The ‘pay-as-you-go’ car: Ride-hailing just the start

The c.$7 tn global mobility market is speeding into the era of the “pay-as-you-go” car. Ride-hailing services such as Uber and Didi are pioneering a ‘cloud’ mobility system, which is using data to change how the wealthiest cities move. In Rethinking Mobility, we model how the ride-hailing opportunity can grow to $285 bn by 2030, and is the precursor to a broader technological and social transformation. We examine how the market might live up to the high valuations of its pioneers, why car sales may prove surprisingly resilient despite the change, and where automakers have a chance to transform their profitability as operators of fleets of autonomous cars.
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*Prices in this report are based on the market close of May 22, 2017.*

*Other contributing authors: Alexander Duval, Kota Yuzawa, Piyush Mubayi, Heather Bellini, Simona Jankowski and Gungun Verma.*
Portfolio managers’ summary

Cloud mobility: Disentangling usage from ownership

The global mobility market is worth $7.0 tn and growing: The global mobility market (ground transportation, i.e. on cars and mass transit) is growing, fueled by population growth and intensified by urbanization. At the same time, the private car is running out of space, with congestion, pollution, low utilization levels and a rising cost of ownership all weighing on its viability.

‘Cloud’ mobility businesses are changing how cities move: The assumption that we need to own the vehicle in which we travel is dissolving. Cloud mobility services (in effect invented by Uber, Didi Chuxing and peers) are emerging, disentangling ownership from usage, improving vehicle utilization and driving costs of mobility down.

On our market sizing analysis, ride hailing is set to overtake and ultimately eclipse taxi markets: In select cities, the ride-hailing market is already outsizing the local taxi market by multiple times. San Francisco (the birthplace of ride hailing) is the most progressive example (ride hailing is >4x its local taxi market). But on a global basis, it is early days: the taxi market ($108 bn) is still 2.9x larger than today’s ride-hailing market ($36 bn).

We expect the ride-hailing market to grow eightfold to $285 bn in 2030: Rapid growth has already occurred (c.120% yoy in 2016 from $16 bn in 2015). Our ride-hailing market estimate of $285 bn (with bear and bull scenarios of $177 bn and $492 bn respectively) is derived by thinking about how big the ride-hailing opportunity could be relative to today’s local taxi markets: we assume it is four times larger in tier 1 cities (as per San Francisco today), three times in tier 2, and two times in tier 3 (see page 1! for details of city tiering). In our forecasts, we assume ride-hailing companies themselves would take a 23% commission on gross market revenues, i.e. $65 bn in 2030.

The cloud mobility ecosystem is attracting capital

We focus in this report on ride hailing (e.g. Uber, Didi and Lyft), but many business model variants are vying for share, for example smart shuttle bus services (such as Via and Chariot) and various types of car-sharing services (e.g. Car2go, ZipCar, Maven and Turo).

We monitor this via our Venture Capital Horizons work: private companies are targeting new urban mobility business opportunities through a diverse set of models including car sharing, ride-hailing and intermodal ‘aggregator’ services. We highlight 20 companies that have collectively attracted $36 bn in funding: the common thread running through them is improving asset utilization of vehicles.

Autonomy: The trigger to transform the ecosystem

We believe the relationship between ride hailers and drivers will ultimately unwind… Autonomous cars may significantly disrupt the current ride-hailing ecosystem, opening up new risks for today’s winners. Drivers’ influence over business models today is such that their removal can quickly alter the competitive landscape. Ride hailers’ cost of expansion (i.e. hiring or subsidizing drivers) is a significant contributor to the lack of operating profit in the segment today: ultimately, fully autonomous vehicles have the potential to supplant 6.2 mn drivers from the workforce.
...Opening up the biggest revenue pool in new mobility: Autonomous fleets. The business opportunity of providing autonomous fleets to ride hailing would open up a new and even bigger revenue pool than that of ride hailing itself: we estimate $220 bn by 2030, up to 3.4x bigger than the ride-hailer revenue opportunity at that point. We model a scenario in which a fleet manager could generate profit of $14k per car over three years, nine times what an OEM currently makes from selling a car.

Autonomous fleets are potentially transformative for OEMs: If OEMs can provide self-driving technology through their assembly lines, they can create autonomous fleet management businesses that would improve their margins, reduce cyclicality and potentially improve (currently weak) investor sentiment towards them. Regional coverage will be important for OEMs entering mobility services, possibly a factor behind all recent automotive industry consolidation being intra-regional in nature (e.g. GM’s withdrawal from Europe, PSA’s acquisition of Opel, Nissan’s purchase of a stake in Mitsubishi and Toyota’s takeover of Daihatsu).

Tech companies likely have a different vision: One in which they evolve from being suppliers (to OEMs) into customers (of OEMs), installing equipment into cars and potentially resulting in ‘Foxconn-ification’ for certain OEMs, i.e. the loss of control over their own product differentiation.

Autonomy will also remove the ride hailing’s growth shackles in several key ways: (1) Eliminating driver subsidies, thereby reducing operating costs; (2) facilitating geographic expansion by making it easier to co-locate supply with demand (by simply moving the car); and (3) reducing regulatory challenges around employment contracts and worker rights. Autonomous cars bring risks too, creating an opportunity for new market participants. We do not envisage ride-hailing companies trying to buy or build their own autonomous fleets given that they prize their current asset efficiency.

We do not believe autonomy heralds cheap mobility: This is because savings from the removal of the driver would for the most part not accrue to customers, as they would be absorbed by the cost of operating fleets. In addition, the scope to further improve the asset utilization of ride-hailing vehicles is finite. We also see the risk of additional taxes on ride hailing as authorities seek to replace taxes lost from challenged taxi industries.

Cities will feel the change

Our GS Urban Mobility Change Matrix reveals the cities where change could be strongest. We analyze the 100 wealthiest cities, and find that those likely to feel change most acutely are the ones where push factors (pollution, heavy traffic) and pull factors (wealthy cities with low private car penetration and utilization) intersect. Many Asian megacities screen as ready for disruption, with a secondary group of primarily US and European cities identified as ‘willing adopters’.

Regional champions: Ride hailing seems to be developing as regional champions (e.g. Didi in China, Uber and Lyft in the US), with regulatory factors (employment laws and other regulations) still leaving significant question marks over whether and how mobility in continental Europe might evolve.
We expect car ownership to survive

2030E: Cars on the road peaking…but sales holding firm: Population and GDP growth mean the big-city car population is likely to keep rising. Only on our most bullish change scenario do we see alternative mobility concepts growing fast enough to cause a decline in the tier 1 and 2 cities’ car parc by 2030. Car sales volumes on the other hand are likely to be stable even if the parc declines. This is because shared cars will be utilized more, and thus replaced more frequently.

Car ownership may prove surprisingly resilient: Overall, we forecast a stable global car parc of 1.2 bn cars in 2030 vs. 1.1 bn today, with global car sales slightly higher at 100 mn vs. 87 mn today – in contrast to the commonly held view that declining private car usage among younger drivers heralds a structural decline in car ownership.

The purchase decision is separate from the usage decision: To buy a car does not mean to always go by car. Urban dwellers may choose mobility services more often (e.g. for convenience, or to avoid expensive town center parking), but retain their own cars even though they drive them less frequently. Elements of car ownership are completely non-substitutable (e.g. security, optionality, status). Separately but importantly, the desire to own a car is still strong in developing markets.

Top 10 Takeaways

1. **Mobility is a big business.** The $7.0 tn global mobility market is about to change as pay-as-you-go models disentangle usage and ownership.

2. ‘Cloud’ mobility is changing how cities move: We focus here on ride hailing, but many business model variants are vying for pre-eminence, such as smart shuttle bus services and various types of car-sharing services.

3. Ride hailing is 33% the size of today’s global taxi market, but could grow eightfold to **$285 bn by 2030**, ultimately outsizing the taxi market by 5.3x.

4. Autonomous cars have the potential to be the trigger that transforms the ecosystem. They would cause the relationship between ride hailers and drivers to ultimately unwind: by 2030, the arrival of autonomous fleets could supplant **6.2 mn drivers globally**.

5. Autonomous fleet management has the potential to be the biggest revenue pool in urban mobility: the revenue opportunity is up to **3.4x larger** than that for ride hailing itself.

6. Autonomous fleets are potentially transformative for OEMs: we estimate a revenue opportunity of $220 bn by 2030, modeling a scenario in which a fleet manager could generate profit of $14 k per car over three years, nine times what an OEM currently makes from selling a car. Tech companies have their own dreams of owning the value chain.

7. We identify cities that we believe will change most dramatically. Our GS Urban Mobility Change Matrix reveals the cities where change could be strongest – they are predominantly wealthy Asian capitals.

8. Ride hailers are developing into regional champions (e.g. Didi in China, Uber and Lyft in the US), with regulatory factors (employment laws and other regulations) still leaving significant question marks over whether and how mobility in continental Europe might evolve.

9. Investors’ access to the ecosystem today is predominantly via private routes. Through our Venture Capital Horizons work, we identify 20 key companies that have collectively attracted $36 bn in funding.

10. Car ownership will survive. Car purchase and usage decisions are separate, and there are many reasons not to give up our cars. We forecast global car sales holding firm and rising slightly to 100 mn in 2030 vs. 87 mn today, helped by rapid turnover of ride-share cars, in spite of declining car penetration.
### Rethinking Mobility in Numbers

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<th>Ride-Hailing Opportunity</th>
<th>Stellar Growth</th>
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<td><strong>$285 bn</strong></td>
<td><strong>83 bn</strong></td>
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<td>Size of the ride-hailing market in 2030, according to our base case estimate. That equates to $65 bn in net revenue to ride hailers. (p. 13)</td>
<td>Our upper estimate of the number of ride-hailing trips per year by 2030. This compares with a current 6 bn trips annually. (p. 14)</td>
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<th>Think San Francisco</th>
<th>Taxis Tank</th>
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<td><strong>&gt;4x</strong></td>
<td><strong>$54 bn</strong></td>
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<td>Size of San Francisco’s ride-hailing market compared with its local taxi market. Globally, the taxi market is 3x larger than ride hailing. (p. 11)</td>
<td>Estimated global taxi market opportunity in 2030. That’s half the size of the market in 2016. (p. 13)</td>
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<th>Drivers Displaced…</th>
<th>…Here Are Some of the Reasons Why</th>
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<td><strong>6.2 mn</strong></td>
<td>Proportion that a ride-hailing driver takes home from a fare, after costs. That’s c.$4.20 from a global average fare of c.$9. (p. 36)</td>
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<td>Potential number of drivers that could be replaced by autonomous fleets. (p. 27)</td>
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<th>Private Cars Seldom Used…</th>
<th>…Yet Car Sales May Be Resilient…</th>
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<tr>
<td><strong>5.0%</strong></td>
<td><strong>23 mn</strong></td>
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<td>Average amount of time a car in the US is used. (p. 47)</td>
<td>Estimated number of cars sold in the 100 wealthiest cities in 2030. That’s a slight increase from 21 mn in 2016. (p. 44)</td>
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<th>…As Cars Are Replaced More Often</th>
<th>Car Manufacturers’ Dream?</th>
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<td><strong>3.5x</strong></td>
<td><strong>7 x</strong></td>
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<td>Replacement rate of ride-hailing vs. private cars. This should make car sales hold up well. (p. 44)</td>
<td>How much more EBIT car manufacturers could make per car by running a fleet of autonomous vehicles. That’s $14k a car versus the global industry average of $2k EBIT for each new car sold. (p. 29)</td>
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Pay-as-you-go mobility  Our ride-hailing market forecasts

- Our base case: $285 bn market by 2030E (p. 13)

- The bull and bear scenarios: What to expect if adoption is unexpected (p. 14)

- Potential bottlenecks: Regulatory obstacles, lower-than-expected demand, lack of willing drivers, worsening traffic, shift to other mobility options (p. 16)
‘Pay-as-you-go’ mobility: Car usage separating from ownership

The c.$7.0 tn global mobility market is already changing profoundly in the largest, wealthiest cities. As we pay-as-we-go, a ‘cloud’ mobility service system is emerging, disentangling ownership from usage. In San Francisco, ride hailing is >4x bigger than the local taxi market, indicating the potential for the service. If all global tier 1 cities (see page 11 for details of city tiering) fostered ride-hailing businesses 4x the size of their local taxi markets (with lower multiples in tier 2, 3 and 4 cities), ride hailing could grow eightfold to $285 bn in 2030 (versus today’s taxi market worth >$100 bn): this is the base case used in our analysis. We frame our estimate with bear ($177 bn) and bull ($492 bn) scenarios, and discuss sensitivities around other variables such as overall societal mobility demand, uptake of ‘pooling’, and last-mile services.

Total mobility market of c.$7.0 tn…and growing

Whether for work, education, shopping or simply to visit friends, people want and need to travel. Globally, we spend $7 tn each year on ‘mobility’, including buying and running cars, and various forms of public transport (excluding air travel).

Exhibit 1: Total mobility market size is $7.0 tn

Source: Haver, Goldman Sachs Global Investment Research.

The urban population is growing, driven by global population growth and amplified by rural to urban migration. Based on UNPD projections, the urban population is set to grow at a CAGR of 1.6% to 2030, vs. 2.2% average growth over the past two decades. With more people comes increased demand for mobility. However, cities’ mobility ‘capacity’ is not growing with population, as the car runs out of space in which to travel. Worsening congestion and pollution are driving authorities to legislate cars out of many large urban centers, and this is in turn creating an opportunity for new mobility models, in particular pay-as-you-go models that separate car usage from car ownership.

Exhibit 3: Population growth drives mobility demand...

Source: Goldman Sachs Global Investment Research.

Exhibit 2: Leisure accounts for the majority of trips

Source: TfL Planning, Strategic Analysis

Exhibit 4: …assuming trips per person remain constant

Source: Goldman Sachs Global Investment Research, Brookings Institution.
‘Cloud’ of mobility services separating usage from ownership

‘Pay-as-you go’ mobility is on the rise. A transition is under way from a world where moving people, goods and services requires owning a vehicle, to one where we can ‘bid’ for single journeys – or ‘packets’ of mobility – and consume them on a pay-as-you-go basis. The switch is as much about convenience as it is about cost. It is becoming increasingly likely that in cities, we travel in a vehicle we do not own.

Ride-hailing services like Uber and Didi-Chuxing have essentially invented a ‘cloud’ mobility network (akin to cloud computing). Whereas today we ask a specific service to take us from A to B, we are moving to a world where we request to go from A to B, and have the ‘cloud’ offer mobility solutions (perhaps involving various prices, times, speeds or levels of luxury). ‘Aggregator’ services will be the point of contact for the consumer, i.e. the app through which we access a broadening range of mobility options, including ride sharing, public transport, and potentially bicycle hire and other options.

