CHALMERS
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The Impact of Autonomous Vehicles on Real Estate Valuation in Gothenburg

Master's thesis in Civil Engineering in the master's program Design and Construction Project Management

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ABSTRACT

The introduction of autonomous vehicles (AVs) will have an impact on the infrastructure of cities in the coming years. The city of Gothenburg is already testing AVs but there is still a lack of research on how this may impact how residential buildings are valued within urban environments. Therefore, this study aims to investigate how and to which extent the implementation of AVs may affect real estate value in the city of Gothenburg. To do this, real estate value factors and parameters were adapted from a report by Spacescape (2016) that described what the citizens of Gothenburg value in their residential buildings. There are three different real estate value factors: Density, Accessibility and Recreation which were applied to condominiums and houses. Each factor has several parameters with variables that explains how they are affecting real estate value. There is a weighting between the parameters which describes how much each factor was deemed to contribute to real estate value.

The implementation of AVs was projected as two possible future scenarios with AVs fully implemented in urban environments. The first scenario is called Privately owned Autonomous Vehicles (POAV) which assumes that all privately owned manual vehicles have been replaced with POAV. The second scenario is called Shared Autonomous Vehicles (SAV) assumes that all privately owned manual vehicles have been replaced with shared AVs which are used as a service. This study investigated potential impacts from the two scenarios on the real estate value parameters from Spacescape (2016) by creating assumptions regarding AV effects on Parking, Roads, Traffic flow and Value of time. The effects from AVs depending on the scenario were then compared to each value adding parameter. From that, a potential positive or negative impact on real estate value parameters could be estimated which were summarised as qualitative results.

To validate the assumptions regarding AVs effects on the real estate value parameters a questionnaire and interviews were conducted with 13 participants working within the fields of future transportation, city development, traffic and real estate. The result from the interview study was summarised and indicated how the real estate value parameters most likely would change with the implementation of AVs. There were discrepancies between the results from the literature study and the interview study which were addressed in the discussion. The discussion brings up weaknesses and strengths of the study. In conclusion, for scenario POAV there is two potential positive impacts from AVs and two potential negative impacts. These impacts could cause three outcomes, with either an increase in real estate value, a decrease of real estate value or no change. For scenario SAVs, real estate value in Gothenburg will either increase or stay the same. Thus, when comparing the outcomes from the two scenarios, SAV is more attractive scenario from a real estate value perspective. As this study is speculative in its results, the conclusions reached should thus only be considered as speculative as well. Depending on how autonomous vehicles are implemented and with which laws and policies are implemented to regulate the usage of AVs will ultimately decide how real estate value will change consequently.

Keywords: Accessibility, Autonomous vehicle, Density, Real estate value, Recreation

Påverkan av Autonoma Fordon på Fastighetsvärdering i Göteborg

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SAMMANFATTNING

Introduceringen av autonoma fordon kommer att ha en påverkan på infrastrukturen inom städer de kommande åren. Göteborgs stad testar redan autonoma fordon i stadsmiljöer men det finns en brist på forskning som visar hur autonoma fordon kan påverkan fastighetsvärdering inom dessa stadsmiljöer. Den här studien ämnar därför att undersöka hur and till vilken grad implementeringen av självkörande fordon kan påverka fastighetsvärden inom Göteborgs stad samt vilka parameter som kan påverka fastighetsvärderingen mest. För att kunna genomföra detta har fastighetsvärderande faktorer samt deras parametrar använts från en rapport av Spacescape (2016) som beskriver vad Göteborgs invånare anser vara värdeskapande för bostadsrätter. Det finns tre faktorer som beskrivs i rapporten som är: Täthet, Tillgänglighet och Rekreation som är uppdelade inom lägenheter och hus. Varje faktor har flera parametrar med variabler som förklara hur parametrarna blir påverkar fastighetsvärderingen.

Implementeringen av autonoma fordon åskådliggjordes genom två framtidsscenarion där autonoma fordon är fullt implanterade i stadsmiljöer. Scenario nummer ett heter privatägda autonoma fordon (POAV) och utgår från att de manuella privatägda fordon som finns idag har ersatts med privatägda autonoma fordon. The andra scenariot heter delade autonoma fordon (SAV) och utgår från att de manuella privatägda fordon som finns idag har ersatts med gemensamt utnyttjade autonoma fordon som används som en service. Den här studien undersöker vilka potentiella påverkningar dessa två scenarion kan ha på parametrarna inom fastighetsvärdering från Spacescape (2016) genom att ta fram antaganden gällande autonoma fordon effekter på Parkering, Vägar, Trafikflöde samt Tidsvärdering. Effekterna från autonoma fordon beroende på scenariot var därefter undersökt mot varje parameter som skapar fastighetsvärde. Från detta kunde potentiella positiva eller negativa påverkningar på fastighetsvärdering tas fram och sammanfattades som kvalitativa resultat i tabell 6 och 7.

För att undersöka ifall antaganden gjorde i litteraturstudien gällande autonoma fordons påverkan på parametrarna inom fastighetsvärdering gjordes ett frågeformulär samt en intervjustudie med 13 deltager som jobbade inom områdena, framtidens transport, stadsutveckling, trafik och fastigheter. Resultatet från intervjustudien sammanfattades i tabell 9 och 10 som bygger på tabell 6 och 7 men som visar hur fastighetsvärderingen mest sannolikt kommer att påverkas genom implementeringen av autonoma fordon. Det finns diskrepanser mellan resultatet från litteraturstudien och intervjustudien som analyseras i diskussionen. Diskussionen tar även upp styrkor och svagheter med genomförandet av studien som helhet. Som slutats kunde det fastställas att scenario POAV hade två potentiella positiva påverkningar from autonoma fordon samt två potentiella negativa påverkningar. Dessa påverkningar kan leda till tre utfall, med antingen en ökning av fastighetsvärderingen, en minskning av fastighetsvärderingen eller ingen förändring. För scenario SAV blev resultaten fem potentiella positiva påverkningar på fastighetsvärdering vilket kan leda till två utfall, en ökning av fastighetsvärderingen eller ingen förändring. Därmed kan med vid jämförelse av de två scenarierna dra slutsatsen att scenario SAV är mer attraktivt utifrån ett fastighetsvärderings perspektiv. Då den här studien är spekulativ i sina resultat så borde slutsatserna som nåtts anses vara spekulativa också. Beroende på hur autonoma fordon är implementerade och vilka lagar och policyers som implementeras för att regalera användandet av autonoma fordon kommer slutligen bestämma hur fastighetsvärderingen kommer att påverkas.

Nyckelord: Autonoma fordon, Fastighetsvärdering, Rekreation, Tillgänglighet, Täthet

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PREFACE

This master thesis is a part of the M.Sc. programme in Civil Engineering, Design and Construction Project Management, DCPM, at Chalmers University of Technology, Gothenburg. The study has been conducted during the spring semester of 2020.

We would like to thank our supervisor Frances Sprei at Chalmers University of Technology for taking the time to help us with this thesis. Thank you for taking the time to give us feedback, come with suggestions and support us in our writing. Without your expertise, dedication and guiding we would not have fulfilled this thesis.

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A great thanks to AFRY for wanting to participate in this study and that so many of the employees wanted to take the time to be in the questionnaire and interviews.

And a final thanks to all who participated to the questionnaire and interviews. Your answers and discussion really helped us to take this study to the next level. There was some interesting conversation during the interview that helped us wider the perspective of the future city planning.

Gothenburg

May 2020

Amalie Lennartsson and Lars Olsson

LIST OF ABBRIVATIONS

AV	Autonomous Vehicle
CBD	Central Business District
CM	Combined Mobility
MV	Manual Vehicle
POAV	Privately owned Autonomous Vehicle
SAV	Shared Autonomous Vehicle
VOT	Value of Travel Time

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1 Introduction

During the last century, a metamorphosis in transportation transpired, as automobiles became inexpensive to produce through mass production and thus more accessible to the larger population (Bardou, Chanaron, & Fridenson, 1982). Sweden was no exception and underwent a paradigm shift in transport behaviour during the 1950s. The number of privately-owned cars increased during this decade from approximately 200 000 to 1.2 million. As a result, new problems regarding traffic safety as well as a lack of space occurred within cities. A new city planning ideal was developed that focused on the car as the main mode of transport (Göteborgs Stad, 2018).

Prior to cars being commonplace, cities in Europe needed to have short distances between vital city functions, which created a central business district (CBD), a high-density pocket of urban activities in the city centre (D'Acci, 2018). The car unlocked the possibility for longer travels which created a new city planning ideal with sparse cities and urban sprawls. The reasoning behind this ideal assumed that multiple CBDs and a decentralized city would result in a more equal distribution of welfare. There were however downsides to the new car focused ideal. Instead of distributing welfare equally there often became physical and social gaps between different parts of the city, enhanced by the distances between the CBDs. Gothenburg adopted this new ideal in the 1950s and constructed smaller CBDs and local markets dispersed in different parts of the city. The distances between the CBDs were longer and as a result, the widespread city of Gothenburg was created as seen it today (Göteborgs Stad, 2018).

