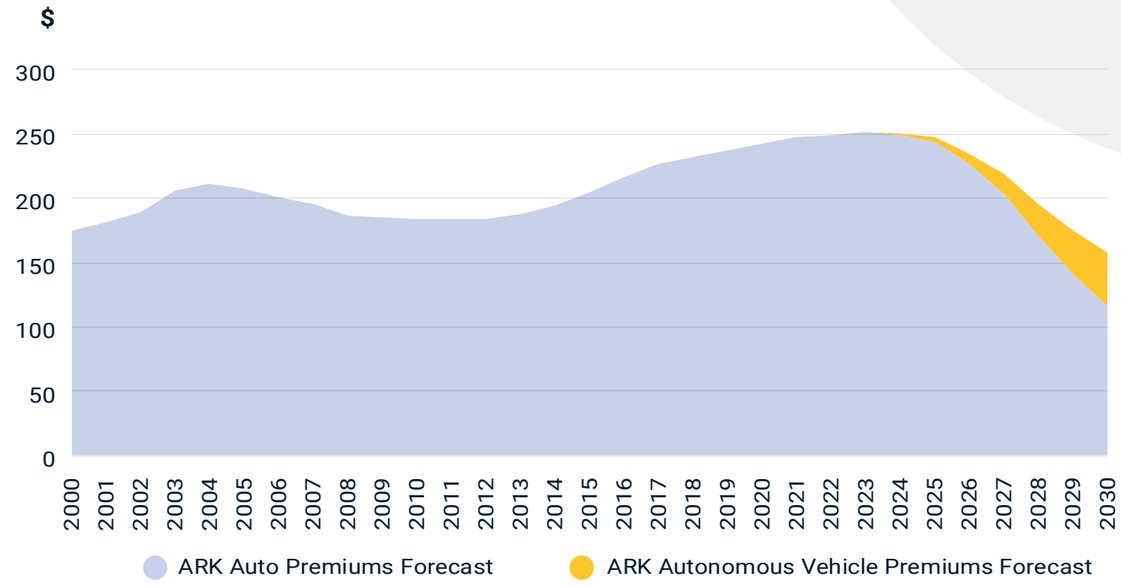
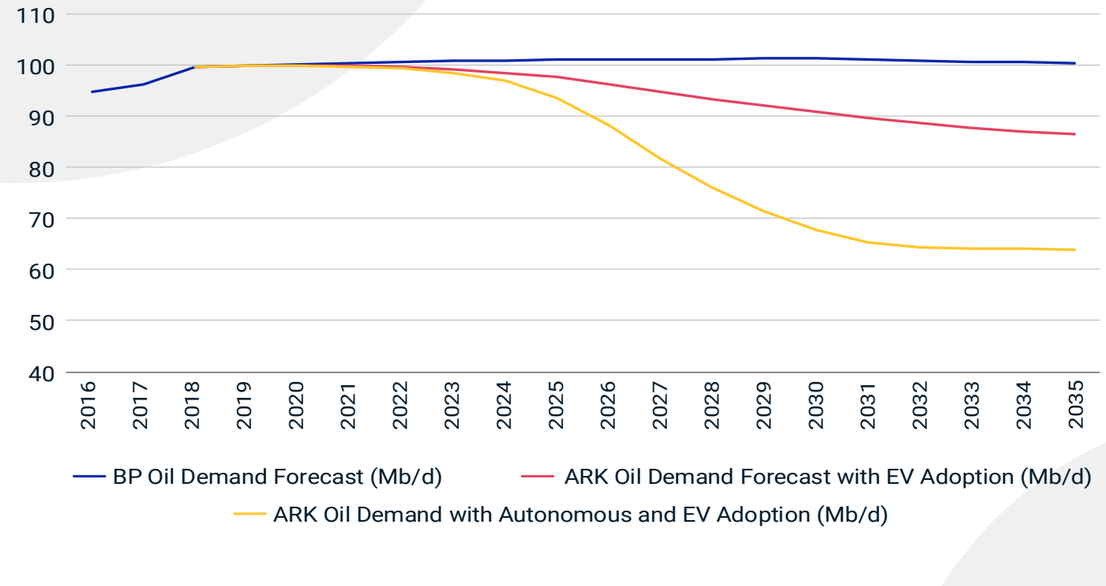