Exhibit 5: The separation of use and ownership

We’re moving from a world where people own their car to one where they “consume mobility”

The global taxi market is worth >$100 bn

To size the market opportunity for cloud mobility, we begin by estimating the global taxi market size. We believe the global taxi market to be worth $108 bn. This is a difficult figure to validate given limited data and a lack of formal revenue recognition in the industry. However, based on the few regions where figures are available (see Exhibit 6), we have extrapolated a ratio of taxi spend to GDP (c.0.2%) and applied it to global urban GDP to reach our market size estimate. We use the same assumption of 0.2% of GDP to decompose our taxi market size estimate by city size. The ride-hailing market, at $36 bn, is just under a third of the size of the global taxi market ($108 bn) on our estimates. Ride hailing is growing very rapidly, with the market having more than doubled in 2016 vs. 2015 (c.$16 bn). Uber outgrew peers in 2016, more than tripling its gross revenues from $2 bn to $6.5 bn (+225% yoy).
Exhibit 6: We estimate the global taxi market to be worth $108 bn

<table>
<thead>
<tr>
<th>$ bn</th>
<th>Taxi and limo market</th>
<th>GDP</th>
<th>Taxi and limo spend, % GDP</th>
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<tbody>
<tr>
<td>Japan</td>
<td>15.36</td>
<td>4,684</td>
<td>0.31%</td>
</tr>
<tr>
<td>US</td>
<td>18.90</td>
<td>17,393</td>
<td>0.11%</td>
</tr>
<tr>
<td>o/w NYC</td>
<td>1.90</td>
<td>1,403</td>
<td>0.14%</td>
</tr>
<tr>
<td>o/w San Francisco</td>
<td>0.14</td>
<td>331</td>
<td>0.04%</td>
</tr>
<tr>
<td>o/w Las Vegas</td>
<td>0.39</td>
<td>94</td>
<td>0.41%</td>
</tr>
<tr>
<td>Germany</td>
<td>3.99</td>
<td>3,937</td>
<td>0.10%</td>
</tr>
<tr>
<td>UK</td>
<td>11.52</td>
<td>3,030</td>
<td>0.38%</td>
</tr>
<tr>
<td>France</td>
<td>4.77</td>
<td>2,679</td>
<td>0.17%</td>
</tr>
<tr>
<td>Italy</td>
<td>1.72</td>
<td>2,180</td>
<td>0.08%</td>
</tr>
<tr>
<td>Spain</td>
<td>3.10</td>
<td>1,394</td>
<td>0.22%</td>
</tr>
<tr>
<td>Global urban GDP</td>
<td>55,200</td>
<td></td>
<td>0.20%</td>
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<tr>
<td>Taxi market</td>
<td>108.11</td>
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Source: Brookings Institute, IBISWorld, Statista, NYC TLC, Nevada Taxicab Authority, TFL, Uber, Goldman Sachs Global Investment Research

Exhibit 7: In 2015, San Francisco’s Uber revenue was already 3.6x its local taxi market

San Francisco gross revenues, taxi market size according to Uber

Changing mobility is focused on top-tier cities

We believe the cloud mobility opportunity is concentrated in top-tier cities (see below). We estimate that in tier 1 and 2 cities (i.e. the top 100) around 5% of GDP is spent on mobility. Of that, around 18% is spent on public transport. However, significant regional variations exist: for example, in Hong Kong, heavy traffic and very efficient public transport mean that public transport takes 57% of mobility spend. In contrast, public transportation services in Los Angeles have a lower share in mobility (22%) owing to high car ownership and limited public transport infrastructure.

Exhibit 8: We focus on tier 1 and 2 cities by absolute GDP, constituting 12% of the world’s population but 44% of its wealth

City tiering explained
The concept of city tiers is often used to talk about urbanization in China, where cities are generally categorized into tiers based on GDP: tier 1 cities typically have GDP > $300 bn (five cities including Beijing and Shanghai), tier 2 between $68 bn and $299 bn (20 cities), tier 3 between $19 bn and $67 bn (130 cities) and tier 4 < $17 bn (400 cities).

In this report, we broaden the concept of city tiers and apply it to global cities to help us define the emerging urban mobility opportunities. We assume Tier 1 = top 30, Tier 1-2 = top 100, and Tier 1-3 = top 300, as ranked by absolute GDP. We focus in particular on top-tier cities, as our analysis indicates that urban mobility here will experience the fastest and deepest changes. Tier 1 and 2 cities (i.e. the 100 wealthiest cities by total GDP) generate 44% of the world’s wealth, while housing only 12% of the world’s inhabitants. Of all urban dwellers, around one fifth (22%) live in one of the tier 1 and 2 cities.

Exhibit 9: Spend in cities
Mobility spend excludes air travel

San Francisco: An indicator of the potential of ride hailing
According to Uber’s estimates in 2015, the San Francisco taxi market had annual revenues of $140 mn – at which time Uber generated $500 mn annually in the city, i.e. Uber revenues were 3.6x larger than the local taxi market, and still growing rapidly. It is worth acknowledging that San Francisco is not a typical city in that: (1) it is Uber’s most mature market (the company was founded here in 2009); and (2) limits on taxi license (‘medallion’) issuance have historically curtailed numbers. However, San Francisco does illustrate that taxi market size is likely a very conservative yardstick against which to estimate the ride-hailing opportunity.

In 2030, the tier 1 and 2 cities could look like SF today
The ride-hailing opportunity clearly extends beyond the taxi opportunity. Per-mile costs are typically substantially lower, and ride hailing is anecdotally taking share from private cars (and even potentially public transport), as well as from local taxis. For analysis purposes, we find it useful to use today’s taxi market as a yardstick against which to measure the future ride-hailing opportunity. San Francisco demonstrates that ride hailing has potential to grow to >4x today’s local taxi market. In our base case scenario, we assume all tier 1 and 2 cities (by GDP) develop ride-hailing markets on average 4x and 3x the size of today’s local taxi markets, respectively. In tier 3 (the next 200 wealthiest cities) and tier 4 (the next 700), we assume lower such multiples (2x and 1x respectively).
Today, private car travel remains the most prevalent single mode of urban transport. Over a third (36%) of our urban mobility demand is met by car, while public transport accounts for around a fifth. We estimate that the 1.97 bn trips per day carried out in tier 1 and 2 cities are split as detailed below.

Exhibit 11: How we travel: Ride hailing accounts for c.1% of total mobility demand today...
2016 modal split in # trips, tier 1 and 2 cities

On our estimates, ride hailing currently meets 0.5% of this trip demand, i.e. 15 mn trips per day, which we expect to grow to 97 mn daily trips by 2030 from current levels, meeting c.4% of urban mobility (trip) demand (Exhibit 14).

Exhibit 13: We expect the number of ride-hailing trips to grow from 15 mn per day to 97 mn trips per day by 2030...
Tier 1 and 2 cities, mobility demand (bn trips per day)

Exhibit 14: ...and constitute c.4% of urban trip demand by 2030 (vs. 0.5% today)
Tier 1 and 2 cities, mobility demand (bn trips per day) 2030E
Ride-hailing market to grow 8x to $285 bn by 2030E

We estimate the current (2016) ride-hailing market size at $36 bn. This figure represents gross revenues (i.e. total customer spend), of which ride-hailing companies make a commission (we estimate c.23%, based on known commission rates typically between 20% and 25%). We estimate this amount (‘net revenue’) at $10.0 bn (Exhibit 16), which is split among the key players (Uber, Lyft and Didi Chuxing).

The ride-hailing market has already shown rapid growth: c.120% yoy over the past year (Exhibit 15). We forecast ride-hailing gross revenues to grow to $285 bn by 2030, a figure derived by thinking about how big the ride-hailing opportunity could be relative to today’s local taxi markets: four times larger in tier 1 cities (as per San Francisco today), three times in tier 2, and two times in tier 3. We find that the ride-hailing opportunity is focused on tier 1 and 2 cities, i.e. the world’s 100 wealthiest cities by absolute GDP (see page 11 for details of city tiering).

Exhibit 15: Ride-hailing gross revenues increased c.120% over 2015-16

<table>
<thead>
<tr>
<th>Year</th>
<th>Uber</th>
<th>Didi</th>
<th>Lyft</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>15.9</td>
<td>5.4</td>
<td>9.0</td>
<td></td>
<td>30.3</td>
</tr>
<tr>
<td>2016</td>
<td>12.1</td>
<td>2.7</td>
<td>20.0</td>
<td></td>
<td>34.8</td>
</tr>
</tbody>
</table>

Source: Company data, Goldman Sachs Global Investment Research.

Exhibit 16: We forecast the market to grow 8x to 2030

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Revenues</th>
<th>Net Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>$36 bn</td>
<td>$10 bn</td>
</tr>
<tr>
<td>2030</td>
<td>$285 bn</td>
<td>$65 bn</td>
</tr>
</tbody>
</table>

Source: Company data, Goldman Sachs Global Investment Research.

Ride hailing to draw spend from private cars and taxis

In tier 1 and 2 cities, we estimate that ride hailing grows from 2% of mobility spend today to 16% in 2030. This share of spend is captured primarily from the private car, which we estimate falls from 80% of spend today to 65% in 2030. However, ride hailers take mobility share from many modes of travel, with public transport potentially affected, and of course taxis significantly affected.

Some US cities have experienced significant falls in taxi demand: In Los Angeles, over a three-year period post the arrival of ride-hailing services, the number of pre-arranged taxi rides fell 42% and overall taxi rides fell 30% (according to the LA Times in April 2016). The same reports indicated even steeper falls in San Francisco taxi demand, but less dramatic declines in Boston and New York City.

Ride hailing is not a direct substitute for a taxi: Physical hailing and airport business remains strongly defensible by taxis. Taxis in denser cities with lots of cars available also seem more defensible. Regulatory factors may further defend taxis in many cities. However, if Californian cities can serve as templates for global cities’ mobility transition path, it might be reasonable to assume a halving of the global taxi market opportunity to $54 bn by 2030, from $108 bn in 2016.
Bear and bull scenarios

We lay out two scenarios which, relative to our base case assumptions, reflect: (1) rapid disruption in mobility (bull case); and (2) a more ‘slow-burn’ approach to change (bear case). The degree of change in our cities will reflect consumers’ willingness to alter their behavior with regard to mode of travel and willingness to share.

In our bear case scenario, only the 30 wealthiest cities attain a ride-hailing market 3x larger than their current respective taxi markets, and outside the top 300 cities, ride hailing gains no presence. For context, Uber currently lists on its website around 400 cities in which it has a presence, although for many of these, we assume its operations to be very limited. In our bull scenario, the ride-hailing market grows to 5x the size of today’s taxi markets in all tier 1 and 2 cities, and 4x in tiers 3-4. In this scenario, ride-hailing is therefore potentially a prevalent mode of travel in all cities, not just the world’s capitals.

To summarize, in our base case estimates (see Exhibit 17), the ride-hailing market grows to $285 bn, i.e. c.8.0x its current size, by 2030. In our bear scenario, this figure is $177 bn (c.5x the current level). In our bull scenario, this market grows to $492 bn (14x today’s level).

Exhibit 17: We estimate the future ride-hailing market size in relation to today’s urban taxi spend levels ($ bn)

<table>
<thead>
<tr>
<th>#cities</th>
<th>Taxi market 2016</th>
<th>Taxi market 2016 GS estimate</th>
<th>Multiplier</th>
<th>Ride-hailing market 2030E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>30</td>
<td>32</td>
<td>0.7x</td>
<td>97</td>
</tr>
<tr>
<td>Tier 2</td>
<td>70</td>
<td>27</td>
<td>0.4x</td>
<td>54</td>
</tr>
<tr>
<td>Tier 3</td>
<td>200</td>
<td>27</td>
<td>0.1x</td>
<td>27</td>
</tr>
<tr>
<td>Tier 4</td>
<td>700</td>
<td>22</td>
<td>0.0x</td>
<td>0</td>
</tr>
<tr>
<td>All urban</td>
<td>1,000</td>
<td>108</td>
<td>0.3x</td>
<td>177</td>
</tr>
</tbody>
</table>

Exhibit 18: Ride-hailing trips set to increase...
Number of ride-hailing trips globally, bn

Ride hailing could meet 30 bn-83 bn trips by 2030
Ride hailing currently delivers 6 bn person-trips annually, on our estimates. By 2030, we estimate that this could rise to between 30 bn and 83 bn trips. We see the key determinants as: (1) the proportion of mobility demand growth met by ride-hailing; and (2) the degree to which ride-hailing remains a big-city-only service: the greater the adoption outside tier 1 and 2 cities, the greater the adoption overall.

Exhibit 19: …and their share of total trips to grow to between 3% and 6% % share of ride-hailing in total trips in 2030E under bull scenario and bear scenario vs. 2016

Source: Company data, Goldman Sachs Global Investment Research.

Source: Goldman Sachs Global Investment Research, Brookings Institution

Source: Goldman Sachs Global Investment Research
Ride occupancy is a key variable to consider

Higher ride occupancy results in lower overall fare income. We assume that there are currently c. 1.5 passengers on average per ride-hailing ride, and our base assumption is that this remains unchanged. Factors that could change the number of passengers per ride include: (1) greater (or lesser) willingness of consumers to ride together; and (2) geographic mix effect: note that regionally (Exhibit 20), average car occupancy (here including normal private cars) is significantly higher in China (2.3 people) than in Europe (1.6). Within cities (Exhibit 21), Indian car occupancy (c. 3.2 people) is higher still.

Exhibit 20: Average vehicle occupancy varies…
Number of occupants (passengers per ride, 2016)

Exhibit 21: …by geography
Number of occupants (passengers per ride, 2016)

Total fare income could be between $177 bn and $492 bn

Total fare income is the gross revenue received by ride hailing, i.e. the total customer spend on ride hailing. We estimate this figure at $36 bn currently. Our bear scenario implies a fivefold increase to $177 bn in 2030, while our bull scenario implies an increase of 14x to $492 bn. These scenarios imply a CAGR for ride-hailing revenues of between 12% and 21% to 2030, vs. our base case estimate of 16%.

Exhibit 22: Fare income could increase to $177 bn-$492 bn
Fare income under our base case, bull and bear scenarios, $ bn

Exhibit 23: …with share in customer spend to increase to 9%-16%
% share of total customer spend on mobility received by ride hailing under our bull and bear scenario in 2030E vs. 2016

Source: Goldman Sachs Global Investment Research, Brookings Institution.

Source: EEA, European Journal of Transport and Infrastructure Research, WIT Press, NHTSA, Gov.UK

Source: Goldman Sachs Global Investment Research.
Further variables: Mobility levels, pooling, and last mile

‘Pooling’ services (e.g. Uber Pool, Lyft Line and Ford’s Chariot) give consumers access to discounted ride-hailing services (typically by 25%-40%) in exchange for agreeing to share all or part of the ride with another 1-2 passengers. The drawbacks are: (1) loss of privacy; and (2) potentially a deviation from the quickest route. The benefits are: (1) a lower ride cost for the consumer; (2) higher utilization of the vehicle (which in turn implies less traffic to achieve the same fulfilment of mobility demand); and (3) potentially (so long as demand is sufficient that available pools are actually used) higher profits for the ride hailer.

What level of mobility will urban dwellers demand? Currently, we estimate that the average daily per capita mobility demand in tier 1 and 2 cities is 2.2 trips. This is a complex function of the many different reasons why people travel (see Exhibit 2 earlier). For modelling purposes, we assume that human mobility demand will be stable at this level. However, city-dwellers’ mobility consumption levels could decline as a result of factors such as a reduced number of shopping trips in favor of online purchases, and declining commuting in favor of home working or virtual communication tools. Conceivably, mobility demand could also increase should technological change or infrastructure improvements make travel faster, better or more economic.

There are potentially further opportunities serving the ‘last mile’. For the purposes of our analysis, we have limited ourselves to the ride-hailing opportunity, or essentially the ‘people-moving’ opportunity. A broader analysis might seek to incorporate the movement of goods. Amazon contracts its deliveries to independent owner-drivers much like the ride hailers do, except the vehicles are delivery vans rather than passenger cars. The urban split between passenger and freight traffic is broadly 60-40, so the further opportunity for pay-as-you-go ‘last mile’ delivery services is substantial (an opportunity under evaluation by Ford, for example).

