Trends affecting the business model of a parking operator in the 21st century

Final Report

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1. Introduction

Parking plays a key role both in mobility and in urban development. The role of parking in the mobility chain is and will continue to be important, but it is subject to the many trends and developments that will influence the sector thoroughly in the coming decades. **Socio-economic trends** such as aging population, migration to the (inner) city, changing working relationships and the ongoing development of the knowledge economy have consequences for car drivers and their parking behavior **Technological developments** such as electric, self-driving and smart cars, and the diffusion of Mobility as a Service (MaaS) applications, create new opportunities in the parking sector, but also introduce new players and changing power relations. **Social developments** such as e-shopping, the sharing economy, individualization and growing attention to health affect mobility behavior and mobility needs, especially of the emerging millennial generation. Last, also **policy trends** such as decentralization, increasing attention for sustainability, re-prioritization of the use of scarce inner-city space and the desire or necessity for a greater role for private actors in urban development might affect the parking industry.

Parking operators will retain an important role, **but changes could take place** in parking demand, in supply conditions and in **the wider playing field in which they operate**. Understanding these key trends and their potential impact on the parking sector helps to think through what adaptations may be needed to make sure that parking business models remain future-proof.

The **goal of this report** is **to explore key trends that might results in challenges or opportunities for the parking sector in the coming decade**. It deliberately does not focus on trends within the parking sector itself, but on trends that are initiated outside of the parking sector but with potential impact on parking operators. The focus on impacts over the **coming five to ten years** is chosen in order to stay within the ***horizon of predictability***, beyond which analysis becomes so uncertain and hypothetical that few specific recommendations could be made. At the same time this study also refrains from trying to make precise forecasts for the immediate future, since this would limit the analysis to scenarios close to business as usual and would distract from trends that are likely to remain small over the coming five years but may strongly impact the parking sector soon after. The report does not attempt to cover all possible trends and scenarios but instead limits itself to what appear to be the most influential or widely discussed issues in mobility today.

The report is built around **four key themes** that are currently being debated among experts, entrepreneurs and policy makers:

1. Cars are changing and it's imperative to understand what are the [parking] needs of these cars;
2. The way we use cars is also changing, because of changing consumer attitudes, sharing economy concepts, and other changes to automotive business models. Does this influence the demand for parking, and the playing field in which parking operators work?
3. The mobility system as a whole is changing towards an integrated system. Which are the new major stakeholders in this system? And what will be the role of parking?
4. The cities in which we live, work and entertain are also changing; how does the car and the parking garage fit into the city of the future?

Given the time depth of this study and the pace of (technological) development currently underway in the society, this study works from the perspective of ***deep uncertainty***[1]. This means that uncertainty is not limited to the decisions of stakeholders and the outcomes of (company) policies, but also extends to the entire system of actors, stakeholders, technological systems and their interactions. In short, the task at hand is to map out who will be the relevant actors who may influence the parking sector, what resources these actors have access to, and what their power relations will be. The **goal** of this study is therefore not to give specific predictions, but **to map out different potential outcomes and to help parking operators to build a future-proof business model**.

The findings of this study are based on a wide-ranging desk research, followed by a total of 14 expert interviews to validate the findings. The report is written in essay style, and discusses expert views and observations – both mainstream and speculative – without attempting to give final verdicts on their likelihood. The slower process of gathering and analyzing concrete evidence to underpin or challenge these expert opinions is left for further research. Moreover interview partners are not quoted directly in the text in order to allow them to speak freely and think outside of current business interests. The experts stem from a range of different sectors, from the automotive sector, to public transport, energy, sharing economy, retail, real estate, urban planning, public law and transport policy. Chapters 2 through 5 discuss the main themes of this study one by one. Chapter 6 then distills from this the key takeaways for the parking sector.

[1] For example see Walker, W, Lempert, R en Kwakkel, J (2013) Deep Uncertainty. In: Gass, S. en Fu, M (eds) *Encyclopedia of Operations Research and Management Science*. Springer, Boston, MA

2. Are cars changing?

Cars have continuously evolved ever since their first introduction, but in recent years several technological developments appear to have accelerated. The electric car is finally breaking through as a mass market product, and hydrogen cars are already technologically (but not commercially) viable. Autonomous cars have also appeared in various forms and levels of sophistication, and are thought to promise a radical change in our mobility system. Are cars changing? And if so, what cars will we drive five to ten years from now, and how will we park them?

The electric vehicle

The technology for making cars drive on electricity was invented more than a century ago, and modern mass market electric vehicles (EV's) have been available since the 1990s. But after decades of existence as a niche product, the past few years have seen a clear acceleration in development. **EV's have become far more convenient in terms of driving range and reliability** and have gained considerable consumer appeal. **Charging infrastructure is expanded rapidly**, though with big differences between countries and regions within the same country. Recently **several** large **governments** (such as the EU, India and China) have made **ambitious declarations** of a total phase-out of new car sales with internal combustion engines (ICE). Even if these ambitious targets are not set in stone, they did succeed in triggering a sense of urgency among car manufacturers. Most major car manufacturers have committed to EV models and are ramping up production. There is now a consensus among experts that the EV has reached the stage of breakthrough and will represent an increasing share of new car sales in the coming five to ten years.

While the replacement of ICE cars by EV's appears unavoidable in the long run, it is still an open question what the share of EV's will be in the coming five to ten years. Scaling up production is a major challenge, and long delays in EV delivery plague not just Tesla but most automotive OEM's[2]. Further up the value chain dealers have been found to be generally less motivated to sell EV's with the same energy as ICE cars because of a lack of familiarity and because they feel that it takes them more time to explain the features of an EV to first-time buyers. Moreover the relatively high purchase price of EV's still forms a barrier to mass market uptake. Parity in terms of total cost of ownership (counting both initial costs as well as fuel cost and maintenance throughout the life span) is expected around 2025, even without government subsidies. But the idea of a higher initial price compensated by lower marginal costs is still difficult for consumers to take into account in their purchase decision. Finally even if EV cars represent a high share of new car purchases by 2030, under normal circumstances the car fleet only turns over by a few percent per year leading to lower shares in the fleet as a whole.

Uptake of EV's could speed up if car sharing concepts grow faster over the coming years (see next chapter). This is because thinking in terms of total cost of ownership comes much more naturally to fleet operators rather than individual consumers, and firms who can optimize the usage frequency of cars also reap more benefits from the lower marginal cost of EV's compared to ICE cars. Moreover, a major boost to EV sales could result if the concept of **Car as a Service** (see chapter 4) takes off. Cars with a high initial purchase price but low usage costs are ideally suited to lease constructions, since a fleet owner can afford the high initial price and can spread out these fixed costs in the monthly price. The market for employer-provided lease cars is already well developed in the Netherlands, and for other consumers the Car as a Service

[2] Original Equipment Manufacturers

concept is started to be rolled out in the form of private lease contracts. EV's offered through (private) lease could become highly price competitive over the coming years, and could allow the EV to outcompete conventional cars on price alone.

Beyond the question of how many EV's there will be, a further question is how these shares are divided among different types of EV's. While plug-in hybrid electric vehicles[3] (PHEV) have been the dominant form of EV for the past several years, there is almost a consensus among policy makers and mobility experts that plug-in hybrids will no longer play a major role in the rise of EV's, and that electric cars by 2030 will consist (almost) entirely of battery-electric vehicles (BEV). Policy makers have lost interest as it turned out that plug-in hybrids, which in many countries are currently or have until recently been subsidized, are rarely driven in electric mode. Hence the potential emissions savings from using their electric engine have not been materialized, and emissions may even have been higher than necessary because carrying unused electric engines and batteries leads to even higher CO_2 emissions.

However there are signs that automotive OEM's still have future plans for the plug-in hybrid electric car, and that the plug-in hybrid may still play a key role in the coming five years and beyond. Manufacturers at least in the EU have an interest in continuing plug-in hybrid car development, firstly because they do not want to lose the technological expertise they built up in ICE cars, but also because hybrids help them comply with EU emission standards in a cost-effective way. A key challenge for car manufacturers is to meet EU standards for the emission of CO_2. These standards are set not at the level of individual cars, but at the level of the entire fleet of car sales. These emissions standards have reached a level where simply improving the efficiency of ICE cars is no longer sufficient. But at the same time they are also not strict enough that only BEV's could meet them. So plug-in hybrids turn out to be the ideal middle way to meet the minimum requirements with the lowest development costs to manufacturers.

Given these incentives, automotive companies can be expected to use their marketing power to reignite consumer interest in plug-in hybrid cars. Even policy interest may return if lease companies enforce their customer to drive their hybrids in electric mode for a minimum share of driving distance. Moreover recently BMW started the Electric City Drive project in Rotterdam[4] as an experiment to improve the sustainability of plug-in hybrid cars, by notifying users to switch to electric mode when they enter Rotterdam city center. The goal is to eventually switch automatically to electric mode. This increases the attractiveness of plug-in hybrid electric cars and could be a reason for policy makers to return to supporting hybrid cars as sustainable vehicles.

Charging in parking garages

From the perspective of the parking sector, the key impact of electric vehicles is their need for charging. The higher the share of electric vehicles, the more important offering charging opportunities could be as a service to parking customers. At the same time it is essential to offer the right charging speed and capacity at the right place, or risk creating expensive stranded assets. Which charging facilities are needed

[3] Besides plug-in hybrids (PHEV), with a battery that can be charged from a power socket, there are also hybrid electric vehicles (HEV) which only charge from recovering braking energy and can be considered more efficient internal combustion engine (ICE) cars. In this report whenever we discuss hybrid vehicles, we mean PHEV.

[4] https://www.ad.nl/rotterdam/bmw-kiest-rotterdam-als-duurzame-proeftuin~a9d4ea56/

depends on the further development of EV technology, the relative importance of BEV's as opposed to plug-in hybrids, and on the development of charging infrastructure beyond parking garages.