Today cities face a similar paradigm shift as autonomous vehicles (AVs) are introduced. There is uncertainty regarding the implementation of AVs and how they may affect urban areas. AVs may produce faster, safer, and more convenient transportation, while requiring less space. The implementation of AVs has the potential to promote a new city planning ideal that focuses on people instead of cars (NACTO, 2019). However, there are not only positive aspects of AVs. Studies suggest AVs may increase the car usage as more people become eligible to drive, are willing to drive larger distances and more often (SOU, 2018). Such a growth could result in an increased congestion and thus negate the positive effects of AVs. One major concern for cities is that AVs could influence people to move away from the cites, creating a trend of de-urbanisation and leading to urban sprawl (Medina-Tapia & Robusté, 2018).

To avoid such a scenario, it is important to analyse how the effects of AVs could impact factors that generate real estate value in cities. The study *Value-creating Urban development* (2016), was made by several key stakeholders in the city of Gothenburg, to identify key factors that the citizens perceived relevant in determining real estate value. Three main factors were identified in the study: A*ccessibility*, D*ensity* and R*ecreation* (Spacescape, 2016). By analysing how these three factors are affected by the implementation of AVs this may give an indication in future real estate values.

This study firstly focuses on expanding upon what parameters the three real estate value adding factors are based on and the potential impact in real estate value these parameters could have. Thereafter, the study analyses the potential effects AVs may have, based on two different scenarios. One where AVs are privately owned and one scenario where they are shared, either as public transport or as a service. This result was then used in an interview study, with people knowledgeable in the fields of AV, real estate, city planning and traffic, to elaborate how likely the estimation from the first part of the result is and to gain further insight in how likely the outcome of the result is.

1.1 Purpose

The purpose of the study is to analyse how AVs may impact the real estate value adding factors and parameters, identified in the report *Value-creating Urban development* (2016). The factors are *density*, *accessibility* and *recreation*, see figure 1, and their additional parameters are described in the theory chapter. To delimitate this study two separate scenarios are used, where AVs are assumed to be fully implemented. These two scenarios are taken from the article *Forces of change: The future of mobility* (2017) and represent two extreme cases when considering ownership of AVs.

- Privately owned Autonomous vehicles (**POAV**) – In this scenario the AVs are fully implemented and no Manual Vehicles (MVs) are in use. The ownership of the vehicle is assumed to be on the same level as it is today, meaning that all privately owned MVs today are replaced with POAV.
- Shared Autonomous Vehicles (**SAV**) – In this scenario the AVs are fully implemented and no MVs are in use. The ownership of the vehicle is shared, meaning that each person can rent the vehicle during that period when it is needed through a service. When a person reaches the destination, a new person can book the vehicle for their usage. This may be through both public and private companies. The mobility companies can specialize in having different vehicles depending on the needs of the passenger. SAV is a concept that is separate from ridesharing. Ridesharing means that a person is sharing a vehicle with other passengers while SAVs means that that the vehicle is not owned privately and could result in only one passenger riding a vehicle.

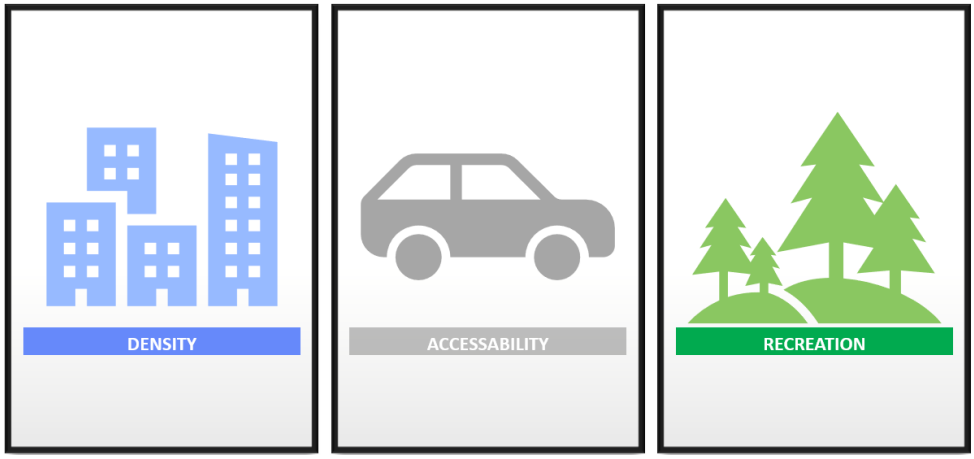


Figure 1- The three real estate value factors in Gothenburg

1.2 Research questions

The result of the study explains how real estate value may be affected by the implementation of AVs in the city of Gothenburg, by answering the following research questions:

1. How does the implementation of AVs, depending on the scenario, affect the parameters within the three value adding factors D*ensity*, *Accessibility* and R*ecreation*, in Gothenburg?
2. Which parameters within the three factors are mostly affected by an implementation of AVs depending on the scenario?
3. How do these impacts affect the real estate value?

The first question analyses how the factors are affected by the implementation of AVs for the scenarios POAV and SAV.

The second question analyses the potential effects AVs could have on the real estate value parameters and potential impacts are summarised in the result section in a table.

The third research question discusses the results from the first question which are the potential changes to the real estate evaluation and how these results may affect the attractiveness of Gothenburg as a city. The result from the literature study combined with the result from the interviews and questionnaire and shows how AVs could affect the different real estate factors and from that how much each parameter changes, and if this has a positive or a negative outcome.

1.3 Assumptions

Following assumptions and delimitations are established for the study to make the results concrete and manage the results and complete the study within the time frame.

Assumptions

- No change in work culture which means that people are still commuting to work and is therefore in need of transport between their house and workplace.
- In the study it is assumed that the AVs are level 5 of automation (see definition below in section 2.1.2). Therefore, it is also assumed that these vehicles have the technology to drive and park by themselves, be connected to every vehicle around them to create an efficient flow of traffic, is connected to apps to manage pick up and drop off.
- It is assumed that there already are laws and regulations in place that allows for AV to be used in traffic.

Geographical delimitations

The study is investigating how the housing market in the city of Gothenburg could be affected by the implementation of AV. Since the data regarding real estate value is derived from the report *Value-creating Urban development* (2016), this study is limited to the same geographical area named inner-city, showed in figure 2. The report by Spacescape (2016) included the regional area around Gothenburg but the data regarding this area was limited and it is therefore not included in this study.

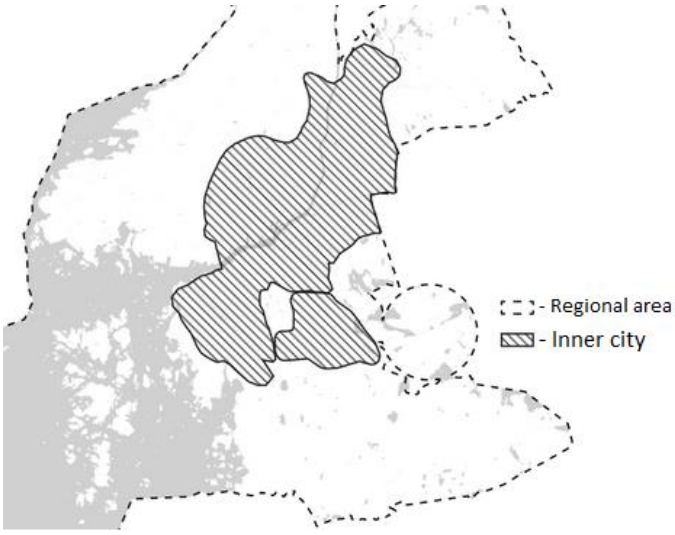


Figure 2. Map over the geographical area that the study is based on. Taken from Spacescape (2016) with permission.

Real estate value factors

The study investigates how housing real estate value will change with the implementation of AVs and no other real estate markets such as offices and commercial buildings. Only condominiums and houses are considered and not tenancies.

2 Background

This chapter is divided into several parts, aiming to give some background to the reader regarding the subjects of AVs, the future of public transportation and Gothenburg. Relevant information regarding AVs is included to explain the predicted outcome from the implementation, the characteristics of the vehicles and the estimated benefits and disadvantages. Possible future development regarding public transportation is defined and how this may be affected by the implementation of AVs. A section regarding information about Gothenburg, that describes the current situation in the city regarding areas that could be affected by AVs such as: parking, policies, traffic and parks.

2.1 Autonomous vehicles

This section will highlight the general characteristics of AVs and how they differ from MVs.

2.1.1 Levels of automation

A terminology was developed by the Society of Automotive Engineers (SAE) to define the different levels of automation from no automation to full automation. There are currently six levels that have been adapted in the terminology, described in figure 3. The most common vehicles in traffic today are vehicles with automation level 1 or 2 (Trafikanalys, 2018) and one of the major challenges with the implementation of level 3 is a lack of progress in regard to introducing new laws and regulations for AVs. Different studies suggest different timelines for a full implementation, but optimistic estimates suggest that publicly approved cars with automation level 5 could be here by 2022, whilst other estimations suggest an implementation by 2040 (Gavanas, 2019).

