Longer Term Investments

Smart mobility

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- Smart mobility is set for take-off. Regulatory changes and technological advances will lead to greater electrification of cars, autonomous driving and new car-sharing mobility concepts. This will reshape the way we experience and use individual mobility.
- By 2025, we believe the annual addressable market of our theme will be around USD 400bn, or 8-9 times today's size.
- We see opportunities in electronics and electric components related to electrification and autonomous driving. We think car-sharing concepts are best approached through private equity at this stage.
- We recommend exposure through a broadly diversified stock selection to minimize company- and technology-specific risks. We also advise revisiting single automotive-related stock holdings as the way we look at them in a smart mobility world will change.

Our view

We define smart mobility as a combination of smart powertrains (electrification), smart technology (autonomous driving) and smart car use (car-sharing/car-hailing). Urbanization is the main driver and an aging and growing population a supporting factor with higher safety, better fuel efficiency and lower emissions playing to our theme.

Over the next decade, we expect smart mobility to grow significantly, revolutionizing not only the car industry but also the way that cars are used. More favorable regulation, which supports alternative powertrains, and new smart use / mobility concepts, should help. Rapid technological progress and a change in consumer behavior in which the use of the asset is more important than ownership of the asset support our smart mobility theme.

By 2025 we think the annual addressable market of our theme will be around USD 400bn, or 8-9 times the size it is today, offering substantial business opportunities. Electronics and electric components related to electrification and autonomous driving are the near-term drivers of our theme. Car-sharing concepts, including fleet management will increase in importance. However, only the broad-based adoption of robotaxis beyond 2025, leading to a peak in annual car sales shortly thereafter, will ensure 100% of revenues end up in the hands of the operators.

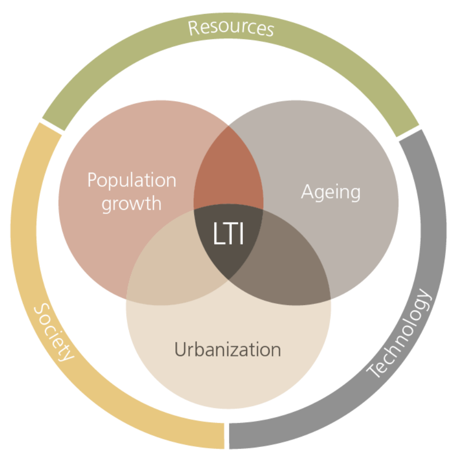
Introduction to the Longer Term Investments (LTI) series

– **The Longer Term Investments (LTI)** series contains thematic investment ideas based on long term structural developments.

– Secular trends such as population growth, ageing, and increased urbanization create a variety of longer term investment opportunities.

– These investment opportunities are influenced by the interplay of technological advancement, resource scarcity, and the societal changes.

– Investors willing to invest over multiple business cycles can benefit from potential mispricings created by the typically shorter term focus of stock markets.



The combination of more favorable regulation, falling costs and technological advances make smart mobility attractive for investors with a long-term focus, as the theme is cyclical in nature. We expect our theme to outperform the wider market and recommend exposure to smart mobility through a broadly diversified stock selection to minimize company- and technology-specific risks

Smart mobility drivers

Modern society has long aspired to the individual freedom offered up by the car. But while that concept of freedom endures, structural, technological changes based on electrification, autonomous driving, and car-sharing concepts, which collectively make up our definition of **smart mobility**, will challenge how we "consume" mobility in the future. **Urbanization** is the main long-term driver of our smart mobility theme, with **aging** and **population growth** supporting factors (see Figs. 1–3). A drive toward better safety, improved fuel efficiency, lower emissions, the rise of millennials, and increasing mobile connectivity will all be supportive of this theme

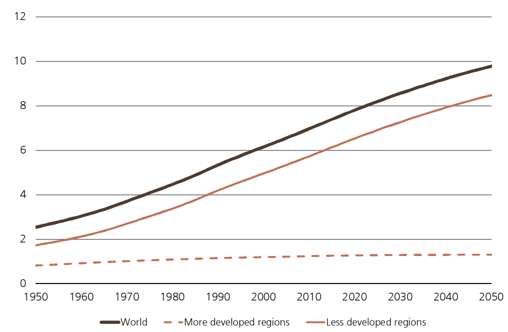
Looking at the technological drivers of smart mobility, **electrification** is increasingly gaining acceptance among governments and consumers alike. Costs, however, remain the biggest hurdle, though UBS's recent tear-down of a Tesla Model 3 proves the cost and technological progress the electric powertrain makes. In our view, regulatory change and steeper cost reduction will trigger a faster rollout of electrified powertrains than currently expected by the market. However, adequate charging and power infrastructure is also needed. **Autonomous driving** with vehicles employing a wide range of electronics, sensors, increased connectivity, and vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications will change the car and the way we drive forever. Finally, using a car does not mean owning it – **car-sharing concepts** will change the way automobiles are "consumed."

Whether car sharing will catalyze the migration to electric vehicles (EV) or new energy vehicles (NEV), or whether such vehicles will catalyze the migration to car sharing, is debatable. However, what is indisputable is that the rise in car sharing – especially "robotaxis" if they are adopted on a mass scale – could offer shorter investment payback periods through higher utilization. This makes car sharing an attractive option for consumers and an interesting business opportunity for companies. **Electrification, autonomous driving, and car sharing form our smart mobility theme.**

Urbanization supports car sharing and autonomous driving
Urbanization and the need to get around often leads to congestion in existing infrastructure. Autonomous technology will help reduce congestion and the loss of both time and energy (such as gas and diesel; see Sustainable Investment aspects below). In many areas, roads and parking spaces are stressed to the limit. While the need for mobility will not go away, the usage of vehicles – rather than their ownership – will come into focus. And while "sharing economy" business models are often identified with millennials, they are attractive to other generations too. House-sharing (e.g. via AirBnB) is well established; for cars, we believe it is still in its infancy. Cars in general

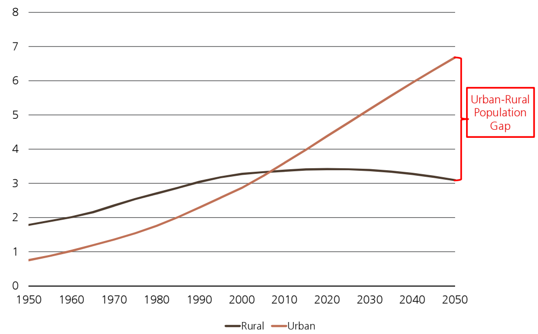
Individual sub-chapters of this report

Fig. 1: World population (in billions, 1950–2050)
Less-developed countries fuelling growth



Source: United Nations, Department of Economic and Social Affairs, Population Division (2018 revision); Note: including long-term forecasts

Fig. 2: World urban and rural population (in billions, 1950–2050)
By 2050, a majority of the world's population will live in urban areas



Source: United Nations, Department of Economic and Social Affairs Population Division (2018 revision); Note: including long-term forecasts are an underutilized asset, with an average utilization of around 4% at any given time; this supports the case for car sharing (which is not the same as sharing a trip in the same car). That said, autos are an emotional and prestige product and rarely bought on economic grounds alone. Hence, a fundamental change in the current auto-usage model, including mass adoption of car sharing and so-called robotaxis will happen – but only over time. But mobility needs will continue to increase, and a slowly but surely growing fleet of robotaxis will gradually reduce the overall number of individual cars sold. As a result, we believe annual global car sales will peak around 2026-2028. Furthermore, the concepts of autonomous driving and car sharing may diverge greatly, not only by region, but also between urban and rural areas. But change has begun and we expect **mobility as a service (MaaS)** to gain in importance.

Aging society supports car sharing and autonomous driving

In an aging society, autonomous or automated driving will allow the elderly to maintain their mobility. A key long-term driver that supports this trend is the higher purchasing power of this age cohort. That said, car-sharing concepts also offer mobility for the less wealthy, as they allow people to pay for the usage of MaaS rather than the upfront cost of owning a car.

Sustainable investment aspects: Improved safety, better fuel efficiency, lower emissions, greater inclusion and more green spaces

There is an increasing awareness in both developing and developed societies that changes in car usage are needed. This growing awareness of environmental, health and safety concerns has been around long before the Volkswagen diesel scandal broke in 2015.

A broad-based adoption of autonomous features, including artificial intelligence, could make driving both safer and more environmentally friendly. It may also lead to fewer and less deadly road-traffic accidents and a reduction in traffic-related deaths. According to the World Health Organization, in 2016, more than 1.3 million people died in traffic accidents worldwide – i.e. more than 3,000 per day – and 20-50 million people were at least temporarily incapacitated. As objective algorithms overrule individual egos, the flow of traffic would be more fluid, potentially reducing traffic jams and improving fuel efficiency per mile traveled.

We see an increasing trend toward electrification in cars (see Box 1 for definitions and Fig. 4). We estimate that by 2025, around 25% of new vehicles sold globally could be electrified, with at least 10% being battery electric and the rest plug-in and full hybrids. This is certainly more demanding than the International Energy Agency's (IEA) base case, which believes in a EV share of 13% by 2030 (pls see "Our energy future: How will electric vehicles affect global energy demand", published 24 September 2018). A wide-ranging rollout of 12 & 48 volt mild-hybrid vehicles is not factored into our figure, which could become standard for another 20-25% of all global new car sales, in our view. All this means that local emissions will be reduced, even if greenhouse gas (CO_2) emissions remain dependent on the way electricity is produced. In our view, health issues and deaths caused by pollution (from nitrogen oxides and particulates, among others) should fall rapidly over time.

Box 1: Definitions for car electrification:

a) BEV (battery electric vehicle): Propelled purely via electric power stored in a battery and converted into mechanical power by means of an electric motor. BEVs are charged externally (with a power cord) and through regenerative braking, i.e. the electric engine serving as a generator during the braking phase, charging the battery.

b) PHEV (plug-in hybrid vehicle): Can be driven on both purely electric power or fossil fuel power (gasoline or diesel). This vehicle's powertrain contains both an e-motor and a battery that can be externally charged, and an internal combustion engine (ICE) that burns fuel to propel the car. PHEVs typically have a pure electric range of 30–50km, lower than the ranges for a BEV.

c) EV (BEV & PHEV): All plug-in electric cars.

d) New energy vehicles (NEV): China's definition for battery electric and plug-in hybrid vehicles (equal to EV definition above).

e) FCV (fuel cell vehicle): Propelled by an electric motor (like an EV), but uses power generated from hydrogen as fuel rather than power stored in a battery. An FCV carries compressed hydrogen gas in a tank and employs a fuel cell to ultimately convert the hydrogen gas into electricity.

f) HEV (full hybrid vehicle): Like a PHEV, it carries two powertrains (electric, including battery and e-motor, and ICE). In contrast to PHEVs, the battery cannot be charged externally. The battery is recharged only through regenerative braking. The pure electric range is lower than that for BEVs/PHEVs. HEVs typically use electric power at steady speeds and for acceleration to save fuel.

g) 12 & 48 Volt mild hybrid: Smaller electric engine used as a booster during the acceleration phase. The 48-Volt system contains an extra 48-Volt battery. Both systems can also be used to power e.g. an electric turbocharger, and are not externally charged, but recharged via regenerative braking.

h) Internal combustion engine (ICE): Traditional gasoline or diesel powered.

Source: UBS

Car-sharing concepts will also enable greater social inclusion by making mobility available to people who do not have, or cannot afford, their own vehicles. And because roads and parking spaces use up 15–20% of city space, car sharing should reduce congestion given fewer vehicles on the road and consequently less parking and road space needed. This should contribute to the greening of "smart" cities.

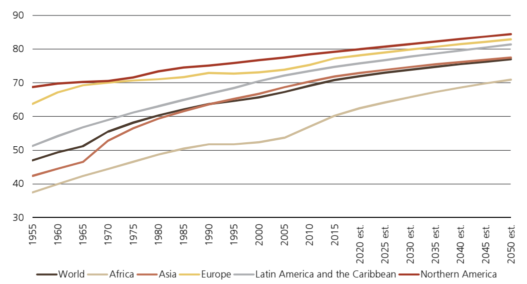
The smart mobility market

This year, we expect around 96 million vehicles to be sold globally, representing a market in excess of USD 1.5 trillion a year. Assuming a 2% growth rate in car demand (below its 20-year historical average of 3% to reflect slightly slower vehicle growth than previously assumed), unit sales could increase to 110 million in 2025, driven by demand from emerging economies. Beyond 2026, we think we'll start to see the rollout of robotaxis, but even in 2030 around 90 million ex-robotaxi cars will be sold (see Fig. 5). Note that at this stage our theme's focus is on vehicles that provide individual mobility; it excludes commercial vehicles such as heavy trucks, buses and vans which would add another lucrative dimension to this theme.