As EV's continue to expand their driving range, the need for charging outside the home appears to become less over time. **However, EV drivers are still likely to continue expecting chargers in off-street parking garages for the foreseeable future**. Firstly, as discussed above, there are reasons to believe that over the coming five to ten years a significant number of electric vehicles could actually be plug-in hybrids rather than BEV's. If plans to incentivize hybrid drivers to actually drive in electric mode are implemented, then these hybrid drivers would attach great value to being able to charge at every parking location. Plug in hybrid cars tend to have very limited electric driving range, and expanding this seems unlikely because it would result in the already heavy vehicles to become even more heavy and bulky. This means that hybrid drivers quickly deplete their batteries and would appreciate or even demand charging opportunities not only at home but at the worksite, during shopping trips and for any other trip purposes where off-street parking garages may be used. Due to the small battery capacity of hybrids the speed of charging would be less important.

Secondly, even if BEV drivers could do with only home charging, a substantial and increasing share of homes is not suitable for installing a charger. Most homes in the Netherlands and other highly urbanized countries do not have private garages or driveways where people can park within a short enough distance from their home such that they can span a charger between their home and the car. And with the trend of further densification of cities (see chapter 5), **such homes are likely to become rarer in the future**. Some cities do have policies to install EV chargers at inner-city on-street parking spaces for people who cannot home-charge, but as densification continues and on-street parking spaces might be reduced in number these places are unlikely to be sufficient to guarantee a home charging spot every single day. Fast-charging stations along highways may cover part of this charging demand, but not all trips pass along a highway and not all agendas leave time for waiting for unplanned charging sessions of 30 minutes or more. This means that even BEV drivers living in urban areas **may continue to expect charging points in off-street garages, as a necessity or at least as a service**.

Thirdly EV charging points can serve another purpose besides recharging car batteries, namely to form a flexible shell of energy storage capacity to equalize peaks and troughs in energy supply and demand. In this vehicle-to-grid setup, EV's should be left connected to a charger as much as possible to make sure that there is always sufficient equalizing capacity. Solar and wind power are notorious for creating peaks in energy supply, and without storage capacity this energy is either lost or delivered to the grid at a loss-making price. On the demand side EV charging creates peaks in electricity demand, which increasingly strains the grid because of rising battery capacity and charging speed. Dynamic pricing of electricity, rising and falling with demand, seems unavoidable to limit the strain on the grid. Then EV users directly benefit from changing their charging times (for example during a city center visit instead of at home) as they can avoid the most expensive charging times. At the same time EV owners can earn money by allowing their car to feed energy to the grid during peak demand and recharging during low demand. **If off-street parking garages facilitate this by offering copious numbers of charging points, this may increase their attractiveness. However, some experts doubt whether vehicle to grid will really take off because frequent discharging and recharging reduces the lifespan of EV batteries, and vehicle to grid does not help address the much more important challenge of equalizing summer and winter energy supply and demand imbalances**.

The demand for EV charging can be seen as both an opportunity and a threat for parking operators. It is an **opportunity** in the sense that it **offers parking operators a new form of customer service**, which they can use to distinguish themselves from competitors and from on-street parking especially if high speed charging is offered. Moreover parking operators can make a margin on offering charging, by taking (part of) the price difference between the wholesale electricity price and the end consumer price. Lease car drivers may have an especially high willingness to pay for charging, since they do not normally pay these bills themselves.

A **further opportunity could be that the need for EV charging could be an argument for introducing residential off-street parking garages**. While it is currently uncommon in the Netherlands to let parking operators offer residential parking, this would be especially attractive in neighborhoods where homes do not have direct access to the street, and where on-street parking is behind reduced. If residential off-street garages are introduced in such neighborhoods with ample EV chargers, this facilitates EV use and allows more cars to take part in vehicle-to-grid solutions. This could be **combined with e-bike charging, which is also a growing challenge in high density urban neighborhoods**. Urban apartments often do not offer space for storing and charging an e-bike indoors, while these bikes are too valuable to be left on the pavement. These issues are a key reason for the disappointingly low uptake of e-bikes in city centers, in spite of the rising driving range, consumer appeal and policy attention for e-bikes. If residential off-street parking garages offer safe e-bike storage and charging then this problem could be solved. About 12 e-bikes can be charged on a single EV charging point.

On the other hand, EV charging can also be seen as a **threat** to the parking sector. The **cost of installing charging points** rises substantially when going further than a few chargers per garage, as the grid connection will have to be upgraded. Smart chargers (which are programmed to divide charging capacity over a larger number of charging points) can help to limit the costs, but when EV market share reaches high levels thorough grid upgrades will be needed involving expensive ground works. **For some parking garages this may be especially expensive, putting them at a competitive disadvantage vis á vis other parking garages**. Currently EV chargers are a satisfier that can be offered in small numbers, but when EV market shares rise the absence of a sufficient number of high capacity EV chargers is likely to become a **dissatisfier instead**. The cost of hosting EV's may also include insurance costs, since they can introduce new safety risks to parking garages. According to experts these risks do not lie in the chargers, these are designed to be safe even in the presence of groundwater. But the electric vehicles themselves are turning out to be a fire hazard much harder to extinguish than normal cars, particularly in underground parking garages.

Beyond the direct cost of EV chargers, a **further threat** could lie in the **need for municipalities to find space for energy storage and recharging of electric vehicles**. As more and more solar and wind power is generated within cities, and as in the Netherlands entire neighborhoods are taken off the gas grid at relatively short notice, more energy storage may be needed to equalize supply and demand. **In dense city centers few suitable open spaces are left to accommodate battery storage** (for comparison: two or three containers, the size of a parking spot, are needed to power an office building), **and off-street parking garages may be one of the few sizable locations left**. This could lead to pressure on parking operators (especially those who rent rather than own their real estate) to give up some of their garage space in order to store batteries there. Moreover the high initial purchase price of EV's combined with their lower price per kilometer make them especially attractive to firms and utilities, such as for example mail delivery, street cleaning and other services that require fleets of small vehicles that travel relatively short distances

within city centers. These vehicles would also need charging stations in city centers, and if no alternative locations are available municipalities may look towards off-street garages to host this. This could be also an advantage for private parking operators, when cities decide to use their own parking facilities to charge the electric fleets.

Further into the future contactless charging may become an important attention point for parking operators. The technology for contactless charging is already available, and offers several advantages over normal charging by power cable. Contactless charging increases the convenience for drivers as they won't need to plug and unplug a wire to car. Moreover it facilitates smart charging as it becomes easier to divide charging capacity over multiple parking spots. But the downside is that in order for contactless charging to work efficiently, the car needs to park at exactly the right spot with a margin of error too small for human drivers. If the car is parked only slightly away from the ideal charging position, the rate of energy loss in transmission increases quickly. In other words, the use of contactless charging requires autonomous parking, and will only become important when such autonomous driving features become common, will take a while.

The autonomous vehicle

While most experts agree about the future role of EV's, the potential for autonomous vehicles (AV's) is much more uncertain and contested. An optimistic and a pessimistic camp can be distinguished among experts, with most experts somewhere in the middle of this spectrum. According to the more optimistic perspective, the rise of the AV is a case of exponential growth, with seemingly imperceptible progress early on accelerating into very rapid change at a later stage. This analogy seems appropriate, since the key challenge for AV's is to gather data on real-world traffic conditions and based on this to learn how to behave in all possible traffic conditions. AV's learn collectively since a condition experienced by one car will be shared with all other cars at least within the same fleet, leading to exponential increases in quality and reliability.

Still there is considerable difference of opinion about how long it will still take before AV's become a normal part of the transport system, with a pattern of much higher optimism in North America and much stronger skepticism in Europe. The optimistic viewpoint is that the first fleets of autonomous shared vehicles will drive in suitable urban areas by around 2020-2022, while by 2030 AV's will already play a substantial role in transportation and by 2040 they may dominate urban transport. Optimism is backed up by the fact that tech players such as Waymo[5] are making large-scale investments in AV technology, while players such as Uber and Lyft make highly public claims of autonomous fleets becoming available to customers within the coming years. They plan to start with short, low-speed urban trips under good weather and road conditions, and then gradually expand the scope for autonomous vehicles as AV capabilities are being upgraded until eventually nearly all trips can be undertaken by AV's. It goes without saying that ridehailing companies have extremely powerful incentives for making AV's work, since their main cost and the main risk factor in guaranteeing service quality, safety and availability is the human driver.

Experts in the Netherlands tend more towards the pessimistic perspective on AV's. Expected timelines are much longer, with the range of 2045-2085 for large scale market penetration proposed by the Netherlands

[5] Subsidiary company of Alphabet, originally the self-driving car project within Google

Institute for Transport Policy Analysis (KiM)[6]. Moreover besides longer timelines, the question of whether AV's will ever become a dominant feature of the transport system is still considered unanswered. In other words the possibility that autonomous driving never moves beyond intermediate levels of driving support or niche applications of full autonomy is not excluded. Another point of disagreement is about what places will first see AV's breaking through. In North America city centers are seen as the ideal place to start with AV's, because driving speeds are lower and there is a customer base for autonomous ridehailing vehicles. But in the European context city centers tend to be regarded as least suitable as proving grounds for autonomous driving because of the complexity of urban traffic. According to this perspective AV's, if they appear at all, will be limited to highways for a long time and considered impractical or even banned from city centers until very high levels of reliability are reached. Special lanes where AV's are allowed could then connect highways to parking garages on the edge of the city center, where travelers continue on foot or by other (human operated) transport modes.