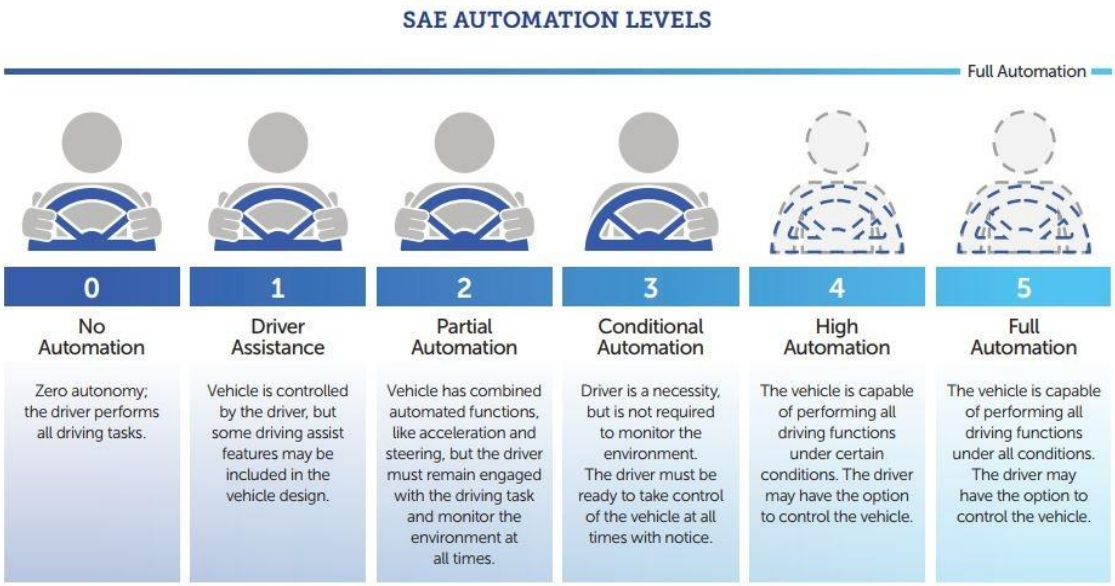


Figure 3. Taken from E International and J3016 with permission (2014)

2.2 Impacts of implementing AV

The implementation of AVs will, depending on the scenario, have different impacts that are categorised into direct and indirect effects. Direct effects are explicit consquensecs caused by the implementaion of AVs which include changed travel cost, reduced congestion, reduction in pollution, less road space needed from smoother and more accurate driving, higher safety and more flexible ridesharing (Medina-Tapia & Robusté, 2018). The indirect effects impact the equilibrium between the supply and demand regarding transportation (VTI, 2017). The indirect effects include reduced value of time (VOT), reduced traveling costs which may lead to changed travelling patterns and new eligible users. These users are people such as elderly, children and disabled, which will be eligible to ride a vehicle without having to

drive themselves, which could result in an increased number of total trips. There could as a result be an increase in traveled kilometers that is driven without passengers (Medina-Tapia & Robusté, 2018). In the case of everyday passenger mobility, the VOT for commuting drivers will be affected, since the drivers can do other activities when traveling (Gavanas, 2019).

2.2.1 Improved safety

AVs have the potential to increase safety as most of the current traffic accidents are caused by human error and accounts for approximately 90 percent of all the collisions. Still with the estimated increase of total travelled kilometres, this number may not be reducing as much. Even with a lower percentage pf collisions per kilometre, with a high enough increase of total travelled kilometre the impact from AVs will not decrease with the first speculated 90 percent (Litman, 2020). This will however require infrastructure solution for higher safety measures for AVs (Gavanas, 2019; Åsljung, 2017).

2.2.2 Flow of traffic

AVs have the potential to improve the flow of traffic. This is due to a number of factors such as: even driving speed, knowledge of surrounding traffic and reduction of safety distance (Greiwe, 2017). AVs can communicate with each other. This allows them to know in advance if any surrounding vehicle will break or turn. It is credible to assume that the safety distance between the vehicles could therefore be shorter which would reduce congestion (Medina-Tapia & Robusté, 2018). As an indirect effect of optimized flow of traffic more people might move to the suburbs, as commuting becomes faster and more convenient. This may increase the number of vehicles since more people will then travel further and more often (Greiwe, 2017).

If AVs are shared according to scenario SAV this could lead to a reduction of the total number of vehicles (Medina-Tapia & Robusté, 2018), and an even greater reduction could be made through ridesharing (Greiwe, 2017). A study of parking behaviour in Europe showed that around 30 percent of the traffic in a city are drivers looking for a parking space. As this serves no purpose and increases congestion the implementation of SAVs has the potential to reduce this number, since there is no need for permanent parking (Kellett, Barretob, Van Den Hengel, & Vogiatzis, 2019). If AVs are privately owned according to scenario POAV there could be an increase in traffic. There are fears that people might let their vehicles roam around driverless in the city instead of parking if that is cheaper. They could also be directed to drive back to the home during the day instead, an outcome which would effectively double the number of trips (SOU, 2018; SKL, 2018). There are other factors that indicate an increase in traffic with POAV. As the number of cars will presumably stay approximately the same, if more users become eligible to drive the number of trips will increase (Sprei, 2017).

2.2.3 Parking space

There are several possible changes in parking behaviours because of implementing AVs. Some studies show that AV may eliminate the need for parking spaces all together (Ataii, Kemp, Simpson, & Zhang, 2019), but a more realistic assumption shows a reduction of parking spaces rather than an elimination (Archer, 2017; UK department for transport, 2016), and a reduction in the areal that parking spaces require. With SAV, some studies suggest that vehicles could eliminate the need for parking as they are constantly in motion transporting passengers (Ataii, Kemp, Simpson, & Zhang, 2019), unless there is a surplus of cars in proportion to the demand. In that case there may still be a need for parking spaces, but in much lower numbers than currently (Corwin, Vitale, Kelly & Cathles, 2015). With SAV the parking spaces themselves could be smaller in size as AVs will be more precise (Bahrami, Nourinejad, & Roorda, 2018). The article *Shared and self-driving cars: A game changer in real estate and area development?* (2018), suggested that SAVs could remove all on-street parking spaces (NACTO, 2019).

For scenario POAV, Bahrami, Nourinejad, and Roorda (2018) discusses two potential outcomes regarding parking. The first outcome assumes that our parking behaviour will stay the same with AVs, but that conventional parking can be done more efficiently since AVs can park on its own. Thus, there

is no need to allocate space in the parking lots for humans which means parking spaces can be smaller. An example of this can be seen in the figure 4 below (Bahrami, Nourinejad, & Roorda, 2018). The second outcome speculates that the attitude towards public parking will change to where people will not park their car within the city. This assumes that the cost of parking could be more expensive than the cost of having the car either drive home or to drive around in the city during the day. Then the need for public parking space would become much smaller. At the same time however, congestion would increase in the cities as cars with no passengers would be driving around to avoid paying for parking (Bahrami, Nourinejad, & Roorda, 2018). There might also be a need for some pick-up and drop-off areas so that the AVs can do this in a safe manner and be accessible for the users, regarding both scenarios (Gavanas, 2019).

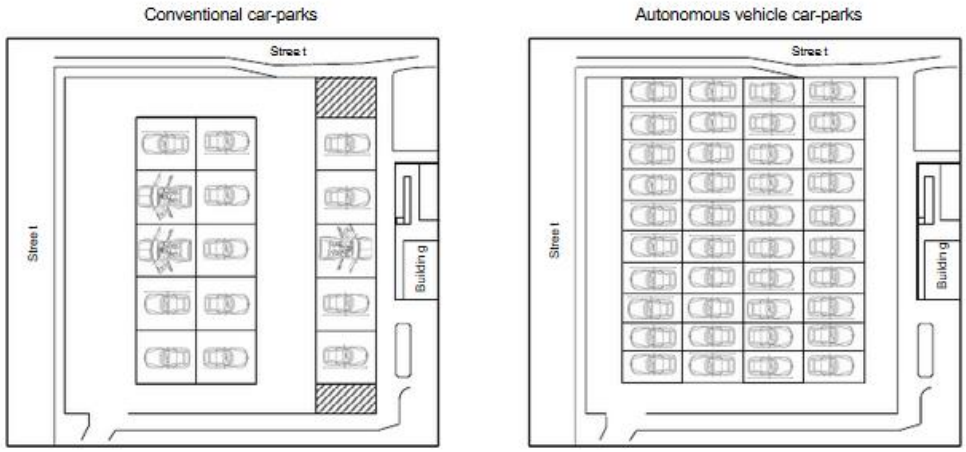


Figure 4. Comparisons conventional parking vs Autonomous parking. Taken from (Bahrami, Nourinejad, & Roorda, 2018)

2.2.4 Roads

AV are estimated to become more precise in its driving compared to MVs and can thus use the road lanes more efficiently which could result in smaller lane widths. This excessive space could be used for other means of transportation or other redevelopments (Gavanas, 2019; Kellett, Barretob, Van Den Hengel, & Vogiatzis, 2019; VTI, 2017). With AVs, studies suggest an increase in roads speed limit could occur (Donkers & de Wit, 2017) (Greiwe, 2017). In scenario SAV, the reduced number of vehicles could potentially lead to a reduction in the number of lanes required in certain areas (Snyder, 2018). There is a suggested increase of roads that will lead directly to entrances, to increase the convenience of using pick-up- drop-off services (Donkers & de Wit, 2017).