Given this large addressable market for individual mobility, the long-term success of our smart mobility theme depends on the regulatory environment, the technology deployed and the costs these changes entail. We are confident, however, that the trend toward smart mobility is overwhelming and, based on technological advances, may advance faster than currently assumed. The individual components and technologies behind our smart mobility theme are strongly interlinked. We estimate that by 2025 the overall annual addressable market of our theme could be **around USD 400 billion** (see Fig. 6), i.e. about 8-9 times larger than it is today. We also made the following assumptions for market size, adjusted from our original October 2017 estimates, consistent with slower market growth:

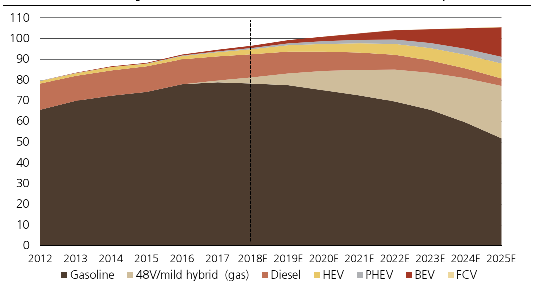
- Electrification – powertrain for suppliers: **USD 70-100 billion** (from around USD 5 billion today), with the traditional supply chain at risk of losing USD 65–130 billion. Electrification will cannibalize traditional internal combustion engines (ICE). A faster rollout of battery electric at the expense of plug-in hybrids would result in the higher end of the potential loss for traditional powertrain suppliers (see also Appendix 2 for the impact). This is because plug-in hybrids still contain an ICE and, hence, even more ICE would be replaced (see Fig. 6).
- Electrification – battery value chain: **USD 80-175 billion** (from low-double-digit USD billions today), which includes not only the battery cells, but the whole battery pack.
- Autonomous driving: **USD 90 billion** (increasing some fourfold from current ADAS = advanced driver assistance system market value).
- Car-sharing/car-hailing – fleet and platform: we estimate current gross revenues of approximately USD 50-70 billion, of which 20–30% ends up with the ride hailers (i.e. with the car-sharing, car-hailing businesses), translating into USD 10-15 billion currently. The remainder (70–80%) ends up in the hands of the drivers. Based on current growth rates, we believe the car-sharing, car-hailing businesses will see an increasing share of revenues, or some **USD 85–105 billion** by 2025. Only in a "robotaxi" world would 100% of revenues end up in the hands of the car-sharing concepts. We expect this from 2025 onwards.

Fig. 3: Aging (1955–2050)
Average life expectancy at birth (in years)



Source: United Nations (UN) Population and Aging Database 2017, UBS; Note: including long-term forecasts

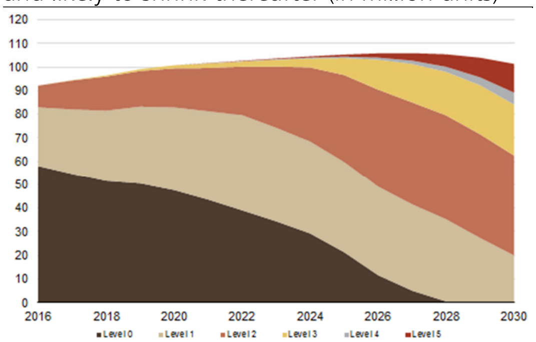
Fig. 4: Powertrain mix shift ahead
Traditional gasoline and diesel down, 12 & 48 Volt (mild) hybrids and electric vehicles up



Source: UBS as of November 2018

Note: HEV = (Full) hybrid electric vehicles; PHEV = Plug-in hybrid electric vehicles; BEV = Battery electric vehicles; FCV = Fuel cell vehicles; 48V/mild hybrid (gas) = gasoline engines combined with 12 & 48 Volt mild-hybrid systems

Fig. 5: Robotaxis impact car sales
Traditional car sales will peak around 2026-2028 and likely to shrink thereafter (in million units)



Source: UBS, as of October 2018
Note: ADAS levels = advanced driver assistance systems = autonomous driving levels, tiered from level 0 (no automation) to level 5 (full automation)

While the value we see in the smart mobility market remains unchanged, at USD 400 billion by 2025, we have revised the value of the individual sub-categories compared with our initial October 2017 publication. We reduced our estimate for the size of the global car market in 2025 from 120 million to 110 million vehicles. The lower figures for Electrification are mainly due to a faster decline in costs, especially for batteries (see Fig. 7). However, this should be supportive of sales volumes of electrified vehicles, which may lead to stronger growth rates than shown in Fig. 8. We show separately the market for full hybrid (HEV) vehicles (see Fig. 6). We increased the Autonomous Driving market from USD 70 billion to USD 90 billion, driven by our belief that Level 3 "conditional automation" will see strong demand from consumers. And we increased the minimum market size for car-sharing/car-hailing as we believe this concept will gain in stature, driven by the growth rates displayed by the current market players.

Fig. 6: Smart mobility addressable market

By 2025, smart mobility should be a USD 400 billion annual market

in USD bn in 2025		Slow battery-electric rollout, high plug-in hybrid share	Faster battery-electric rollout, low plug-in hybrid share
Powertrain suppliers	Battery electric vehicles (BEV)	30-35	60-65
	Plug-in hybrids (PHEV)	25-30	15
	Full hybrid (HEV)	6-7	6-7
	12 & 48 Volt mild-hybrid	10-15	10-15
	gaining	70-85	90-100
	losing	-65	-130
Battery value chain	Battery electric vehicles (BEV)	60-80	120-160
	Plug-in hybrids (PHEV)	15-20	8-9
	Full hybrid (HEV)	3	3
	12 & 48 Volt mild-hybrid	3-4	3-4
	gaining	80-105	130-175
Autonomous Driving	ADAS	90	90
Car-sharing / Car-hailing	Fleet and platform	85-105	85-105
Smart Mobilty total		325-385	395-470

Source: UBS estimates November 2018; car-sharing/car-hailing numbers based on Goldman Sachs, September 2017 and UBS estimates November 2018.

Note 1: ADAS = advanced driver assistance systems

Note 2: Slow-battery rollout assumes 10% battery electric, 10% plug-in hybrid and 5% full hybrid vehicles by 2025. The faster battery electric rollout assumes 20% battery electric and 5% full hybrid, but only 5% plug-in hybrids by 2025

Note 3: Our market estimates are rounded.

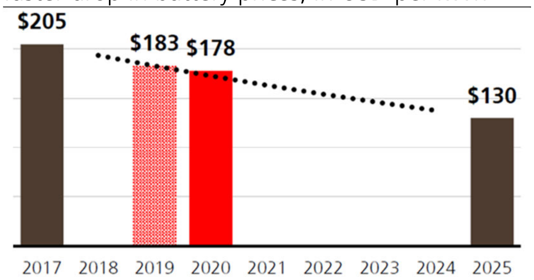
Key messages of smart mobility

Electrification

The rollout of electrification is underway. We expect growth to be exponential rather than linear from 2020 onwards. We think that by 2025 around 25% of new cars could be electrified, of which at least 10% will be battery powered full-electric vehicles and the rest plug-in and full hybrids. We also expect a further 20–25% of mild hybrids based on 12 & 48 volt technology. This creates long-term business opportunities. (see Figs. 4 and 8)

Fig. 7: Electric cars – battery cost will be key and might fall faster than expected

Tesla Model 3 at USD 178 per kWh - a two year faster drop in battery prices, in USD per kWh



Source: UBS, as of 15. August 2018

Autonomous driving (ADAS)

Autonomous driving is tiered from levels 0 (zero automation) to 5 (full automation). We believe that over the next 10 years, most new cars will reach level 2 to 3, with level 3 ("hands-off") in particular (conditional automation) offering profitable opportunities for companies. To quote Daimler's head of R&D, "horsepower is being replaced by the speed of semiconductor chips." Semiconductors and sensors are key for autonomous driving. As an aside, they collect a vast amount of potentially lucrative data over time. (see Fig. 9)

Car-sharing concepts

The combination of electrification, autonomous driving, and connectivity will play a major role in increasing shared mobility as a service model (MaaS), with autonomous driving being the ultimate trigger. It is debatable if sharing catalyzes the migration to EV/NEV, or if EV/NEV catalyzes the migration to car sharing, but increased utilization of car-sharing concepts (car sharing and car hailing) and ultimately robotaxis should lead to lower costs to the consumer and generate a viable business model for providers. (see Fig. 5, and Box 2)

Box 2: Car hailing vs car sharing definition:

Car hailing = Chauffeured services like Uber, Lyft

Car sharing = Sharing with other drivers/owners i.e. pooling cars like Mobility in Switzerland, so far car2go (Daimler) and DriveNow/ ReachNow (BMW), which combined now as SHARE NOW

Robotaxi = fully autonomous, driverless vehicle

Source: UBS

Our theme focuses on the whole smart mobility value chain, with a strong emphasis on electronics and electric components related to electrification and autonomous driving which will ultimately also power car-sharing concepts (see Fig. 10). In the following chapters, we address these individual sub-categories.

Electrification

The rollout of electrification is underway. We expect growth to be exponential rather than linear from 2020 onwards. We think that by 2025 around 25% of new cars could be electrified, of which at least 10% will be battery powered full-electric vehicles with the remainder plug-in and full hybrids. We also expect a further 20–25% of mild hybrids based on 12 & 48 volt technology. This creates long-term business opportunities. (see Figs. 4 and 8)

Current stance

Since 2006, we have seen a 30–40% improvement in fuel economy. However, current combustion engine technology has its limits, with only around 2% further annual improvements possible, as the low-hanging fruits of efficiency gains driven by direct injection, turbocharging, downsizing, gear-box optimization, axle-drive ratio etc. have been reached. In our view, tougher regulation to reduce CO_2 emissions and fuel consumption will lead to a significant increase in the electrification of powertrains. These will take the form of full hybrid, plug-in hybrid, and battery electric vehicles, be it battery or potentially even fuel-cell powered (together, alternative powertrains).

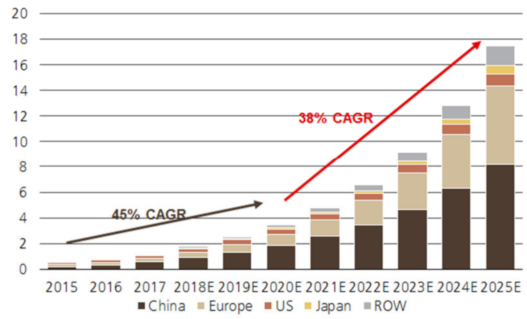
Based on the latest data from the European Automobile Manufacturers Association (ACEA), the overall market share of alternative powertrains in Europe (EU + Norway + Switzerland) in 2018 was 2.5%, a 33% yoy increase compared with just 1.8% in 2017. This translates into 183,000 plug-in hybrids and 201,000 battery-electric vehicles, which supports our growth case, albeit these numbers are off a low base. In addition, 606,000 full and mild hybrid vehicles were sold in Europe last year, again a 33% increase over the previous year. In spite of the strong yoy increase, government incentives, such as Germany's EUR 4,000 subsidy for full-electric cars and EUR 3,000 for plug-in hybrids, have had only an incremental impact on consumer demand as the selection of vehicles currently available is limited – but this will change. The market share of electrified vehicles worldwide (full-electric and plug-in hybrid) stands at just 1-2%.

Regulation

Regulation will encourage car manufacturers to build and roll out more models, and consumers to switch to electrification over time, at least in China and Europe. China, with its NEV initiative of zero- and low-emission vehicles is at the forefront of global supply and demand. It is already the world's leading electric car market – Chinese consumers have the largest selection of electrified cars to choose from – and it is accelerating its electrification efforts. Monthly sales figures of 96,000 NEV (+140% yoy) for January 2019 support our views. China is aiming for a NEV quota of 10% and 12% by 2019 and 2020 respectively, and 20-25% by 2025. The NEV formula is complicated and does not mirror market share with credit granted to comply with the NEV quota dependent on vehicle range and efficiency. This should translate into around 4% more, or one million new NEV vehicles sold in 2019 and 2020. Our meetings with industry officials, including VW management, suggest China's NEV goal could translate into 600,000 NEVs a year by 2025 for VW alone.

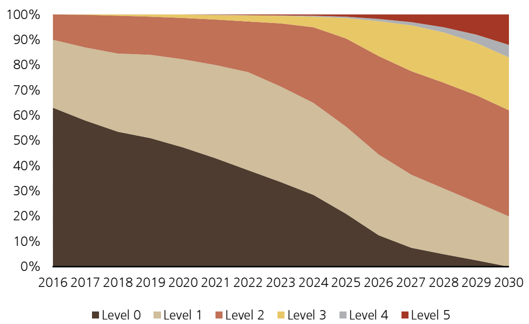
In Europe, various countries are set to phase out traditional combustion engines (diesel and gasoline). In the UK and France, this is slated for 2040 (Paris is aiming for 2030). In Asia, China is looking at ridding itself of

Fig. 8: Electrified cars – strong growth driven by China and Europe
Annual vehicle sales (in million units)



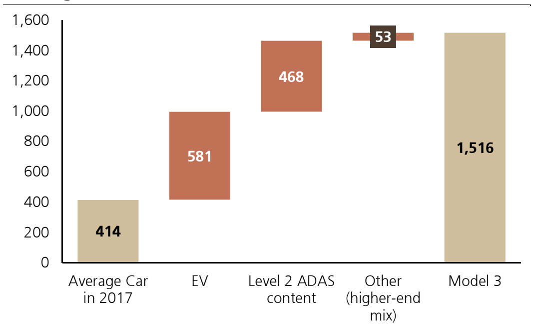
Source: UBS, as of October 2018; Note: chart includes battery electric, plug-in hybrids and fuel-cell, but excludes full and mild hybrid vehicles

Fig. 9: Autonomous driving penetration
AV adoption curve by ADAS level – in % of global new car sales



Source: UBS, as of May 2018

Fig. 10: Semiconductor content on the rise
Semiconductor content of a full-electric, level 2 autonomous car (Tesla Model 3) versus an average car , in USD



Source: UBS, as of September 2018
Note: EV = electric vehicle related; ADAS = advanced driver assistance system; Other includes e.g. comfort related content like entertainment/navigation etc.

combustion engines by 2030. The ban on diesel engines from inner cities (emission zones) or potentially a ban on all ICE-powered vehicles, as well as mandatory EV quotas, has been widely discussed. In some German cities, diesel bans are already in place.