While the potential for fully autonomous vehicles is still contested, there is little doubt that partially autonomous cars (levels 1 through 3) are viable and will soon become a normal feature of our transport system. Many premium models already contain features such as lane keeping assist and parking assistance, which constitute lower levels of vehicle autonomy. These and other support and safety features are quickly turning cars into sensors on wheels, with cameras, lidar and radar embedded and generating precise data about the cars' surroundings. While such data are in the first place intended for use by the vehicle itself to anticipate and respond to traffic conditions, these data could potentially be transmitted back to the owner or servicer of that vehicle to build up a database of traffic conditions, car use and parking availability. This fits the logic of the Internet of Things, where objects such as cars, mobile phones and other devices communicate with each other and with data centers that track and analyze their movement and usage.

If car companies, lease companies and possibly other stakeholders start exploiting the full potential of these partially autonomous sensors on wheels, this **could have consequences for the parking sector**. Currently the operators of off-street parking garages have a near information monopoly on competition-sensitive data such as actual parking capacity, parking occupancy and tariff structure. Once the data generated by sensor-laden vehicles becomes systematically stored and analyzed, other parties outside of the parking sector could end up knowing more about parking availability and the behavior and preference of parking customers than parking operators themselves. This could put pressure on the pricing strategies of parking operators and lead to more flexible and price sensitive customers. However there's still the question of who will end up as the owner of such data. End users are the ones generating it and may have privacy concerns about sharing the rights over this data with other parties. But for lease cars and shared cars it's already much more accepted that cars transmit usage data back to their fleet operator, and the potential rise of private lease and carsharing (see next chapter) could cause a much larger share of cars to fall within a leasing arrangement in the coming years. And Tesla demonstrates that car manufacturers can also convince their users to allow constant communication of their car with the factory, for product maintenance and upgrading but possibly also for analysis purposes.

If and when fully autonomous vehicles (level 4 and 5) really break through, a key question becomes who will decide where to park the car, the user or the algorithm? Usage of navigation software combined with data generated by partially autonomous vehicles already provide much scope for the owners of car

[6] KiM (2017) Paden naar een zelfrijdende toekomst: vijf transitiestappen in beeld.

navigation to influence parking decisions, by suggesting preferred parking locations and offering to reserve and pay for them. This could lead to a Booking.com effect (see also chapter 4 on integrated mobility) in which stakeholders outside the parking sector could control a share of parking transactions and charge a fee for them. In the case of full autonomy, **the pricing power of parking operators** and the scope for employing marketing techniques in order to do price yielding further diminishes **as their business shifts from a B2C to a B2B situation**. Instead of a multitude of end consumers, the parking operator ends up negotiating with a small number of AV fleet owners who decide on parking location choice directly or through the algorithms that steer the AV's they own or service. Besides pricing power this may also impact what counts as a strategic parking location. While human decision makers are in control, it may be important for a parking garage to be visible from strategic stretches of road and to have well-placed signs and information screens along logical driving routes. But when AV algorithms carry out the parking decision, more objective parameters such as ingress and egress distances to likely final destinations are likely to become more important. Within the parking garage itself, quality factors such as lighting, driving routes and the dimensions and angle of parking spots could become less important, and parking places can be made up to 15% smaller thanks to the precision of autonomous parking.

It has been suggested that the rise of AV's could have much more fundamental consequences for parking operators, as their drivers could have their AV drop them off at the final destination and then park itself on cheap parking locations at the edge of town. This would strongly decrease the demand for city center parking, and reduce or eliminate the price premium for parking locations close to popular destinations. However such driving behavior would come with sharp increases in urban congestion, which is unlikely to be tolerated by transport authorities. The rise of EV's is already a strong trigger for governments to consider using road pricing (see next chapter), and socially undesirable AV driving behavior leading to empty rides and congestion would make the introduction of road pricing even more likely. Finally countries with a strong urban planning tradition, with the Netherlands as a prime example, can simply decide that out-of-town parking is socially undesirable and refuse planning permission.

Other trends

Several other trends have been proposed which would change the cars we drive. These trends are more speculative, and are therefore discussed in less detail. The first of these trends is the **customization of cars**. As sharing concepts in mobility grow in importance (see next chapter), there is less reason for most passenger cars to still follow the basic model of four seats and a trunk in the back. If passengers rent or hail cars for single trips, they can be offered a variety of different types of cars which fit more closely their needs at that moment. This can mean a larger car with more storage space for furniture shopping, but a much more common change could be towards single-person cars. One reason for urban congestion is the fact that most cars have capacity for four passengers but in practice only contain a single passenger at most times. Carsharing and ridehailing companies have an incentive to refrain from offering cars that are larger than needed, especially once autonomous driving becomes more common in cities. For example, vehicles like the Biró[7] are already being offered for rent by sharing companies. And governments may decide to promote smaller cars with privileged access to peak hour lanes or scarce parking spaces. If cars become more variable in size, this would conflict with the idea of offering parking spaces with fixed

[7] Compact fully electric two-seater vehicle produced by Italy-based Estrima. Highly compact, and in the Netherlands treated as a microcar allowed to drive on bicycle paths

dimensions. Half-size parking spots for single-person vehicles could be a way to tie in with this trend and use available parking space more efficiently.

Another proposed trend is the rise of hydrogen cars as a sustainable option and as a more convenient alternative to the EV, given its longer driving range and faster recharge time. Hydrogen cars already exist and some experts believe they have already started an exponential growth curve. Major oil companies like Shell, and national governments including Japan, have made public statements announcing their backing of hydrogen as the fuel of the future. But it still seems unlikely that hydrogen cars will make up a substantial fraction of cars over the coming five to ten years. The bottleneck lies in the production of hydrogen, which is relatively expensive and requires vast amounts of electricity. Converting power to hydrogen and then back to electricity in the car engine is relatively inefficient compared directly charging car batteries from the grid.

Eventually, as solar and wind power scale up and continue to cut their production cost, large amounts of electricity will become available for hydrogen production. This green hydrogen will first be used in other applications where few alternatives to fossil fuel are available, such as trucking, public transport, airplanes, shipping, industry, rural driving and home heating in remote areas difficult to connect to the grid. Only when hydrogen prices drop to very low levels will it make sense to start using it in cars. The technology and infrastructure for distribution and retail sale of hydrogen pose few challenges and can benefit from the existing fossil fuel infrastructure. So once the bottleneck of high electricity prices is lifted, hydrogen cars can quickly spread. **If this were to happen faster or at a larger than expected scale then EV chargers in parking garages could become stranded assets**. But it is more likely that EV's will dominate the coming five to ten years alongside internal combustion engines, and that eventually hydrogen vehicles will come to co-exist with electric vehicles rather than replacing them. The strategies of automotive firms seem to confirm these expectations, as they are giving hydrogen significantly less attention than EV technology but still keep some development lines in hydrogen vehicle technology to make sure they do not fall behind in this technology. Energy companies appear to do the same.

This chapter has moved through the almost certain rise of electric vehicles, through the far more contested topic of vehicle autonomy, and ending with some more speculative vehicle trends. The next chapter moves the focus from changes to the car itself, to changes in the way we use cars.

3. Car ownership and use

The previous chapter discussed possible ways in which cars may change over the coming five to ten years. But apart from changes to the car itself, there are also signs that the way we use cars may be changing. These changes are related to **socio-demographic** changes, **lifestyle** changes, and **fiscal changes with respect to car use**. Together these trends could either increase or decrease how much we drive, and how many of these trips are likely to terminate in an off-street parking garage. And as we will see, **these trends may also amplify some of the technological trends discussed in the previous chapter**.

Demographic shifts

Changes to the age structure, spatial distribution and other **aspects of the population happen slowly but are among the most powerful drivers of shifts in mobility patterns**. This report focuses on the case of the Netherlands, but some trends may also carry over to other contexts as well. Three major demographic shifts are likely to have visible effects over the coming five to ten years, namely population ageing, diversification, and internal migration to the cities. Each of these trends are already visible today and have already influenced mobility patterns over the past decade or more.

Population **ageing** is a demographic fact, produced by rising life expectancy and the relatively large Babyboom generation reaching retirement age. While traditionally car use decreased with age, the Babyboom generation (defined as those born between 1946 and 1955) appears to be different. Having grown up in a period of motorization and optimism about the benefits of a car-oriented society, the everyday habits and preferences of this aging generation appear to revolve around the car more than later generations do. Moreover the generations currently approaching or past retirement age also have more purchasing power than senior citizens had in the past, enabling them to undertake more activities at further distances, and more often by car. The oldest Babyboomers are already turning 72 years old in 2018, and will soon reach an age bracket where car use necessarily decreases due to declining fitness and activity levels. In sum, population aging is no longer necessarily a force leading to lower car use, but over the coming years the temporary boost to car use caused by the Babyboomers will gradually decrease.

The second demographic shift is the **rising diversification of the Dutch population**. Immigrants and their descendants are forming an increasing share of the Dutch population, and their origins are becoming more diverse. This may impact car ownership and use because familiarity with and attitudes towards the car are influenced by cultural norms and expectations. While households with an immigration background used to have relatively low rates of car ownership and use, this was partly caused by their lower average incomes and by their tendency to live in highly urbanized areas where the car tends to be less necessary and convenient. A share of the descendants of immigrants is likely to move into higher-paying jobs, while at the same time a rising share of new immigrants could be expats who already have higher incomes to begin with. For them rates of car use will be less determined by socio-economic background and more by their own preferences. While more research is necessary on this topic, **there are signs that several ethnic groups actually have stronger than average preferences for car use** and avoid walking and cycling if they can avoid it. The net effect of the diversification of the Dutch population on car use is still uncertain, but **higher shares for the car in urban trips (both long and short) seems a possibility**.