Bottlenecks to adoption

Many issues and unresolved questions might slow the future adoption of ride hailing and indeed other ‘cloud’ mobility services, including: (1) regulatory obstacles (e.g. legal restrictions on operation, or increased service prices owing to taxes or driver benefits); (2) limits to utilization: limited further geographical rollout, owing to demand limitations in lower-tier cities; (3) lack of willing drivers as a result of weak profit opportunities, better labor opportunities elsewhere, or rising costs of car operation; (4) worsening traffic, making travel times longer; (5) declining overall travel demand, for example owing to more remote working and/or online shopping; and (6) a shift towards other mobility options, such as public transport and cycling.
Emerging mobility models  Venture backing developments

- The emerging “optimizer” role for ride hailing (p. 18)
- The venture capital landscape: Private players leading the charge in ride hailing (p. 20)
- Other innovative mobility models (p. 19)
The new ecosystem: Ride hailers are ‘optimizers’ of assets

‘Pay-as-you go’ mobility is on the rise via an emerging ‘cloud’ of mobility services, which is separating usage from ownership. A transition is under way from a world where moving people, goods and services requires owning a vehicle, to one where we can ‘bid’ for single journeys – or ‘packets’ of mobility – and consume them (conveniently) on a pay-as-you-go basis. It is becoming increasingly likely that in cities, we travel in a vehicle we do not own.

An aggregator layer

Need for aggregation services emerging: In a world of ‘cloud’ mobility, the ‘aggregator’ will be a point of contact for the consumer, i.e. the app through which we access a broadening choice of mobility options. Ride-hailing and related services are proliferating, and existing regional champions (e.g. Didi Chuxing) have ambitions to broaden their geographic reach. While this is an emerging opportunity, the candidates for exploiting it include Citymapper, Transit and Moovel: apps that allow users to compare routes across modes of transport in cities. Similarly, Google Maps embeds transport offers in the directions offered by its mapping apps.

Exhibit 26: Ride hailers (and other ‘optimizers’) operate symbiotically with owner-drivers

The mobility value chain today

Ride hailers are first and foremost technology companies, whose technical strength is deep pools of data and predictive algorithms. Their core business model is to match supply of mobility with passenger (or goods) demand in the most efficient way possible. To this end, they have developed consumer-facing brand identities.

The optimizing layer

Ride hailers need to optimize asset utilization: Drivers are not employees of ride hailers, but they do provide the capital that enables the business model (i.e. the car). Because of this symbiotic relationship with their drivers, ride-hailing companies must allow sufficient profits for their driver partners to keep them from defecting to other platforms or jobs; at the same time, they need to keep customer fares cheap. The only way to achieve both aims is to optimize the utilization of the asset base.

Ride-hailing companies and their drivers make uncomfortable bedfellows: Ride-hailing companies take a 20%-25% cut of drivers’ fares, and thus depend on drivers to make money. Conversely, however, ride hailers need to recruit drivers to grow, and need to subsidize (or even occasionally fully pay) those drivers to attract new customers. This costly growth is the primary reason why no ride hailer has ever to date booked positive operating profit. The evolution of this relationship as autonomous cars become available should significantly reshape ride hailing, and reconfigure the value chain for OEMs and tech companies.
Ride hailing only one of many possible solutions

Ride hailing is not the only ‘solution’ at the intersection of cars and the sharing economy. Car sharing, Airbnb-style models, and minivan shuttle services are all jostling for position too – but all seek to improve asset utilization relative to the c.5% level of private cars...and of course to deliver mobility with convenience to customers. The ride-hailing model revolves around its symbiosis with its drivers, and the growth of such services hinges on successful balancing of customer acquisition (achieved through subsidies) and asset utilization. Capital is flowing into the space; in the following section, we provide a list of companies that have collectively attracted some $36 bn of investment capital (Exhibit 27).

Multiple business models

Ride hailing is perhaps the most obvious meeting point between the ‘sharing economy’ and the car. Sharing economy models aim to improve the utilization of a wide range of assets by allowing users to ‘book’ and rent those assets via technology platforms. All of the below business models will experience change in a post-autonomous world.

Ride-hailing companies aim to improve vehicle utilization by allowing users to book the service for customized trips. Uber (market leader in the US) and Didi Chuxing (#1 in China) are the dominant players in the ride-hailing market (c.90% of the global market by revenues), while Lyft is the global #3, with operations currently confined to the US. The smaller GrabTaxi was founded in Malaysia and is the #1 ride hailer in Southeast Asia.

Another group of business models has emerged as an add-on to local taxi industries: Gett (in which VW has a $300 mn stake) has originated from an app-based service for booking local (traditional) metered taxis. Similarly, Daimler-owned MyTaxi currently has a Germany focus, and takes a flat booking fee on a per-ride basis.

Shuttle-services: Another set of variants uses minivans or buses to shuttle multiple passengers together. Unlike traditional buses, the aim is to have dynamic routes that vary with demand. Examples include: (1) Via, which operates in North America and is partnered with Mercedes. Via collects customers from the nearest block as opposed to an exact location, and charges a low flat fee irrespective of the distance; and (2) Chariot (acquired by Ford last year for >$65 mn), which has features similar to Via, but is much smaller in size and operates only in San Francisco.

Car-sharing services: The final group of variants is essentially ‘self-drive’ business models. Unlike traditional (e.g. airport-based) rentals, customers rent cars for short periods of time (by the hour or minute) from collection points generally within cities. Cars may be returned to the collection point, or alternatively ‘free-floating’ services let cars be dropped off anywhere within designated urban areas. Examples include: (1) Car2go (Daimler’s joint venture with Europcar), which has a customer base of >2 mn users and provides a fleet of smart or Mercedes vehicles; (2) ZipCar (a wholly owned subsidiary of Avis group), which has a customer base of c.1 mn members and operates in similar regions as Car2go; and (3) Maven, GM’s US-based car-sharing service.

Peer-to-peer car share models (Airbnb-style) allow car-owners to make money by letting out their own cars for short periods, e.g. Turo and Daimler-owned Croove.

The common goal among business models is to improve asset utilization: The key competencies for matching people with mobility are technological ones. Locating a customer, taking their destination, and passing it to the nearest available driver (all smartphone-dependent tasks) is the start. The key to minimizing per-mile costs is maximizing asset utilization. This in turn demands algorithms that can estimate journey times, and ultimately predict demand to avoid having idled or empty vehicles that are not earning a return. In other words, the goal of the technology is to optimize the utilization of the asset base.
Venture Capital Horizons: Today, private companies are leading the charge

As part of our Venture Capital Horizons initiative, we outline below some of the highest-profile investments in mobility in recent years. The shared mobility ‘space’ covers a reasonable breadth of business models, including car sharing (effectively urban short-term self-drive car rental services); ride hailing (i.e. Uber, Didi Chuxing and peers); and notable variants such as Waze’s dynamic mapping business, which is experimenting with carpooling, and Citymapper, an ‘aggregator’ of service offerings. The companies highlighted in Exhibit 27 have collectively attracted $36 bn of investment capital. As a group, the ride hailer’s total valuation implied by known funding rounds is c.$133 bn.

Exhibit 27: Total funding going into key mobility service providers

<table>
<thead>
<tr>
<th>Company</th>
<th>Segment</th>
<th>Geographical presence</th>
<th>OEM investment/partnership</th>
<th>Valuation ($mn)</th>
<th>Funding ($mn)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car2go</td>
<td>Car sharing</td>
<td>Europe, N America, Asia/Other</td>
<td>Daimler (75%) JV with Europcar (25%)</td>
<td>-</td>
<td>-</td>
<td>B2C car sharing service: ~2 mn members. Uses mostly Smart Fortwo vehicles.</td>
</tr>
<tr>
<td>ZipCar</td>
<td>Ride sharing</td>
<td>Europe, N America</td>
<td>Wholly owned by Avis group. Strategic partnership with Didi Chuxing, Ford, Uber, VW (hybrid cars)</td>
<td>-</td>
<td>-</td>
<td>B2C car sharing service: ~1 mn members. Partnership with Didi (Nov’16) lets Didi users book ZipCar services through Didi’s app. Uber arrangement lets Uber drivers effectively use ZipCars on short term lease. OEMs partnerships provide access to vehicles.</td>
</tr>
<tr>
<td>DriveNow</td>
<td></td>
<td>Europe, N America, Asia/Other</td>
<td>BMW JV with Sixt (50% stake each)</td>
<td>-</td>
<td>-</td>
<td>B2C car sharing service: ~0.5 mn customers. Uses BMW vehicles.</td>
</tr>
<tr>
<td>EV Card</td>
<td></td>
<td>Europe, N America, Asia/Other</td>
<td>SAIC (51%)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Uber</td>
<td>Ride sharing</td>
<td>Europe, N America, Asia/Other</td>
<td>Toyota (undisclosed amount), Volvo (on AVs), Daimler (on AVs), GM (on car rental)</td>
<td>69,000</td>
<td>12,500</td>
<td>#1 ride hailer in US, Europe. Several OEM partnerships: Leasing deals with Toyota, GM’s Maven. R&amp;D collaboration with Volvo. Autonomous car agreement with Daimler.</td>
</tr>
<tr>
<td>Didi Chuxing</td>
<td></td>
<td>Asia/Other</td>
<td>VW (JV)</td>
<td>44,500</td>
<td>15,738</td>
<td>China’s #1 ride hailer. Investors include SoftBank, Silver Lake Kraftwerk, China Merchants Bank, Bank of Communications. Didi acquired Uber China in Aug’16</td>
</tr>
<tr>
<td>Lyft</td>
<td></td>
<td>Asia/Other</td>
<td>GM ($5.5bn), Didi Chuxing ($100mn)</td>
<td>6,900</td>
<td>2,613</td>
<td>#2 in N America. Didi invested $100 mn in Lyft’s Mar’15 funding round.</td>
</tr>
<tr>
<td>OlaCabs</td>
<td></td>
<td>Asia/Other</td>
<td>Tata Motors, Didi Chuxing, BMW</td>
<td>3,500</td>
<td>1,667</td>
<td>#1 ride hailer in India.</td>
</tr>
<tr>
<td>Grabtaxi</td>
<td></td>
<td>Asia/Other</td>
<td>Didi Chuxing ($350mn)</td>
<td>3,000</td>
<td>1,430</td>
<td>#1 ride hailer in SE Asia. Fares calculated pre-journey.</td>
</tr>
<tr>
<td>BlaBlaCar</td>
<td></td>
<td>Mexico</td>
<td>-</td>
<td>1,400</td>
<td>333</td>
<td>Car pooling service, riders share costs. &gt; 35 mn members</td>
</tr>
<tr>
<td>Gett</td>
<td></td>
<td>Europe</td>
<td>VW ($300mn)</td>
<td>600</td>
<td>622</td>
<td>Corporate bookings represent ~ one third of income.</td>
</tr>
<tr>
<td>Via</td>
<td></td>
<td>Europe</td>
<td>Mercedes (partnership, providing vans to Via)</td>
<td>-</td>
<td>137</td>
<td>Low cost ride-hailing service with bus-like service elements, i.e. 1) customers are collected from the nearest block rather than from an exact location, 2) vehicles can carry several passengers, 3) low-cost and flat fees.</td>
</tr>
<tr>
<td>99Taxis</td>
<td></td>
<td>Europe</td>
<td>Didi Chuxing</td>
<td>-</td>
<td>125</td>
<td>Largest ride-sharing app in Brazil, with ~70% market share</td>
</tr>
<tr>
<td>Chariot</td>
<td></td>
<td>Europe</td>
<td>Acquired by Ford for &gt;$65mn in 2016</td>
<td>3</td>
<td>-</td>
<td>San Francisco-based shuttle-van service</td>
</tr>
<tr>
<td>Ofo</td>
<td></td>
<td>Europe</td>
<td>Didi Chuxing</td>
<td>2,000</td>
<td>580</td>
<td>Bike sharing platform/service provider (own fleet in multiple cities), collaborate with bike makers for hardware</td>
</tr>
<tr>
<td>Mobilebike</td>
<td></td>
<td>Europe</td>
<td>Didi Chuxing</td>
<td>1,000</td>
<td>325</td>
<td>Bike sharing platform/service provider (own fleet in multiple cities), collaborate with bike makers for hardware. Investors include Tencent, Citrip</td>
</tr>
<tr>
<td>Inrix</td>
<td></td>
<td>Europe</td>
<td>Porsche SE acquired 10% for $55mn in 2014</td>
<td>495</td>
<td>143</td>
<td>Mapping: real-time and predictive traffic</td>
</tr>
<tr>
<td>Waze</td>
<td></td>
<td>Europe</td>
<td>Acquired by Google for $996mn in 2013</td>
<td>-</td>
<td>67</td>
<td>Alphabet (Google)-owned dynamic mapping / traffic data company. Experimenting with Uber-style car pooling</td>
</tr>
<tr>
<td>Citymapper</td>
<td></td>
<td>Europe</td>
<td>Uber, Hallo, Car2Go, Gett</td>
<td>305</td>
<td>50</td>
<td>Urban navigation app. Other partners include Apple, Google, OpenStreetMaps, Yelp, Foursquare</td>
</tr>
</tbody>
</table>

** Denotes partnership with ride hailers.

Source: Crunchbase (www.crunchbase.com), compiled by Goldman Sachs Global Investment Research.
## Future of mobility services: highlighting the developments by key players

<table>
<thead>
<tr>
<th>Company</th>
<th>What are they doing in mobility?</th>
<th>Why does it matter?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMW</strong> (Stefan Burgstaller)</td>
<td>DriveNow is BMW's free-floating car-sharing platform, operating in 11 European cities (5 in Germany); ReachNow is US-based, and allows customers to book rides and car owners to rent their cars</td>
<td>• BMW has allocated €500 mn to BMW Ventures, focused on electric mobility and mobility services</td>
</tr>
<tr>
<td><strong>Daimler</strong> (Stefan Burgstaller)</td>
<td>Daimler's Moovel is an 'aggregator' platform for mobility services; Daimler owns 'optimizer' service platforms MyTaxi and car2Go, and has stakes in chauffeur service Blacklane and Groove (car sharing)</td>
<td>• Daimler's CASE (Connected, 'Automous, 'Shared &amp; Service, 'Electric Drive), feeds into its vision of future mobility</td>
</tr>
<tr>
<td><strong>Ford</strong> (David Tamborino)</td>
<td>Ford's Smart Mobility (subsidiary) is focused on building future mobility models, both organically and through acquisitions</td>
<td>• For the Shared &amp; Service portion at least, Daimler is likely to remain in investing mode in the medium term</td>
</tr>
<tr>
<td><strong>General Motors (David Tamborino)</strong></td>
<td>• Building car-sharing services internally e.g. through Maven (on-demand) and BOOK (subscription-based)</td>
<td>• Ford expects to achieve 20%+ EBIT margins from new future mobility business models over time</td>
</tr>
<tr>
<td><strong>Tesla</strong> (David Tamborino)</td>
<td>• Invested $500 mn in ride-hailing service Lyft, and offered short-term rentals to Lyft drivers called Express Drive</td>
<td>• It has invested in Argo AI developing a virtual driver system for SAE level 4 self-driving vehicles</td>
</tr>
<tr>
<td><strong>Toyota</strong> (Kota Yuzawa)</td>
<td>Toyota Mobility Services Platform (founded in 2016) aims to connect companies and service providers on the MSP</td>
<td>• GM acquired Cruise Automation in May 2016, which sped up its autonomous vehicle development</td>
</tr>
<tr>
<td><strong>Volkswagen</strong> (Stefan Burgstaller)</td>
<td>VW, through its urban mobility business MoIA, plans to develop and market its own mobility services; It is developing an app-based shuttle service for urban cities for mass transit; In e-mobility, it plans to launch &gt;10 EV models by end-2018 and &gt;30 new BEVs by 2025</td>
<td>• GM acquired Cruise Automation in May 2016, which sped up its autonomous vehicle development</td>
</tr>
<tr>
<td><strong>Delphi</strong> (David Tamborino)</td>
<td>In 2018, it intends to extend the pilot program to cities in Europe and the US</td>
<td>• It is testing a self-driving fleet of its all-electric Chevy Bolt as its foray into autonomous mobility</td>
</tr>
<tr>
<td><strong>Didi Chuxing (private)</strong></td>
<td>Acquired Uber China in Aug 2016; also has a long-term strategic partnership with Volkswagen China in the ride-hailing segment</td>
<td>• Unlike other OEMs, Tesla is vertically integrating its car production, AV technology, and ride-sharing network</td>
</tr>
<tr>
<td><strong>Gett (private)</strong></td>
<td>Running ride-hailing services in Europe (#1) and the US (concentrated only in New York), has partnered with VW</td>
<td>• It has outfitted customer-owned vehicles with hardware capable of fully autonomous driving to collect data for its Autopilot software</td>
</tr>
<tr>
<td><strong>Lyft (private)</strong></td>
<td>Business model complements the local taxi industry by partnering with traditional drivers as opposed to competing with them</td>
<td>• Toyota is focused on shorter replacement cycles in future, after-sale services, and durability of vehicles</td>
</tr>
<tr>
<td><strong>Uber (private)</strong></td>
<td>Divested in a partnership with ZipCar for car sharing and Ofo for bike sharing; Running ride-hailing services in the US (#2 in India), Ola (#1 in India), Grab (#1 in Singapore), and 99Taxis (#1 in Brazil)</td>
<td>• It could leverage its large fleet on road to deliver big data and offer advertising services delivered to cars</td>
</tr>
<tr>
<td><strong>Alphabet (Heather Bellini)</strong></td>
<td>Alphabet's Waymo project has the most established autonomous driving technology, having conducted 2 mn miles of road tests; Launched a self-driving partnership with May in May 2017</td>
<td>• It plans to expand its ride-hailing businesses organically and via partnerships</td>
</tr>
<tr>
<td><strong>Avis</strong> (David Tamborino)</td>
<td>Has one of the world's largest car-sharing operations, post acquisition of Zipcar in 2013; Unlike peers, ownership of the assets remains with Avis, as opposed to private citizens renting out/utilizing personal vehicles</td>
<td>• In China, (apart from Didi), VW has collaborated with GoFun (car sharing), Shouqi Group (car leasing)</td>
</tr>
<tr>
<td><strong>Hertz</strong> (David Tamborino)</td>
<td>ZipCar will give access to Avis for data collection/mining, and also acts as an avenue for testing new services</td>
<td>• Its aims is to expand its European shuttle services to &gt; 20 cities by 2021, and deploy AV fleets by 2025</td>
</tr>
</tbody>
</table>