Uncertainly surrounding diesel emissions and vehicular access driving bans has caused considerable ambiguity among European consumers. This has led to a sharp fall in the market share of new diesel vehicles (see Fig. 11 and Box 3). The result: European consumers have switched to gasoline engines (as viable electrified products remain limited) leading to an increase in CO_2 emissions.

With CO_2 emissions on the rise, ever more electrified vehicles will be needed to meet the upcoming European CO_2 regulations, which are due to tighten from the current 130g CO_2/km to 95g CO_2/km by 2020/21 (around 4 liter/100 km = 59 miles per gallon consumption) and by a further 37.5% from the 2020/21 levels by 2030 (i.e. around 2.5 liter/100 km = 94 miles per gallon average fleet consumption). In our view, non-compliance is not an option for manufactures, as this could lead to hefty fines and reputational damage.

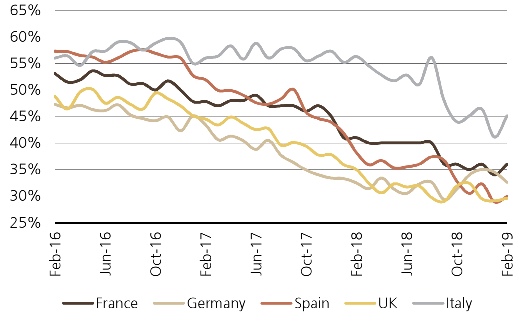
Clearly, the electrification of cars will help reduce local emissions i.e. in cities and urban areas. However, to really make a dent in overall environmental CO_2 emissions, national grids need to move away from carbon energy toward renewables (see our LTI: Renewables, published 9 January 2019 and our LTI: Clean air and carbon reduction, published 18 May 2018). In our view, Smart Mobility, Renewables, and Clean air and carbon reduction will become increasingly important in the years to come. New regulations are vital in driving this step-change in mentality.

Growth

We believe that when infrastructure improves, costs fall and more attractive products hit the market, consumers will increasingly embrace electrified vehicles. We think that further cost reduction (mainly batteries), and the rollout of attractive battery-electric vehicles from 2020 onwards will lead to exponential smart mobility growth. From a total cost of ownership (TCO) perspective, cost parity exists in Europe between ICE and battery electric vehicles (BEV) and is not far behind elsewhere (see Fig. 12.1.) with annual running costs for diesel cars e.g. in Europe likely to rise while battery-electric costs fall (see Fig. 12.2). Sustained or even increasing subsidies could bring the timeline forward. For car manufacturers, we expect decent profitability (i.e. a 5% EBIT margin) to follow, but with a delay, potentially from 2023 in Europe, and later in other regions. In our discussions with Daimler at the Frankfurt IAA Motorshow in September 2017 we were told that first-generation electric car margin contribution would be roughly half that of traditional ICE vehicles. However, markets evolve rapidly. More recent discussions with VW management suggest an increasing confidence in scale benefits. Based on our findings following our tear-down of a Tesla Model 3 where we observed a faster drop in battery prices, we feel increasingly confident that the stated inflection points are realistic. However, at this point, most automakers are not necessarily the winners in smart mobility as upfront investments remain high and payback will only come over time.

Fig. 11: Diesel market share in Europe

European diesel-powered car sales under severe pressure (market share in %)



Source: National Car Associations, February 2019

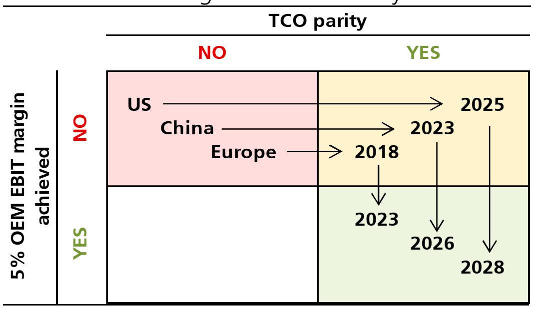
Box 3: A word on diesel

The share of diesel-powered car sales has fallen significantly in Europe, from above 53% pre the diesel crisis to around 34% today. However, digging deeper, this fall is not all down to the emissions scandal. Some small and mid-sized vehicles no longer offer diesel technology as to do so would render them unprofitable due to the cost of complying with new emission standards. The share of German premium diesel-powered cars has dropped as well. However, in the case of large sedans like the BMW 7 Series or large SUVs, diesel still represents more than 70% of sales. But we are also seeing an increasing share of gasoline for plug-in hybrids.

Source: UBS

Fig. 12.1: Inflection points

Close to TCO parity for consumers and auto manufacturer margin to follow 3–5 years later



Source: UBS, as of 18 May 2017

Note: TCO = Total cost of ownership. TCO parity = the point when all-in costs for battery electric vehicles equal internal combustion engine vehicles

While we expect growth rates will be strong, these will off a very low base. Even with a projected drop by UBS of 35% in battery pack prices by 2025 from 2017 levels (see later chapter) we believe a battery-electric car will likely cost at least USD 15,000 (for 200km short-range models) to USD 20,000 (for 400km long-range models). However, the costs of improving internal combustion engine efficiency are on the rise, and the gap versus battery-electric vehicles could shrink if battery costs fall faster, which may lead to a faster rollout of battery-electric vehicles. Nevertheless, we believe the growth in alternative powertrains will take place in areas with higher incomes and purchasing power, or geographies under greater regulatory pressure. We see the greatest potential for growth in alternative powertrains in China and Europe (which together we believe should account for 80% of the market by 2025), rather than emerging markets, while the US is likely to lag on the full-electric front (see Figs. 4 and 8).

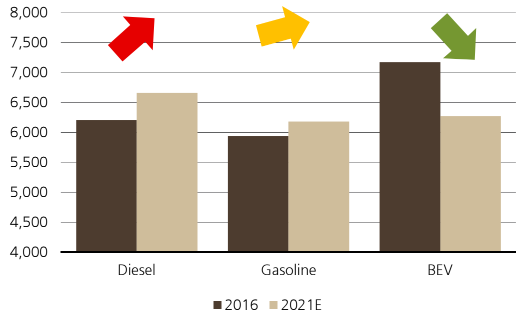
We believe luxury and premium cars, equipped with alternative powertrains, will be first to market as their buyers are less price sensitive. These will be followed by the volume segment. The introduction of various premium SUVs in 2018, support this view. However, volume producers are fast on their heels. Offering cheaper mainstream vehicles at lower price points will clearly depend on battery costs (see next section). The three German auto heavyweights currently sell a combined 15 million vehicles annually. According to their management teams, they target 15–25% electrification of their car divisions' sales (full-electric plus plug-in hybrid) by 2025. This translates into around four million electrified vehicles a year.

At this stage, we believe that by 2025 around 25% of new cars worldwide will be electrified, of which at least 10% will be battery-powered full-electric vehicles with the remainder full and plug-in hybrids. This is not too far away from auto supplier Continental, which sees full-electric vehicles taking a 10% share of the market, plug-in hybrids at 5%, full hybrids at 7%, and 48V mild-hybrids at 14%. However, industry estimates vary widely, as faster progress in battery technology and falling costs could speed up the rollout of battery electric cars at the expense of plug-in hybrids. While a lot has been written about fuel-cell vehicles (FCV), we believe battery-powered vehicles (BEV) will be adopted first, while FCV may come at a later stage (see Box 4).

From a production perspective, UBS estimates the breakeven point for a battery electric compared with a plug-in hybrid (which still needs a combustion engine) to be at a battery pack cost of around USD 140/KWh. This could potentially arrive by 2020–2021, some two years faster than we expected a year ago because battery costs have fallen faster. Thus, the cheaper batteries become, the weaker the case for plug-in hybrids. Nevertheless, we believe plug-in hybrid technology will be with us for some time to come. The next generation of plug-in hybrids, available from around 2020 onwards, should offer 100km electric range, or enough to meet 90% of road trips. As vehicle range improves, so too will consumers' willingness to buy into this technology, as long as battery costs for full-electric vehicles remain relatively high compared to today's levels. In the long run, however, we think plug-in hybrids will become obsolete.

Fig. 12.2: Cost of ownership of diesel cars

Likely to turn into a disadvantage (annual costs in EUR)



Source: UBS estimates, as of February 2019

Box 4: Fuel-cell vehicles (FCV)

Hydrogen propelled fuel cell electric vehicles have been discussed as a viable long-term powertrain solution. For example, Audi announced a partnership with Hyundai to develop fuel-cell vehicles, which Hyundai has already accomplished. Japan and several Japanese auto companies are also heavily engaged in this technology, while Daimler has created an SUV as a technology base to gain broader experience. In May 2018, Toyota announced the expansion of its fuel cell stacks and hydrogen tanks business as it anticipates selling at least 30,000 vehicles per year (a 10-fold increase from current levels) from 2020 onwards. But this would translate into just 0.3% of its 10 million global vehicle sales, indicating the niche character of FCV. We believe a near-term broad-based roll-out appears unrealistic because: 1) the way battery costs are evolving; 2) the lack of hydrogen gas station infrastructure in most countries, vis-a-vis the availability of electricity sockets; 3) efficiency losses from the creation of hydrogen until it ends up at the wheel. However, fuel cell technology may become viable for commercial vehicles, such as buses and short-haul trucks, as they have a set starting point for their trips where a hydrogen gas station could be easily installed. Further out (beyond 2025), we see a chance that more auto companies will diversify their technology in order to manage the dependency / access to commodities and certain geopolitically sensitive areas.

Source: UBS

Furthermore, we also assume that by 2025 pure ICE vehicles will no longer be sold. Rather, we see pure ICE being accompanied by 12 and 48 Volt mild hybrids, adding to the revenue opportunities for technology-focused suppliers (see also Appendix 2). In our view, the US will embrace the change at a later date, phasing out pure ICE (without at least a mild-hybrid system) by 2030. Hence, we expect at a minimum a further 20–25% share for mild hybrids based on 12 or 48 Volt technology by 2025, reducing emissions and replacing demand for new diesel vehicles at reasonable cost.

Consequently, the value-added share of automakers and traditional auto suppliers is likely to fall due to the disruptive forces in the industry, away from mechanical parts toward electrical and electronic ones (see Fig. 13 and Appendix 2). In 2017 we expected suppliers that support powertrain electronics to increase their content by up to 11x to around USD 600 per electric vehicle compared to a traditional combustion engine vehicle. Furthermore, battery cell and battery pack producers would likely take a substantial share of the value.

A word on batteries

Regulation aside, the rollout of electric cars depends to a large extent on further advances in existing and new battery technology. Battery know-how is both key, and a strategic asset. Increasing energy density and reach, while substantially reducing costs and weight, will be crucial in increasing demand. Battery costs have already fallen significantly and are expected to drop still further. Up until the middle of last year we assumed a 35% drop in battery pack prices from 2017 levels by 2025 (see Fig 14.1). However, the swifter fall in battery-cost reduction we saw in the Tesla Model 3, some two years faster than we forecast in 2017, may mean we are too conservative in our forecasts (see Fig. 7), which should propel electric vehicle demand. While the environmental impact of producing and recycling batteries is controversial, we believe the extended life of batteries and technological advances mean battery recycling may be less of an issue than feared (see Box 5).

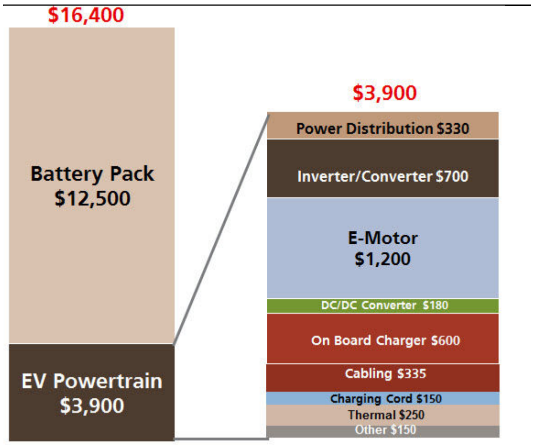
Currently, substantial investment in battery capacity is being made, which will more than double global battery capacity from 2017 levels in 2021. This includes some of the larger Asian players which already have, or are in process of building, capacity in Eastern Europe. Cost reduction also comes from scale, and we expect smaller companies to suffer from high capital expenditure requirements and ongoing price erosion, which would only be partly compensated by a strong increase in volume. In addition, battery technology is advancing. So-called solid-state batteries, with superior characteristics, may be several years away. However, a faster break-through could speed-up the move to full-electric vehicles and change the competitive landscape of battery producers. Hence, we would avoid smaller battery companies, which lack scale, research & development capabilities and financial resources.

Implications for raw material demand

Production and demand of graphite, lithium, cobalt, manganese and copper is expected to rise and with it the cost of these raw materials –over the past two years, raw material prices have soared, and now represent around 50% of battery cell costs, or around one-third of the overall cost of a battery pack. In our view, this will nudge the auto and battery industry to seek out alternative technologies and materials, not least due to supply concerns (cobalt, for example, is mined in politically sensitive Democratic Republic of Congo). Renault-Nissan has already committed around EUR 1bn to explore cobalt-free batteries.