Finally, a key demographic trend in the Netherlands is the **growth of cities**, especially the largest ones, at the cost of the countryside. Living in city centers has long been a relatively short life phase which only

applied to a limited segment of the population, namely those who study and/or start their career in city centers and then move to the suburbs and beyond once they start a family. This urban life phase is now becoming longer as people study longer or take more time to settle into a stable career, and applies to a larger segment of the population as more people study, stable jobs become more rare over time, and also more people return to the state of a single household through divorce or later in life through the loss of their partner. At the higher age range, seniors also appear to become more attracted to city life as it offers them convenience and entertainment, and bonds with birthplaces are becoming weaker. Some experts also see signs that a rising share of families is considering to postpone the move to suburban living, or not moving out of the city center altogether. Whether this trend is able to continue of course strongly depends on the housing market, as on the one hand city center house prices are rising to unaffordable levels, but at the same time many cities do focus on the city center for their new housing construction.

A population shift towards the larger cities could lead to a drop in car use since it implies a net move away from places where the car is essential, and towards places where trips tend to be shorter and more likely to suffer from congestion. The former makes car use less necessary, and the latter makes it less attractive. However this does not necessarily imply a drop in demand for off-street parking. If fewer car trips are made, but more of the remaining trips have an urban destination, then **off-street parking demand could stay the same or even increase**. Net migration from less to more urbanized areas does not necessarily imply that more households will be completely carless. Differences in car ownership between cities and less urbanized areas mostly result from households having fewer second cars, rather than not having a car at all.

Millennials and the car

Going beyond demographic trends, some experts suggest that mobility preferences themselves are changing. The focus of such discussions tends to be the Millennial generation, the cohort born between roughly 1980 and 2000. Having grown up with modern ICT and social media, this generation is said to have different attitudes towards consumption and entertainment, and therefore also on mobility. Specifically they are said to value experiences over physical goods, to prefer access to cars over ownership, and to carry out more activities online instead of through physical travel. While a numerically relatively small generation in the Netherlands, their importance for the mobility sector will gradually increase as Millennials enter the labor market and increase their purchasing power.

So far little systematic research has been done on this topic, and as Millennials are still early in their (study) career and family life it is difficult to see what their later life decisions will look like. Experts who have studied this question **tend to caution against expectations of a generation with strongly different preferences and behavior**. Data does show somewhat lower car ownership among Millennials, but this could partly be a temporary effect of entering the labor market during a recession and having weaker purchasing power due to rising study debt and an unhinged housing market. Changes in car ownership would only be structural if they result from changes in preferences, and experts have not found clear evidence for this. **Most likely Millennials have not decided to buy fewer cars, but instead to postpone the moment of purchase**. Car manufacturers generally also do not expect Millennials to be very different customers. But they do recognize that new car sales could drop somewhat due to postponed car purchase, the smaller size of generations now coming of age, coupled with fewer second cars and possibly a more pragmatic rather than status-driven orientation towards cars.

The sharing economy

The rise of sharing concepts in mobility is one of the key ways in which the way we use cars may change over the coming five to ten years. Usually the supposed change in preferences of Millennials from ownership to access is given as evidence that sharing concepts could grow in importance, but such a shift is not clearly visible at least in the Netherlands. Still, sharing concepts could grow over the coming years not because of a demand pull, but because of a supply push. **A wide range of stakeholders is developing business models focused on sharing concepts applied to the car**. In order to avoid confusion, this report will refer to car sharing as the set of all sharing concepts applied to the car. Sometimes the word 'car sharing' is also used to refer to modern versions of car rental, such as peer-to-peer car rental (also known as car clubs, for example Snappcar) and innovative forms of business-to-consumer (B2C) car rental in which cars can be accessed and left behind in a variety of places rather than at a central garage (similar to bikesharing, for example Car2Go). This is referred to as C2C and B2C car rental in this report. Other car sharing concepts are ride hailing (ICT-mediated taxi services such as Uber and Lyft) and ride sharing (the shared version of ride hailing concepts such as Uber and Lyft). Developments in ICT are making it more and more easy to set up such systems, and the cost savings they promise to car users could eventually create a substantial demand for them.

There are several factors that could make it attractive to share cars. Cars are stationary 95% or more of the time, and could in theory be used by others during that time. While this has been the case for most of the existence of the modern car, this old argument is amplified by the rise of EV's since they have a higher purchase cost but lower costs of use. This makes it even more attractive to use cars as efficiently as possible, while also increasing the cost of buying a car and not using it most of the time. Transaction costs have been a factor holding back car sharing, since it creates the need for large numbers of small transactions to handle the payment and insurance involved in car sharing. ICT developments are now pushing the costs of such transactions down, and blockchain is designed to reduce the cost of small and privacy sensitive transaction much further. Moreover, if a car is owned by a company instead of by an individual (as in B2C car sharing), the car owner saves costs by not having to pay retail prices for equipment, fuel, repair and cleaning, and by being able to achieve economies of scale in activities they choose to do themselves (e.g. car cleaning). These cost savings can then be passed on to users in the form of lower car use costs. Finally, as discussed in the previous chapter, car sharing makes it possible to offer consumers the most fun and convenient car for each trip they make, rather than having to make every trip with the same standard car. Consumers could rent or hail a minivan or pick-up truck when shopping for bulky goods, a stylish car with enhanced entertainment systems for going to a party, and a cheaper and easy-to-park single-seater car for solo trips.

In spite of the potential advantages, so far the rise of car sharing concepts has been disappointing in the Netherlands. C2C car rental is hampered by a lack of supply of rentable cars, while most other forms of car sharing are still too expensive to be competitive for most potential users. The sharing economy appears to be stuck in a chicken-or-egg situation: cost savings only become large enough to draw customers once sharing concepts can be offered at a large enough scale, but upscaling is held back by the limited demand due to currently high prices. Only when households can be convinced to get rid of their second or even their first car, will car sharing lead to net price savings for most consumers. But **fully relying on car sharing requires a level of certainty of availability and quality which currently is not available yet**.

Eventually the chicken-or-egg problem can be broken by the rise of autonomous vehicles, as eliminating the cost of human drivers could make ride hailing and ride sharing cheap enough to outcompete private car ownership for most consumers. In the nearer future, mobility integrators and Mobility as a Service applications (see next chapter) could also give a major boost to car sharing. In the meantime government policy could play a role in forcing a breakthrough in the chicken-or-egg problem earlier. Urban planning concepts such as smart urbanism (see chapter 5) could bring less availability and higher prices for residential parking, while shared cars could be allowed privileged access to car restrained neighborhoods and free or cheap parking. This would make sense from a policy perspective because car sharing helps solve residential parking pressure and has also been found to reduce car use by about a third compared to private car ownership. The latter is because users are more aware of the full costs of driving (the cost per kilometer as well as the discounted fixed costs of car ownership) when they pay for a shared car by trip or by hour driven, rather than paying a large initial purchase price followed by a low usage price as is the case with a private car.

In the case of ride hailing and ride sharing another key policy issue is the question of whether policy makers will give business licenses for these activities in the first place. Pressure from traditional taxi companies have caused local governments to be hesitant to allow these sharing concepts to operate, and in some cities (most notably New York) ride hailing has even caused more rather than less congestion in dense urban areas because of empty cars circling blocks for passengers. With higher demand the cars used for ride hailing and ride sharing will be used more efficiently, and should lead to less rather than more congestion. If congestion savings become large enough such that the societal interests of fighting congestion counterweight the interests of traditional taxi companies, local governments may be tempted to lift bans on operation or even promote ride hailing and ride sharing. In sum, it seems reasonable to assume that in the coming five to ten years car sharing will grow to substantial levels in the largest cities, but will only take on a dominant role in the transport system once Mobility as a Service applications become commonplace and eventually also when autonomous vehicles become widely available further in the future.

Parking and car sharing

The sharing economy could have major impacts on the parking sector. Firstly, as explained above, **all forms of car sharing** lead to fewer car kilometers driven per person. This **may come in the form of shorter trips but could also lead to fewer trips and hence to fewer parking transactions**. Moreover, sharing concepts also increase the share of time that cars are in use, and **therefore reduce the time they are parked**. For some sharing concepts the impact on the parking sector is even deeper. For car rental concepts the impact is still limited, as they still involve a human driver who can choose to park in an off-street parking garage. The only impact could be that municipalities may want to give such cars privileged parking spots (as is currently done for NS Greenwheels at on-street parking spaces, and is planned for residential parking in car restrained neighborhoods), and if no on-street spaces are available they may request off-street parking garage operators to provide privileged parking spaces below market prices.

Impacts are deeper in the case of ride hailing and ride sharing, since these trips do not involve any parking transaction and, to the extent that they replace car trips rather than public transport or walking/cycling trips, **directly replace trips that could have terminated in an off-street parking garage**. **At the same time the vehicles used for ride hailing and ride sharing will require parking** when they are not in use at night or at off-peak hours, which could represent an **opportunity for the parking sector** if mutually attractive

deals can be made with the owners of these cars. **When shared cars become EV's** (which is likely because of the low usage cost of EV's) **they will also require charg**ing, which can also be supplied in off-street parking garages. Parking operators may find it easier to make such deals when the fleet of shared cars is owned by the sharing companies themselves, but possibly more difficult if the cars are owned by their individual drivers (as is the case with Uber and Lyft) as they would have to make deals with each driver separately.

Finally, while some forms of car sharing could lead to lower parking demand, this would only affect the business model of off-street parking operators if the total supply of parking space remains the same. However governments could also see the lowered demand for parking as an opportunity to reduce the supply of on-street parking, as they would if they follow smart urbanism principles (see chapter 5). In that case the drop in parking demand would be limited, at least in the case of off-street parking locations where competing on-street parking is also available.