Source: Goldman Sachs Global Investment Research.
The new ecosystem  Autonomous the future battleground

- Why autonomy doesn’t mean cheap mobility (p. 24)
- The role for OEMs as “integrated fleet managers” (p. 28)
- Profiles of autonomous services undergoing testing (p. 32)

“Whoever delivers the most drives, they are the service that collects the most data. And data remains the most valuable part of mobility going forward.”

- Di-Ann Eisnor, Waze
  December 2016
The ride hailer-driver relationship will likely ultimately unwind

Although the driver accounts for close to half of per-mile ride-hailing costs, we do not think that the arrival of autonomous cars will bring correspondingly cheaper ride hailing. Asset-light ride hailers have little interest in entering the asset-heavy fleet business, a situation that could open up the biggest revenue pool in new mobility: autonomous fleets. The autonomous fleet business is potentially transformative for OEMs. Tech companies likely have a different vision, involving bestowing intelligence on cars via the installation route.

The driver accounts for almost half of per-mile ride costs

We estimate that it costs $1.48 to travel a mile via ride-hailing services (with prices above average in the US and Europe, and below average in China). This $1.48 breaks down as follows: fuel $0.15, vehicle purchase costs (i.e. depreciation) $0.17, commission to ride-hailing company $0.34, and other costs (primarily maintenance and cleaning, insurance) $0.11. On our estimates, the driver keeps the remaining $0.71 as profit.

Conventional wisdom: No driver = lower costs

Conventional wisdom is that per-mile costs will decline owing to a combination of: (1) improving asset utilization; and (2) (in the longer term) autonomous technology removing the need for the driver, and therefore removing his or her ‘salary’ ($0.71 in the schematic above) from per-mile costs.

We do not envisage autonomy heralding cheap mobility

We do not believe autonomous technology will necessarily lead to cheap mobility, for the following reasons:

- **Savings may not be passed onto customers**: Instead, these would likely be absorbed by the cost of operating fleets.

- **Scope to further improve utilization is finite**: Per-mile costs depend on asset utilization – the decline in per-mile costs for ride hailers versus traditional taxi services, for example, has been substantial. Additional cost declines depend on the extent to which vehicle utilization can be stretched further. Here, the main levers to improve utilization are ‘pooling’ services (e.g. Uber Pool, Lyft Line), or finding additional revenue streams via deliveries or other add-on services.
**Exhibit 31: Ride-hailing cost per mile depends on utilization rates**

Cost per mile ($)

Source: Goldman Sachs Global Investment Research, Company data

- **Additional taxes may be levied on ride hailing:** In cities where taxi usage has declined because of ride hailing, city authorities are likely to seek to replace lost tax income (e.g. from medallions, registration fees etc.) with some form of ride-hailing taxation. Taxes of this kind are likely to be employed more aggressively if the growth of these services is seen to be reaching levels where traffic (or pollution) problems are being exacerbated.

**Exhibit 32: Driver income removed from the equation, but additional costs largely offset savings**

Ride-hailing per-mile estimated cost breakdown (current)

<table>
<thead>
<tr>
<th>Driver-based</th>
<th>Autonomous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fee to ride hailer</td>
<td>$0.26</td>
</tr>
<tr>
<td>Cost of car (ex-fleet manager profit)</td>
<td>$0.34</td>
</tr>
<tr>
<td>Running costs</td>
<td>$0.71</td>
</tr>
<tr>
<td>Fleet manager profit</td>
<td>$0.14</td>
</tr>
</tbody>
</table>

Source: Goldman Sachs Global Investment Research.

**Exhibit 33: We estimate autonomous per-mile costs at $1.24, split as shown below**

Ride-hailing per-mile estimated cost (assuming autonomous car)

| Running costs | $0.51 |
| Fees to ride hailer | $0.28 |
| O/W fleet manager profit | $0.14 |

Source: Goldman Sachs Global Investment Research.

---

**The autonomous fleet manager needs to cover costs**

Furthermore, replacing the driver will require a new fleet management business model, which comes with its own costs:

1. **The cost of the self-driving car:** The technical content of the car (especially while the technology is young) will make it substantially more expensive than a conventional vehicle. Technology companies, suppliers, and OEMs all hope to recoup many millions of development miles financially. We assume $50k vehicle costs and a three-year life.

2. **Whoever manages the autonomous car will require a sufficient return on capital,** just as the owner-driver today requires a return on capital (his or her salary). The vehicle must be purchased (likely financed in some form). It must be stored when not in use. It must be cleaned and maintained. All of these activities have associated costs that must be borne by the fleet manager and contracted out.
Ride-hailing companies wish to remain capital-light

The required ingredients for operating an autonomous vehicle fleet are: (1) (obviously) the cars themselves; (2) financing capabilities (e.g. via asset-backed securitization); (3) physical facilities for maintenance, cleaning and repairs; and (4) real estate for parking (and potentially recharging of batteries).

Ride-hailing companies likely have no desire to take on the fleet management business. So, just as ride hailers today have a symbiotic relationship with drivers, with autonomous cars, the ride hailer of the future will find itself in a symbiotic relationship with whoever runs its vehicle fleets. We explore the autonomous fleet management opportunity in detail on pages 28-29.

OEMs enjoy a strong starting position, for various reasons: First, they manufacture the vehicles and therefore have some control over their supply. Second, they have strong financing capabilities via their own financial services businesses, which already have strong credit ratings and asset-backed securitization capabilities. Third, their dealer networks could provide bases for servicing and maintenance.

The Daimler Uber deal may be the blueprint for a new symbiosis: Daimler announced in January 2017 an agreement with Uber to ‘supply and operate’ self-driving cars in the future, a deal that might form a template for other OEMs. It is likely that through such deals, OEMs will seek to provide fleet offerings that are accretive to their own return on capital – this is another reason to doubt that ride-sharing costs to the consumer can decline substantially further.

Car rental companies are also well positioned (e.g. Avis, Hertz, and Avis-owned car sharing operation Zipcar): they have experience in financing, buying, and reselling large numbers of vehicles, and have the real estate and physical urban presence to maintain, clean, and potentially (in an electric car context) run fleets. Their current relationship with OEMs is a symbiotic one: they acquire (cheaply) cars from OEMs, thus absorbing excess inventory. Car rental companies are likely to be willing participants in autonomous fleet management joint ventures or partnerships.
The biggest revenue pool in new mobility: Autonomous fleets

Ride hailing likely to gravitate towards a fleet model

Ride hailers have clear incentives to remain asset-light. We believe that no current ride-hailing company has any desire to acquire and operate its own fleet of vehicles. To do so would mean: (1) moving far beyond its current competencies; and (2) moving from being an asset-light tech company to a traditional asset-heavy capital enterprise. A transition to autonomous cars would cut the owner-driver out of the value chain and force the industry to fill the funding gap with a new source of capital. Commercial fleets of autonomous cars would start to make economic sense.

Autonomous fleets are the future battleground: Ride-hailing companies currently take a 20%-25% cut of drivers’ fares; at the same time, they need to recruit drivers to grow, and need to subsidize (or even occasionally fully pay) those drivers to attract new customers. We believe customer subsidies are a significant contributor to the lack of operating profit generated by the major ride-hailing companies today. We estimate that the business opportunity of providing autonomous fleets to ride hailers has the potential to supplant a population of 6.2 mn drivers. Despite the societal disruption, this process could open up a new and even bigger revenue pool than that of ride hailing itself. We estimate $220 bn by 2030, up to 3.4x bigger than the net ride-hailer revenue opportunity at that point. We model a scenario where fleet managers could generate profit of $14 k per car.

Fully autonomous vehicles will disrupt mobility services

Most industry participants now agree that fully autonomous (L5) cars are technologically possible and will be deployable to some degree during the next decade, if not sooner. However, there remains limited consensus around the precise timing and form of the rollout of such products or services.

Fleets have the potential to create economies of scale: Hailing services today use cars (mainly provided by owner-drivers) from a highly fragmented set of sources. The use of fleets in some form is likely to increase: in the first instance, this would enable economies of scale. Then, as autonomous cars roll out, fleets would become a necessity, since the owner-driver would no longer be present in the value chain to provide the capital to purchase the vehicle. While consumers could buy autonomous cars and lease them out to the ‘cloud’ (Airbnb style), we think commercial, logistical, and maintenance hurdles mean commercial autonomous fleets make more sense.

Self-driving cars bring many benefits to ride hailers

Fully autonomous cars could benefit ride hailers in several key ways: (1) eliminating driver subsidies, thereby reducing operating costs; (2) facilitating geographic expansion by making it easier to co-locate supply with demand (by simply moving the car); and (3) reducing regulatory challenges around employment contracts and worker rights. All of this creates the opportunity for a significant reconfiguration of the value chain, involving replacing ride hailing’s owner-drivers with fleets of self-driving cars. What remains unclear is how, by whom, and in what form these fleets will be provided.
Autonomous fleets are potentially transformative for OEMs

The OEMs’ dream: ‘Integrated’ fleet management
The best way for OEMs to capitalize on cities’ future demand for fleets is to become ‘integrated’ fleet managers, i.e. to undertake wholesale the role occupied by human owner-drivers today. This would mean the OEM building, operating and maintaining the cars. If OEMs can bring self-driving technology through their assembly lines, they can create autonomous fleet management businesses that would improve their margins, reduce cyclicality, and potentially improve (currently poor) investor sentiment towards them. OEMs’ existing capabilities in financial services (supported by strong credit ratings and experience in issuing asset-backed securities), plus dealer networks as bases for servicing and maintenance, could work to their advantage.

Regional coverage will be important for OEMs entering mobility services, possibly a factor behind all recent automotive industry consolidation being intra-regional in nature (e.g. GM’s withdrawal from Europe, PSA’s acquisition of Opel, Nissan’s purchase of a Mitsubishi stake and Toyota’s takeover of Daihatsu).

OEMs currently face a considerable incentive to ‘disrupt’ themselves. According to our global automotive profit pool model, the global average OEM automotive operating margin is 6.8%. We estimate that the average operating profit per car is c.$2 k. Not only is this a relatively slim margin, but it is likely overstated owing to the relative attractiveness of spare parts and component businesses (which we believe typically comprise 20%-30% of EBIT) that OEMs book within EBIT but do not disclose separately.

A $220 bn revenue pool: Up to 3.4x the ride-hailer revenue pool
As outlined earlier, we estimate the 2030 ride-hailing market at $285 bn (with a range of c.$177-492 bn). This is an overall customer spend number (i.e. gross revenue). Ride hailers currently retain commission of c.23%, and assuming this rate remains unchanged, the 2030 ride-hailer net revenue opportunity would be c.$65 bn. In a world where drivers continue to own and operate cars, the remaining c.77% ($220 bn) would go to those drivers.

To phrase this differently, the revenue pool for the operation of ride-hailing cars in 2030E is around 3.4x the revenue pool for the ride-hailing companies themselves. This $220 bn potential revenue pool is the basis for the autonomous fleet management business opportunity.
$14k per car profit achievable by fleet managers

In terms of revenue generation, based on today’s average fare of (we estimate) $8.9, the ride hailer makes $2.0 per ride (23%) and the owner-driver gets $6.8. If the fleet manager would be willing to undercut the owner-driver by 20%, the fleet manager would receive $5.5 per ride. Such a car might reasonably be utilized for 15 rides per day. Over its three-year life, this gives a revenue potential per car of $90k.

On the costs side, we assume an autonomous taxi might cost $50k, significantly above today’s average ride-hailing car on account of its technological content (especially while the technology is young). We assume that our autonomous taxi has a depreciable life of three years, and zero residual value. With: (1) wear and tear from daily usage limiting the potential life; and (2) no current resale market, we view these assumptions as reasonable. We assume additional per-car costs over three years of: $4.5k maintenance, $3k cleaning, $3k insurance, and $750 financing costs, as well as $14.8k in fuel costs (at $0.15 per mile). Total costs sum to $76k.

Revenue minus costs gives an assumed operating profit per car of $14k, earned over the car’s three-year life, or $4.6k per car per year.

Exhibit 36: The OEMs’ dream
Mobility value chain in which OEMs undertake integrated autonomous fleet management businesses

Upside to OEM margins, cyclicality, and perceptions

We estimate that the average EBIT per unit sold for the global car industry is around $2k. However, this figure includes undisclosed profits from (high-margin) spare parts businesses, and the true profit from new car sales is certainly lower. Clearly, even $2k per car is very modest vs. a $14k per car fleet management EBIT potential. Furthermore, car sales are largely discretionary and therefore highly cyclical. Low margins and high cyclical risk are pivotal factors behind the sector’s low valuation multiples (our global OEMs coverage trades at an average of 7.8x 2018E earnings). Given this backdrop, pursuing fleet management opportunities represents not only an attractive profit stream for OEMs, but also the opportunity to reduce cyclical risk and potentially modify market perceptions of overall business model risk.
Tech companies likely have a different vision

The OEMs’ nightmare: ‘Foxconn-ification’
Volume manufacturers today compete largely on price. OEMs left behind in the autonomous technology race will find themselves in a parallel situation. **Without access to the technology** (or indeed direct access to a ride-hailing customer base), manufacturing cost will be key. While local regulations and tax regimes may mean local manufacturing champions retain a role, the strongest such manufacturers will be those which (like Foxconn) can cut costs the most through **scale, automation, or low-cost location.**

Exhibit 37: The mobility value chain
Mobility value chain in which tech companies ‘disentangle’ the physical car from the value chain

Exhibit: Goldman Sachs Global Investment Research.