Fig. 13: Electric engine powertrain

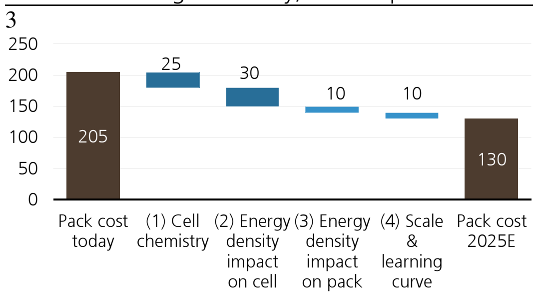
The battery is the biggest cost item (in USD)



Source: UBS, as of 18 May 2017

Fig. 14.1: Electric cars – battery cost will be key

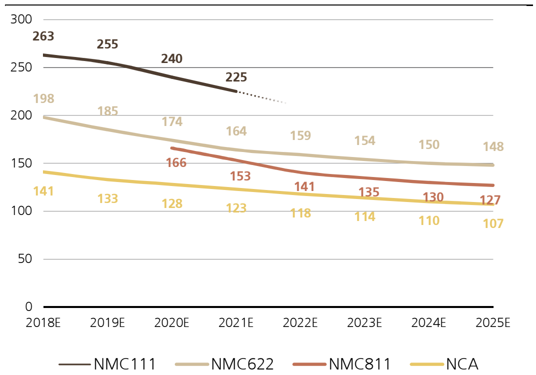
Battery pack cost to decline by around 35% by 2025 on existing chemistry, in USD per kWh



Source: UBS, as of 18 May 2017

Fig. 14.2: Battery pack cost development

Depending on cathode material mix, in USD per kWh



Source: UBS, September 2018

While commodity costs will continue to drive prices, technological advances in battery cell chemistry should help increase the energy density and reduce the required size and costs of batteries. Cathode material is a major cost-component of a battery. Looking at the latest announced changes in cathode chemistry, the shift from so-called NMC 111 batteries (1 unit of nickel, 1 unit of manganese, 1 unit of cobalt) or NMC 622 batteries to substantially cheaper NMC 811 batteries confirms that the auto and battery industry is trying to bring costs down – as a result demand for nickel will increase at the expense of cobalt. In our view, costs for a battery pack based on an NMC 111 cathode could be USD 225 per kWh in 2021, whilst an NMC 811 might be less than USD 153 by the same time, i.e. 30% cheaper. Assuming a 60 kWh battery, the resulting cost savings would be around USD 4,300 – and we believe costs can fall further (see Fig. 14.2). As an aside, with battery pack costs falling, the share of commodities as a percentage of overall battery costs, even assuming stable raw material costs, is likely to increase from around one-third to around one-half of the overall battery pack cost by 2025. But investing in commodities or commodity-related sectors may be the most volatile part of investing in our smart mobility theme due to the supply/demand dynamics and the long lead-time they are facing. Various commodities have experienced high volatility and price setbacks, as the market has sometimes got ahead of itself, with initial investments in mining capacity only followed by strong demand in the years to come. For example cobalt was at USD 55,000 per ton in Q2 2017, peaked at above USD 90,000 in Q1 2018 and is now back at around USD 31,000 at the time of writing.

Charging infrastructure

While there has been a strong increase in the number of charging points in China (where investments in charging infrastructure have been in the low-double-digit USD billions), it remains in its infancy in Europe. Estimates of the investment needed vary widely and start at around USD 200 billion, while UBS projects that USD 300 billion of investments are needed globally to establish an adequate and broad-based charging infrastructure. In our view, we face a chicken-egg problem – consumers are unwilling to buy electric cars because of 'range anxiety' i.e. the fear of running out of charge with no charging facilities in sight. On the flip side, charging-infrastructure providers are not investing fast enough, as there are too few electric vehicles to make it a lucrative business.

As an example, the German government is targeting 100,000 charging points by 2020. We believe in Germany alone, substantially more than 25,000 fast-charging points are needed to cater to increased electrification. Reality is some way off. The current infrastructure, as of June 2018, included 13,500 charging points, of which only 13% are fast chargers – up from 10,700 charging points in June 2017 (source: bdev.de - Bundesverband der Energie-und Wasserwirtschaft). In Norway, which has the highest EV penetration in Europe, press reports illustrated bottlenecks in charging points; ongoing investment in charging infrastructure has not been able to keep up with the demand. For many countries, a broad-based coverage of (fast) charging stations remains a long way off, representing a major near-term bottleneck for the rollout of electric vehicles – but we believe this will be solved. This will not only require additional investment by governments, but also offer business opportunities in the long run, e.g. via exclusive licenses to build up charging infrastructure for a decent return on investment. Further opportunities may also lie in wireless (inductive) charging infrastructure for private households over time.

Box 5: Battery – three stages of life

What is the impact on the environment of full-electric vehicle batteries?

Much of the raw material used in making batteries comes from geographically sensitive areas, and environmental, social and governance (ESG) issues are of utmost concern.

Talking to auto companies it looks like in the **first stage** of life, batteries can be used much longer than originally projected i.e. they endure many more charging cycles than originally projected and should last at least 10 years, depending on their usage and the way they are treated. When their performance drops, they may be used in the form of stationary energy storage. This is the **second stage** of life for a battery. Companies such as Daimler and Renault are already running, or have announced plans to use, used batteries in battery storage centers. The auto industry put this 'extra' life at 10 years. In those already existing and planned centers, a few thousand batteries are being used to store energy from renewable energy sources, to stabilize the grid, to power multiple households, or to fast-charge vehicles on highways, supporting a more decentralized energy distribution and storage system. It is only in **stage three** that batteries will be torn-down in order to recycle their constituent valuable metals and other commodities. This will create new business opportunities (see our LTI: Waste Management and recycling, published 30 May 2018). We don't, however, see this happening until 2030 and beyond when more and more of the first generation of batteries reach stage three.

Source: UBS

Autonomous driving (ADAS)

Autonomous driving is tiered from levels 0 (zero automation) to 5 (full automation). We believe that over the next 10 years, most new cars will reach level 2 to 3, with level 3 ("hands-off") in particular (conditional automation) offering profitable opportunities for companies. To quote Daimler's head of R&D, "horsepower is being replaced by the speed of semiconductor chips." Semiconductors and sensors are key for autonomous driving. As an aside, they collect a vast amount of potentially lucrative data over time. (see Fig. 9)

The trend toward electrification plays nicely into the trend toward autonomous driving and connectivity. ADAS or "advanced driver assistance systems," is tiered from levels 0 (no automation) to 5 (full automation, i.e. no steering wheel needed). Currently, most cars are at levels 0 and 1, some are at level 2, with a few at level 3 (but not all functions are fully activated). In our view, the ability to automate driving will occur slowly over the next 10 years, with most vehicles reaching at least level 2 to 3, but we believe current estimates (see Fig. 9) could be too conservative. Increasingly applying connectivity and vehicle-to-vehicle and vehicle-to-infrastructure communication will change the way we use automobiles.

To increase road safety and reduce fatal accidents, we believe many ADAS features will become mandatory and think that the adoption of ADAS will exceed that of the overall growth of the car market by far. We experienced autonomous technology in a real-driving environment in 2017. Since then technology has advanced considerably. It is our strongest belief that by 2020, around 50% of all new cars could be equipped with some kind of basic autonomous equipment (Fig. 9).

Right now, level 3 autonomous developments (conditional automation) appear the most promising. Our discussions with auto manufacturers confirmed high-end consumers' willingness to pay for such comfort and safety features. We think Level 3 ADAS penetration, i.e. a "highway pilot," will become reality from 2020 onwards, but it will require the further development of expensive and sophisticated sensors, such as front Lidar (light detection and ranging, a laser-based radar system), and far-range front-view cameras – overall, around 25-30 sensors are needed per car.

Manufactures appear willing to collaborate and meet the technological, cost challenges and strong competitive positions thrown up by some of the non-automotive technology companies.

Level 4 ADAS would allow some robotaxi services in so-called geo-fenced areas from 2021–2025 based on the ongoing discussions with auto manufacturers and suppliers. Those companies also highlight that this "urban pilot" would require that vehicles carry some 40 sensors. Current costs remain prohibitive for a large scale rollout to non-fleet buyers. However, costs for autonomous technology will fall. But even in 2030, UBS projects up to USD 15,000 of additional costs for level 4/5 vehicles, which limits this technology to robotaxi services and high-end premium vehicles, in our view.

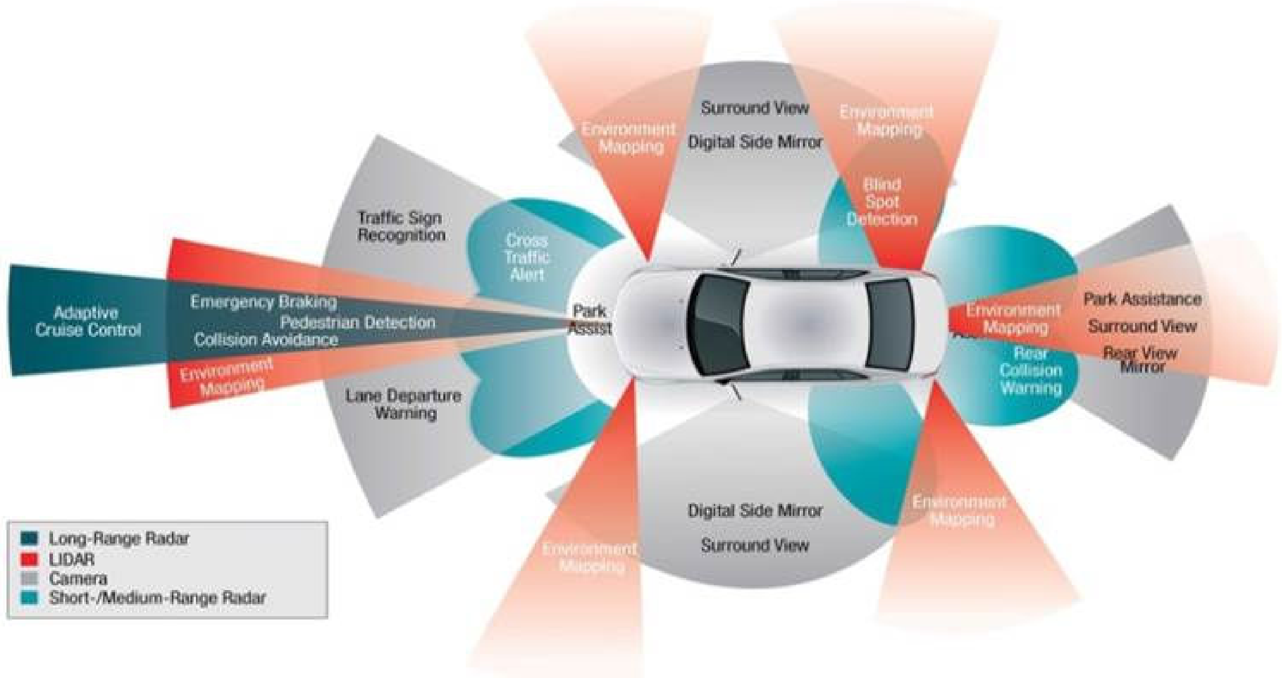
We see ADAS as a **USD 35-40 billion (EUR 30-35 billion)** annual revenue market by 2020, **more than doubling to USD 90 billion (EUR 75 billion) by 2025**, and quadruple that of 2017/2018 levels.

Clearly this market is attractive and technology players are heavily engaged in the ADAS space. At the end of October 2018, CNBC reported that the California Department of Motor Vehicles (DMV) has granted the state's first permission to test level 5 autonomous vehicles on public streets under all-weather conditions and without a safety driver. In November 2018, San José, California will become the pilot city for a level 4/5 automated on-demand ride-hailing service in 2H 2019. And in December 2018, an autonomous taxi service was launched in Phoenix, Arizona. We think this launch will serve as an important test case for eventual wide-spread commercial roll-out of driverless ride-hailing services.

Together, we think electrification and autonomous driving will translate into a multi-billion dollar business beyond the classic auto supplier industry. Related industries such as electronics, software (algorithms), artificial intelligence (AI) hardware, and semiconductors should increasingly gain in importance. The same is true for sensors (see Fig. 15), which will play a major role in an autonomous and connected world. The broad-based application of laser, radar, LIDAR (light detection and ranging, a laser-based radar system), ultrasonic, and cameras should also increase and, together with connectivity and mapping, serve as the backbone for the development of autonomous driving (see next section).

Linking things is complex and machine learning (artificial intelligence) will be a game-changer in a future where sensors and AI work hand-in-hand to ensure a smoother and safer ride. This ability will help make car features, such as learning speedbumps and adjusting the shock absorbers or automatically increasing the car’s height the next time it approaches a hump, standard in a few years. Smooth deceleration to avoid braking before roundabouts, recuperation to fully charge the battery before the next hill, advance gear-shifting to optimize torque management and many more features will ensure a smooth and autonomous ride.

Fig. 15: Sensors will be key
The number of sensors i.e. cameras, laser, radar, LIDAR, ultrasonic will increase substantially



Source: Texas Instruments Inc.