2.2.5 Value of time

Value of time (VOT) is a concept that describes how much a passenger is willing to pay to reduce traveling time. For a real estate perspective this translates to how much more a person is willing to pay for a residency to reduce the travel distance each day. VOT affects the decision of which alternatives of transportation is chosen of train, bus, tram or car (Athira, Muneera, Krishnamurthy, & Anjaneyulu, 2016).

A report by Donkers & de Wit (2017) suggested that with AVs people could commute to their workplace or any other destination while doing other activities such as working, reading or something else. This could reduce the perceived travel time since the trip would not be part of the driving loop. This was evaluated and used to calculate the change in VOT in a study by Medina-Tapia and Robusté (2018). The result showed that there would be a reduction of around 20 percent of the current VOT with AVs. The reduction of VOT would most likely increase car travel and willingness to travel longer distances. This may in turn impact the decision of where to live and how the real estate value in some areas could

alternate from today's valuation (Medina-Tapia & Robusté, 2018) which could lead to an urban sprawl (Gavanas, 2019; Donkers & de Witt, 2017). In general, the maximum commuting time is approximately one hour and is called Marchetti's constant, no matter if the transportation is by car or with public transportation (Donkers & de Wit, 2018). Research on commuting habits in Sweden indicated that when the commuting time is more than 15 minutes, each additional travel minute have a large reduction in the willingness to commute. This is true up to 50 minutes where the curve of willingness starts to flatten out. It also shows that if the estimated commuting time increases, for example through congestion, the willingness to commute would jump down even further. If the commuting time is lower than 15 minutes or higher than 50, the willingness to commute remains unchanged (Klaesson & Pettersson, 2015). The figure 5 below shows how the willingness of commuting varies combined with Marchetti's constant.

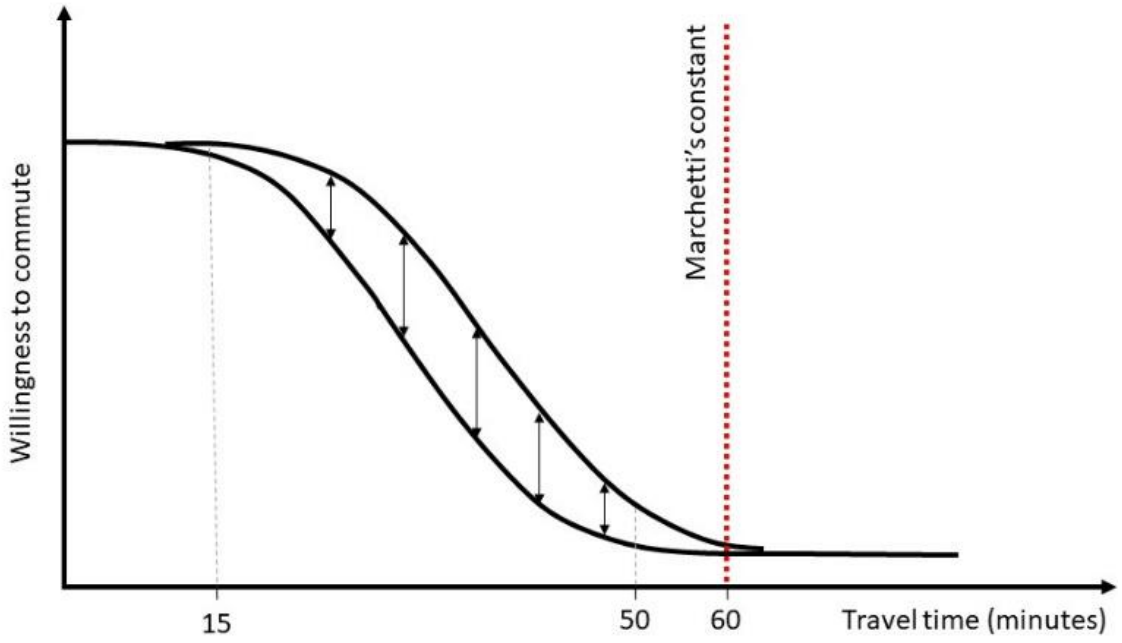


Figure 5. Graph over the decreased willingness to commute over total travelled time combined with Marchetti´s constant

2.3 Public transportation

AVs will eliminate the need for human drivers within public transits which could cause positive consequence for the users. It will lower operating costs leading to lower ticket prices, making public transport a more attractive option. There will be a removal of the scheduling constraints when not having a driver, increasing the flexibility of the time schedule. The reduced cost and increased flexibility would then allow for a more frequent public transportation in the city and its surrounding areas (SOU, 2018).

Instead of people opting for fixed stations, a wider point-to-point service with smaller AVs may be a more attractive solution. This would resemble todays taxi service but be cheaper and more manageable. Such a solution increases the flexibility, however, to meet the high demands of the total transportation buses and trains would still be necessary. The point-to-point service would be a compliment, which could increase the capability and flexibility through ridesharing and combined mobility (Lam, Leung, & Chu, 2016).

2.3.1 Ridesharing

Ridesharing is a concept with several potential benefits, such as reducing congestions, reducing pollution and lower travel costs compared to POAVs (Lam, Leung & Chu, 2016). Ridesharing will remove costs relating to investing in vehicles, gas or other energy sources, maintenance and insurance for the users. Instead the only expenses would be the fees for using the transportation service (Barillas, 2018), leading to an estimated cost reduction of 69 percent (Corwin, Vitale, Kelly, Cathles, 2015). There

are disadvantages to ridesharing, as it will subsequently mean giving up comforts such as privacy and could result in longer traveling times (Lam, Leung & Chu, 2016). It is also suggested that shared car services could be detrimental to the real estate market having built their business model on accessibility to public transport. There is a risk that shared cars may outcompete public transport and therefore eliminate any value it might add (Bragg & Pazzano, 2017).

2.3.2 Combined mobility

Combined mobility (CM) is a combination of several different transportation modes, such as car, bus, tram, train, bicycle or walking, to transport a person from point A to point B (SOU, 2018). A person can combine transportation modes by themselves or they could order a finished service package from a company. Such a product is called Mobility as a Service (Sprei, 2017). The current problem with CM is that high capacity transportation modes, such as busses and trains, cannot transport a person to the exact destination. This means that it may be more convenient, faster and cheaper for people to use their own vehicle rather than a CM service. SAVs as part of the CM system could be a solution as it could offer transportation during the first and last part of the trip. This would be performed through smaller SAVs that would collect and drop off passengers at the destination or to another transportation hub, while the main trip is conducted by high capacity vehicles. As such there is less need for smaller stations, but instead the stations are for the express buses and trains. A study concluded that a CM system including SAVs, could reduce 90 percent of existing vehicles. However, there would also be an increase for each vehicle´s total kilometre travelled by 9 percent (SOU, 2018).

2.4 Summary of impacts of AVs

There are multiple different studies that have estimated the impacts AVs could potentially have. The following two tables are a summary of different key figures regarding the impacts of AVs in cities depending on the scenario. Some of the same key figures appears on both tables as they are not changed depending on the scenario.

Table 1. Scenario POAV: 100 percent implemented and privately owned

Category	*Description*	*Result*	*Source*
Parking	AV needs less space when parking and when parked	-10-15%	(SOU, 2018)
Parking	A parking belt will be created around the work zones of commuters	97% of commuters' cars will be parked there	(Zakharenko, 2016)
Parking	AV needs less space when parking and when parked	35% less space	(Bragg & Pazzano, 2017)
Traffic flow	When dropped off at work letting the vehicle drive back home to park	+ 200% trips/distance	(NACTO, 2019)
Traffic flow	Increase in congestion and empty parking spaces	If 15 % of car fleet is empty driver speeds in	(Millard-Ball, 2019)

		the inner city slows down to 2 km/h	
Traffic flow	More and longer trips when the convenient increases and more users	+15-20%	(Sprei, 2017)
Traffic flow	Less cars needed	-70% cars	(Sprei, 2017)
Roads	Less road space required, both in lane with and in head space	-20% lane width	(Gavanas, 2019) (Kellett, Barretob, Van Den Hengel, & Vogiatzis, 2019)
Roads	Less lane width	30-40% less	(SNYDER, 2018)

Table 2. Scenario SAV: 100 percent penetration, shared and not privately owned vehicles