The tech sector’s dream: ‘Disentangling’ the physical car
**Tech companies** likely have a different vision, in which they evolve from suppliers (to OEMs) into customers (of OEMs), installing equipment into cars. They are developing **software and hardware** to effectively **bestow intelligence on cars enabling** them to be driverless. The tech sector has no current capabilities in **car manufacturing**, a highly capital-intensive and competitive business. However, if successful, tech companies would gain control over the supply of autonomous vehicles from the OEMs. Tech companies’ autonomous car design approach might be radically different from that of the OEMs: for example, their cars could be lower volume, more utilitarian and/or electric.

The firm likely epitomizing this approach is **Waymo** (formerly known as the ‘Google self-driving car project’). Waymo was spun out of its parent at end-2016 with a mandate to monetize its seven-plus years of research. It is already working with FCA and Honda, but with a **guarded approach** to technology-sharing.

**Broad competencies needed in the mobility ecosystem**
No single company is in a position to provide end-to-end autonomous pay-as-you-go mobility services (a point illustrated graphically in the following exhibit). This kind of offering needs: (1) a **brand**, comprising both customer recognition and customer service; (2) the **software**, including self-driving tech, high-density maps, and the optimization algorithms (as owned by today’s ride hailing) that match consumer mobility demand with the fleet; (3) **infrastructure** for physical repairs, parking and (in the case of electric vehicles) charging, as well as vehicle financing capabilities; and (4) the **manufacturing** competencies required to manufacture the vehicles themselves and physically build the autonomous systems.
Cities might not need as much traditional public transport

For emerging market cities with limited public transport infrastructure, there may be scope for ride-hailing models in some form to play a role in the cities’ fundamental transport infrastructure. It is conceivable that if shared-car based transport became a prominent mode of travel, it might replace or suppress development in ‘traditional’ public transport systems such as bus or rail.
Apple has long been the subject of speculation that it is developing a car, within a workflow called ‘Project Titan’. The existence of the unofficial project appears largely irrefutable: Tesla CEO Elon Musk has described the project as an “open secret”. However, the project’s timeline, scope, and level of ambition have been the subject of significant debate in the press. For example, there is a lack of agreement on whether Apple is developing an Apple-branded car as a consumer product, or whether it is developing self-driving technologies to be ‘supplied’ to existing manufacturers (as its CarPlay infotainment suite is today).

Press reports also suggest that the company’s level of commitment to the project has fluctuated: initial stories in September 2015 (The Wall Street Journal) suggested Apple had assigned several hundred employees to vehicle development. One year later (September 2016), The New York Times reported that Apple was ‘rethinking’ its strategy on self-driving cars, and had laid off ‘dozens’ of employees.

While Apple has not officially announced the project, there is evidence of activity. Apple is now trialing its technology on roads in California, evidenced by its participation (as of April 2017) in California’s department of motor vehicles (DMV) autonomous vehicle tester program. In addition, late last year (November 2016) Steve Kenner, Apple’s director of Product Integrity, wrote a now-public letter to US car safety regulator NHTSA urging a loosening of the administrative burden around autonomous car testing. Apple invested $1 bn in Chinese ride-hailer Didi Chuxing in 2016, suggesting some interest in broader mobility concepts as distinct from the car as a pure consumer product.

Apple has also engaged in discussions regarding partnerships in technology and manufacturing. Discussions with German carmakers BMW and Daimler (separately) ended over disagreements over who would lead the projects, and who would own the data, according to Handelsblatt in April 2016. Apple also approached supercar builder and F1 team owner McLaren regarding its potential acquisition, according to the FT in September 2015. On the manufacturing front, FAZ (April 2017) claims that Apple will contract Magna Steyr (a subsidiary of Magna (MGA)) to build the vehicle.

In terms of timing, reports (The Information, July 2016) suggest a planned launch in 2021, pushed back from a previously planned 2020, highlighting the significant manufacturing and technological challenges involved in such a project.

Delivering mobility services via autonomous vehicles is a complex challenge being addressed on multiple fronts by various companies all along the value chain. Alphabet (Google) has long-established technology, but not yet a clearly disclosed vision of how to monetize it. Uber, various automotive manufacturers, tier 1 suppliers, and new entrants are all working in various forms towards bringing such services closer to reality.

**Alphabet: Technology front-runner**

- **Alphabet’s Waymo** project has so far driven more than 2 mn miles on road, mostly in California (plus 1 bn miles in simulation). The self-driving car project started in 2009 within Google and used various modified production cars; from 2014, it also trialed a fully self-driving vehicle with no driver controls.

- In 2016, the project was renamed Waymo and spun into a separate company that remains wholly owned by Alphabet, but with a **clearer mandate to monetize the technology**. Waymo has a stated target to release the first commercial driverless vehicle in 2020.

- Another Alphabet-owned company, Waze, has begun experimenting with service offerings, operating car-pooling trials in Israel and the San Francisco Bay area.
Uber: Entering the fray

- Uber is piloting an autonomous ride-hailing program in Pittsburgh (and next in Arizona). A driver remains in place in the test cars for legal reasons, but real customers have been offered (at present free) rides. Uber’s technology originated from Carnegie Mellon University, which has been conducting research into autonomous driving since the mid-1980s. Cars are currently speed-restricted to 35mph. Using the data gathered though its trial vehicles, Uber is seeking to build its own detailed urban maps.

Most of the largest OEMs are testing vehicles

- Most of the world’s largest automotive manufacturers (plus all premium automakers) are conducting self-driving car tests in some form. Levels of disclosure vary greatly, but one rare quantifiable measure of progress is the California ‘disengagement’ data: California requires any company road-testing autonomous cars to disclose times when test drivers had to manually intervene.

Exhibit 39: California autonomous road test data: Alphabet’s Waymo has reduced ‘disengagements’ to 0.2 per 1000 miles

<table>
<thead>
<tr>
<th>Company</th>
<th>Miles driven</th>
<th>Disengagements</th>
<th>per 1000 miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphabet</td>
<td>635,868</td>
<td>124</td>
<td>0.20</td>
</tr>
<tr>
<td>BMW</td>
<td>638</td>
<td>1</td>
<td>1.57</td>
</tr>
<tr>
<td>Ford</td>
<td>590</td>
<td>3</td>
<td>5.1</td>
</tr>
<tr>
<td>Nissan</td>
<td>4,099</td>
<td>28</td>
<td>6.8</td>
</tr>
<tr>
<td>GM - Cruise</td>
<td>9,776</td>
<td>181</td>
<td>18.5</td>
</tr>
<tr>
<td>Delphi (testing Audi)</td>
<td>3,125</td>
<td>178</td>
<td>57.0</td>
</tr>
<tr>
<td>Mercedes</td>
<td>673</td>
<td>153</td>
<td>227.3</td>
</tr>
<tr>
<td>Tesla</td>
<td>550</td>
<td>189</td>
<td>343.6</td>
</tr>
<tr>
<td>Bosch</td>
<td>983</td>
<td>1,442</td>
<td>1,466.9</td>
</tr>
</tbody>
</table>

Source: California Department of Motor Vehicles, Goldman Sachs Global Investment Research

- These data are only a snapshot as they refer to a limited (and not necessarily scalable) geographic area. However, Alphabet’s Waymo has c.8x fewer (0.2 per 1000 miles) disengagements per mile than the second placed company (BMW), reflecting the relative maturity (seven years-plus) of its research.

Other notable developments in driverless services

- In Singapore, NuTonomy (a MIT spin-off autonomous vehicle software startup company) has launched its electric self-driving cabs in Singapore Business Park as a controlled experiment (top speed 37 mph), but plans to roll out such vehicles on a commercial scale by 2019.

- China internet services company Baidu has conducted autonomous car tests on the roads of Wuzhen city in China. Joint research with BMW on self-driving cars ended in November 2016.

- Volvo’s self-driving cars project began in September 2016 in Gothenburg, with consumers involved in the trials. Volvo plans to expand the trial to London this year and a Chinese city at a later date.

Automotive tier 1 suppliers are conducting their own trials:

- Delphi is running a three-year trial using a small fleet of automated taxis (with drivers present for backup) in Singapore in conjunction with the local Land Transport Authority. It has been separately testing an automated prototype called ‘Road Runner’ in the US since 2016.

- Other technology-focused suppliers are building technical know-how: Bosch is testing systems in Germany, the US and Japan, and works with TomTom on mapping and Nvidia on artificial intelligence systems. Autoliv (via a 50-50 JV with Volvo Cars called Zenuity) targets delivering fully automated driver assist by 2021, and partial automation by 2019. Valeo and Continental are testing their own technology in self-driving prototypes.
Regional considerations  Cities ripe for disruption

- Introducing the GS Urban Mobility Change Matrix (p. 38)
- Push and pull forces at work: A case study in car ownership from Singapore (p. 42)
- Challenges and advantages of regulation from a ride hailer’s perspective (p. 40)
Regional variations in urban mobility

Ride hailing’s geographic limits are determined by drivers’ ability to earn a ‘reasonable’ wage. Why should ride hailers care about utilization when they take a cut of every trip and incur no costs when cars sit idle? The answer, we believe, is that drivers need to be able to make a living wage to be attracted to partner with ride hailers. Other important factors include spatial characteristics of the city, regulation, traffic and pollution.

No ride hailing without owner-drivers...

Low demand for ride hailing (i.e. low utilization) results in drivers failing to earn a living. Furthermore, since the drivers are responsible for ride-hailing’s fixed costs (vehicle depreciation, insurance, servicing), they are disproportionately financially exposed to the risk of declining demand. For these reasons, the ride-hailing companies are acutely aware that they cannot expand geographically without new drivers signing up. Our discussions with companies suggest that to this end, ride hailers target >70% utilization (vs. traditional taxi services typically achieving in the ballpark of 50%).

Ride hailers therefore must initially subsidize the service when expanding their geographic coverage, to be able to generate a customer base. These subsidies take different forms: in 2012, Uber in London (starting up in the city) reportedly (according to The Guardian) paid drivers an hourly flat rate to await forthcoming customer demand. By 2014, this had evolved into a driver incentive scheme (paying £1 ($1.3) per job). Today, Uber (and peers’) financial losses remain to a significant extent attributable to subsidies such as driver incentives and customer promotions, albeit with other cost headwinds also potentially at play. Uber made a $2.8 bn operating loss in 2016 (according to Bloomberg), with subsidies playing a significant role. According to The Information, Lyft lost $600 mn in 2016, of which $300 mn was spent on “sales and marketing”, which we believe largely comprises the cost of new driver (and rider) acquisition in the form of subsidies. Our discussions with ride hailers indicate that balancing driver hires with new customer acquisition is a significant ongoing challenge for management.

...and no owner-drivers without initial subsidies

We estimate global ride-hailing per-ride fares average c.$9 per ride globally, from which a driver, after costs, takes home c.45% (c.$4.2). At an average speed of 13.5mph (to reflect heavy central urban traffic), trip length of six miles, and 70% utilization, a driver could make c.1.6 trips – 1.6 x $4.2 = $6.8 per hour. This is low in the US/European context, but we estimate that 36% of 2016 ride-hailing revenues originated in China (where driver per-hour earnings are likely a fraction of the average level). Hourly rates may be double these in developed cities, especially when/where traffic flows more freely.

Utilization depends on demand density and ‘randomness’...

For ride hailing to be profitable: (1) a certain demand level is necessary; and (2) trips cannot all be in the same direction: a demand pattern involving repeatedly ferrying passengers from A to B (with no demand on the return journey) would not support the business model, as the maximum utilization would by definition be only 50%.
Exhibit 40: The world’s tier 1 and 2 cities
As ranked by absolute GDP (shown)
GS Urban Mobility Change Matrix

Our Urban Mobility Change Matrix attempts to quantitatively evaluate how (and why) cities’ mobility systems might change in the coming years. We divide the change drivers into push and pull factors: **push factors discourage private car use** and **pull factors encourage alternative mobility concepts**.

**Push factors** include pollution or poor air quality more broadly, heavy traffic, and the scope to push people away from cars and towards alternatives means of travel (specifically public transport).

Exhibit 41: Screening for cities where severe anti-car measures are likely

‘Push’ factors

Exhibit 42: Screening for cities willing to adopt new mobility services (e.g. ride hailing)

‘Pull’ factors

Pull factors mean alternative mobility concepts ‘make sense’: As a result, cities that are wealthy in terms of absolute GDP (generally by nature large, dense cities), and where car ownership is limited and cars are less utilized are more suitable for concepts such as ride hailing. Note that regulation is another highly influential factor, which we deliberately leave out of this analysis to enable cleaner quantitative comparisons among cities. Our findings are summarized in Exhibit 43.

Many Asian cities are ‘ready for disruption’: We categorize cities such as Tokyo, Shanghai and Hong Kong as ‘ready for disruption’ on account of the high likelihood (in many cases already firmly in motion) of regulatory pressure on the private car – in addition to these cities having other characteristics that make them suitable for ride hailing. The ‘willing adopters’ quadrant contains several cities where ride hailers have already gained traction, e.g. San Francisco, Los Angeles and New York, but where regulatory pressure to limit car use seems relatively benign. The ‘suffocated by cars’ group is characterized predominantly by emerging market cities where the growth in car use has begun to have significant negative impacts on the population. Cities classed as ‘car-oriented’ are most likely to have, and to continue to have, high levels of private car usage. Many relatively low-density US cities feature in this quadrant.
Exhibit 43: Push and pull factors determine which cities are likely to experience the greatest disruption

Low population density hampers business case

Dense, wealthy cities with highly varied trip purposes (leisure, shopping, personal, etc.) support these kinds of random demand patterns best. In these same cities, however, car ownership frequently faces additional regulatory costs (e.g. taxes and other costs aimed at limiting pollution and traffic). Conversely, outside cities, ride-hailing services are less likely to achieve threshold utilization levels.

Is there a minimum city density?

Although it stands to reason that dense areas are best for ride hailing, it is much harder to figure out exactly where the requisite density threshold level lies to make such services profitable. Indeed, many other variables (traffic speeds, predictability of travel patterns, when the journeys occur etc.) weigh into the equation. We assume for modeling purposes that 80% of the world’s ride-hailing revenue is generated within tier 1 and 2 cities. If ride-hailing services are better able to adapt to the next tier of cities, and to lower population densities more broadly, then the impact of ride-sharing might be broader geographically and larger in magnitude than the assumptions in this report.
Ride hailers are already firmly on regulators’ radar
Ride-hailing companies (especially Uber) have in recent years come under scrutiny from local regulators, notably concerning: (1) the employment status/workforce rights of drivers; (2) the extent of applicability of traditional taxi regulations; (3) in China, the banning of rural migrants as drivers; and (4) more recently, the legality of autonomous vehicle tests. The rapid growth of such services makes further such challenges likely, potentially posing risks to the business case.

Governments have the power to halt the business. Ride hailers cannot operate without the agreement of local authorities, and we must recognize regulatory risk as an important growth consideration. This is evidenced in many Asian countries by the significant restrictions and fines governments have imposed on ride-hailing services, notably Uber. In Hong Kong, for example, strict driver controls have limited operations (Reuters, March 2017), and in Denmark (BBC, March 2017) Uber is closing operations altogether.

Regulatory risks intensify with greater usage. There are many factors that could trigger greater regulatory scrutiny for ride hailing. Notably, increased adoption (if not immediately accompanied by lower private car use) might worsen traffic. A likely response is higher taxes in some form. Many cities are already experimenting with dynamic road pricing (see our vignette on Singapore on page 42) or other congestion charging schemes, which are likely to be employed aggressively if autonomous cars suddenly exacerbate traffic problems.

However, regulations can work to ride hailers’ benefit too
Private cars, particularly in advanced economies, are seen in many cities as a problem on some level. In developed markets (and increasingly also in developing markets), city planners are deprioritizing cars relative to pedestrians, cyclists, and other transport modes. Deprioritization here in effect means: (1) limited road building; and (2) higher costs of car ownership (e.g. road tolls, zoning charges, alternate day travel schemes, additional costs for urban license plates, and elevated parking charges). Traffic and pollution are the key rationales here (Exhibit 44 shows the biggest problem cities).