Connectivity
The auto industry is working on linking cars with smart devices to cater to the needs of the digital generation and beyond. When it comes to connectivity, linking the music database of a smartphone to the car was only the beginning. Integrating smartphones and watches for last-mile navigation in order to provide multi-modal mobility services, be it by foot, bicycle, or public transportation, is already developed. The vehicles' interior and connectivity capabilities will come into focus, with the latest voice control technology and intuitive handling coming to the fore. Cars will serve as vessels for connectivity and entertainment in the not-too-distant future. Furthermore, software updates via the internet (OTA = over the air) rather than by visiting the car dealer will be a common feature of new cars in the next five years, according to all the discussions we have with automotive companies. We believe connectivity in new vehicles will reach a penetration rate of 100% by 2022 at the latest, corresponding to nearly 50% of the cars in use by then.

Mapping
Data is continuously collected and processed to add more safety and comfort features to modern cars. This enables vehicle-to-vehicle communication systems that warn other vehicles of accidents or slippery roads, as well as smart routing and live-traffic information. In addition, it enables intelligent traffic control, i.e. vehicle-to-infrastructure communication, by interlinking cars with traffic lights and speed restrictions. We experienced this technology in person in September

2017. An artificially-created incident (car breakdown with hazard lights activated) was registered by the sensors, processed, sent to the cloud, and distributed from the cloud to all connected cars in the area within two seconds. Warning of potential hazards is a big improvement in increasing road safety and more innovations are coming.

Looking at the combination of connectivity and mapping, we are arriving at an important inflection point. The role-out of 5G technology globally in 2019, with countries such as China, the US, Japan Korea and Australia powering ahead, will be a driving factor for ADAS. Connected vehicles will use 5G standards for vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and vehicle-to-pedestrian (V2P) communications that will support the safety requirements of autonomous driving (see our LTI: Enabling technologies, published 21. May 2018).

Data ownership as the basis for future commercial success
But connectivity goes well beyond that. Based on a current global average car speeds of 40km per hour and 16 trillion km (10 trillion miles) of car travel per year, owners spend an estimated 400 billion hours in unconnected cars, and passengers an additional 200 billion hours, according to a study by Morgan Stanley. Based on a range of economic values per hour, time spent inside a private vehicle could translate into an opportunity cost of several trillion US dollars.

Using more apps on the car's display will generate more data that could be of value to better understanding and "owning" the car consumer. The auto industry is battling the IT giants which are grabbing this opportunity, with its own alternative systems (as also highlighted before with level 5 autonomous driving testing). Owning the mapping and navigation data and, in general, all the data created in the car, which will be collected over time through the sensors built into the car, will become valuable. Hence, both the auto and IT-related industries will try to own and commercialize the large amounts of valuable big digital data created in the connectivity process for their mobility services and beyond.

Embracing connectivity with the possibility of autonomous cars as "the fourth screen" is driving a fast-rising trend in online/internet functions in cars, which could be commercialized by providing media content and advertising. UBS sees a USD 400bn in-car time monetization opportunity by 2030, although we are not incorporating any value at this stage as many commercialization strategies appear vague. We still believe the proportion of such business to overall sales will be limited this decade but could offer additional revenue streams at a later stage.

Security issues
Bringing connectivity and autonomous driving together, security and liability concerns become a big issue. These will also affect the auto insurance industry, among others. At 180kph (around 110mph) on a German autobahn, a car travels 50 meters (164 feet) per second. At this speed or slower, cyber-crime could become a serious threat. Any interruption or manipulation of the car's hardware or software could have fatal consequences. The increasing trend to over-the-air (OTA) software updates is adding to those risks. Hence, (cyber) security and safety will play a crucial role as an indirect way to invest in the autonomous driving trend. Please see our Longer Term Investments series *Security and Safety*, dated 16 January 2019.

Car-sharing concepts

The combination of electrification, autonomous driving, and connectivity will play a major role in increasing shared mobility as a service model (MaaS), with autonomous driving being the ultimate trigger. It is debatable if sharing catalyzes the migration to EV/NEV, or if EV/NEV catalyzes the migration to car sharing, but increased utilization of car-sharing concepts (car sharing and car hailing) and ultimately robotaxis should lead to lower costs to the consumer and generate a viable business model for providers. (see Fig. 5, and Box 2)

Where we stand

Globally, there are around 1.1 billion cars, and each year around 10 trillion miles (16 trillion km) are driven – a substantial source of revenue for many businesses. The underlying long-term growth in car demand is around 3% a year. However, back in November 2018, we reduced the growth rate until 2025 to 2% as urban areas are becoming larger and more congested, supporting car-sharing concepts. Given the low estimated 4% average utilization per car (i.e. around 1% per seat), **car sharing** could in theory replace up to 25 private cars, and **car hailing** an estimated 5–10 cars (see Box 2). This makes privately-owned cars an inefficient asset.

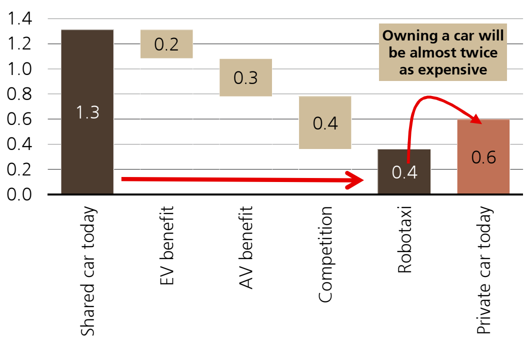
However, car hailing or car sharing will not completely replace private car ownership, not least as car-sharing concepts might also face potential bottlenecks during rush hours. This might be partly solved by sharing a trip in the same car at reduced costs, or with the help of algorithms that determine where to best place the vehicle to optimize its use and keep it from running idle, i.e. avoiding "empty trips." Car-sharing concepts will also not end the sale of new cars. Rising car usage will increase the wear-and-tear of shared vehicles. Consumers might want to share in order to reduce costs, but they are probably less willing to compromise, i.e. they do not want to sit in an unkempt, run-down vehicle. Hence, the churn for shared vehicles could be 3–4 times higher than private purchaser demand, i.e. they could be replaced roughly every three years, according to various company meetings we attended.

Price reduction will be key

Car-sharing concepts can greatly reduce the price of new technologies on a cost-per-mile basis and hence spur further adoption. It is debatable if car sharing catalyzes the migration to electric vehicles or if electric vehicles catalyze the migration to car sharing. However, what is indisputable is the rise in car sharing, if adopted on a mass scale, could offer better economics to users. Higher capacity utilization from car sharing will spread the initial price/investment of the car over more miles. Lower variable costs to run the vehicle (cheaper electricity vs. fuel, lower maintenance costs), autonomous driving – i.e. replacing the driver in the long run – is key to bringing the cost-per-mile down from today's levels. The arrival of robotaxis in particular should reduce costs by around 70%, substantially below private car ownership costs (see Fig. 16). Depending on the number of people sharing a trip in the same car, robotaxis could become even more cost-competitive than public transportation (see Fig. 17). In our view, robotaxis could result in a peak in traditional car sales around 2026-2028, reducing the annual growth of traditional car sales (see Fig. 5). However, if robotaxis become a real threat to public transport, with too many robotaxis congesting cities and streets, they might also be subject to regulation, which might limit individual mobility over time.

Fig. 16: Robotaxis will be cost competitive

Electrification, autonomous driving, and increasing competition will bring costs down (in EUR/km)



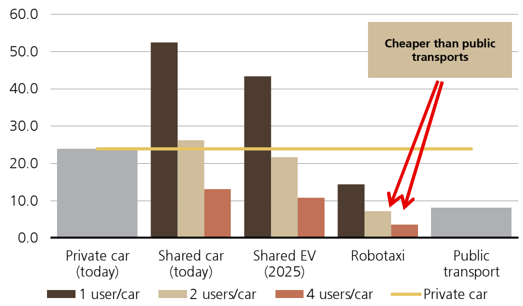
Source: UBS, as of 28 September 2017
Note: EV = Electric vehicle; AV = Autonomous vehicle

Operators are benefiting as well

The application of the aforementioned technologies will make cars more expensive initially. However, technology costs will ultimately fall e.g. Lidar costs should drop substantially once they are produced on a larger scale (see Appendix 2). Competition is another reason why we expect car-sharing and car-hailing prices to drop. The ride-hailing industry has a strong interest in replacing the driver with a driverless robotaxi. The above argument about price reduction is valid as well, as it may shorten the payback period for car-sharing concepts to less than three years, according to our discussions with those automotive companies being involved in mobility services. This will be key to making mobility-as-a-service (MaaS) a viable business model. From recent meetings, we understood that even in today's non-autonomous world, in a city with 500,000 people, a shared fleet of 500 vehicles could be operated at a profit.

Fig. 17: Robotaxi beats public transport

Daily commute costs in Europe if several passengers share the overall fee (20km driven per leg; 40km driven per day), in EUR



Source: UBS, as of 28 September 2017

Note: 1) EV = Electric vehicle; 2) The cost for private combustion engine stays the same, as the private car owner is unlikely to split the cost by the number of passengers in the car.

Market development

We are just at the beginning of the car-hailing/car-sharing trend. Given our belief in the trend toward consuming rather than owning a car, we believe that by 2025 around 10–12 million cars, i.e. 8–10% of overall car sales, will be used for car-sharing/car-hailing purposes, which may include some 1–2 million robotaxis. By then, we think several concepts will have succeeded and be running in parallel in a smart-mobility world, serving the individual preferences of consumers through combinations of car sharing and car hailing even from the same provider, as well as personalized car sharing, where the car automatically adjusts to the driver's known preferences. Furthermore, private consumers might also get more involved in peer-to-peer car sharing, i.e. renting out their privately owned car during the day, or while they are on holiday. We think the main breakthrough will happen toward 2030. By then, robotaxis should be gaining traction due to technological progress and their strong cost advantage, and 30% of new car sales could be linked to sharing concepts. Especially for urban driving (i.e. geo-fenced areas) and consumers with short-to-medium distance driving needs, robotaxis would make sense. However, the concepts of autonomous driving, robotaxis, and car sharing will likely diverge greatly not only by region but also between urban and rural areas (e.g. New York City versus the US Midwest). Furthermore, as we are still in the early stages of the trend, a lot of the regulatory, liability, and even tax consequences have yet to be addressed.

Who will be the winners?

According to various industry sources, in excess of USD 30 billion has been invested into ride-hailing startups, an asset-light and low-entry-barrier business. In our view, future profitability and returns are not guaranteed, as even the large players continue to post large losses.

So far in ride-hailing businesses, drivers have not only devoted their time but also contributed their own cars. Looking further ahead, in an autonomous driving world, we believe tech companies are unlikely to aim to be asset-heavy, i.e. they may be less willing to take potentially hundreds of thousands of ride-hailing cars on their balance sheets, and finance, manage, and maintain them. Hence, in an autonomous-driving/robotaxi world, we believe managing the fleet (including the financing, i.e. providing the balance sheet as well as the maintenance and after-sales of the fleet) will be a large business. We see a kind of revenue-sharing model between ride-hailing companies and fleet managers as likely. There is room for new entrants such as financial services and car rental companies, but there is also a fair chance of the existing auto industry grabbing a large chunk of this fleet business, in our view. Given the large revenue pool in the next decade, the major automotive companies want to benefit from it. In 2017, Goldman Sachs estimated the global ride-hailing market at USD 36 billion, which it forecast to grow eightfold to **USD 285 billion** by 2030, split between ride hailers (**USD 65 billion**) and fleet managers (**USD 220 billion**). Given the growth rates we've seen in this market, we believe current gross revenues should already be in the **USD 50-70 billion** region.

Currently, gross revenues are split roughly 20–30% for the ride hailers and 70–80% for the drivers as the latter provide the car and manpower. Hence, of the current USD 50-70 billion, only around **USD 10-15 billion** can be assigned to car hailers. Looking at the current growth rates of this car-sharing concept, **by 2025** we believe this amount could be **USD 85–105 billion.** The real breakthrough starts with robotaxis. We believe they will increase usage due to their cost advantage, but only in a robotaxi world will 100% of the revenues end up in the hands of car-sharing concepts and fleet managers. We see this happening in 2025 and beyond, and believe this could translate to a more than USD 1 trillion in 2030 – a value we do not incorporate at this stage.

Please see our Appendix 1 for more information and frequently asked questions (FAQ) related to car-sharing concepts.

Link to sustainable investing

We think our theme fits nicely into the SI thematic framework as it addresses various aspects of sustainable transport. This includes improving safety, reducing deaths through autonomous driving, reducing local pollution through electrification and more fluid traffic flow, providing opportunities for social inclusion through autonomous driving, and reducing resource use and pressure on road infrastructure through shared mobility.

The sourcing of minerals from conflict areas is an issue that is more specific to batteries, semiconductors and electronic equipment. Chemical safety and the phase-out of chemicals of concern are a key issue in the electronic equipment industries. Product safety is also relevant for electronic equipment, but even more so for the auto (component) industry, which has continuous issues with product recalls that can have massive financial consequences and cause reputational damage. On the corporate governance side, several companies have issues with anticompetitive behavior; a few others have been involved in high-profile cases around bribery and tax evasion. These are company-specific issues that need special scrutiny when selecting stocks for portfolios with sustainable investing focus.

Link to impact investing and UN SDGs

Impact investing in smart mobility can contribute to various UN Sustainable Development Goals, including good health and well-being, sustainable cities and communities, and climate action.

- One of the targets listed under the good health and well-being goal is to halve the number of global deaths and injuries from road traffic accidents. Smart mobility solutions can contribute towards this goal. An example would be software solutions that analyze traffic data with the ultimate goal of reducing death and injury from accidents. This includes real-time traffic systems in order to warn surrounding traffic participants of any hazards, or even early warning systems highlighting specific high-risk locations such as intersections. Demand for these solutions is growing and technological advances facilitate supply.