The price of mobility

A final trend that could change the way we use cars is related to the **price of car use**. Some experts have suggested that **car use could become significantly cheaper over the coming years**, which could lead to a strong increase in the number of trips and trip distance. Three sources for this drop in the price of mobility have already been discussed. Firstly electric vehicles have a much lower cost per kilometer traveled than fossil fuel cars, and could also lead to lower cost of car ownership if offered through (private) lease or other Car as a Service concepts. Secondly car sharing can cut driving costs further by using cars more efficiently. And thirdly autonomous vehicles reduce the price of mobility in the sense that they reduce the accident risks of driving and reduce the effort and energy of driving, and eventually (when full autonomous mode becomes available) all time and effort costs of driving are eliminated as the driver becomes a passenger who can use driving time to work or relax. Besides these trends, experts also suggest that the production costs of cars will go down in the coming years. Robotization of car manufacturing, usage of 3d printing, and the development of cars as flexible platforms that are updated sequentially rather than developing every model from scratch all push down the costs of producing a new car. And in the next 5-10 years EV's are likely to become significantly cheaper to produce than conventional cars are now, because of their simpler design and the strongly downward trend in battery cost.

Cheaper mobility would, all else equal, lead to more trips and hence more demand for parking (except for shared and autonomous vehicles). However it is unlikely that the government would allow car use to become much cheaper and car demand to grow out of control. A simple and elegant policy solution would allow the government to return the price of car use to its original level, or to any other level that the government decides is socially optimal. This solution is road pricing, or the charging of a price per kilometer driven.

Road pricing has long been proposed by economists as an optimal policy tool for managing the demand for car use to a level where congestion and emissions are at a socially acceptable level. Few countries have ever implemented road pricing in practice, first because of technical difficulties and later because of privacy concerns (cars need to be tracked in order to charge them the correct fee) and a general resistance from car users. However, **the rise of the EV makes it almost unavoidable for governments to consider road pricing, because it eliminates fuel taxes as a major source of government revenue**, **and because it makes driving so cheap that congestion could reach untenable levels**. Charging a different (higher) tax rate on electricity when used as a car fuel is technically possible if car users are forced to use devices that

track their electricity use for car charging. But this becomes unpractical in a future where more households generate their own energy, as charging an EV on self-produced energy would mean paying zero tax on driving.

The convenience of fully autonomous vehicles will eventually be an additional reason for introducing road charging, in order to counter socially undesirable and congestion causing behavior like having AV's drive empty to park in cheap locations or to avoid parking altogether by circling the block. Moreover fully autonomous cars also make it possible for road pricing to be applied in its optimal form, namely with dynamically varying prices by road segment and time of day in order to charge driving in heavily congested times and places more than driving off-peak and on quiet roads. Human drivers would be unable to process and respond to such detailed price information, but the algorithms driving autonomous cars can easily be programmed to take such road prices into account.

The bottom line is that a future with significantly cheaper car use, and hence more car use, is unlikely at least in countries with a central government powerful enough to introduce road pricing when needed. Even if the amount of car use under road pricing remains the same, it could possibly induce some shifts in parking choice. Road pricing with dynamic prices can practically eliminate congestion, and hence make parking garages located in congestion-prone areas more attractive to visit. At the same time the road prices charged at congestion-prone areas will be higher, which could incentivize price-conscious drivers to avoid parking garages located there. The net effects of such processes is hard to tell, but shifts in parking demand by type of customer segment could occur, with implications for parking marketing.

4. Integrated mobility

So far, we have discussed trends related to changes to the car itself, and to the way we use our cars. In this chapter we start zooming out to see whether the role of the car in the wider transportation system is changing. A movement towards integrated mobility, possibly culminating in Mobility as a Service, could bring new stakeholders into powerful positions in the automotive sector, with potential consequences for the parking sector.

Rise of the integrators

Developments in ICT as well as horizontal and vertical integration have brought great changes to the retail sector. New players have sprung up from formerly niche markets, such as hotel and travel booking, book retailing, and navigation software. Few people would have expected that these seemingly marginal sectors could spawn retail giants who would go on to disrupt seemingly unrelated retail sectors and place themselves at the heart of integrated sales platforms. Booking.com now offers not just hotel stays but also flights, rental cars, taxis, restaurant reservations, museum tickets, cooking classes, and the list goes on. The expansion of Amazon.com is even more amazing, having started as a bookstore it now undertake R&D to develop autonomous vehicles. And the potential for Google Maps to suggest, reserve and arrange payment for activities, transportation, meals and hotel stays is only starting to be exploited. Integrators offer convenience and consistent service quality to their customer, as well as cost savings through economies of scale and through negotiation with the many smaller companies that rely on them for sales. The trend towards integration in retail is very likely to occur in the mobility sector as well over the coming five to ten years.

Having experienced low prices and seamless consumer experiences in retail, consumers are likely to bring the same high expectations to the mobility sector. By comparison, the mobility sector is still **an archipelago of disconnected services**, each with their own brands, purchasing channels, access cards, reservation systems (if available) and payment systems. **A range of stakeholders are now preparing initiatives for setting up integrated mobility products to try to string part or all of this archipelago together into a seamless customer experience**. Experts mention several specific stakeholders who have either made their first move, or could potentially gain a strong position if they saw the potential of integrated mobility.

One group of stakeholders who are making their first moves into integrated mobility are the **automotive manufacturers**. Until recently the situation has been such that after a car has left the dealer, its buyer maintains hardly any contact with its manufacturer anymore. Because of this, car companies had very little knowledge about who their customer is, how they will use the car they have bought, and have few options for creating brand loyalty except for delivering a quality product. The automotive has long wanted to change this in order to build up a stronger bond with their customers and have recently begun to improve the situation. Besides being a good marketing strategy, this also fits in the general move away from selling cars as a mass market product, and towards selling fewer cars but with higher margins from customized features and auxiliary services. Integrated mobility turns out to be an attractive way to reach these goals.

Several automotive companies, especially premium brands, have started adding related products and services to their product package. BMW and Daimler have stepped into the car sharing sector by setting

up respectively DriveNow and Car2Go, and have recently announced to combine forces to increase the scale of their car sharing fleet. Car sharing allows their customers to have the same product experience whether they drive in their own car or when a rented one is more convenient. Within the car, customers find the navigation system they are familiar with, which at the same time allows the car company to collect data on usage patterns of their cars. Navigation software supplied by car manufacturers currently tends to be of a relatively low quality, but automotives understand the importance of navigation for generating data that helps them understand their customers better. A further step would be to build additional services into the navigation system, for example helping the customer find and reserve parking with trusted parking operators. GM offers another example of developing in-car as a new retail channel, by building a coffee button into their car with which customers can order coffee from trusted suppliers with a single push of the button. Beyond cars, some brands have started supplying folding bikes and electronic steps to carry their customers the last mile from the parking location to the final destination. While all of these services still seem baby steps, they suggest a move towards creating a seamless premium customer experience that ties multiple modalities together into a 'walled garden' product environment organized around the car.

Some experts observe that **car producers may eventually also want to step into the ride hailing sector**, taking on a role like Uber. The reason for this, besides adding another layer to their branded customer experience, is to avoid ending up in a weak position if ride hailing takes on a dominant role in the transport system. The way ride hailing firms like Uber and Lyft work is to focus only on linking rides with customers, while leaving drivers to purchase and maintain their cars. When AV's eventually make drivers obsolete, Uber and Lyft may try to get car manufacturers to take on the role of owning and maintaining the fleet, essentially taking the role of the "Uber driver". Besides being a weak position with small margins, this would also put automotives into a situation where they sell most cars B2B to the handful of ride hailing firms, rather than B2C. If automotives can instead become "Uber" instead of becoming "the Uber driver", they would gain a high-margin service sector. Whether automotives really move into such a dominant position is still uncertain, but their interest in integrated mobility is becoming increasingly clear.

Whether automotives gain a strong position in the ride hailing market or not, **ride hailing companies and other sharing economy firms are also emerging as key candidates for becoming mobility integrators**. Uber has already moved into bikesharing by taking over a bikesharing firm in the US (JUMP bikes). Moreover it has started to experiment letting its users rent cars through Getaround from inside the same customer environment as Uber's ride hailing products. Uber explains these moves as a strategy to offer its customers not just (shared) taxi rides, but also ride **by any other transport mode that happens to be the most convenient and affordable to users at that time and place**. This should eventually also include public transport rides, which would bring Uber very close to a full Mobility as a Service product (see below). However including public transport operators is probably the most difficult step, since from an international perspective they are highly fragmented, and Uber has little leverage to force them to cooperate. Until ride hailing becomes a dominant transport mode, Uber will have to rely on goodwill to convince public transport companies to join its integrated mobility scheme. And goodwill has so far been one of the weaker aspects of Uber as a company.

Related to the previous point, another group of stakeholders that are a clear candidate for becoming mobility integrators are the **public transport operator**. In the Netherlands the national railway company has long been active in setting up services to improve the ingress and egress trips of their customers, offering shared taxi services and more recently also Greenwheels car rental and bikesharing. However the

ambitions of public transport companies still tend to be limited to servicing their own customers, with little interest in moving beyond their core business. So while the potential is there to become integrators in wider mobility products, no clear ambitions have yet been shown.

Another candidate for integrator status, which has not realized its full potential yet, is formed by the **lease companies**. In the Netherlands a large share of commuters drive cars owned and maintained by lease companies, and a small but growing group of customers lease their car through a private lease contract. This makes lease companies one of the few stakeholders with intense, long-term contact with their customers, and the potential to offer a range of auxiliary services and custom upgrades to their customer throughout the lease contract period. Moreover through navigation and sometimes tracking devices, lease companies can access large amounts of usage data, giving them deep insight into their customers and their needs and preferences. If lease companies are reimagined as Car as a Service (CaaS) providers, it is a small step for them to also move into the wider Mobility as a Service market by offering additional packages with access to other transport modes along with the lease contract. CaaS could have the potential to grow strongly over the coming years thanks to the low usage cost offered by EV's, possibly enabling CaaS providers to offer 100 euro per month car leases in the near future. This could be a very attractive platform for adding additional services, especially if lease contracts could be made more flexible by varying contract length or allowing breaks during periods when customers are better off with the intermittent access to a vehicle offered by car sharing rather than continuous car lease. However none of the experts interviewed for this study has seen concrete signs that lease companies consider moving into such a role. Seeing the potential of this business space, it is not unlikely that car producers may actually move into the Car as a Service sector and take over the position of lease companies, thereby strongly enhancing their bond with end users and adding a powerful new product to their integrated mobility products.