Exhibit 44: We rank the top 20 cities on pollution and traffic levels, as well as availability of good public transport
An index for likelihood of imposition of car restrictions

<table>
<thead>
<tr>
<th>Highest pollution</th>
<th>Top 20 cities ranking on key metrics</th>
<th>Good public transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest traffic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Riyadh</td>
<td>1 Mexico City</td>
<td>1 Hong Kong</td>
</tr>
<tr>
<td>2 Shijiazhuang</td>
<td>2 Bangkok</td>
<td>2 Seoul-Incheon</td>
</tr>
<tr>
<td>3 Delhi</td>
<td>3 Chongqing</td>
<td>3 Bogota</td>
</tr>
<tr>
<td>4 Kuwait</td>
<td>4 Shenzhen</td>
<td>4 Milan</td>
</tr>
<tr>
<td>5 Xi’an</td>
<td>5 Guangzhou-Foshan</td>
<td>5 Monterrey</td>
</tr>
<tr>
<td>6 Zhengzhou</td>
<td>6 Cairo</td>
<td>6 Cairo</td>
</tr>
<tr>
<td>7 Cairo</td>
<td>7 Chongdu</td>
<td>7 Mexico City</td>
</tr>
<tr>
<td>8 Tangshan</td>
<td>8 Delhi</td>
<td>8 Guangzhou-Foshan</td>
</tr>
<tr>
<td>9 Jinan</td>
<td>9 Jakarta</td>
<td>9 Rio de Janeiro</td>
</tr>
<tr>
<td>10 Tianjin</td>
<td>10 Fuzhou</td>
<td>10 Tokyo</td>
</tr>
</tbody>
</table>

Source: Goldman Sachs Global Investment Research.

‘Electric’ ride hailing may be regarded more favorably. In addition to traffic, pollution has become a significant urban health issue. Cities are responding by encouraging electric cars through preferential tax treatment, infrastructure or even incentives on purchase prices. Internal combustion engine cars (and diesel cars in particular) are facing intensifying regulatory obstacles.

Ride hailing could free up city space. The land area allocated to parking can sometimes exceed the space allocated to roads themselves. In Los Angeles County (according to JAPA), the ratio of parking land to road area is 1.4x, and 14% of the land area is allocated to parking. There is therefore scope for parking land in cities to be repurposed, with planners envisioning additional green space, cycle lanes, or pedestrian areas as options. Such land use changes would likely be possible only if: (1) ride hailing can reduce car ownership; and (2) shared vehicles are stored elsewhere when not in use.
Regional ride-hailing champions emerging

The ride-hailing business model is dependent on scale, for which substantial investment is a requisite. Building up a population of owner-drivers that is: (1) right-sized to customer demand in the region; and (2) confident of sufficient work to earn their required wage is a costly process. Uber pulled out of China in 2016 (having incurred regional expansion costs peaking at $1 bn a year), selling its operations to Didi. We believe that ride hailers will continue to develop into regional champions as market participants approach aggressively competitive markets with continued caution. Continental Europe remains a largely open market opportunity, mainly because of the aforementioned regulatory hurdles limiting opportunities to date in selected countries.

5G infrastructure plays an enabling role

We expect 5G networks to play a meaningful role as a technological enabler for autonomous vehicles. While L2 vehicles currently in production largely rely on sensors within the vehicle, our Tech analysts have previously argued that wireless connectivity will be an important element of technology underpinning fully autonomous vehicles.

For instance, V2V connectivity will be relevant for autonomous driving. While the processing of data from sensors on the vehicle itself can facilitate autonomy, V2V can add an extra layer of robustness such that regulators have enough confidence to allow L4/L5 driving. In this context, vehicles would need to gather information from other cars and make informed decisions quickly. This demands extremely reliable communication systems given that human safety is involved and owing to the exacting failure rate requirements of automotive grade technology. We note that Nokia sees end-to-end latency requirements in this context as being as low as 5-10ms. As a result, the improved latency qualities of 5G base stations (as opposed to those of 4G ones) will be required.

Further, in line with our colleagues’ thesis, real-time mapping will be an important component of autonomous driving. While again, a car could in theory operate autonomously solely based on a sensor array and intelligent processing of the generated data on the car, frequently updated maps of key road features (crowdsourced from consumers’ cars) will add extra needed reliability. This means that vehicles will be generating significant amounts of data that will be sent to the cloud to be processed and integrated into a constantly evolving granular map, and will also need to receive mapping data frequently so that the car can react in a new driving scene. While the bandwidth of data transfer required can vary with different approaches to mapping (i.e. 2D vs. 3D maps), we see 5G as a key enabler for autonomous driving given faster speeds (c.600x faster than LTE) and ultra-low latency features.

Finally, we also expect 5G to enable OTA (over-the-air) software and firmware updates in cars (Cloud-to-Car connectivity), which could be pivotal for autonomous driving from a security perspective (with updates potentially occurring with relatively high frequency). Given recent hacking incidents, we expect an intense focus on the ability to dynamically upgrade the car to protect against threats.

Under the ground or into the air

The tech sector is evaluating mobility-oriented ideas significantly more radical than ride hailing. Small vehicles that can take off vertically in urban environments are an old idea gaining renewed traction: Airbus plans to begin testing a self-piloted flying vehicle during 2017, with the idea that this could be used in urban hailing scenarios. Uber is also exploring flying vehicles, and plans to give an ‘urban aviation ecosystem’ demo by 2020 (in partnership with the cities of Dallas and Dubai). Meanwhile Tesla CEO Elon Musk has established a tunneling business (‘The Boring Company’) and presented a concept for an underground network of tunnels that carry cars on electrified trailers on rails.
Singapore: Private cars in the firing line

Singapore in some ways offers a potential glimpse into the future of our relationship with the car in cities. Car ownership is heavily discouraged via taxes, road use is charged electronically, and the government encourages other modes of travel, notably public transport. Singapore is among the top 10 wealthiest countries globally, with a per capita GDP of $52.9k (2015) while also being the third most densely populated country in the world (Exhibit 46). Densely populated cities tend to have relatively low car penetration, and as a city state, Singapore has 170 cars per 1,000 people (an extremely low level among developed markets). Cars are heavily regulated and therefore expensive. The cost of owning a private car in Singapore can be up to 5-6 times higher than in other countries owing to taxes and other costs. The three additional levies on car purchases are: (1) Additional Registration Fee (ARF), a registration tax that is higher for more expensive cars (100% of the base selling price for the first S$20k ($14.3k), rising to 180% over the S$50k threshold ($35.7k)); (2) excise duty and sales tax, of 20% and 7% respectively on the base price; and (3) certificate of entitlement, in effect the legal ‘right’ to own a car. These are limited (effectively capping car ownership) and are bought through an online auction system.

Exhibit 45: Singapore has relatively low car penetration... GDP per capita vs. car penetration

Source: Company data, Goldman Sachs Global Investment Research.

Singapore’s total car population shrank to a five-year low in 2015 (six-year low excluding growth in rental cars), reversing a decade-long trend. Short-term car rentals have grown as constraints on car ownership have increased.

Exhibit 47: Below-average spend on mobility

Source: Haver, Goldman Sachs Global Investment Research.

Singapore has a system of Electronic Road Pricing (ERP) aimed at combating congestion. There are c.80 gantries placed at key locations in the city, and vehicles pay tolls when passing through. The busiest routes are priced higher (up to S$6; US$4.3) with maximum charges during the busiest times and free passage for many gantries during non-rush hours. Tolls are levied automatically and remotely via mandatory in-vehicle sensors. Public transport is an attractive alternative for commute as it is c.80% cheaper to travel via bus, rail or taxis relative to a private vehicle. Singapore has one of the most cost-efficient public transport networks globally; as many as 5.4 mn trips are made per day on the country’s public transport system, with c.60% of the population using at least one mode of public transport daily.

Exhibit 48: The motor vehicle population declined in 2015

Source: Department of Statistics Singapore.
Car market impact  Ownership to survive, sales to hold firm

- Understanding the high-turnover model for ride-sharing vehicles (p. 44)
- Emerging market considerations: Ownership still the goal (p. 46)
- Developed market considerations: Ownership and sharing aren’t substitutes (p. 47)
Ride-hailing impact on private car ownership

We expect car sales to hold up well relative to the number of cars on the road owing to the significantly faster (by 3.5x) replacement rate of shared vs. private cars. Note that for modeling purposes, we keep the private car replacement rate and the private car utilization rate both constant. Since the changes we discuss are primarily big-city in nature, the overall impact on the global fleet and parc will likely be quite muted.

2030: Cars on the road peaking…but sales holding firm

Our base case assumes that total car sales in tier 1 and 2 cities rise slightly by 2030, from 21 mn to 23 mn, driven by increased demand for shared cars. Across all three scenarios that we consider, we assume urban car sales volumes are resilient, but with a pronounced mix shift towards ride-hailing cars.

For new car sales volumes, we estimate the replacement rate of ride-hailing cars is 3.5x faster than that of private cars (i.e. the ride-hailing fleet turns over around every four years, vs. the private fleet’s c.14 years). This difference in velocity is due to the higher utilization of shared (23k annual miles) vs. private cars (5.9k), and is in spite of our assuming a 1.5x higher scrappage mileage for shared cars (234k miles) vs. private (156k).

Assumptions: Modelling the car sales and fleet in cities

Car sales volumes depend on: (1) the size of the required fleet; and (2) the replacement rate (i.e. the proportion of the fleet replaced by new cars each year). The required fleet in turn depends on: (1) the mobility demand to be met by car; and (2) the average utilization rate of cars.

For the purposes of our analysis, we keep the private car replacement rate and the private car utilization rate both constant. In other words, we assume that the number of private cars bought and on the roads changes in proportion with changing use. Note that in our base case, private car sales and the private car fleet remain flat over 2016-30.
We may cling onto our own cars while driving them less

We recognize the risk that the number of cars on the road could decline slower than modelled above. Assuming flat private car utilization allows us to retain a degree of modelling simplicity. In reality, the risks to urban car utilization are likely skewed to the downside. This is fundamentally because adoption of ride hailing will likely increase faster than consumers become willing to relinquish car ownership, which in turn means that cars in cities will (at least in the medium term) sit idle for longer.

The allure of car ownership in developed markets, especially to the young, is not what it was. While car penetration has held up, utilization is declining and fewer young people are obtaining driving licenses. However, it does not necessarily follow that existing car owners will be willing to give up owning cars.

The future trajectory of car ownership is a topic of lively debate. The argument that car ownership might decline is supported by data in developed markets showing: (1) US car utilization is in decline (Exhibit 56); i.e. while car ownership remains high, people are using cars less; and (2) evidence that younger people are less car-dependent, e.g. a steady fall in the proportion of drivers’ licenses that are held by young people (notably those under 24 years old), as shown in Exhibit 57.
Evidence of willingness to relinquish cars is limited. For us to expect a significant decline in car ownership, we would need to see widespread evidence that car owners are willing to give up car ownership. We have yet to see this (although this could be partly due to limited data availability, especially outside the US).

Desire to own a car is still strong in developing markets. While car sales in developed markets are growing at slower rates (and in some cases declining), car ownership in emerging markets remains aspirational and continues to grow. Car penetration in China, for example, is still 12% and increasing as cars become affordable to a growing number of people, as the middle classes continue to expand.
Private car penetration to decline but not collapse

Many elements of car ownership (status, true on-demand availability, privacy) are non-substitutable. This means that many car owners will see ride hailing as a supplement to (rather than a substitute for) their own cars. We thus forecast car penetration declining but not collapsing, from 31% in 2015 to 27% in 2030. Regional variations are important: car penetration is stable in developed markets but has a long way to rise in China and emerging markets, on our estimates.

The purchase decision is separate from the usage decision. The decision to use a ride-hailing service has little to do with whether one owns a car or not. We believe car owners are likely to weigh up the benefits (speed, cost, convenience) of going by car vs. ride hailing (or indeed public transport) on a case-by-case basis.

Elements of car ownership are non-substitutable, including: (1) status (i.e. social status conferred by owning the asset); (2) immediate guaranteed availability (as distinct from ride hailing or car sharing, where availability is not guaranteed); (3) privacy (the sense of having one’s own space); and (4) familiarity (the ability to store personal effects and fit special equipment like child seats or sports equipment carriers).

For most car owners, ride hailing will be a supplementary service. Since car ownership cannot be fully substituted, in the medium term, we believe ride hailing will be an add-on to car ownership rather than replacing it. As a result, our base case assumes that the global urban private car utilization rate remains unchanged at c.5% to 2030, and that urban car penetration (i.e. private car ownership per capita) declines but does not collapse, from 31% in 2015 to 27% in 2030. This mild decline would likely reflect lower penetration in developed markets, partly offset by continued penetration growth in China and emerging markets.

Exhibit 58: Car penetration depends on the available fleet
Private car penetration calculation

Exhibit 59: We expect private car penetration to decline but not collapse by 2030
Private car penetration rate, tier 1 and 2 cities

Source: Goldman Sachs Global Investment Research.
Relationship with cars varies substantially across regions. Car penetration (i.e. cars per capita) is **stable at a high level** (90%; Exhibit 60) in North America, owing to a combination of well-developed roads, low population density, limited rail infrastructure and low car running costs. In China (as with other growth markets), car penetration is **low but increasing rapidly** (Exhibit 61).

**Exhibit 60: N. America has the highest car penetration, while China has the lowest**

Private car penetration (total and urban-only)

<table>
<thead>
<tr>
<th>Region</th>
<th>Total</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. America</td>
<td>90%</td>
<td>74%</td>
</tr>
<tr>
<td>Europe</td>
<td>67%</td>
<td>53%</td>
</tr>
<tr>
<td>Asia ex-China</td>
<td>36%</td>
<td>35%</td>
</tr>
<tr>
<td>L. Am</td>
<td>34%</td>
<td>18%</td>
</tr>
<tr>
<td>China</td>
<td>19%</td>
<td>12%</td>
</tr>
</tbody>
</table>

**Exhibit 61: China car ownership still has significant scope to increase**

Private car penetration rate, US and China

Source: Goldman Sachs Global Investment Research, Euromonitor.
Sizing the ride-hailing market: Further thoughts

We estimate the ride-hailing market could generate $285 bn in gross revenues by 2030, equating to $65 bn in net revenues to the ride hailers. Uber’s most recent fund raises have been at an implied whole company valuation of $68 bn (source: The Guardian, August 2, 2016).

We assume constant fares and constant commissions

We assume that the average number of passengers per car ride remains stable at the current level of 1.5. We keep the ride fare of c.$9.0 constant (based on the available 2016 revenue estimates of global ride hailers and tier 1 and 2 cities’ trip demand) to calculate the ride-hailing gross revenues. We keep ride-hailing commissions fixed at current levels (we assume 23%) to reflect a stable pricing environment for ride hailers (and as such implicitly stable pricing power over owner-drivers).

Cross-checks on our core assumptions

Our forecast that 4% of cities’ vehicle travel (trips) will be conducted via ride-hailing services in 2030 implies that in the tier 1 and 2 cities combined: (1) private car penetration declines from 31% in 2015 to 27% in 2030; (2) one in fourteen cars produced would be for the use of car-hailing services (7% of total car production vs. 3% currently); (3) ride-hailing cars account for 2% of the overall fleet by 2030 (vs. 0.3%) today; and ride-hailer segment net revenues increase 6.5x from the current level (to c.$65 bn from $10 bn).