- Car-hailing and car-sharing models. Cars are one of the top contributors to greenhouse gas emissions. Optimizing vehicle usage would lower overall emissions levels. Increased car sharing will not only reduce vehicle ownership rates, but could also have a positive impact on emissions, not least as the search for parking will become redundant.

- Electrification in general, though not directly a smart mobility investment, also contributes to emissions reduction. Government regulations aimed at reducing emissions are fueling the demand for electric and hybrid vehicles, and the regulatory environment remains highly favorable. Driven by a strong drop in battery prices, we firmly believe electric cars should end up with the majority share of new car sales by 2040 or even sooner.

The greatest impact is likely to be achieved by focusing investment on geographies with particularly high population growth combined with rapid urbanization. These regions experience heightened environmental pollution, threatening the population's health as well as the environment. Their health and safety are also threatened because swamped traffic systems tend to be accident-prone. As regulatory changes and technological advances make smart mobility concepts more necessary and viable, investment in smart mobility should serve as an impactful and financially appealing opportunity in regard to these issues.

Investors may access this theme through specialized private equity impact funds or via generalist direct and fund investments. While investment in smart mobility can contribute to each of these areas, not all smart mobility investments qualify as impact investments. As always, when investing using non-impact-specific vehicles, impact investors must assess on their own whether individual investments meet their impact criteria, including intent, measurability and verification.

James Gifford, Head of Impact Investing
Andrew Lee, Head of Sustainable and Impact Investing, Americas
Andrew Little, Sustainable and Impact Investing Associate

Box 6: From driving experience to passenger and consumer experience

Rather than differentiating via the sound of the engine, in the future, car companies will seek to find unique selling points based on autonomous features, which are the most challenging technological changes this industry has ever faced. The vehicles' interior will come into focus, with the latest voice and gesture control technology and intuitive handling coming to the forefront. Cars will serve as vessels for connectivity and entertainment in the not-too-distant future. Pure connectivity will be the basis in every newly sold car by 2022 at the latest, in our view, but commercializing this technology will likely be challenging at the start for auto companies. One solution includes selling the data they collect over time through the sensors built into the car. Nonetheless, their plans are vague at best at this stage.

While classic car ownership will still prevail, looking further ahead, it will be about the experience rather than ownership. And with Daimler's and BMW's merging their car-sharing operations and their other mobility services together, we believe they are getting ready for this shift. Conventional mobility for on-demand taxis will be replaced by robotaxis the further we move toward 2030.

As part of the experience, the way the industry sells cars will change (see also Appendix 2): many consumers are configuring their cars online, and the value-added of dealers is becoming increasingly limited. VW announced to start online car sales in 2020, using dealers only to actually deliver the car and also replicating the Tesla concept of having stores in city-center locations. On that note, Tesla at the end of February 2019 announced that they will end the store concept and plan to go pretty much fully via online sales.

On the experience side, using virtual reality (VR) equipment at dealers (or in the future also at home) has helped to up-sell – car buyers are more willing to spend more for certain specifications (e.g. nicer alloy wheels, more expensive colors, leathered dashboards) if they are able to see them at least first through VR. Furthermore, keeping customers digitally informed where the production of their new vehicle stands offers the ability for highly lucrative "last-minute" up-selling.

Source: UBS

Investment conclusion

Smart mobility is set for take-off. We define smart mobility as a combination of smart powertrains (electrification), smart technology (autonomous driving), and smart use (car-sharing concepts). Over the next decade, we believe we'll see a significant growth in smart mobility. It will not only revolutionize the automobile industry but also the way vehicles are "used." Costly technology will be deployed and disruptive forces will drive traditional car companies and auto suppliers to either participate and adapt to those changes, or risk being replaced (at least partly) by new entrants from the tech industry. More favorable regulation, which supports alternative powertrains, and new smart use and mobility concepts, including the introduction of robotaxis, should help. Rapid technological progress and a change in consumer behavior (in which the use of the asset is more important than ownership of the asset), and the trend from driver experience to passenger and consumer experience (see Box 6) will drive our smart mobility theme.

We believe smart mobility offers substantial business opportunities. By 2025, we estimate the annual addressable market of our theme will be around **USD 400 billion**, compared to an estimated USD 40-50 billion today. We estimate the value of the global car market stands at USD 1.5 trillion per year currently.

Our theme focuses on the whole smart mobility value chain, with a strong emphasis on electronics and electric components related to electrification and autonomous driving, which will ultimately also power car-sharing concepts (see Fig. 10). Car-sharing/car-hailing exposure can, in general, only be invested via the private market at this stage, although media reports (e.g. WSJ) indicate that several of these private firms may be preparing to go public.

While car sharing / car hailing and fleet management could become a large and lucrative business, we still believe it remains too small to have a meaningful impact on quoted companies in the foreseeable future, especially in a non-robotaxi world. This may change over time.

We think the combination of increasingly favorable regulation, falling costs, and technological advances makes smart mobility attractive for investors with a long-term focus, as the theme is cyclical in nature. Given that we are at the beginning of this structural shift toward smart mobility, we think it has yet to be fully recognized by the market. With many auto-related stocks suffering hefty share price declines in 2018, we believe our theme can outperform the wider market in the long-run. We firmly believe that smart mobility will continue to change the way we look at automotive-related stocks. Consequently, we recommend a review of single automotive-related stock holdings and focus on smart mobility through a broadly diversified stock selection along the whole value chain to minimize company- and technology-specific risks.

Risks

Regulation
For autonomous driving, broader scale regulation is lacking, which may limit its broad-based rollout. Data privacy from sharing GPS and mobile-phone data with a number of apps facilitating shared mobility could raise consumers' or regulators' concerns. Regulatory restrictions or changes of licenses may affect car-sharing platforms, and crowded cities may try to limit individual traffic, including car-sharing concepts.

Technology (batteries, hybrids, autonomous features)
If major developments on the battery side (costs, energy density, shorter charging times) are not delivered, it would hamper the rollout of electrified vehicles, as consumers generally still have "range anxiety" or the fear of being stranded due to an insufficiently charged battery. In premium vehicles, autonomous driving at least to level 3 (conditional automation; "hands-off") already works quite well, but any major setback or reports of serious autonomous-driving-inflicted accidents may cause a loss of trust and could affect the rollout of the technology. Level 4 (high automation; "eyes off") and level 5 (full automation; "driver off," "steering-wheel off") will still take some time – any delay will also negatively affect car-hailing companies, who are counting largely on autonomous cars/robotaxis to make a viable business model.

Consumers' acceptance and willingness to pay for electrification
Consumers have not been willing to fully pay for the additional costs that electrification technology entails. While some state subsidies might be granted, the incentives are likely to expire over time (e.g. the US's up to USD 7,500 or Germany's EUR 4,000 subsidies), hindering a faster rollout of electric vehicles.

Raw materials
Raw material prices related to EVs are highly volatile and have significantly increased over the last few years. The auto industry and battery manufactures will look for alternative technologies and materials, not least also due to supply concerns as they come from sensitive regions (e.g. the Congo). Hence, the lack of supply and its consequence of battery prices not coming down as projected could hamper the speed of the battery electric car rollout, and hence the smart mobility theme overall.

Electricity generation, distribution, charging
Burning fossil energy (e.g. coal) to generate electricity to propel EVs is suboptimal and poses a risk for EV penetration. A wide-reaching rollout of charging infrastructure is needed for highways and cities to ensure consumer acceptance. In urban areas, the lack of fixed parking still needs to be addressed to ensure individual charging can take place.

Shared mobility/platform challenges
The growth of car-sharing concepts could be overestimated, and the breakeven point for earning money is, in some cases, years away. This could lead to large share price/valuation corrections. So far, platforms are forced to constantly reinvest in pricing strategies and drivers to maintain their network and market share. Replacing the driver with a driverless robotaxi will be key to ensuring a long-term viable business. As they are "platform only," i.e. not owning the fleet, captive auto finance and service subsidiaries might grab a large chunk of the business. Providing a platform might be a good start, but other platforms might arise, consolidating all others.

Appendix 1

Car-sharing concepts – Frequently asked questions (FAQ)

What's the big picture?
The rise of car-hailing and car-sharing services due to the consumer preferences of millennials, technological advances, and newly created platforms poses additional challenges to the auto industry but also offers great opportunities for others. Car sharing and car hailing are two sides of the same coin in that they raise utilization of private vehicles – the former by sharing with other drivers/owners, the latter by offering a chauffeured service (see Box 2), with the introduction of robotaxis being the ultimate solution the closer we move to 2030.

Will car-sharing concepts bring the new-car market to an end?
No. While car-sharing/car-haling could lead to a substantial reduction in the global car park in the long run, it need not necessarily impact annual global car sales to dramatically due to rising car usage and the resulting increased wear-and-tear of shared vehicles. Consumers might want to share in order to reduce costs, but they are probably less willing to compromise, i.e. they do not want to sit in an unkempt and run-down vehicle. After an initial rebalancing of new car demand, the absolute level of new car sales should come back as replacement cycles will be shorter. We estimate the churn will be 3–4 times higher than private purchaser demand, as vehicles will be replaced roughly every three years, as we learned from various company meetings we attended. However, in our view, robotaxis could result in a peak in traditional car sales around 2026-2028, reducing the annual growth of traditional car sales thereafter.

Will car-sharing concepts end private car ownership?
No. In our view, car hailing and car sharing will not completely replace private car ownership. They will complement it, e.g. for going out in the evening, the same way they will complement public transportation, which will remain an important backbone for peoples' mobility needs. In our previous discussion with Uber, we noted that in London, for example, around one-third of all Uber trips start or end at a tube (subway) station, confirming the complementary character of the various forms of transportation. Furthermore, car-sharing concepts might also face potential bottlenecks during rush hours, which probably not even robotaxis would be able to solve.

Is there one single car-sharing solution?
No. We believe in the future we will see a combination of car sharing and car hailing, and even a combination of both concepts by the same provider, depending on consumer preferences and, among other things, the parking situation at the point of destination. We will also see personalized car sharing, where upon opening the car via a smartphone app, it automatically adjusts the seats and air conditioning, and plays the driver's favorite radio station. Private consumers may also get more involved in peer-to-peer car sharing, i.e. renting out their privately owned car during the day or while they are on holiday. Car owners would benefit from generating an additional income stream and/or avoid parking costs, while the renter benefits from attractive rental rates.

While peer-to-peer might compete at the same time with professional car-hailing companies, it also enables professional players to "lure" those cars on their platform, earning some additional returns from bringing both sides together. In our view, several concepts can be successful and run in parallel in a smart mobility world, to serve the individual preferences of consumers. However, we are still in the early stages of the trend and a lot of regulatory, liability, and even tax consequences have yet to be addressed, including the broad-based application of robotaxis in the long run.

Why should car sharing lead to substantially lower costs?
It's about spreading fixed costs. Electric and autonomous vehicle technology costs are expensive, and their high upfront battery-related costs are fixed, while variable costs are much lower (cheaper electricity vs. gas, 60–70% less maintenance costs). Utilization is key; higher utilization via car sharing and car hailing will spread out the initial price/investment of the car over more miles. Adding the replacement of the driver in the long run will reduce the payback period for car-sharing concepts to less than three years. This will make mobility-as-a-service (MaaS) a viable business model, and the consumer benefits as well.

Is the traditional auto industry involved?
Yes. Auto manufacturers are also trying to grab the opportunity and several companies are actively engaged in this field, deploying different approaches to participate in car sharing and mobility-as-a-service (MaaS). Over the last 12 months, we have clearly see an increasing trend across the auto industry and beyond to collaborate and look for partnerships, not at least to share costs and risk.

So it is already a big business?
No. None of their ventures are commercially relevant or profitable at this stage. For all of them, it is still too far in the future to make it a large enough business to influence the top or bottom line. Being active in the rise of car-sharing services is a good indication of who "owns" the consumer and thus should be able to generate additional revenue streams in the future. The existing players might be better positioned than many believe. Their existing large fleet of sold cars on the road, their increasing willingness to cooperate, and with the help of their own mapping service (HERE), they might be able to commercialize their know-how and data. They might surprise to the upside, putting additional (pricing) pressure on Uber and the like and rearranging the landscape in the long run.

Does the market still assign a value to car sharing companies?
Yes. Business models and underlying technologies in these areas continue to evolve rapidly, and many companies that provide pure-play exposure have chosen not to list yet, instead taking funding from venture capital firms or corporations.

Appendix 2

Smart Mobility: impact on automotive suppliers, car dealers, repair shops and other industries and sectors

Cyclical market changes

We believe global auto sales are nearing a cyclical peak and that growth rates will fall. In 2019, we expect <1% global volume growth. Europe may recover from the disruption caused by the introduction of the Worldwide Harmonized Light Vehicle Test Procedure (WLTP), which came into force in 2018, but we believe auto sales will remain stable at best, which is also our base-case for the US. By contrast, Brazil and Russia may see growth of around 5%. A persistently weak Chinese auto market, driven by the hope of more centralized government subsidies, has led to high car inventories and production cuts, which will take time to reverse. What happens in China will dictate global volume growth in 2019. In addition, tariff uncertainty adds to near-term concerns. Ultimately, we believe US-Sino tariff tensions will be resolved. However, the situation in Europe remains unpredictable, with the US threatening to slap 25% tariffs on European cars and parts. We believe this uncertainty could drag on for some time to come. Further out, with overall visibility remaining opaque, we forecast around 1% global volume growth in 2020.