Some other stakeholders could potentially move into integrated mobility. **Tech companies**, like Google, Apple and Amazon, are already active in the mobility sector through navigation software (in the case of Google and Apple) and through investment in autonomous vehicles. Currently navigation software can only suggest possible trips by public transport, and possibly provide information on parking locations when data is made available. If public transport, parking, bikesharing and other mobility players are willing to make their services available for reservation and booking through for example Google navigation apps, this would directly put Google or other tech players into the position of a mobility integrator able to offer complete Mobility as a Service product packages. Finally, in some countries, though not especially in the Netherlands, **large retailers** are taking on more long-lasting relations with their customers by offering car loans and other substantial credit commitments. This could evolve into a lease construction, and from there into a wider Car as a Service product. However few signs suggest that retailer have intentions for making such moves.

Mobility as a Service

The ultimate form of integrated mobility is called Mobility as a Service. This is an ideal end-state, in which a single company operates as both a booking.com and a Netflix combined. Like booking.com it has the capability to offer a range of different products and services which can be reserved and paid through its customer interface, and like Netflix it offers these products as part of a monthly subscription plan with several levels of premium services. For example Whim, credited as the first working example of a complete Mobility as a Service product, offers an unlimited mobility subscription plan that includes public transport,

bikesharing and ride hailing at a price below the average monthly cost of owning and driving a private car. The goal is to convince customers to get rid of their own car, and use the money saved in this way to buy all mobility needs through the MaaS app. Recently Whim and its subsidiary companies have gone international, and in the Netherlands 2019 will see small scale launches of several regional MaaS pilot projects hoped to grow into wider integrated mobility services.

The ability to offer MaaS revolves around **having access to real-time information on transport availability and scheduling, easy reservation and payment, seamless inter-modal connections and full coverage of all relevant transportation services be it private or public**. Whim shows that a private company can play this role, but the level of cooperation and goodwill that it found in its native Helsinki is unlikely to be available everywhere it tries to expand. Also some government stakeholders worry that **allowing a private company to grow into such a strong position could leave travelers dependent on a monopolist**, and in the Netherlands the national government decided to seed smaller parties and consortia to set up their own MaaS systems. The Growth of Mobility as a Service also depends on the growth of car sharing, since car rental, ride hailing and especially ride sharing have turned out to be key selling points in pilot MaaS projects and feasibility studies. If car sharing concepts grow strongly in availability and quality, and achieve cost savings that are passed onto customers, then they can form the backbone of MaaS systems in addition to public transport. Moreover, the growth of MaaS also depends on the extent to which customers are willing to pay for premium experiences, rather than joining MaaS just to save money. If premium segments can be attracted to MaaS, tech companies and other mobility integrators will be more motivated to enter this market and use their considerable investment capital to speed up its take off.

Regardless of who becomes the integrator and MaaS operator of the future, one clear trend that would be amplified further by MaaS is the **trend towards contactless payment**. One of the key benefits of MaaS is that it eliminates the need to make single transactions per trip and per mode, as these are covered by a monthly subscription payment instead. Booking and payment of individual trips is then handled by the MaaS operator, ideally out of sight of the consumer. The consumer only needs to inform the operator where he or she wants to go, and if multiple alternatives exist to choose one (for example based on price, speed or comfort). This implies that reservations are made in a mobile environment, and paid by the MaaS operator before or after the trip. **In the parking sector mobile payment is already becoming quite common for on-street parking, and some off-street parking operators have also started implementing it**.

Outside of the mobility sector and particularly in the retail sector there is also a clear trend towards payment before or after receiving a product or service, such as supermarkets who allow payment after leaving the shop through the Tikkie app. Automized payment where no user input is needed has also been implemented in a few cases, most notably at the experimental Amazon Go supermarkets. While up to now such services have still been relatively novel (satisfiers that increase customer satisfaction when available), **it seems safe to assume that they will become basic expectations (dissatisfiers that reduce customer satisfaction when not available) over the coming 5 to 10 years**. Other requirements for MaaS, such as accurate near-time availability forecasting, **seems realistic for parking operators to offer and would give them a leg up over on-street parking where data availability and analytics capability are less likely to be sufficient**. Garages already know their total occupancy and tend to have good historic data for forecasting. With sensor technology, which is getting better and cheaper to use (such as ceiling sensors that cover multiple spaces, instead of ground sensors that only cover one spot), off-street garage operators can also track availability of specific parking spots and have a check on data quality. Finally as

discussed in chapter 2, it will probably become possible to purchase occupancy data (about ones own parking offering and those of other operators) from owners of fleets of sensor-loaded cars.

Public transport renaissance?

Part of the enthusiasm about Mobility as a Service comes from public transport companies, who see it as a way to increase their convenience and ridership. MaaS makes public transport trips easier to find, reserve and pay, and facilitates public transport passengers to find ways to improve the convenience of their ingress and egress trips (towards the public transport stop and from the final stop to the final destination). Some experts go further and expect widespread use of MaaS combined with the rise of car sharing concepts to increase the competitiveness of public transport with the car, leading to a public transport renaissance. Moreover, the growth of high density urban areas (where public transport tends to perform better) at the cost of less densely developed areas could further increase the attractiveness of public transport.

If public transport were to gain market share at the cost of the private car, this could lead to fewer parking transactions. However it is still too early to estimate whether this is likely or not. Experts do remark that the perception of public transport, particularly among the younger generations such as the Millennials, is gradually becoming more positive. This could partly be because of a change in preferences (the perceived attractiveness of public transport), or thanks to improvement in the service quality of public transport (the actual attractiveness of public transport). MaaS could lead to an improvement of both. Moreover there could be other innovations in public transport apart from MaaS, that would strengthen its competitiveness vis á vis the private car. However, experts who have studied the potential for innovations in public transport generally do not see major improvements in urban public transport emerging over the coming five to ten years.

Integrated mobility and parking

The **rise of integrated mobility could impact the parking sector in several ways**. Firstly, as discussed above, **it could decrease the demand for off-street parking** if trips by private car are substituted by public transport trips or trips by ride hailing or ride sharing. As discussed earlier in this chapter and in chapter 3, such substitution is certainly possible though the likely extent is difficult to assess. Secondly the development of integrators in mobility **can also create important new B2B relations between parking operators and stakeholders** they traditionally may not have had extensive contacts with. If integrated mobility products, possibly culminating in Mobility as a Service, do emerge then their operators are likely to seek integration of parking services into their mobility products. For example, car manufacturers could wish to offer parking reservation in their seamless premium mobility environments. And for a Mobility as a Service operator it would be attractive to offer parking reservation and payment as part of the multimodal trips they offer to their users.

If mobility integrators were to gain a powerful position in the mobility sector, **a question would be how the parking sector should respond to this**. The worst outcome for the parking sector would be if a “booking.com effect” arises in which powerful integrators control a large share of the bookings at off-street parking garages, allowing them to push for lower parking prices in order to benefit their own customers and/or take a margin on the parking transaction. Parking operators should monitor the mobility sector in order to anticipate the emergence of mobility integrators. And as discussed above, mobility integrators can also have their origins in other sectors such as retail. When an integrator does arise, the parking sector would have a stronger position if it coordinates its response and proactively reaches out

with it to build up strategic relations. For example, **integrators require high-quality data on parking availability**, and convenient data architecture that allows them to translate and connect parking data with their own data systems. **If the parking sector cooperates to set up such systems jointly, they could have a strong negotiation position**. Other aspects that integrators will pay attention to is operational excellence and whether operators can offer **national or international coverage** within the same data architecture.

Finally, the rise of integrated mobility could also impact the parking sector **by unlocking currently unavailable parking supply**. Peer-to-peer parking sharing, in which consumers (C2C parking sharing) or companies (B2C parking sharing) offer their spare parking space to other users through sharing applications, has so far seen very little real-world application. One reason for this may be the inconvenience of having individual end-users on the demand-side of such sharing transactions. If powerful stakeholders emerge in car sharing (including both car rental concepts and ride hailing and sharing concepts) and integrated mobility, they could be a much more attractive party on the demand-side of peer-to-peer parking sharing. This would change car sharing from a C2C or B2C into a C2B or B2B proposition. **Moreover, mobility integrators may also find it attractive to incorporate valet parking**, since they could operate this at scale rather than as a small-scale premium service. This too would mobilize more parking supply which currently from the perspective of off-street public parking providers would not count as competing offers. However as discussed before, any scenario where parking demand drops or new parking supply enters the market could lead to lower demand for off-street garage parking, but could also trigger local policy makers to **reduce on-street parking availability in line with smart urbanism principles**. In the latter case demand for off-street garage parking would not have to be affected.

5. Are cities changing?

The previous chapter already zoomed out to the wider transport system in which the car plays a changing role, and this chapter zooms out even further by considering possible changes to cities themselves. Parking and car travel demand are derived from the activities people wish to undertake, and the extent to which the car is convenient in facilitating those activities. For the parking sector activities occurring in or near city centers are most interesting, as this is where paid parking in structured parking facilities mostly takes place. Changes in retail and urban planning could impact how often we visit city centers, and the extent to which the car represents the most convenient means for doing so.