Using Uber and tech peer comparators as a cross-check for market growth

Disclosure of ride hailers’ financials is limited. Press reports (The Guardian, August 2, 2016) suggest that Uber’s most recent fund raises have been at an implied whole company valuation of $68 bn. Further reports (Techcrunch, December 21, 2016 and Bloomberg, December 19, 2016) suggest Uber generated net revenues of $2.0 bn in 2015 and $6.5 bn in 2016. Uber’s fastest growing tech peers (chosen on the basis of: (1) being covered by Goldman Sachs; and (2) having annual sales growth exceeding 25% on our colleagues’ 2016-18 estimates) trade at 6.1x 2018E sales (using market cap/sales).

Based on this data, we can cross-check our ride-hailing growth assumptions for the market using Uber as a proxy. For illustrative purposes, assuming that Uber was valued at the same 2018E market cap/sales multiple as this group of tech peers and solving for 2018 revenues implies that Uber would need to grow revenues from the reported 2016 level of $6.5 bn at 40% per year to $12.8 bn in 2018. We emphasize that we take no view on Uber’s ability to achieve this. We also (in using market cap/sales) take no view on Uber’s net debt position.
Electrification is not a factor in our modelling

Car manufacturers are accelerating development of electric vehicles in recognition of increasing consumer appetite for such vehicles, as well as regulatory pressure to reduce emissions from fossil fuel combustion. It is highly likely that electric cars will feature heavily in the emerging urban mobility systems discussed in this report. However, in the interests of simplicity, we assume no change in fuel ($0.15 per mile) or maintenance costs in our modelling. Electrification is ultimately likely to reduce per-mile running costs.

We also (again, for simplicity) assume no change in insurance costs: The evolution of insurance costs is a topic of debate. On one hand, additional vehicle content (e.g. sensors) might increase premiums. Against this, active safety features and autonomous crash avoidance are likely to reduce the incidence of collisions.

Our analysis is intended as an illustrative framework to help conceptually quantify developments in mobility. We do not attempt to provide comprehensive coverage of the possible variables.

Core modeling assumptions in our base case scenario:

- Individuals’ mobility demand (i.e. trips per capita) remains at current levels, with total mobility demand thus growing in line with population growth.
- Trip length and timing (i.e. peaks and troughs) remain unchanged.
- Public transport usage grows in line with population growth (and the share of mobility demand met by public transport remains unchanged).
- We make no attempt to ‘rebalance’ the composition of tier 1, 2, 3 and 4 cities in future years.
- We assume no change in urban traffic speeds.
- We assume no change in fuel and maintenance costs.

---

**Exhibit 64: Technology peers’ key financials**

Local currency, mn

<table>
<thead>
<tr>
<th>FX</th>
<th>Revenues 2016</th>
<th>Revenues 2018</th>
<th>CAGR 2016/18</th>
<th>Market cap 2018</th>
<th>M.cap/sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shopify Inc.</td>
<td>$389</td>
<td>$950</td>
<td>56%</td>
<td>$8,988</td>
<td>9.5</td>
</tr>
<tr>
<td>Trivago N.V.</td>
<td>$754</td>
<td>$1,627</td>
<td>47%</td>
<td>$6,077</td>
<td>3.7</td>
</tr>
<tr>
<td>Mobileye NV</td>
<td>$358</td>
<td>$722</td>
<td>42%</td>
<td>$14,645</td>
<td>20.3</td>
</tr>
<tr>
<td>NetEase Inc.</td>
<td>$38,179</td>
<td>$70,375</td>
<td>36%</td>
<td>$262,358</td>
<td>3.7</td>
</tr>
<tr>
<td>HTC Corp.</td>
<td>$78,161</td>
<td>$147,117</td>
<td>37%</td>
<td>$58,075</td>
<td>0.4</td>
</tr>
<tr>
<td>Twilio</td>
<td>$277</td>
<td>$483</td>
<td>32%</td>
<td>$2,111</td>
<td>4.4</td>
</tr>
<tr>
<td>Talend SA</td>
<td>$106</td>
<td>$190</td>
<td>34%</td>
<td>$1,004</td>
<td>5.3</td>
</tr>
<tr>
<td>HubSpot Inc.</td>
<td>$271</td>
<td>$453</td>
<td>29%</td>
<td>$2,800</td>
<td>6.2</td>
</tr>
<tr>
<td>Mimecast Ltd.</td>
<td>$175</td>
<td>$289</td>
<td>28%</td>
<td>$1,559</td>
<td>5.4</td>
</tr>
<tr>
<td>RingCentral</td>
<td>$360</td>
<td>$613</td>
<td>27%</td>
<td>$2,692</td>
<td>4.4</td>
</tr>
<tr>
<td>Wirecard</td>
<td>$1,028</td>
<td>$1,664</td>
<td>27%</td>
<td>$7,049</td>
<td>4.2</td>
</tr>
<tr>
<td>Arista Networks Inc.</td>
<td>$1,129</td>
<td>$1,771</td>
<td>25%</td>
<td>$11,168</td>
<td>6.3</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>35%</strong></td>
<td><strong>6.1</strong></td>
</tr>
</tbody>
</table>

Source: Company data, Goldman Sachs Global Investment Research.

---

**Exhibit 65: Illustrative analysis: Uber would need to generate a 31% revenue CAGR to 2018 to trade at a similar multiple to tech peers**

$ bn

<table>
<thead>
<tr>
<th></th>
<th>2018E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uber equity value</td>
<td>$68.0</td>
</tr>
<tr>
<td>Peer group market cap/sales (2018E)</td>
<td>6.1</td>
</tr>
<tr>
<td>Implied Uber net revenue (2018E)</td>
<td>11.1</td>
</tr>
<tr>
<td>Uber net revenue</td>
<td>11.1</td>
</tr>
<tr>
<td>% yoy</td>
<td>31%</td>
</tr>
<tr>
<td>Required revenue CAGR to equal peers’ valuation</td>
<td>31%</td>
</tr>
<tr>
<td>GS estimated ride hailing industry revenue</td>
<td>$49.3</td>
</tr>
<tr>
<td>Uber market share</td>
<td>65%</td>
</tr>
<tr>
<td>Uber revenues 2018E CAGR</td>
<td>31.9</td>
</tr>
</tbody>
</table>

Enablers of the ride-hailing revolution

- Private companies in focus: Uber and Didi (pp. 56-7)
- How rental car companies are getting into the game (p. 58-9)
BMW (BMWG.DE): Gearing up for iNEXT

**What is BMW doing in mobility?**
BMW's mobility offerings are centered on its DriveNow and ReachNow services. DriveNow is primarily a free-floating car-sharing platform, operating in 11 European cities (of which five are in Germany). ReachNow is US-based and adds the ability to book rides (i.e. cars with a driver), as well as for car owners to rent out their cars (Airbnb style) to others. BMW also says its iNEXT model (due 2021) will be the ‘basis’ for fleets of fully autonomous cars, although the vehicle (incorporating tech from BMW’s Mobileye/Intel partnership) will be partially rather than wholly self-driving.

**Why does it matter?**
Post disappointing demand for its i3 electric car (launched in 2013), BMW's approach to both electrification and mobility services now seems more circumspect. That said, BMW operates a breadth of service offerings that prepare it for potential changes to its end markets. In addition, the company runs a venture fund, BMW i Ventures, to which BMW has allocated €500 mn, and which has focused on smaller investments in electric mobility and mobility services, including EV charging network ChargePoint and public transport aggregator Moovit.

Daimler (DAIg.DE): Balancing breadth with focus

**What is Daimler doing in mobility?**
Daimler has arguably invested more broadly across the mobility value chain than any other OEM. Its subsidiary Moovel is an ‘aggregator’ platform for mobility services, born of a 2014 acquisition, RideScout. Daimler also owns several ‘optimizer’ service platforms, most notably MyTaxi, a Germany-based taxi booking service, but also car2Go (car sharing). The company also owns a stake in Blacklane (chauffeur service) and Croove (Airbnb style peer-to-peer car sharing). Its fleet management operations (enlarged post the €1.1 bn/$1.2 bn acquisition of Athlon in 2016) include lease management and financing (via its financial services division) businesses. In addition, Daimler’s 2017 agreement with Uber paves the way for Daimler to provide autonomous cars to sharing fleets in the coming years.

**Why does it matter?**
With all OEMs grappling with how mobility will affect their business model, Daimler is pursuing a breadth of options. In the broader business context, Daimler defines four future fields under the acronym CASE (‘Connected’, ‘Autonomous’, ‘Shared & Service’, and ‘Electric Drive’), which all feed into its vision of future mobility. For the Shared & Service portion at least, Daimler is likely to remain in investing mode in the medium term.
Ford (F): Smart mobility beginning with Chariot

What is Ford doing in mobility?
Through its Ford Smart Mobility subsidiary, Ford is focusing on building out future mobility business models, both organically and through acquisitions, that can exist both pre- and post-autonomous vehicles. To date, the company has acquired Chariot, an on-demand shuttle service, and has increased its internal data and analytics team to build out fleet management capabilities, as well as transportation as a service (TaaS) offerings, including digital services. Ford is aiming to package these services together and sell solutions to/collaborate with cities, which the company believes will be the center choke point for transportation in the future as the world population becomes more urbanized. Further, we believe the recent change in CEO signals a significant change in culture and strategy at Ford, where the company will look to accelerate the pace of adoption and clock-speed of the implementation of new data analytics, AI, 3D printing, etc., to optimize the business as well as its broader mobility offering.

Why does it matter?
The company has made a clear pivot to future mobility business models given the much larger global addressable market for transportation as a service; in this market, Ford not only sees itself as an integral partner through offering higher-value-added services, but as a potentially more valuable asset given that it expects to achieve 20%+ EBIT margins from its new business models over time. In addition, the company has made a strategic investment in Argo AI, which is working on developing the virtual driver system for SAE level 4 self-driving vehicles.

GM (GM): Taking services seriously: Lyft among key partners

What is GM doing in mobility?
GM has focused on building car-sharing services internally, while partnering externally with Lyft (where it has a strategic investment) for shared mobility. Among others, the company has launched two car-sharing services: Maven, an app-based service that allows on-demand short-term rentals; and BOOK, a monthly subscription service that allows customers to drive any available Cadillac model. GM has also made a $500 mn strategic investment in ride-hailing service Lyft, and has offered short-term rentals to Lyft drivers called Express Drive. Over time, the company plans to turn this partnership into a fleet-rental service. In addition, in May 2017, Lyft and Waymo entered a deal to collaborate on self-driving technology, although GM’s role was left uncertain.

Why does it matter?
The company is investing in ancillary revenue streams related to mobility, and is primarily targeting already proven business models akin to ZipCar. GM’s largest strategic move was the acquisition of Cruise Automation in May 2016, which sped up its autonomous vehicle development. On that front, the company has made it clear that it believes its future mobility businesses will be largely dependent on its ability to launch a mass-produced autonomous vehicle, and that its strategy will hinge on producing a market-leading safe AV that will drive customer acceptance. In that vein, the company is testing a self-driving fleet of its all-electric Chevy Bolt as its foray into autonomous mobility.
Tesla Inc. (TSLA): Pushing on with self-driving

What is Tesla doing in mobility?
Tesla has announced its ambition to create a ride-sharing network called the Tesla Network to capitalize on its upcoming self-driving technology. Tesla owners with the fully autonomous software package will purportedly be able to offer their cars for short-term rentals in a self-driving fleet. In addition, the company could also deploy vehicles that come back off-lease in its own fleet, at a time when the vehicle depreciation math makes more sense for a ride-share vehicle. The company has not provided a timeline on the eventual rollout of the service, but we believe it is likely to be offered at the time of the “Full-Self Driving” software update. On that front, the company has a growing number of vehicles racking up miles out on the road with its hardware 2.0 package that should be collecting a run-rate of 1.5 bn miles by year-end 2017 on our volume estimates. For details, refer to Model 3 is all that matters, NDR meeting takeaways, May 15, 2017.

Why does it matter?
The company is doubling-down on its proprietary approach to mobility and autonomous vehicles, similar to other OEMs. However, Tesla is unusual in that it is vertically integrating the vehicle production, autonomous technology, and ride-sharing network, whereas other OEMs have partners and investments, and/or have made acquisitions to gain access to autonomous vehicle technology. Further, in a mobility world dependent on miles and connectivity, Tesla is somewhat differentiated in that: (1) it has outfitted its vehicles with hardware that it believes is capable of fully autonomous driving (although recently, the company mentioned that it has not fully written off LIDAR); (2) those vehicles are customer-owned and collecting data for its autopilot software (vs. OEMs running their own fleets to collect data); and (3) its vehicles are fully over-the-air update capable.

Toyota (7203.T): Mobility Services Platform building broad ties

What is Toyota doing in mobility?
Toyota established the TMSP (Toyota Mobility Services Platform) in 2016, with an aim of openly connecting various companies and service providers on the MSP. The platform includes various features such as the Smart Key Box, flexible leases, telematics insurance, use of traffic information and management of fleet vehicles. In the field of car sharing, Toyota has already announced collaborations with Uber and Getaround, and has plans to invest $1 bn over five years in artificial intelligence research at the recently established Toyota Research Institute (TRI). Other plans include joint work with the NTT group to collect, amass and analyze data to make the world of connected cars a reality. In this way, Toyota is moving to establish a wide array of business models across various vehicle-related fields.

Why does it matter?
Toyota’s fundamental belief is that, unlike consumer electronics, vehicles have a direct connection with people’s lives. However, given the limits to which Toyota can handle the increasingly diverse array of car services by itself, it places value on the creation of partnerships. As a car company, Toyota is focusing attention on dealing with shorter replacement cycles in future, bolstering after-sale services, and, above all, developing vehicles with outstanding levels of durability as the number of vehicles on the road increases. However, in order to be more than a pure car sales company, it will likely seek to rebuild ties with insurance, car-sharing and telecoms companies. From an earnings perspective, we could see Toyota leveraging its significant number of cars on the road to deliver big data and offer advertising services delivered into the car (on the premise that it can be done safely), rather than merely supplying devices with which to use new telecom services.
Volkswagen (VOWG_p.DE): MOIA unit playing on various fronts

What is Volkswagen doing in mobility?
Following the diesel scandal, Volkswagen has accelerated its efforts in new mobility solutions. Through its recently established urban mobility business unit MOIA, it plans to develop and market its own mobility services. VW’s partnerships with the ride-hailing services Gett (May 2016) and Didi (November 2016) mark the first entry point towards exploiting the potential of the fast-growing ride-hailing taxi market. In the mass transit segment, VW is developing an app-based shuttle service for urban cities, combining the features of regular city bus and shared taxis. In electric mobility, VW plans to launch more than ten electric vehicle models by end-2018 and over 30 new battery electric vehicles (BEVs) by 2025. In the field of automation, VW targets building its own self-driving system to start series production by as early as 2021.

Why does it matter?
Volkswagen plans to expand its ride-hailing business organically and via partnerships. In 2017, VW intends to boost growth at Gett in the UK, Russia, Israel and the US, and also enter the new markets of Germany, Spain, France and Italy. In China, in addition to Didi, VW has collaborated with GoFun on car sharing (one of China’s biggest car-sharing companies), and Shouqi Group on car leasing. On mass mobility in Europe, VW’s aim is to expand its shuttle services to > 20 European cities by 2021, and eventually deploy autonomous driverless fleets by 2025. On electrification, VW’s targets that 20%-25% of group sales will be electric vehicles in 2025, and in China alone, c.1.5 mn cars sold will be NEVs (mostly electric) in the same year. On automation, VW expects to bring the first self-driving cars without steering or pedals on road by early next decade.