Structural market changes

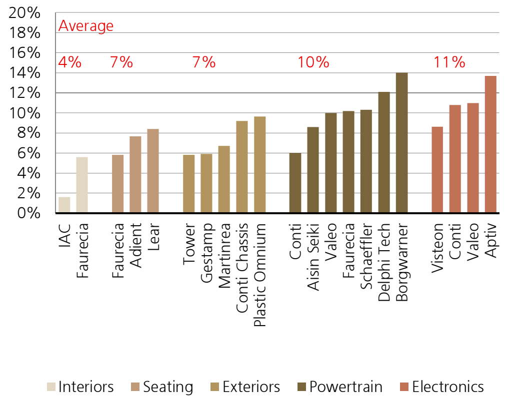
We revised down our mid-term growth rate for car demand to 2% in November 2018 (below its 20-year historical average of 3%) because we think the long-term dynamics of the sector are changing. As highlighted in the main body of this note, from 2026 onwards we believe we'll see the early rollout of robotaxis. By 2026-28 we think we'll see peak traditional car sales. That said, we forecast around 90 million ex-robotaxi cars will still be sold in 2030 (see Fig. 5). Our long term view is that we are in the midst of a structural change in vehicle demand toward electrified, autonomous and shared mobility, which will severely impact the whole automotive value chain in a smart mobility world.

Impact on suppliers

Volume, price and profitability challenges
Despite electrified vehicles comprising just 1-2% of the global auto market, heavily internal combustion engine (ICE) exposed suppliers in the highly profitable powertrain business (EBIT margins >10%, see Fig. 18), should not feel too complacent because of the emerging trend in favor of the EV powertrain.

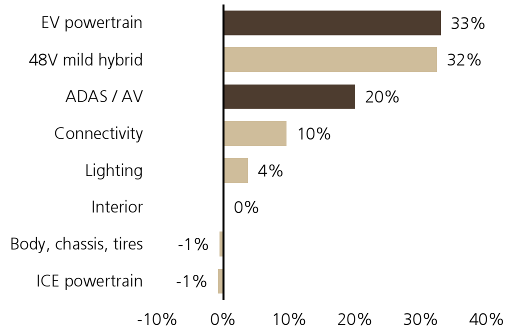
In general, the move towards electrification will cannibalize the traditional internal combustion engine. Initially, as long as ICE are accompanied by a plug-in hybrid or a 12V or 48V mild-hybrid system (together hybrids), traditional powertrain suppliers will remain beneficiaries, as they will continue to benefit from both worlds. However, a faster rollout of electrification via battery electric at the expense of hybrids will hurt the traditional powertrain suppliers most due to the lack of the ICE business (see Fig. 6).

Fig. 18: Profitability of product segments:
Differences in EBIT-margins (2017 figures, in %)



Source: Company data, UBS estimates, January 2019

Fig. 19: 2018-25E revenue pool CAGR
Smart mobility technologies strongly up, while ICE technology starts to decline, CAGR in %



Source: UBS estimates, January 2019
Note: CAGR = compound annual growth rate = average annual growth rate

We believe we'll see little to no ICE powertrain demand growth in the period 2018-2025 (see Fig. 19), with annual ICE growth dropping sharply from 2021 onwards (see Fig. 20). Over the next decade, we'll move increasingly away from ICE toward a much smaller and more compact electric powertrain system (see Fig. 21) with substantially fewer moving parts (e.g. bearings), and less complexity (e.g. only 1 or 2 speed compared with 8, 9 or 10 speed automatic gear boxes currently). Spare-part sales will become less complex, and less lucrative, as the overall content and component split of an ICE and an electric vehicle will change dramatically (see Figs. 22, 23 and 24 with latest Tesla Model 3 teardown findings). By 2030, UBS expects the EV powertrain to make up some 25% of the global total auto supplier revenue pool.

Consequently, the value-added share of automakers and traditional auto suppliers is likely to fall due to the structural shift toward smart mobility. When volume growth slows or turns negative, this will dent pricing. Auto suppliers face annual price reductions as part of their ordinary business. However, the lack of growth will exacerbate this dynamic, and we believe the historically competitive, high-margin powertrain business will come under ever-increasing pressure.

The lack of lower volume growth, and the structural need for high(er) research and development (R&D) spending on future technologies (electrification and autonomous driving) will continue to present costly headwinds for the auto-supplier industry. Looking at publicly quoted European auto suppliers, over the last decade R&D spend rose continuously – in both absolute and percentage terms relative to sales. Furthermore, faster product cycles and the increasing need for innovative technologies leaves less payback time to amortize investments, i.e. burdening margins and return on invested capital. Suppliers today are forced to invest heavily in the technologies of tomorrow, but the ability to generate decent returns is not guaranteed. In our view the ongoing need for innovation is not going to go away and will continue to be a drag on margins for publicly-quoted and privately-held suppliers alike.

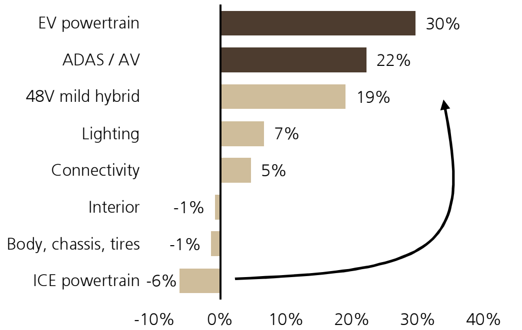
If this were not enough, for suppliers focused on diesel, the ongoing discussions in Europe (>20% of global car market), and specifically Germany, about driving bans are an additional headwind. So far this has resulted in a severe drop in the share of new diesel vehicles sold in Europe (see Fig. 11). We believe this downward trend will continue. As long as suppliers have the ability to support the current switch to gasoline engines, this will mitigate to a certain extent the impact of losing the more lucrative diesel content business.

Potential changes in the industry sourcing strategy

For the auto original equipment manufacturers (OEM), the ongoing (and high) costs associated with smart mobility, such as R&D and the extra electronic and sensor content means that OEMs will look to cut back on features that consumers are less willing to pay for, including such 'extras' as very high-end LED lightening, for example.

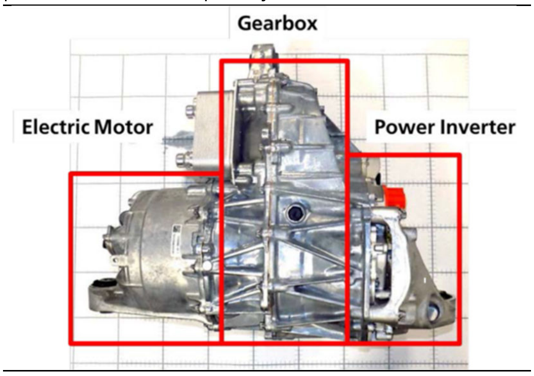
Furthermore, we believe OEMs will increasingly access technology directly by linking up with tech companies, including smaller Tier 2 and 3 suppliers, rather than relying on Tier 1 suppliers. This may offer opportunities for the more technologically well-positioned (privately held) Tier 2 and 3 suppliers.
In UBS's tear-down of a Tesla Model 3, one of the key findings was

Fig. 20: 2018-30E revenue pool CAGR
ICE technology under severe pressure, CAGR in %



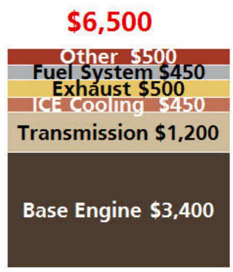
Source: UBS estimates, January 2019
Note: CAGR = compound annual growth rate = average annual growth rate

Fig. 21: Drive assembly of a Tesla Model 3
Small, compact and powerful - (c. 300 horsepower, c. 550 NM torque) – fewer moving parts and less complexity



Source: UBS

Fig. 22: Internal combustion engine (ICE)
Indicative cost composition



Source: UBS, as of 18 May 2017

that traditional Tier 1 supplier content amounted to USD 7,900, representing just 21% of the overall content. This compares to the suppliers' share of around 70% in a generic ICE car today (see Fig. 25). The difference is not driven by the battery in an EV, which is by far the largest cost item, but in the case of Tesla by a lot of in-house powertrain and electronics content, leaving a much smaller proportion to traditional auto suppliers. Not every OEM will follow this path, but we believe this serves as an indication of future trends. While a generic ICE car contains around USD 13,200 Tier 1 supplier content, in generic battery-electric vehicles, this amount could drop by USD 1,000 to US 12,200 – an 8% drop in content by value, according to our analysis (see Fig. 25).

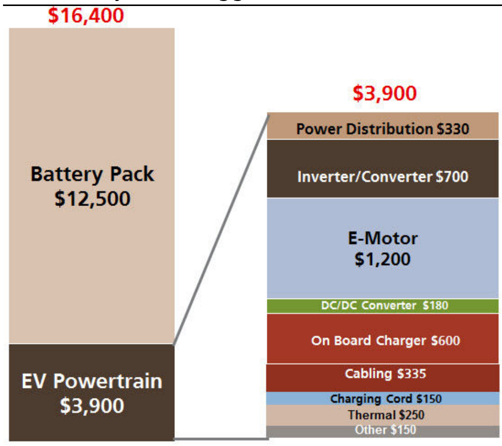
Furthermore, OEMs may consider the reintegration of formerly outsourced components, i.e. away from suppliers. The rationale is that in an full-electric world, the overall complexity of powertrain technology will fall dramatically. As an indication, the substantially lower complexity could result in 70% fewer employees needed for e-motors compared with traditional ICE powertrains, in our view. As a result, all auto manufactures face the significant challenge as to how to deploy their existing workforce – some contracts with unions dictate ongoing employment guarantees, for example. In our view, the increasing risk of insourcing components should not be ignored, especially for the larger suppliers, while smaller suppliers, with niche products and services, too small to make a difference in the case of a re-integration by the OEMs, are potentially less affected.

But there remain some brighter spots for the supplier world.

Growth opportunities exist in electronics and sensors
In order to facilitate the move toward autonomous driving (ADAS), we expect the share of value of electronic components, including sensors, in a car to increase substantially. And it will not only be electronic components and sensors – we believe all features related to connectivity will offer growing business opportunities in the years to come (see Figs. 19 and 20). In 2017, UBS expected the suppliers surrounding powertrain electronics to increase their content by up to 11x to around USD 600 per electric vehicle compared to a traditional combustion engine vehicle. The lack of ability of car-users to control the vehicle will require the highest level of consumer trust in the brand, and this means trust in the software and the computer power running the vehicle. To ensure 100% safety in all situations, in our view, OEMs will be willing to invest a lot in high-end semiconductors and software.

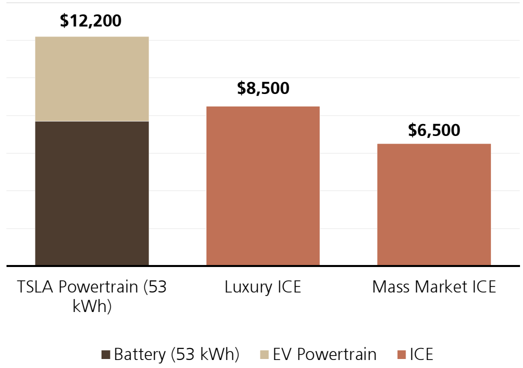
While sensors are in a sweet spot right now, we believe the increase in scale, and technological advances, will drive prices down, as seen by the more aggressive pricing behavior for camera systems. UBS assumes around a 10% annual drop for camera and radar, and >30% fall in Lidar costs. While expensive today, Lidar costs could fall from >EUR 10,000 to EUR 300 in 2025 and below EUR 100 by 2030 based on substantial scale benefits, according to UBS. Despite this projected fall, the available revenue pool should increase substantially (see Fig. 27) given strong volume growth – we estimate a fivefold increase in sensor volumes by 2025 and up to 14 times more sensors by 2030 compared to 2017. Thus, we see interesting business opportunities in sensors, as volume growth will compensate for falling prices.

Fig. 23: Electric engine powertrain
The battery is the biggest cost item (in USD)



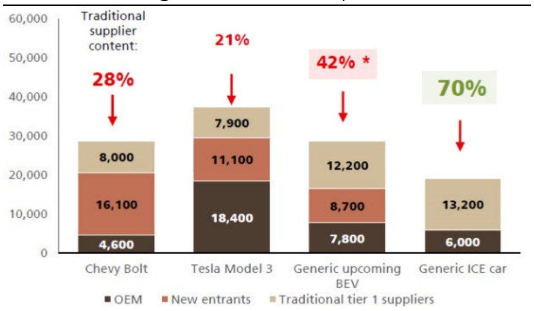
Source: UBS, as of 18 May 2017

Fig. 24: Electric versus ICE upfront costs
Updated comparison after the Tesla Model 3 teardown, in USD



Source: UBS, as of August 2018

Fig. 25: Tier-1 content share shrinks
Share could drop from 70% to 42% in a BEV vehicle, shaving off USD 1,000 per car



Source: UBS estimates, September 2018

We also see promise on the software side, too, where OEMs will try to establish themselves as a driving force. By 2030, UBS expects the overall ADAS, and necessary software and hardware to run autonomous vehicles, will represent around 8% of the total global auto supplier revenue pool.