Category	*Description*	*Result*	*Source*
Parking	AV needs less space when parking and when parked	-10-15%	(SOU, 2018)
Parking	Less public parking	-100%	(Ataii, Kemp, Simpson, & Zhang, 2019)
Parking	Less public parking	-95%	(Archer, 2017)
Parking	Less parking spaces	-62 - 87%	(Choi, 2019)
Parking	Less parking spaces	-62%	(Nourinejada, Bahramib, & Roorda, 2018)
Parking	Less public parking	- ≥90%	(Greiwe, 2017)
Parking	No curb-to curb parking spaces	-80% of all curb-to-curb parking reduced, which is 20% the total street space in a city	(SOU, 2018)
Traffic flow	Congestion decreases	-100%	(Archer, 2017)
Traffic flow	Less cars in traffic	-95%	(Ataii, Kemp, Simpson, & Zhang, 2019)
Traffic flow	Less cars in traffic which are searching for a parking space	-30%	(Nash, 2004) (Kellett, Barretob, Van Den Hengel, & Vogiatzis, 2019)

Traffic flow	Smaller number of cars in traffic	-≥50%	(Greiwe, 2017)
Traffic flow	Higher roads speeds as cars can operate with higher efficiency without compromising safety	15% higher road speeds on roads with 40 km/h or less	(Friedrich, 2016)
Traffic flow	Less cars needed	-97%	(Archer, 2017)
Traffic flow	Less cars needed Lisbon	-80%	(ITF, 2015)
Traffic flow	Less cars needed if working with existing public transport Lisbon	-90%	(ITF, 2015)
Traffic flow	Less cars in Singapore	-66%	(Frazzoli, o.a., 2014)
Traffic flow	Less cars in Manhattan	-40%	(Pavone & Zhang, 2015)
Traffic flow	Less cars needed. Service where several passengers can share the same vehicle	-90% (less cars) +6% vehicle kilometre	(SOU, 2018)
Traffic flow	Less cars needed. Service where the vehicles is booked and used by one party at the time.	+89% vehicle kilometre	(SOU, 2018)
Roads	Less road space required, both in lane with and in head space	-20% lane width	(Gavanas, 2019) (Kellett, Barretob, Van Den Hengel, & Vogiatzis, 2019)
Roads	Less lane width	30-40% less	(SNYDER, 2018)
Roads	Less lanes	33% less	(SNYDER, 2018)

2.5 Gothenburg

In Gothenburg, efforts have been made to make transportation more sustainable and less dependent on the car. This has led to increased funding for public transportation and developing new infrastructure for bicycles (Göteborgs Stad, 2018**)**. Gothenburg has also invested in testing AVs in the city and is one of the leading cities to do so. The goal is to test how AV works in the city and the study includes regular families to try to use AVs themselves (Göteborgs Stad, 2020).

One of the cornerstones of creating a more including urban environment is to have a safe neighbourhood with a pleasing surrounding environment. This includes closeness to hospitals, schools, public transportation, and recreation areas such as parks and green areas (Göteborgs Stad, 2018). Large cities

in Sweden has faced an increased demand in housing and a new wave of urbanization as public transport becomes more available and there is a higher density of jobs. This has created a situation where housing demand has increased more than the available supply, which increased pressure on cities to build more homes (Andersson-Sköld, Klingberg, Gunnarsson, & Thorsson, 2018). Gothenburg currently have a shortage in housing and space for new residential buildings is limited, particularly in the denser city centre (ÖP, 2018). Available land is being used for building new homes and creating infrastructure to support a growing population. As a result, other value creating projects are not prioritized (Andersson-Sköld, Klingberg, Gunnarsson, & Thorsson, 2018).

2.5.1 Parking

There are currently around 66000 parking lots within the city that the municipality owns (Göteborgs stad, 2018). A study made by Sigma on behalf of Trafikverket in 2019 investigated parking spaces in the city centre, consisting of eight sections, seen in the figure 6. The study investigated the number of parking spaces owned by two municipal companies, P-bolaget and Trafikkontoret, which in this area are around 23000. The area of the eight sections covers 7.5 square kilometres (Sigma Civil, 2019), which is 3.2 percent of the area of Gothenburg and holds more than a third of all the municipality-owned parking spaces within Gothenburg (Göteborgs stad, 2018).

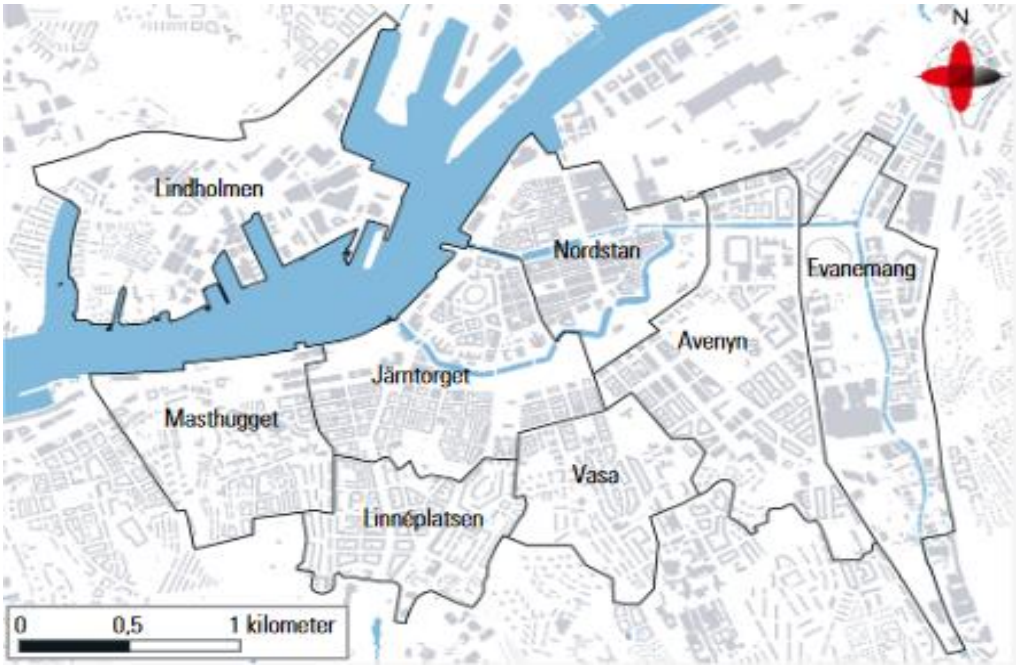


Figure 6. Map over the 8 sections of the inner city of Gothenburg (Sigma Civil, 2019)

2.5.2 Parks in Gothenburg

Gothenburg has adapted a green initiative strategy which aims to preserve and enhance the green areas and parks within the city. Gothenburg has a vision to make small green areas and parks more available to its residents according to table 3 (Park- och naturnämnden, 2014)

Table 3. Benchmark values for parks in Gothenburg (Park- och naturnämnden, 2014)

Type of area	Unobstructed distance to Residency	Size
Smaller parks and green areas	*300 meters from residence*	*Minimum 0,2 hectares*
District parks	*1 km from residence or 15 minutes' walk*	*Minimum 2 hectares*
City parks	*30 minutes with public transport*	*Not specified but large enough to be attractive and add value*
Nature and recreation areas	*30 minutes with public transport*	*Not specified but large enough to be attractive and add value*

Larger and smaller cities in Sweden have approximately the same proportion green ares in realtion to their area independent of population. Yet, when considering the average amount of green areas within 1 km from residency per person, citizens of large cities have considerbale less amount of green areas per person than smaller cities (SCB, 2015).

Gothenburg is no exception. When comparing the amount of green space in Gothenburg with other Swedish cities, Gothenburg has approximately the same proportion green areas with regards to its total areal as other cities in Sweden. When comparing the areal of green space per person, Gothenburg have 127 m2 green areas per person which is 56 percent lower than the average (Göteborgs Stad, 2018). Figure 7 and 8 below describes the relation between how the city of Gothenburg and the report by Spacescape (2016) assess adequate access to parks within Gothenburg.

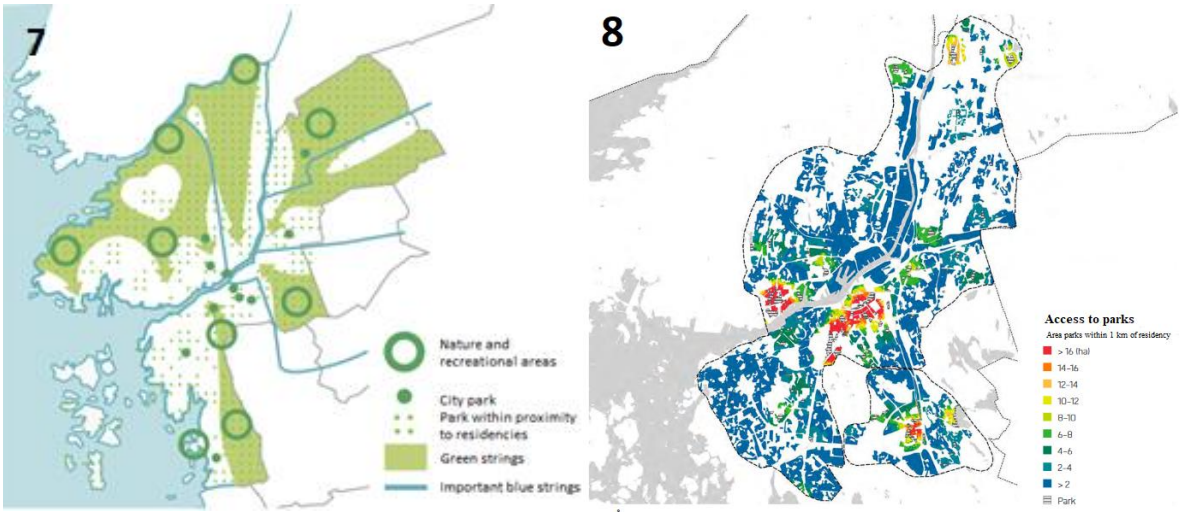


Figure 7. Map of availability of green areas in Gothenburg (Park- och naturnämnden, 2014)

Figure 8. Map over access to parks in Gothenburg (Spacescape, 2016).