Urban densification

A key change which is recognized by several experts is that cities are gradually becoming more densely developed and populated. As discussed in chapter 3, a key potential demographic trend for the coming decades is the attraction of cities, particularly the largest ones, for a growing segment of the Dutch population. This increased preference for city center living is visible in the rise of small or even micro-houses (40 square meters or less), which people accept in order to be able to live in a city center. Also most cities follow a policy where new development preferably takes place in city centers rather than on greenfield locations. Denser development implies more efficient use of scarce urban space, which requires that road space and on-street parking space should be minimized. There have always been proponents for such Smart Urbanism concepts such as walkable and less car oriented cities, but so far most people who suffer negative consequences from cars are also car users themselves. If shared and integrated mobility makes city dwellers less car dependent, this also allows them to take on stronger opinions against car use. The question of which role and how much urban space cities should give to the private car is becoming more and more an open question, and the choices cities make could become more varied over time as they make different trade-offs.

Densification and smart urbanism could create **both opportunities and threats for the parking sector**. Policy goals such as sustainability (less or more efficient car use), livability (higher quality urban public space) and affordability (freeing up more space for housing) all put a strong pressure on municipalities to reduce on-street parking and increase the tariff for remaining curb parking spots. Off-street parking, both above and below ground, is a more space efficient than on-street parking and could fit very well into smart urbanism visions. A reduction in on-street parking would also create more demand for off-street parking as alternative parking options are reduced. And high on-street parking tariffs also support the business model of commercial off-street parking operators. But if higher parking prices and a less hospitable environment for the car leads to fewer car trips to the city center **this could also reduce parking demand for off-street parking**. However if on-street parking availability is reduced by the same proportion as the drop in car trips, the impact on off-street parking garages would be dampened.

Higher density urban development could also create a **business case for a new class of off-street parking garages, namely residential off-street garage**. If all parking spaces for an urban neighborhood are concentrated in an off-street garage, preferably underground, this would free up large amounts of urban space that could be used for housing development or increasing the attractiveness and livability of high density neighborhoods. Therefore, the residential off-street parking garage **could fit very well with the vision of smart urbanism**. Moreover, as discussed in chapter 2, concentrated off-street residential parking

could also help solve the difficulty of EV charging of both cars and e-bikes in dense urban neighborhoods, where home charging is inconvenient or even impossible. So far few examples exist of concentrated residential parking, and experiments in the Netherlands in the 1970s showed that people do have a strong preference for having their car near the house particularly for safety reasons. A key condition for off-street residential parking therefore is that safety is guaranteed. Off-street residential parking also implies that people need to walk up to a few hundred meters to reach their car. However, scarce on-street parking already means that inner city dwellers often cannot park near their house, and given the heightened attraction of city center living it seems a small sacrifice to accept in return for fulfilling one's housing preference.

Project developers also appear attracted to the vision of city center neighborhoods without on-street parking, as it allows more space for innovative urban design and every square meter devoted to housing pays off much better than a square meter of on-street parking space. The visionary Haven-Stad development plan for Amsterdam already shows some of these principles in practice, as early design sketches for this large-scale neighborhood show on-street parking strongly reduced, with a target of one parking spot per five houses realized as much as possible under apartment buildings and in park and ride facilities on the ring road. This plan is designed to fit the mobility needs of city dwellers up to 40 years from now, and gives a revealing yet controversial insight into the vision of project developers for residential parking in the near future.

Further out in the future there are also visions in which the rise of autonomous vehicles directly competes with on-street parking availability. In the intermediate phase of vehicle automation, in which cars can drive autonomously but only on separate lanes rather than in mixed traffic with human-operated cars, there would be a demand to free up road space to create such autonomous-only lanes (possibly combined with buses, taxis and other vehicles with privileged access). Since the use of shared AV's also reduces demand for parking, the space for autonomous-only lanes could be created by cutting on-street parking spaces on a large scale.

Finally, urban densification combined with the technological developments of electric, shared and integrated mobility discussed in previous chapters, could also create **new potential uses for city center parking garages**. This could include **storage of electric batteries, recharging locations for EV fleets, storage and maintenance of shared vehicles, and intermodal hubs for passengers and freight**. This can represent an opportunity for the parking sectors if margins on such services are comparable to visitor parking, but could also be a threat if margins are lower but municipalities still demand that space is made available for this in off-street parking garages. In particular **parking operators who rent rather than own parking garage space could be vulnerable to such new demands for garage space, for which few alternative locations are available in city centers**.

Spatial planning law

Changes in the development of cities can stem from changes in residential preferences and transport technologies but could also stem from changes to the planning system itself. This trend is very specific for the Netherlands, but may fit broader trend in urban planning. A major overhaul is currently underway in the Dutch spatial planning law "**omgevingswet**", which over the coming years could lead to changes in the way urban neighborhoods are planned. The new planning law calls for a more integrated and long term vision on how mobility fits in the wider urban fabric. While in the current planning system traffic and parking are usually only considered last after all other urban design decisions have already been made,

the new system calls for urban development and mobility to be based on a broader and more integrated vision. Future urban design plans will have to answer more fundamental questions such as how much mobility an urban district should invite and what kind of mobility in terms of modal choice fits that district. A more integrated perspective on urban design allows planners to make stronger choices on mobility and parking, and to implement more customized solutions for specific cases. In the new system parking needs to be discussed in the earliest planning stages rather than at the end, and planning outcomes may be less predictable than before.

The new planning law could be an opportunity for the parking sector to take a more active role in urban planning processes, becoming involved in more fundamental questions such as the relative role of on-street versus off-street parking and the possibilities for innovative parking solutions such as residential off-street parking. **Parking operators**, especially those owning their parking real estate, **can be an attractive stakeholder for planners because of the long-term commitment they make when investing in parking structures**. Once built, a parking garage can have a life span of decades just as housing development and the road network, causing parking operators to have the same need for a long term vision as planners have. Moreover urban planners will need to answer more complex questions such as to what extent parking demand is conditional on local circumstances and technological change, such as the extent of car sharing, public transport use and bicycle and walking accessibility, and their impact on parking demand. Stakeholders who can bring such knowledge to the table and offer innovative solutions could help planners face these challenges.

At the same time the new planning system can also be a challenge for the parking sector. For example parking operators should anticipate changes to the tendering system. The possibility to bring innovative visions on transport and parking into the planning process early on, even in the form of unsolicited proposals, could **allow new parties to enter the tendering process** and suggest new solutions or requirements to be taken into account in tenders. If new stakeholders find parking concepts that fit even better in a **context of smart urbanism and integrated mobility**, they could emerge as powerful competitors to the current parking sector. The changes described above, including the possibility of unsolicited proposals, will become possible starting from 2020/2021. The date when municipalities actually start making use of these new planning tools depends on how much time it takes them to understand and implement them, which is likely to differ by municipality. In more smaller or more conservative municipalities changes could take a long time to have visible effects, but larger cities and more progressive municipalities could fully implement the new planning system as soon as it becomes available.

The retail landscapes

Changes to the city can also emerge from more fundamental trends that impact the activities consumers undertake in city centers in the first place. If consumers change how, where and how often they shop and entertain themselves, this could lead to slow but thorough changes to transport and parking demand in city centers. Experts mention at least **three trends that could impact the parking sector**, namely a shift to online shopping and entertainment, a move from city center to peripheral retail, and a shift in fun shopping from smaller towns and cities towards the largest cities.

The most obvious trend is the **gradual increase of the share of time and money spent on online shopping and entertainment**, at the cost of physical travel for the same purposes. This has most likely already lead to a drop in trips to city centers, which implies a drop in parking demand. How far this trend will develop

over the coming five to ten years is difficult to predict, but its consequences probably differ strongly between different cities. At the same time as online shopping and entertainment are growing, retail experts also see a **trend for shoppers to gravitate towards authentic, diverse and unique shopping experiences, for which city centers still enjoy an advantage**. However not all city centers are capable of providing such distinguishing hedonic consumer experiences. **Possibly only the largest cities will be unaffected by online shopping and entertainment**.

Retail experts think **a rift is opening up between the 25 largest Dutch city centers (and particularly the four largest cities), and the smaller city and town centers in the rest of the country**. While the formers are maintaining their attractiveness, also vis á vis online shopping, the latter are falling behind more and more. **Parking operators may need to take this into account in their investment decisions**, focusing on city center garages in the top 25 cities and divesting from the rest. A large number of cities is now in a marginal position, too small to offer the shopping experiences consumers will start demanding over the coming years but with potential to regain some of their competitiveness with active investments and innovative retail policies. **These municipalities may look at their parking offering as one of the aspects of the visitor experience which they can have influence on**. Some will argue for free parking as a way to keep their city centers competitive, others will ask parking operators to offer the highest level of parking convenience and comfort as a red carpet into the city.

Compounding the pressure from online shopping and entertainment, city centers in the Netherlands may also start facing increased competition from new (at least to the Netherlands) physical retail formats located outside the city center. The Netherlands is almost unique in having a planning tradition that strongly enforces a fixed hierarchical structure to the retail sector. The main features of this planning mold are to ensure neighborhoods are supplied with small grocery shopping centers, city centers with higher order (fun) shopping establishments, peripheral (edge of city) locations only with car dealers, furniture, DIY-shops and other shops for bulky goods, and finally enforcing a strictly enforced ban on retail developments that fit none of the above categories. Especially large shopping developments in greenfield locations are strictly banned in the Netherlands, while in most countries these have taken on a central role in the retail sector (for example the Hypermarché in France and the Walmart in the US). This retail planning vision has ensured that Dutch city centers have remained the focus point for retail trips, where in many other countries the city center long ago lost this dominant role.

However starting from the early 2000s, the Dutch planning system has been reformed to make it less prescriptive and to allow more local variation in policy outcomes. This has led to the emergence of a small number of peripheral or even greenfield developments like the Factory Outlet Centers. Change has so far been slow because local and provincial governments have so far not made extensive use of this new planning flexibility, but planning culture can slowly change over time. If over the coming five to ten years the Dutch retail planning system continues to warm up towards peripheral and greenfield retail, this could create magnets attracting shopping trips away from city centers. As paid parking has so far been limited to city centers, this would cause a larger share of shopping trips to fall outside the scope of off-street parking operators.