Exhibit 5:
Oil Demand Forecast

Source: ARK Invest



Finally, the USD 4 trillion oil industry supporting ICE vehicles has likely peaked.[15] Battery system cost declines could lower EV sticker prices to levels below those of their gas counterparts during the next two to three years, stimulating EV demand to the upside (especially while external regulation pressures e.g. auto makers in Europe). While the EIA forecasts EV new sales penetration of 2% in 2022,[16] ARK expect to see up to 20%.[17] In this way, inexpensive electric robotaxis could start to account for a disproportionate share of total mileage. Today, the capacity utilization of a personal car in the US is less than 5%, 10 times less than the 50% that is forecast for robotaxis.[18] Although we believe EVs will account for roughly 15% of the installed base in 2025, electric miles could total roughly 40% of total passenger auto miles traveled.

15 "Bad Ideas Report: The Industries That Could Be Disrupted by Innovation", ARK Invest, October 2020

16 "Annual Energy Outlook 2019 with Projections to 2050." US Energy Information Administration.

17 ARK Invest "Big Ideas 2020"

18 ARK Investment Management LLC, Average Annual Miles per Driver by Age Group.

Autonomous technology and the mobility ecosystem

When assessing autonomous technology and its impact on the mobility ecosystem, the challenge for investors is to assess who will extract the economic rent. That means both directly in relation to the switch to EVs but also as to the changes in social behavior and those players who may control access to ecosystem. ARK Invest, for example, has forecasted autonomous ride-hailing platforms should generate over USD 1 trillion in operating earnings by 2030.[19] Platform providers, or companies that own the autonomous technology stack, will likely gather the lion's share of the profits. Hence, auto manufacturers with successful EV platforms that partner with autonomous technology providers could generate roughly USD 250 billion in earnings by 2030. Fleet owners that own, house, and maintain autonomous ride-hailing vehicles could generate roughly USD 70 billion in earnings by 2030. As the equity market begins to discount the opportunity accumulating to autonomous platform providers by 2030, ARK Invest forecasts that their aggregate enterprise value could scale UD 3.8 trillion in 2025.[20]

19 "Mobility As-A-Service: Why Self-Driving Cars Could Change Everything," ARK Invest, Tasha Keeney, October 2017

20 ARK Invest "Big ideas 2021"

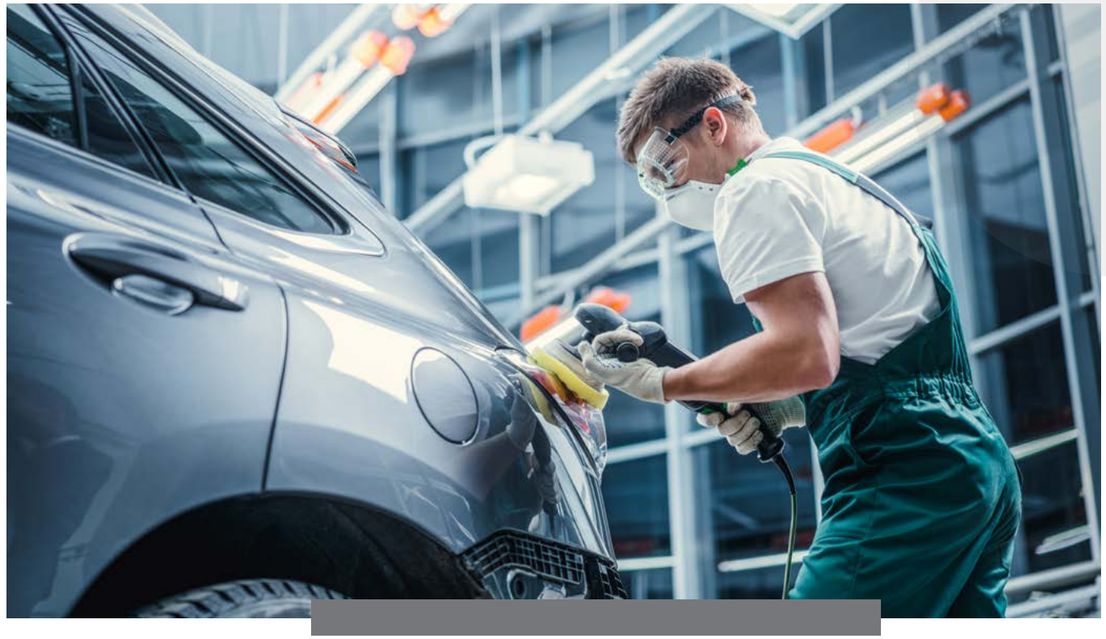
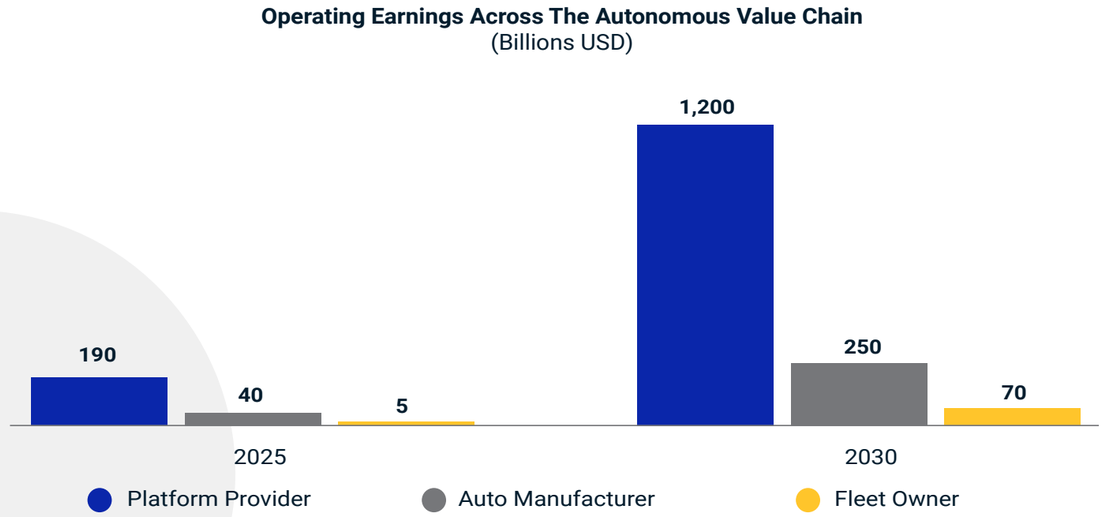