3 Method

This chapter defines the methods in the study and why they were selected. Relevant information regarding data collection, how the results were produced and potential parameters which may have impacted the results are described. This study applies a mixed method as it combines a real estate value theoretical framework with literature studies regarding AVs and interviews. A mixed method had benefits in this study as it allows the data gathered in each method to complement one another (David & Sutton, 2017).

3.1 Deductive and inductive study

This study is abductive in nature as it is combining inductive and deductive methods to reach its results and conclusions. A deductive study is defined by gathering relevant data regarding a specific subject and from that data, construct a hypothesis.

"*Deduction - Creating logical conclusion from logical premises*" (David & Sutton, 2017, p. 463)

The hypotheses are described as several assumptions in this study, and they are assuming that by implementing AVs through different scenarios in Gothenburg there would be impacts on real estate valuation depending on the scenario (David & Sutton, 2017). The literature study is deductive, as a nexus is created with the potential effects an implementation of AVs may induce in the contrived assumptions regarding the key factors of real estate value within Gothenburg. As the goal is to measure how the different factors are connected, to be able to form a relationship between them to see how and how much AV may impact real estate value in Gothenburg, thus discerning which factors are fundamental. To complement the results from the literature study a questionnaire and follow up interviews were conducted. The questions were based of several assumptions made in the deductive study and were intended to investigate the likeliness of the assumptions according to the participants. An inductive study is explorative, without a hypothesis that needs to be confirmed, and instead investigates the data and makes assumptions and discussions from that (David & Sutton, 2017).

"*Induction – inference procedures where it is not enough with purely logical relation between premises*" (David & Sutton, 2017, p. 467)

Instead the answers from the questionnaire and the interviews were used to discuss the likelihood of the different scenarios and hypothesis constructed from the literature study.

3.2 Method of studies

Literature study

As this study aims to investigate how real estate value is affected by the implementation of AVs, the first part of this study needed to accomplish two things. What are credible parameters that can decide real estate value and what effects does implementing AVs have on these parameters. A literature study was done to identify an existing theoretical framework that defines real estate value. The report by Spacescape (2016) which defines real estate value factors for Gothenburg was as result incorporated in this study as a theoretical framework. There were two reasons why the report by Spacescape (2016) was well suited for this study. The first reason is based on the location. As this study is conducted in Gothenburg it is important that the real estate value factors applied in this study are as relevant as possible to Gothenburg. As the report by Spacescape (2016) is unequivocally based on the opinions of citizens in Gothenburg, it is therefore very relevant to apply as a theoretical framework. The second reason is the depth of the report by Spacescape (2016). The report explains in detail how each factor is divided into real estate value adding parameters, what variables these parameters are based on and how the parameters differs between condominiums and houses. This offers a deeper insight in real estate valuation and facilitates the research into how its impacted by AVs. It also included weighting between

the different parameters for the real estate value, that was used to estimate the total level of impact, which is included in Appendix 1.

The report by Spacescape (2016) was also used for the next process of the literature study, which was to find relevant data regarding AVs that could affect the established real estate value adding parameters from the report. The data regarding the effects from AVs is categorised as secondary data. A complication with using secondary data is that it is being applied in circumstances that are different from the purpose that they were gathered and constructed for. The secondary data regarding the effects of AVs were based on studies that have mostly been conducted in other cities and/or countries. Since they were not designed to be applied for the city Gothenburg, the key figures may not be correct when applied to Gothenburg. Another problem with secondary sources is the validity, with who conducted the study, what was the purpose, which method was applied and how the conclusions were reached, and might therefore affect the reliability of the data (Blomkvist, Halling, & Lindell, 2018). This study managed this issue by collecting key figures regarding effects of AVs from multible studies and then summarising them in two tables.

As AVs are a very speculative subject the impacts of AVs are under speculation as well. Different studies claim different key figures on how AVs reduce traffic and make transportation easier. Identifying which effects of AVs to focus on were an iterative process, as not all the effects caused by the implementation would have an impact on real estate valuation. Due to time constraints it was important to focus on the effects of AVs that do impact real estate value. The effects prominent in this study were identified as having an impact on the real estate parameters defined in the theory by Spacescape (2016). The effects were organized into four categories, *flow of traffic, parking space, roads* and *value of time*. This study then summarized the different estimations of effects from AVs from various studies into two tables.

Since the focus of the study is not to investigate in what way AVs are implemented but in how their implementation could affect real estate value, it would be unnecessary to develop our own scenarios. Scenario POAV and SAV were chosen from the article *Forces of change: The future of mobility* (2017), and describes two extreme scenarios. The two chosen scenarios are two extreme cases where scenario POAV only allows privately owned AVs and scenario SAV only allows AVs as a shared service. Because the two scenarios are so different the study hoped to encompass a wide spectrum of possible outcomes by being able to interpolate the results. The results could thus be used to speculate on how other scenarios with AVs with different combinations of POAV and SAV could be interpolated.

To produce actual results of how AVs could impact the real estate value parameters, assumptions were made regarding the effects of AVs which would directly impact the variables the parameters are based on. These assumptions were built on the summarisations of effects by AVs and were related to *flow of traffic, parking space, roads* and *value of time*. By using these assumptions, it was possible to produce indications of potential change in real estate value. The changes in real estate value could then be interpreted as a positive or negative potential or no change for each real estate value parameter which was connected the effects of AVs and was summarised in two tables depending on the scenario.

Interview study

A qualitative study focuses on processes and context to formulate theories of how the qualitative data fits together in the perspective of the surrounding world. Often qualitative studies involve gathering data in the form of interviews and observations (Backman, 2016). Using interviews to gather data is the most common way when writing a qualitative study. It is a relatively easy way to get the needed data, depending on the validity of the persons interviewed. (Blomkvist, Halling, & Lindell, 2018; Eliasson, 2018). As the data from the interviews and questionnaire originates from a direct source, it is primary data. The benefit with primary data is that it has not been processed by others than the authors collecting it and it is therefore free from bias from other authors (David & Sutton, 2017).

As the assumptions made in the literature study was very speculative and mainly influenced by the authors, an interview study was conducted with the aim to either validate or discredit the assumptions made. 16 questions, attached in appendix 2, so that they were formulated and divided within the three value adding factors *Density*, *Accessibility* and *Recreation*. The questions were sent via an online questionnaire to the participants and focused on the likelihood of the assumptions made from a scale of 1-10, with an opportunity for the participants to elaborate their answers in text below each question. The participants had the option to only participate in the questionnaire and to thereafter be part of a follow up interview to elaborate their answers. In total there were 13 participants in the questionnaire and 7 of those agreed to participate in the interview. This number of participants is in line with the necessary number of participants for a qualitative interview study (Blomkvist, Halling, & Lindell, 2018).

The participants of the questionnaire were selected based on their professions and knowledge. They had to work with either AVs, traffic planning, real estate or city planning, and since this study is conducted in collaboration with the company AFRY many of the participants work at this company. Since AFRY has a wide spectrum of different departments, they could offer a good variety of knowledge in different areas. The other participants worked in road and city planning in Sweden, real estate companies and for the project Drive Sweden. There was no separation between the answers depending on the backgrounds as it was concluded that it would not yield any differences to the results.

The aim of the interview was not to only have participants answering the questionnaire, but that the interview would contribute to a deeper understanding behind the potential impacts of AV on real estate value. The interview was between 30 minutes up to 90 minutes and were conducted online through a program called Zoom because of the current circumstances with Covid-19. This was assumed to not have had any impact on the results from the study or the reliability of the data. The interviews were not recorded, instead notes were taken during the interviews which were combined with the participants prewritten answers. The answers were sorted according to the real estate parameters and the assumptions made in the section of the literature result.