The interior of a car will change too

As highlighted in Box 6, in future we'll see a shift away from the 'driver', to the driver being more of a 'passenger'. This will bring changes in consumer experience. So we'll see the use of higher quality plastics, leather, upholstery, displays, more comfort, entertainment and connectivity features. This is the smart mobility vehicle of the future. Spending on traditional vehicle interiors is stalling; however, we see different gadgets. Spending on features that improve our connectivity, gesture and voice control, and displays, will grow. We see these areas as interesting growth segments for suppliers (see Figs. 19, 20 and 28).

Mild hybrids also look interesting, at least over the next decade

Although the growth in sales to OEMs will stagnate, ICE engines will not disappear any time soon. That said, by 2025 we believe pure ICE vehicles will no longer be sold in Europe, rather we'll see 12 & 48 Volt mild hybrids being rolled out, adding to the revenue opportunities for technology-focused suppliers. In our view, the US will follow later; we forecast it will phase out pure ICE vehicles only by 2030. Hence, we expect at least a further 20–25% global share for mild hybrids based on 12 & 48 Volt technology by 2025. In general, all products helping OEMs to reduce emissions and meet challenging CO_2 emission targets at reasonable costs are helpful for suppliers and offer a decent revenue pool, at least until the end of the next decade (see Figs. 19, 20 and 28). Beyond that, full-electric will most likely lead to a severe drop in sales of ICE vehicles in many markets, and the overall revenue pool linked to ICE, including plug-in hybrids and 12 & 48V mild-hybrid, will likely shrink.

Aftermarket exposure will help mitigate the pressure

Currently, there are more than 1.1bn cars on the road and this stock of vehicles is not going to disappear overnight. The ongoing demand for spare-part sales will remain a major pillar of revenue and profitability for suppliers for many years to come. Spare-part sales are also more stable than auto production. So clearly a relative high share of aftermarket exposure mitigates the negative impact of smart mobility, which at least compensates for some of the volume and profit losses the traditional supply of ICE powertrain components to OEM will see.

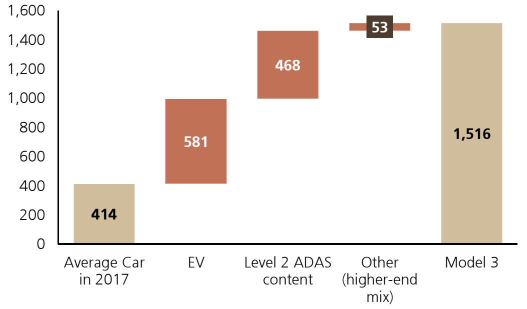
Impact on car dealers and repair shops

Fewer touch points, less maintenance and fewer aftersales

The transition to smart mobility will also have a substantial impact on car dealers and repair shops. Regular maintenance work and spare parts will still be needed and are the most lucrative areas. We believe those annual maintenance costs will fall by around 60%. Fewer moving parts, no oil changes, no spark plugs, no exhaust systems and no timing belts will all lead to much lower capacity requirements and profitability for today’s repair shops. Also the shift toward autonomous driving will ultimately result in far fewer traffic accidents, with a concomitant sharp drop in income for repair work and spare-part sales. At the same time the job of the traditional car mechanic will evolve more into an electric and electronic specialist. This will require a shift in skillset and training.

Fig. 26: Semiconductor content on the rise

Semiconductor content of a full-electric, level 2 autonomous car (Tesla Model 3) versus an average generic car, in USD

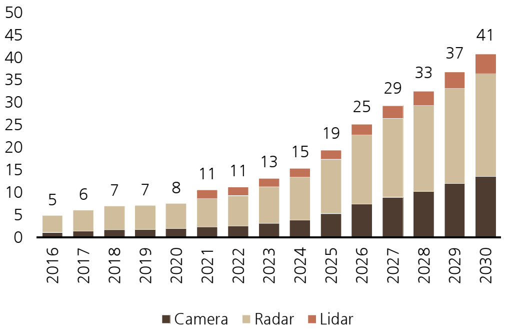


Source: UBS, as of September 2018

Note: EV = electric vehicle related; ADAS = advanced driver assistance system; Other includes e.g. comfort related content like entertainment/navigation etc.

Fig. 27: Sensor module revenue pool

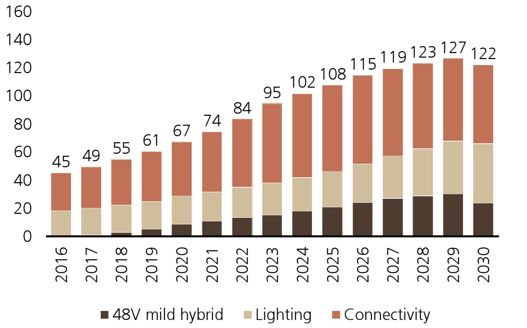
In EUR bn



Source: UBS estimates, January 2019

Fig. 28: 48V mild hybrid, automotive lighting and connectivity revenue pool

In EUR bn



Source: UBS estimates, January 2019

With fewer touch points with engine software updates coming via the internet rather than by visiting a dealer, and with consumers requiring less regular maintenance work, this will hurt car dealers' ability to grab additional aftersales opportunities such as replacing worn-out tires, and offering extra services such as selling roadside-assistance and insurance solutions.

The way cars will be sold is changing – be aware of residual value risks

As highlighted in Box 6, the trend is toward direct online auto sales. This will save costs, not only though better pricing and reduced / zero dealer margins, but also through a better understanding of the end client. Tesla was pioneer in selling cars through its city center stores. At the end of February 2019 Tesla announced that it will cut back its physical store presence and will adopt more or less an online retail concept.

Currently, auto manufacturers' understand little about the ultimate owners of their cars. This will change. Owning client data will open up a world of opportunity and one in which the commercialization of data will likely become profitable in its own right. We see OEMs moving in that direction, probably at the expense of car dealers.

The trade-in and sale of used vehicles will also face challenges. Depending on the regulatory environment (e.g. city driving bans), residual values of diesel powered cars may drop further (an issue isolated to the European market), and residual value guarantees related to lease vehicles may end up becoming very costly. Plug-in hybrid vehicles may gain in importance. However, in the case of any residual value commitments, dealers should bear in mind that in case the development of full-electric advances faster, the residual values of plug-in hybrids may come under pressure, but with a time delay.

Last but not least, with the automobile industries' focus on autonomous features and electrification of powertrains, the faster technology progresses, the faster residual values of existing products will fall. Taking today's smart phones as an example, the latest gadget today will be outdated tomorrow. Hence, this would not only impact the value of used cars with residual value guarantees, but clearly the ability and willingness of consumers to purchase new vehicles in case the trade-in value of their existing vehicle drops.

However, while car dealers and repair shops face challenges, this will not happen overnight.

Cars and even robotaxis still need to be serviced

In a smart mobility world cars still need to be serviced. This also applies to robotaxis. With 1.1bn cars on the road, the need for those services will not disappear overnight. Although repair work will fall due to fewer accidents in an autonomous driving world, neither will it disappear. However, the role and the importance of traditional car dealerships and repair shops will evolve over time.

Impact on other industries and sectors

The overall trend toward smart mobility will also impact other industries, namely the energy sector (see "Our energy future: How will electric vehicles affect global energy demand", published 24 September 2018). Also the real estate sector will be affected. With the convenience of robotaxis and autonomous driving, people may opt to move away from city centers. On the flip side, the long-term trend toward robotaxis and less individual car ownership will also impact the amount of car parking space needed in inner cities. This could lead to the conversion of parking garages into apartments, while parking lots may be used for brownfield developments – both could impact the dynamics of the real estate market. At the moment this remains some way off and is beyond the scope of this report.

Appendix

Terms and Abbreviations

Term / Abbreviation	Description / Definition	Term / Abbreviation	Description / Definition
1H, 2H, etc. or 1H11, 2H11, etc.	First half, second half, etc. or first half 2011, second half 2011, etc.	1Q, 2Q, etc. or 1Q11, 2Q11, etc.	First quarter, second quarter, etc. or first quarter 2011, second quarter 2011, etc.
2011E, 2012E, etc.	2011 estimate, 2012 estimate, etc.	A	actual i.e. 2010A
ADR	American depositary receipt	ARPU	Average Revenue Per User
AUM	Assets under management = total value of own and third-party assets managed	Avg.	average
BCOM	Bloomberg Commodity Index	bn	Billion
bp or bps	Basis point or basis points (100 bps = 1 percentage point)	BVPS	Book value per share = shareholders' equity divided by the number of shares
CAGR	Compound annual growth rate	Cant Inc/Capita	Cantonal income per capita (Switzerland only)
Capex	Capital expenditures	CF	Cash flow
CFO	1) Cash flow from operations, 2) Chief financial officer	COGS	Cost of goods sold
COM	Common shares	Cons.	Consensus
Core Tier 1 Ratio	Tier 1 capital minus tier 1 hybrid securities	Cost/Inc Ratio (%)	Costs as a percentage of income
CPI	Consumer price index	CR	Combined ratio = ratio of claims and expenses as a percentage of premiums (for insurance companies)
CY	Calendar year	DCF	Discounted cash flow
DDM	Dividend discount model	Dividend Yield (%)	Dividend per share divided by price per share
DPS	Dividend per share	E	expected i.e. 2011E
EBIT	Earnings before interest and taxes	EBIT Margin (%)	EBIT divided by revenues
EBITDA	Earnings before interest, taxes, depreciation and amortization	EBITDA Margin (%)	EBITDA divided by revenues
EBITDA/Net Interest	EBITDA divided by net interest expense	EBITDAR	Earnings before interest, taxes, depreciation, amortization and rental expense
EFVR	Estimated fair value range	EIA	Energy Information Administration
EmV	Embedded value = net asset value + present value of forecasted future profits (for life insurers)	EPS	Earnings per share
Equity Ratio (%)	Shareholders' equity divided by total assets	EV	Enterprise value = market value of equity, preferred equity, outstanding net debt and minorities
FCF	Free cash flow = cash a company generates above outlays required to maintain/expand its asset base	FCF Yield (%)	Free cash flow divided by market capitalization
FFO	Funds from operations	FY	Fiscal year / financial year
GDP	Gross domestic product	Gross Margin (%)	Gross profit divided by revenues
H	half year	h/h	Half-year over half-year; half on half
hist av.	Historical average	Interbank Ratio	Interbank deposits due from banks divided by interbank deposits due to banks
Interest Coverage	Ratio that expresses the number of times interest expenses are covered by earnings	Interest exp	Interest expense
ISIN	International securities identification number	K	One thousand
LLP/Net Int Inc (%)	Loan loss provisions divided by net interest income	LLR/Gross Loans (%)	Loan loss reserves divided by gross loans
LPR	Least Preferred: The stock is expected to both underperform the relevant benchmark and depreciate in absolute terms.	Market cap	Number of all shares of a company (at the end of the quarter) times closing price
m/m	Month-over-month; month on month	mn or m	Million
M and A	Merger and Acquisition	MP	Marketperform: The stocks expected performance is in line with the sector benchmark
MPR	Most Preferred: The stock is expected to both outperform the relevant benchmark and appreciate in absolute terms.	n.a.	Not available or not applicable
NAV	Net asset value	Net Debt	Short- and long-term interest-bearing debt minus cash and cash equivalents
Net DPS	Net dividends per share	NIM or Net Int Margin (%)	Net interest income divided by average interest-bearing assets

Appendix

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Net Margin (%)	Net income dividend by revenues	NV	Neutral View: The stock is expected to neither outperform nor underperform the relevant benchmark nor significantly appreciate or depreciate in absolute terms.
n.m. or NM	Not meaningful	NPL	Non-performing loans
OP	Outperform: The stocks is expected to outperform the sector benchmark	Op Margin (%)	Operating income divided by revenues
p.a.	Per annum (per year)	P/BV	Price to book value
P/E or PE	Price to earnings / Price Earnings Ratio	P/E Relative	P/E relative to the market
P/EmV	Price to embedded value	PEG Ratio	P/E ratio divided by earnings growth
PPI	Producer price index	Prim Bal/Cur Rev (%)	Primary balance divided by current revenue (total revenue minus capital revenue)
Profit Margin (%)	Net income divided by revenues	q/q or QQQ	Quarter-over-quarter; quarter on quarter
R and D	Research and development	ROA (%)	Return on assets
ROAE (%)	Return on average equity	ROCE (%)	Return on capital employed = EBIT divided by difference between total assets & current liabilities
ROE (%)	Return on equity	ROIC (%) or ROI	Return on invested capital
Shares o/s	Shares outstanding	Solvency Ratio (%)	Ratio of shareholders' equity to net premiums written (for insurance companies)
sotp or SOTP	Sum of the parts	Tax Burden Index	Swiss tax index; 100 = average tax burden of all cantons
tgt	Target	Tier 1 Ratio (%)	Tier 1 capital divided by risk-weighted assets; describes a bank's capital adequacy
tn	Trillion	UP	Underperform: The stock is expected to underperform the sector benchmark
Valor	Swiss company identifier	WACC	Weighted average cost of capital
WPIC	World Platinum Investment Council	CIO	UBS WM Chief Investment Office
x	multiple / multiplicator	y/y or YOY	Year-over-year; year on year
yr	Year	YTD	Year-to-date

Appendix

or market trends as investors that do not use such criteria. Companies may not necessarily meet high performance standards on all aspects of ESG or sustainable investing issues; there is also no guarantee that any company will meet expectations in connection with corporate responsibility, sustainability, and/or impact performance.

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