Besides threats, the retail trends could also create **new opportunities for the parking sector**. The rapid growth of online shopping has already led to **changes in urban logistics**, with an increase in small-scale deliveries of online ordered goods to people's home addresses. This pattern of goods delivery is neither sustainable (involving large numbers of trips to deliver packages, often after several repeated tries

because receiver are not at home), nor convenient for consumers. If a network of residential off-street parking garages was in place, these would be natural places to facilitate package delivery in the form of lockers, or last-mile distribution centers from which delivery could take place by foot or through small electric vehicles. Many cities have started thinking about solutions for more sustainable urban logistics, and the final form this may take is still uncertain. But **in any case, urban logistics does require storage and transfer hubs located close to or inside city centers**. Few such places are available with sufficient dimensions, **but parking garages may be suitable at least for some urban logistics models**. This could be either an opportunity (if margins are attractive) or threat to the parking sector (if margins are low but participation is enforced, especially for rented rather than owned garage space). However, using parking garages as freight hubs would still be challenging, since it involves designing a parking garage with safety standards and floor height suitable for both passengers and freight.

6. Take-aways for the parking sector

This report has identified and discussed a range of trends in mobility and other relevant sectors whose dynamics could impact the parking sector. Implications for the parking sector, both threats and opportunities, have been discussed throughout the different chapters, along with preliminary recommendations for safeguarding the future-proof parking business model. This final chapter highlights the most important conclusions and suggest some recommendations for the parking sector.

Conclusions

The goal of this report has been to identify and explore key trends and opportunities for the parking sector. Table 1 ranks the trends discussed in this report according to two aspects: the likelihood that these trends will substantially develop over the coming five to ten years, and the extent of impact on the parking sector. Each trend is followed by an indication of the chapter in which it is discussed (e.g. 2 = chapter 2).

		Impact on parking sector		
		Low	Medium	High
Likelihood	High	**-population ageing (3)** **-rise of the Millennial (3)**	**-electric driving (2)** **-urban densification (5)** **-online shopping (5)**	**-integrated mobility/MaaS (4)**
	Medium	**-hydrogen car (2)**	**-vehicle diversification (2)**	**-sharing economy (3)**
	Low		**-PT renaissance (4)** **-(much) cheaper car use (3)**	**-autonomous driving (2)**

Table 1: trends classified according to their likelihood to happen and impact for the parking sector for the next 5-10 years.

Trends that score medium or high on both likelihood and impact are suggested **as priority for parking operators** (green in the table). **Vehicle diversification**, or the trend towards more customization and diversity in vehicle designs from oversized SUV's to single-person or two-seater city cars (see chapter 2), seems reasonably likely as it is boosted by the **sharing economy**. It challenges parking operators to redesign their garages to cope with more diverse space requirements. Also, reasonably likely is the strong

growth of the sharing economy in the transport sector, with carsharing and ridehailing claiming substantial shares of especially urban trips. This not only changes part of the playing field for the parking sector from a B2C to a B2B environment but it could also lead to an overall drop in parking demand.

Highly likely trends are the strong growth of **electric driving, urban densification and online shopping**. EV driving require a clear vision on charging in garages but does not fundamentally alter the parking business model. Urban densification and online shopping could lead to changes in parking demand but could also open up **opportunities for parking garages to take on a role of intermodal passenger or freight hubs**. Finally, the trend towards **integrated mobility** or Mobility as a Service is considered as both highly likely and having a high potential impact on the parking sector. This trend could impact parking demand and **changes the playing field** by introducing powerful integrators who could either become key partners to the parking sector or a strong threat through booking.com effects and depressed margins.

Just as important as identifying key trends that should be prioritized for the future business decisions of parking operators, also the identification of those **trends that do not appear to be likely or impactful** over the coming five to ten years deserves attention. This includes most notably the **autonomous vehicle**, which some experts think is just around the corner but does not appear on the verge of introduction at least in a European context. Similarly, **hydrogen cars** may already be technically possible, but are likely to remain niche products due to their cost or complexity. A **major growth in public transport** use at the cost of the private car, as well **as a strong growth in car use due to much cheaper costs** per kilometer, are both seen as unlikely though they would have impact on the parking sector if they were to occur. Finally, population **ageing** and the rising importance of the **Millennial** generation are demographic certainties, but no powerful impacts on the parking sector were identified in this study.

Recommendations

Based on the findings of this research, we suggest four major recommendations for parking operators:

1. The first key recommendation is to **adapt to trends that are already fast-moving but making sure to really understand what the needs of the customers are**. For example, as discussed in chapter 2 the breakthrough of the electric vehicle is now fully underway and will over the coming five to ten years have clear implications for the parking sector. The key question for EV's is how to facilitate charging in parking garages. Parking operators need to decide how many chargers to offer at which locations, at what level of charging speed and whether to invest in more advanced technologies such as smart charging (connecting more charging cables to a single grid connection) and vehicle-to-grid functionality. These choices should be based on an understanding of the needs of the parking customer, and also depend on a range of other factors such as the future potential of plug-in hybrids, the development of battery capacity, and trends in urban planning that influence the scope for home charging. If investments are made without detailed understanding of these aspects, this brings the risk of creating stranded assets. But if no action is taken, parking operators could risk facing a competitive disadvantage.
2. A second take-away for the parking sector is **to anticipate the development of mobility integrators**, discussed in chapter 4. While a range of candidates for integrator status have emerged, most of them are still in an early stage of development and new challengers could still stand up. The challenge for parking operators is **to monitor this playing field and to anticipate**

how to approach integrators as soon as they have staked out a strong position. When this happens, the parking sector basically has two options to respond: **resist or cooperate**. If parking operators choose to resist the demands of a mobility integrator, they should make sure to work together as a sector and develop an alternative user environment that offers many of the same benefits a mobility integrator would provide (e.g. the ability to easily find and reserve any parking location, seamless payment solutions, and a coherent consumer environment with an international scope). If parking operators wish to cooperate with mobility integrators they should make sure their services are *plug-and-play*, allowing easy and reliable data integration so that mobility integrators are eager to add parking to their product portfolios and motivated to leave parking operators a margin. **A passive stance towards mobility integrators would create the risk that the parking sector could end up on the receiving end of a booking.com situation, with adverse effects on their margins**. This suggest rethinking the customer approach of a parking operator in the future, with a clear switch from B2C to B2B.

3. Thirdly, as discussed in chapter 5, urban planners are faced with tough challenges to ensure sustainability and livability in the face of urban densification, and specifically in the Netherlands to learn to work within the frameworks of the new spatial planning law. **Parking operators should help planners by developing innovative solutions for parking in high density cities**, and by **pro-actively** offering their support from the early stages of the planning process to the final operational aspects. For example, this study proposes new opportunities for the off-street parking garage as an intermodal hub, for both passengers and distribution, and for residential off-street parking garages in dense urban neighborhoods. But at the same time, turning garages into hubs can also compete with space for parking visitors, if for example local governments request that city center parking garages free up space for goods storage, electricity batteries, and service stations for electric shared taxis. The parking sector should at least make sure to be at the table when planners discuss such concepts, and in the new spatial planning system this moment could happen in a much earlier phase of the planning process than before.
4. The final take-away relates to many of the trends discussed in this report and suggests **parking operators might consider rethinking the way in which they calculate parking demand**. Several trends imply a change in parking demand, either in general or at specific locations. For example, sharing concepts, boosted by Mobility as a Service applications and eventually by autonomous vehicles, would reduce parking demand particularly in city centers. Moreover, changes in retail preferences and the rise of online shopping could reduce parking demand in general or shift parking demand from smaller city centers to the largest ones. However, whether such changes to parking demand actually impact parking operators depends on the policies of local governments. If municipalities treat demand drops as opportunities to reduce on-street parking, then the off-street parking sector would not need to be affected. Such a policy response would fit well with trends in urban policy and planning towards efficient use of scarce urban space and investing in attractive and livable urban environments.

Suggestions for further research

If trends are prioritized for further study, some aspects should receive specific attention. Firstly, for each trend a key and usually understudied question is what the consumer wants. Too often innovations are approached from the perspective of what is technically possible, rather than what is needed and desired by consumers. A clear understanding of consumer needs is key to understand the true potential of new technologies and business models. Also, consumers can use new products and technologies in different

ways than foreseen or intended, and a clear understanding of the consumer perspective helps provide insight into this.

Secondly, many trends involve government agencies and other stakeholders, both at a national and local scale. For example, urban planners can create conditions that foster trends to take place or steer their specific direction, and changes to planning needs and visions can themselves trigger trends that could impact the parking sector (e.g. urban densification). Further research could explore the perspective of the policy maker, to understand which challenges they face and what kind of solutions they need to realize their own visions and those of parking operators.

Finally, while this report discusses general trends that could emerge across developed countries, the precise way they could play out and interact with the parking sector is likely to differ by country and even by city depending on local circumstances. Further study could explore the precise way specific trends may play out in specific case areas, and which local conditions could boost or impede their development.

Interviews

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This report was written by the research team of Erasmus Centre for Urban, Port and Transport Economics. Erasmus UPT is a research and education institute based at Erasmus University Rotterdam. At the core of our business are three themes: Urban and Regional Economics, Port Economics and Transport Economics. Erasmus UPT's staff of experts has extensive (international) experience in 'making science work'. Erasmus UPT's mission is to deliver practical research solutions grounded in science. More specifically, its goal is to provide government and industry with cutting-edge knowledge, international best practice advises and workable policy recommendations. Our research serves as input for vision building, decision support and economic evaluation for clients in both the public and private sector. Our mission is also translated in our courses, which include short courses, Bachelor (BSc), Master (MSc) and post-experience programs.

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