The interviews started with the participants explaining their background. Thereafter an explanation was given to the participants regarding the study subject matter, its purpose and how their answers would be used to analyse the likelihood of the assumptions made so far. The interview was conducted so that each question was read to them and what they had answered and then allowing for further elaboration on the subjects. The purpose was to compare what result we had from the quantitative data and see if this aligned with the interviews predictions for the future. Sometimes sub questions was asked during the interview, either to continue the subject or to confirm that the answer was interpreted correctly by the interviewees. Qualitative studies are known to be more flexible and dynamic, which often results in a wider spread of data variation (Backman, 2016). Thus, the interviews were structured in nature, to easier be able to form a connection between the different participants answers.

There were some shortcomings regarding the questionnaire and interviews. During the interview's participants sometimes needed explanations from the authors for some of the questions and would as a result sometimes correct their answers thereafter. This could have resulted in more truthful answers, but it could also mean that some of the authors prejudices might have affected the participants when explaining the question. Also, for the ones than only participated in the questionnaire, some mentioned that they did not understand some questions or felt like they had the knowledge to answer. This could probably have been adjusted if they would have participated in the follow up interviews. Some of the participants mentioned that their answers could have been affected by how they hoped that it would turn out in the future and not what they thought the most likely outcome was. So, what should be considered is that since this is a speculative study the answers from the study will not show sure statements, only estimations and speculations.

In the final result, the tables 6, table 7 and table 8 are alternated according to which assumptions that was likely or unlikely. The result was then presented in Table 9 for POAV, table 10 for SAV and table 11 for the factors. The result and conclusion obtained in this study is not quantitative but qualitative, as the authors make estimations if real estate value within the factor and their subsequent value parameters will change positively or negatively. There are no results that describes the quantitative change in monetary terms as it would require a more in-depth analysis of each parameter.

3.3 Ethical perspective

An ethical study should not be influenced by the author or be constructed to show a misleading result (David & Sutton, 2017). To remove the authors' own opinions, it is important to clearly define the origin of the data. By also explaining in the method which choices made and why, the impact of the authors owns point of views are reduced. The study focuses on investigating how real estate value is impacted by AVs implementation. The results for the subject are not harmful, and the conclusions may prove beneficial to the society as it may help facilitate future development.

To make sure anything said in the interviews is not taken out of its context to be used with malicious intent, the interviewees will be anonymous. To minimize the authors' influence on the participants of the interview, the questionnaire was distributed and answered in advance. For the interviews, the answers were first read to the participants and then it was up to the person to further elaborate with minimal guiding from the authors. By having the participants of the questionnaire and interviews evaluate the likeliness of the assumptions, the aim was to further reduce any influence made by the authors.

3.4 Sustainable perspective

> *"**Sustainable** development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*
>
> -(Brundtland, 1987, page 41)

Sustainable development is a debated subject as it is paradoxical how development could be sustainable as development leads to disruption of status quo. Nevertheless, sustainable development is divided into three categories, social-, economical- and environmental sustainability (Portney, 2015).

As this study aims to investigate potential impacts from AVs on urban environments in regard to real estate value, it aims to help planning for a more sustainable economic future. The real estate value parameter adapted in this study are in line with sustainable development as it promotes public transportation, green areas, urban activities, and shorter distances between city functions. The parameters promote social-, economic- and environmental sustainability as these are categories the citizens of Gothenburg also considered valuable. As the results from this study aim to provide indications of potential positive or negative impacts AVs could have on the parameters it could be used to contribute in the planning for a more sustainable future.

4 Theory

This chapter explains different valuation methods of real estate. The different theories are Monocentric value decline, Preferential centrality model, Extrinsic models, Extrinsic and intrinsic characteristics models and the real estate value factors and parameters for Gothenburg by Spacescape (2016).

4.1 Real estate valuation methods

This section explains some used methods for estimating real estate value.

Monocentric value decline

Older real estate value determination methods concatenate real estate value with distance to CBD. These theories assess urban areas as monocentric with a declining real estate value with an increased distance from the city centre, as the CBDs were the main source of revenue and employment. Real estate value was calculated using models that created linear connections between distance from city centre to place of residency. Thus, there was little consideration for internalities of the resdidency or externalities of the areas encompassing the resdidency (D'Acci, 2018).

Preferential centrality model

Newer models have expanded such theories. The preferential centrality model is an example of this which discards the monocentric model as insufficient in explaining shifting land values. The preferential centrality model endogenously identifies points of interest instead in a city by measuring the distribution of urban activity. Urban activity in this case is defined as the sum of all interactions between different locations (Andersson, Hellervik, & Nilsson, 2019).

Extrinsic models

The extrinsic method investigates extrinsic characteristics, such as quality of area and relative closeness to CBD. In doing so it is possible to explain differences in real estate values of areas that are of similar distance to the city core. A study of the Italian city Turin was conducted in this fashion found that even though closeness to CBD did play a role in the increase of real estate value, quality of area had a larger impact on the valuation (D'Acci, 2018). Quality of an area means parameters which are location based, such as greeneries, access to public transport and urban activities.

A difficulty with using extrinsic methods is that parameters might affect real estate value differently, depending on the method used and the location. The results also differ depending on the country and the city, which could be explained with strong cultural aspects of the area where the methods have been developed. It may therefore be important to consider the local aspects of what engender desirable traits in a residency in the calculations. Such differences makes it hard to find a universal method to measure real estate value based on these extrinsic parameters (D'Acci, 2018).

Extrinsic and intrinsic characteristics models

Real estate value is determined by two sets of characteristics, intrinsic and extrinsic. Intrinsic characteristics are parameters that are connected to the structure of the residency such as size, materials, number of rooms etc. Extrinsic characteristics are parameters that affect the area of the residency such as infrastructure, accessibility to CBD, workplace proximity, green areas. As AVs are expected, according to this study, to not have any impact on the intrinsic parameters this paper only focus on how the extrinsic characteristics are affected by the implementation of AVs. A major part of the data collection will also be to identify which extrinsic parameters will be affected the most and focus on them.

4.2 Real Estate value in Gothenburg

Spacescape (2016) published a report regarding which real estate value parameters had the most impact on housing prices in Gothenburg. The report was implemented with two methods. The first method was polls that were conducted with citizens of Gothenburg as participants to identify which parameters they valued in a residency. The results were then categorised placed into the three real estate value adding factors, *Density*, *Accessibility* and *Recreation*. Two different categories of housing were investigated in the study, condominiums and house. The two categories of housing had different parameters which were considered value adding. The second method consisted of analysing statistical data of house prices in relation to location and identified connections between house prices and areas. The study by Spacescape is based on extrinsic models as it is focusing on extrinsic factors. As the parameters and factors are tied to the location of Gothenburg makes the results from the study not applicable to any other location (Spacescape, 2016).

4.2.1 Results from the study

The results from the polls in the study by Spacescape (2016) identified several different factors that citizens of Gothenburg considered important regarding what adds to the real estate value. Six main parameters were established; street layout, peace and quiet, centrality, access to urban activities, distance to greeneries and distance to water. These six factors were then arrayed as subject to the three parameters D*ensity*, A*ccessibility* and R*ecreation*, see figure 9.

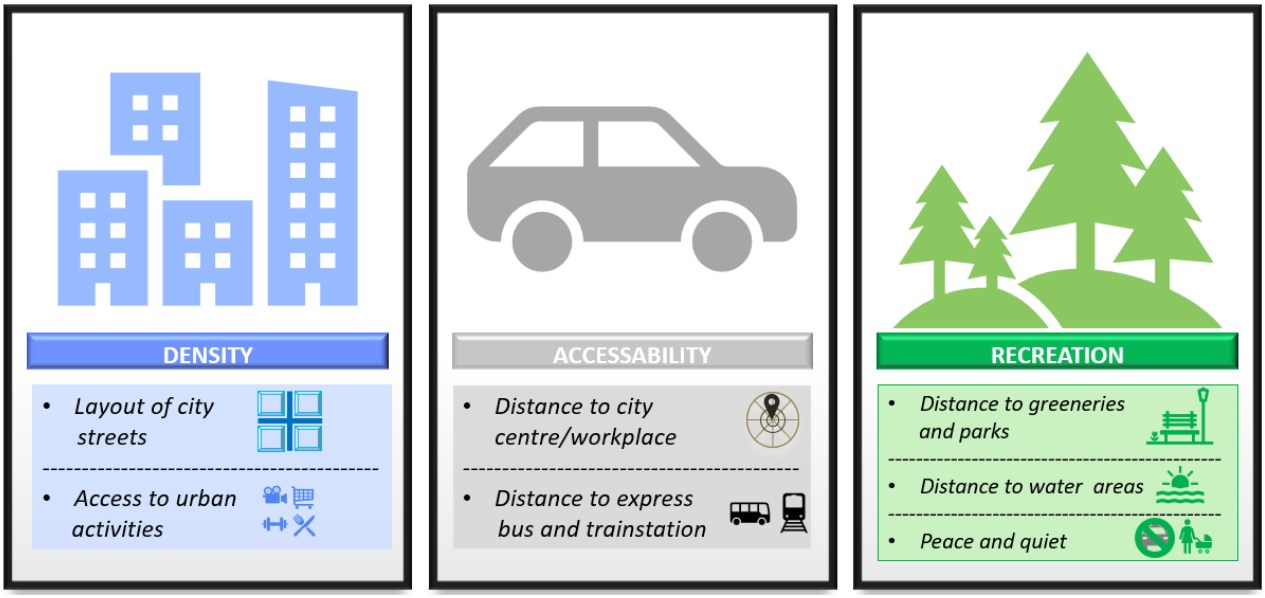


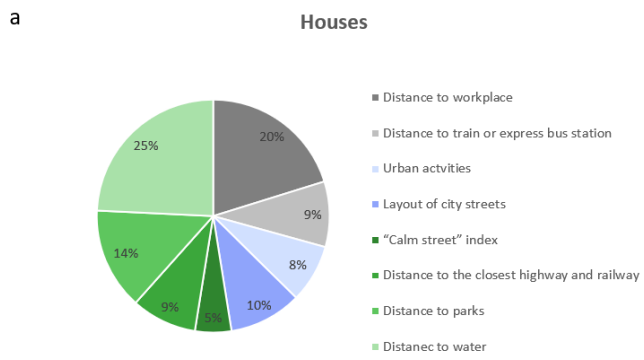
Figure 9. The real estate valuation factors with their connected parameters.