Exhibit 6:
ARK Believes That Autonomous Ride-Hailing Platforms Could Generate More Than $1 Trillion In Operating Earnings Annually by 2030

Source: ARK Invest

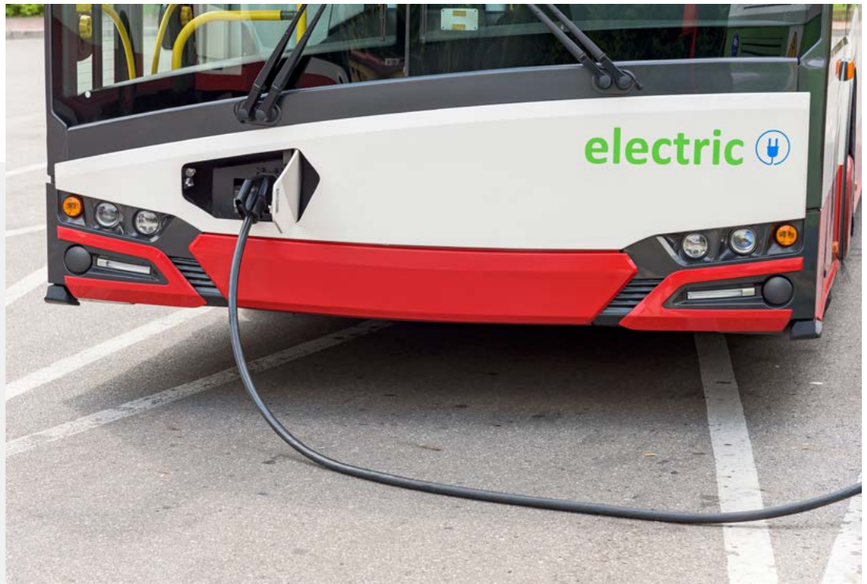


Conclusion

The growth in sophistication of autonomous technology is a key driver for the disruptive changes it is bringing to the mobility ecosystem. Moreover, it is illustrative of the impact of robotics and automation more generally on many other areas of social and industrial activity in the coming years. The case study we have sketched here focused on how autonomous electric vehicles could lead to profound industrial, financial market and social change. But that story is mirrored in the effect that autonomous technology, robotics and industrial innovation could have in the manufacturing, energy and materials sectors, for example.

MSCI would like to thank ARK Invest for useful discussions and insightful analysis of this megatrend, which have greatly facilitated the preparation of this document.

ARK INVEST



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