Delphi (DLPH): AV research includes self-driving pilot programs

What is Delphi doing in mobility?
Delphi currently operates a ride-hailing service to showcase its technology and test autonomous architecture in a real-world application. Currently, the service operates a pilot fleet of six self-driving vehicles in Singapore, which are monitored by staff members and shuttle passengers to and from mass transit stations. However, in the coming year, DLPH intends to extend the pilot program to cities in Europe and the US. In addition to using DLPH’s sensors and radar, the autonomous system is developed in conjunction with Mobileye, which provides the obstacle detection software, and Intel, which produces chips. DLPH is aiming to remove the staff monitors by 2019 and launch the driverless service commercially by 2022. DLPH is also in collaboration with these suppliers and BMW to bring solutions for highly and fully automated driving into series production by 2021.

Why does it matter?
As AV technology moves from the R&D phase to validation in the coming years, there is increased pressure on companies to be first to market and on suppliers to establish leadership in this area. Ride-hailing services as opposed to individual ownership offer a good fit for early driverless car technologies as fleets can stay within specific parameters, trained driver monitors can be used in the interim, and fleet operators can perform daily maintenance and monitor the early technology. DLPH’s early participation in ride hailing gives it the opportunity to test and showcase its turnkey technology and capabilities as a systems integrator for future adoption.
Didi Chuxing (privately held): Leading in China

What is Didi doing in mobility?
Didi is the largest ride-hailing service in China (#2 globally), with annual revenues of c.$3 bn (2016 vs. Uber $6.5 bn, according to press reports), servicing > 300 mn users in over 400 Chinese cities, with average daily rides of 6.6 mn (as of December 2016). Didi’s scale of operations is 5x-6x bigger than competitors, and its service portfolio includes taxi-hailing, ride-sharing, private car-hailing, designated driver (Didi Chauffeur), car rental, and enterprise solution and bus services. Didi is backed by investment from the biggest internet giants Tencent ($15 mn in April 2013), Alibaba (unknown, June 2016) and Apple ($4.5 bn in June 2016). To date, it has raised c.$16 bn in 11 rounds of funding, including a significant $5.5 bn investment in April 2017 (investors include SoftBank, China Merchants Bank Co. and Bank of Communications Co.) at a valuation of $44.5 bn, to grow internationally and work on autonomous driving.

To expand its scale in China, Didi acquired Uber China in August 2016 in a $35 bn deal. It also has a long-term strategic partnership with Volkswagen China in the ride-hailing segment. Further endeavors to broaden its geographical footprint led Didi to invest in regional ride-hailing leaders Lyft (#2 in US, $100 mn investment), Ola (#1 in India), Grab (#1 in Singapore), and 99Taxis (#1 in Brazil), together covering more than 50% of the world’s population. Outside this segment, Didi is also involved in a partnership with ZipCar for car sharing and Ofo for bike sharing.

Why does it matter?
Didi’s recent funding of US$5.5 bn will be used to further execute its international growth/expansion plans as well as undertake investment in artificial intelligence to bring breakthroughs in intelligent driving technologies and smart transportation architecture. It has already opened a research center called Didi Labs in Mountain View, California in 1Q17, to study intelligent driving solutions, as well as to work on areas such as cloud-based security, imaging and human-machine interaction.

Gett: Euro-centric, with VW as a partner

What is Gett doing in mobility?
Gett is an on-demand ride-hailing company (#1 in Europe), with operations concentrated in > 100 cities in the UK, Israel and Russia, while in the US, it is concentrated in New York. With annual estimated revenue of $500 mn in 2016 (Business Insider, December 13, 2016), Gett is significantly smaller than market leaders Uber ($6.5 bn) and Didi ($2.7 bn). Gett’s business model is different from peers in that it complements the local taxi industry, by partnering with the traditional taxi drivers as opposed to competing with them (in London, for example, almost half of the black cab drivers currently use Gett). Gett has received total funding of c.$620 mn to date (eight rounds), of which nearly half ($300 mn) was from Volkswagen (May 2016) alone.

Why does it matter?
The partnership with VW may help Gett expedite its expansion plans to other cities (for example, Gett recently purchased the US ride-hailing service Juno for $200 mn), while giving VW: (1) entry into the fast-growing ride-hailing market; and (2) access to big data (artificial intelligence, predictive algorithms and heat maps) to help it develop its future autonomous services. In 2017, VW aims to accelerate the growth of Gett in existing markets while also pushing its expansion into other European regions such as Germany, Spain, France and Italy.
Lyft: Powerful partners in Waymo and GM

What is Lyft doing in mobility?
Lyft is global #3 in the ride hailing market (#2 in the US), although it significantly lags its peers Uber and Didi in size ($700 mn net revenues vs. $6.5 bn and $2.7 bn respectively), in part owing to its limited geographical presence (it operates in the US alone). Lyft recently announced a (non-exclusive) partnership with Alphabet’s Waymo (Bloomberg, May 15, 2017) in self-driving car testing, which we view as a big step towards the commercialization of the autonomous technology. This would allow Waymo’s best-in-class self-driving expertise to reach more people and more places by utilizing Lyft’s established customer base (c.13 mn rides/month). Waymo has already begun testing self-driving vehicles in Phoenix in April. In addition, Lyft also has an existing self-driving collaboration with GM, under which GM will deploy thousands of autonomous electric cars in test fleets along with Lyft from early 2018. Lyft has raised total funding of $2.6 bn (11 rounds) so far, and is currently valued at $6.9 bn (source: Financial Times, April 6, 2017).

Why does it matter?
Lyft’s powerful partnerships position it better than its market share might suggest. With GM, it has connections to a manufacturing partner. With Waymo, it has an extremely capable technology partner. It remains to be seen whether these connections can ultimately translate into a commercially viable solution to autonomous mobility services. Lyft’s President John Zimmer is optimistic on the company’s efforts in this vertical, and has commented that by 2021, autonomous vehicles will account for the majority of Lyft rides (Business Insider, January 5, 2017).

Uber (privately held): The ride-hailing leader

What is Uber doing in mobility?
Uber is essentially defining the on-demand transportation market. Founded in March 2009, the company now offers on-demand pickup in nearly 600 cities globally. Uber has driven innovation in the category with: (1) UberX, a service that launched in 2012, allowing individuals to join the Uber fleet using their own car; (2) carpooling functionality through UberPOOL in 2014; (3) self-driving car trials in the fall of 2016; and (4) a commitment to launch flying cars by 2020. The company is currently testing autonomous cars in Pennsylvania, Arizona, and California. Uber is not limiting itself to passenger delivery: its food delivery service, UberEATS, now operates in 72 cities; Uber acquired autonomous trucking company Otto in August 2016 and launched Uber Freight, an on-demand long-haul trucking service, in May 2017. UberRush is providing enterprise level on-demand package delivery and fulfilment in New York, Chicago, and San Francisco.

Uber reportedly generated $6.5 bn in revenue in 2016 as it doubled annual gross bookings to $20 bn.
Why does it matter?

Uber is almost unarguably the most disruptive new technology company created in the last decade, to the point that “Uberification” and the “Uber of X” have defined the most recent venture capital cycle in Silicon Valley and its global equivalents. The company’s access to capital, having raised $12.5 bn to date, and technology talent, having acquired or hired high-profile technologists from Google, Carnegie Mellon’s Robotics Engineering Center, NASA, and the University of Toronto, have positioned Uber to join Facebook, Google, and Amazon as “winner take all” companies. Uber is expanding its influence on the future of mobility by partnering with select municipalities to formally supplement their public transportation networks and with property developers to reduce the need for parking. The company is pushing and helping to craft the regulatory framework for ride-sharing, the “gig economy”, and autonomous driving. That process is not without friction as Uber has been the subject of driver protests, regulatory action, fines and lawsuits. Uber’s future will be dependent on its ability to continue to navigate those challenges.

Avis (CAR): Fleet aspirations with Zipcar

David Tamberrino
Neutral, last close $23.65
6m PT $26

What is Avis doing in mobility?

Avis currently has one of the world’s largest car-sharing operations in Zipcar, which it acquired in 2013. Zipcar offers a fleet of vehicles available to its members (monthly or annual fee), billable by the hour or day, for predominantly round-trip rentals, although the company is rolling out more flexible offerings with one-way trips and the ability to change drop-off plans. We view Zipcar as having a slight competitive advantage relative to peers given its size and membership base, which recently passed the million member mark. Further, the product offering differs from other car-sharing/ride-hailing companies/networks as the ownership of the assets remains at the company level, as opposed to private citizens renting out/utilizing their personal vehicles. Overall, we believe Avis’s involvement with Zipcar gives the company a view into the changing mobility landscape and different use cases, allows for data collection/mining, and also acts as an avenue for testing new services.

Why does it matter?

We believe the rental car industry is experiencing slight pressure from a multitude of new mobility options, including ride sharing and car sharing. However, Avis’s early entry into car sharing may position it well for the future of mobility. Although we do not see ride-sharing as a material threat to traditional rental car operators in the near term, in the longer term, penetration of car-sharing operations (private assets being rented peer-to-peer), further growth in OEM mobility platforms, and the potential for autonomous vehicles could create an existential threat to rental car operators. With the right positioning, we believe the next ten years will present a dynamic environment that could prove rental car companies to be either valuable fleet operators or vestigial business models.
Hertz (HTZ): Partnering with the ride hailers

What is Hertz doing in mobility?
Hertz has chosen to turn ride-sharing into a revenue opportunity by partnering with Uber and Lyft through a weekly car rental program for vehicles from its off-airport locations. This has several impacts on Hertz. On the positive side, Hertz is able to improve the utilization of its off-airport fleet – a business that typically experiences lower demand than on-airport locations, by including a minimum one-week rental. In addition, Hertz can use this as a channel for its older vehicles that are nearing their rotation out of the fleet – under the program, Hertz offers mid-size cars that are a little more than two years old or in excess of 30,000 miles, as a way to extend the useful life of the earning asset at a time when the depreciation curve is less steep and potentially wait for a more favorable price in its sales channels. However, with rental rates for this program below industry average revenue and no mileage cap, additional wear and tear on the vehicle may not be offset by incremental revenue.

Why does it matter?
Over the longer term, HTZ’s involvement could potentially evolve into a fleet management business with the ride-sharing companies, where the rental car operators can utilize their fleet maintenance expertise and support networks to provide a valuable service that is complementary to its existing rental car operations. With the right positioning, we believe the next decade will present a dynamic environment that could prove an opportunity for HTZ to be a fleet manager within mobility. However, we note that without participation, and in the near term, ride-sharing does pose an inherent threat for rental car operators, as we believe they are already seeing some pressure as both corporate and leisure customers have a growing transportation alternative on-airport with an easier to use customer interface and increased convenience (i.e. on-phone app as opposed to rental car counter/vehicle pick-up and drop-off experience). Further, this model likely only works if potential ride-hailing partners (i.e. Uber and Lyft) do not want to own their assets, which is still an unknown for the future business model.

Alphabet (GOOGL): Waymo seeks to monetize autonomous tech

What is Alphabet doing in mobility?
Alphabet’s Waymo project has the most established autonomous driving technology, having conducted 2 mn miles of road tests (plus 1 bn miles in simulation). The self-driving car project started in 2009 within Google, and from 2014 showcased a fully self-driving vehicle with no driver controls. In 2016, the project was renamed Waymo and spun into a separate company that remains wholly owned by Alphabet, but with a clearer mandate to monetize the technology. The clearest evidence of this intention came with the May 2017 announcement that Waymo will launch a self-driving vehicle partnership. This will begin with an autonomous ride hailing pilot in Phoenix.

Why does it matter?
Waymo has ambitious aims. Unlike the automotive OEMs that are evolving in self-driving through the addition of ever more intelligent active safety features, Waymo aims to develop fully self-driving cars (no need for human intervention) from the outset. Waymo further differentiates itself from automakers through its intention to manufacture its own hardware: this encompasses the entire sensor suite, including the pivotal LiDAR (a laser-based radar-like technology) systems. OEMs by contrast are creating their systems via various technology partnerships. That said, Waymo has formed automotive partnerships of its own: it announced a ‘technical collaboration’ with Honda in December 2016, and in 2017 has collaborated with Fiat Chrysler on rolling out several hundred autonomous Pacifica minivans.
Valuation methodology and risks

Exhibit 66: Valuation methodology and risks to our views

<table>
<thead>
<tr>
<th>Company</th>
<th>Methodology</th>
<th>Risks to our estimates and target price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>ROIC</td>
<td>Lower (or higher) organic volume growth, weaker (or more resilient) consolidated China profitability, worse (or better) structural cost containment efforts, and FX moves vs. euro</td>
</tr>
<tr>
<td>Daimler</td>
<td>ROIC</td>
<td>Cyclical developments in trucks (especially to the downside in the key NAFTA market), lower (or higher) organic volume growth with the E-Class rollover marking the start of a product cycle pause, weaker (or more resilient) consolidated China profitability, worse (or better) structural cost containment efforts, and significant FX moves vs. euro</td>
</tr>
<tr>
<td>Ford</td>
<td>P/E and EV/EBITDA</td>
<td>Upside: a moderation of price pressures following production cuts, a sustained strong demand environment for pickups, and conservative management projections. Downside: earlier than expected US SAAR declines, incremental competitive pressures in light truck, and a difficult Brexit environment</td>
</tr>
<tr>
<td>GM</td>
<td>P/E and EV/EBITDA</td>
<td>Upside risks: NA cycle elongation, further market share gains, and positive pricing in the United States. Downside risks: weaker NA/China pricing, softer US/China retail sales, and potential dividend instability</td>
</tr>
<tr>
<td>Tesla</td>
<td>SOTP</td>
<td>Stronger Model S/Model X demand and/or production, positive free cash flow generation, and incremental new product announcements</td>
</tr>
<tr>
<td>Toyota</td>
<td>P/B-ROE</td>
<td>Improvement/deterioration in the US sales environment, forex swings (we assume ¥110/$; each ¥1 fluctuation has an impact of just over ¥40 bn on the operating line)</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>ROIC</td>
<td>Faster China profit contraction; weaker volumes/price/mix; US border tax adjustments; electric/emissions investment costs; and further diesel scandal fallout</td>
</tr>
<tr>
<td>Delphi</td>
<td>50% P/E and EV/EBITDA &amp; 50%SOTP</td>
<td>FX volatility, the pace of sales/production in North America, Europe, and China, incremental autonomous vehicle announcements/partnerships by competitors/OEMs, and the cadence of new product launches</td>
</tr>
<tr>
<td>Avis</td>
<td>P/E and EV/EBITDA</td>
<td>Upside: acceleration in demand from growth in leisure and/or corporate travel, a demonstrated ability to raise pricing in the industry, and incremental improvement in asset utilization. Downside: reversal of positive pricing trends in the US, larger than anticipated declines in residual values, and an influx of supply into the market from OEM overproduction</td>
</tr>
<tr>
<td>Hertz</td>
<td>EV/EBITDA</td>
<td>Execution on higher pricing, a rebound in leisure/corporate travel, increased use of alternative channels to dispose of vehicle fleet, higher residual values, delivery on long term cost reduction/margin targets, and increased partnerships with ride-hailing companies</td>
</tr>
<tr>
<td>Alphabet</td>
<td>P/E, EV/EBITDA &amp; DCF</td>
<td>Weaker-than-expected cost discipline, competition, dilutive M&amp;A</td>
</tr>
</tbody>
</table>

Source: Goldman Sachs Global Investment Research.

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Delphi Automotive Plc
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Reg AC

We, Stefan Burgstaller, Demian Flowers, David Tamberrino, CFA, Heath P. Terry, CFA, Yipeng Yang, Heather Bellini, CFA and Kota Yuzawa, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

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Stefan Burgstaller: Europe-Autos & Auto Parts.


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Distribution of ratings/investment banking relationships

Goldman Sachs Investment Research global Equity coverage universe

<table>
<thead>
<tr>
<th>Rating Distribution</th>
<th>Global</th>
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<tr>
<td>Buy</td>
<td>33%</td>
</tr>
<tr>
<td>Hold</td>
<td>53%</td>
</tr>
<tr>
<td>Sell</td>
<td>14%</td>
</tr>
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</table>

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