The study then investigated how these six parameters differed between residents of condominiums and houses and what the parameters definite meant, see table 4.

Table. 4. The parameters divided into real estate value for condominiums and houses (Spacescape, 2016).

Parameters	Condominiums	Houses
Density • **Layout of city streets** • **Urban activities**	• *The formation of the streets and city blocks* • *The total number of urban activities within 1 kilometre*	• *The total number of different urban activities within 500 meters*
Accessibility • **Centrality**	• *Distance to the city centre* • *Distance to the closest train or express bus station*	• *Accessible workplaces within a driving distance of 45 minutes with a car* • *A maximal distance of 400 meter to the closest train or express bus station*
Recreation • **Distance to greeneries and parks** • **Distance to water areas** • **Peace and quiet**	• *Parks within 1 kilometre* • *Distance to water*	• *Distance to the closest green area with recreation qualities* • *Distance to the ocean* • *"Calm street" index* • *Distance to the closest highway and railway*

The results from the table showed that there are mostly overlaps, but with small differences, between the condominiums and houses real estate value parameters. The weighting between the different parameters regarding condominiums and houses can be seen in the figure 10a and figure 10b below.



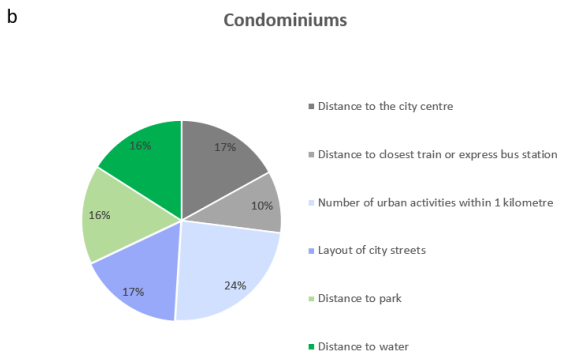


Figure 10a. The weighting between the real estate value parameters for houses. Based on Spacescape, 2016.

Figure 10b. The weighting between the real estate value parameters for condominiums. Based on Spacescape, 2016.

4.2.2 Density

Density is connected to the overall feeling of a city and having a variety of essential businesses in the vicinity. Density is divided into two parameters: layout of the city streets and urban activities.

Layout of the city streets

The study showed that condominiums value buildings with entrances and facilities facing outwards toward the street where it is pleasant to move around as a pedestrian and gives the impression of a safe neighbourhood. To measure this, a block index has been used which is a combination of two variables: What proportion of a blocks outer edges have been built towards the street and what proportion of

entrances faces towards the street. A higher value in either variable will increase the real estate value for the area. Areas in Gothenburg which have succeeded in this according to Spacescape (2016) are Linnéstaden and to some degree Haga. The block-index is to a high degree affected by how accessible an area is by walking and how much space is dedicated (Spacescape, 2016).

Urban activities

Urban activities are an umbrella term for activities such as commerce, restaurants, coffeehouses, cultural activities and commercial services. Residents in both condominiums and houses desire urban activities close within walking distance of the residency. The difference between the real estate value parameters variable is that houses desire a more diverse selection of urban activities, rather than having many. This is derived from that houses usually have fewer urban activities in proximity, and the diversity of those is therefore valued important. The urban activities valued the highest for condominiums and houses was day-time-activities. Those are more common close to people's workplaces, thus uncommon in suburban areas where there are fewer workplaces. There was also a direct correlation between walking friendly streets and blocks to an increase in urban activities and block index. The study by Spacescape (2016) asserted that the connection between the number of urban activities and real estate value could not be defined as linear. If an area hosts multiple urban activities, adding more urban activities would not increase the real estate value as much as it would for an area which have none. The city centre for example which has many urban activities within a close distance of the residential building will not see an increase of real estate value if another one opens. In areas with low density of urban activities however the effect will be much higher so there the increase of a few urban activities can have a massive impact (Spacescape, 2016).

4.2.3 Accessibility

An accessible city is described to have good connections to all the essential parts and where the transportation is easy and convenient. Accessibility has been divided in the to two parameters: Distance to the city centre and workplaces, and distance to the nearest express bus- or train station.

Distance to the city centre or workplace

For the citizens of Gothenburg, the distance to the city centre and workplaces is something that is highly valued for the residents. As condominiums are less likely to own a vehicle compared to houses, fast transportation to the city centre is therefore value adding. Value adding variables in this case is the distance to the city centre, which is connected to fast and easy transport through either walking, biking or public transportation. For houses there is a higher majority who own their car, and the value is therefore connected to the commuting time of less than 45 minutes to the workplace with a car. The variable connected to this parameter is the total number of workplaces that is accessible within a commuting time of 45 minutes (Spacescape, 2016).

Distance to closest express bus- or train-station

For both condominiums and houses having an express bus- and train station is value adding. For condominiums the distance should be less than 1 kilometre, since most of those residents do not own their own vehicle and will therefore walk or bike when getting to the station. As houses often own cars, public transportation must be fast and convenient to be value adding. The distance to the public transportation should be within 400 metre or five minutes of walking, if not people will use their cars instead, meaning there is less real estate value added to this parameter. The public transportation that increases real estate value for houses is express busses, trains and trams. Since they travel far in a short amount of time and the stations are generally permanent. Public transportation is valued higher in the city centre than the regional areas. Outside of the city the public transportation might be less frequent and reliable which instead increases the usage of taking their own car. Still the study shows

that the distance to a rail or express stop is a value adding parameter. It is explained as a paradox where the people living in houses want the benefit of owning their own house with more privacy, but they still want the many transportation options (Spacescape, 2016).

4.2.4 Recreation

Three main parameters were connected to recreation quality: access to parks and greeneries, access to waterfronts, and peace and quiet.

Access to parks and greeneries

Condominiums and houses considered access to parks as a value adding parameter. A park is defined in the report by Spacescape (2016) as a green area which is maintained continuously. Parks need to be within ten minutes of walking from the residence to add value and parks were having a larger positive impact in proportion to increased size. Green areas which were not maintained also added real estate value for houses but not for condominiums. The green areas must however have certain characteristics to be considered value adding, such as trails and viewpoints which makes it an attractive option to experience nature (Spacescape, 2016).

Access to water

For houses only ocean is stated to impact on the real estate value, while for condominiums any waterfront was considered value adding. Spacescape (2016) concluded the reason for this is assumption that condominiums usually are not located close to the ocean, while houses could be, thus impacting the real estate value if they are. For condominiums and houses water areas such as ocean or lakes needs to be fast and convenient to access in order to increase real estate value. If it is a short distance but troubling to get to the water this will not increase the value (Spacescape, 2016).

Peace and quiet

Peace and quiet is characterised by low speed roads and far distance to highways and rails. It is considered more important for small house owners compared to condominiums, which could be explained that houses are generally associated with more calm neighbourhoods while condominiums are associated with busier streets. The measurement of how low speed roads affects real estate value is dependent on residents needs for a close road network that is safe to travel. Thus, this value parameter is a combination of the amount and proportion of roads around with a speed limit of 30 km/h or lower within 1 km from the residency. Distance to highway and rails are disturbing elements, from noise and pollution, and will negatively affect real estate value that is within 1 km of the residency. The citizens of Gothenburg value the possibility to have safe streets for pedestrians, with little car traffic and low speed streets to increase the feeling of safety (Spacescape, 2016).

5 Result

The result chapter is divided into two sections. The first section compares the findings from the literature study regarding the effects of AVs and how they could potentially impact the three value factors, *accessibility*, *density* and *recreation* underlying parameters, which was described in the section 4.2 of the theory. The results from the literature are summarised in Table 6 for scenario POAV, Table 7 for scenario SAV and Table 8 for the real estate value factors. As the results are based on speculative data, some assumptions had to be made for how AV effect the parameters. These assumptions were based on the variables for each parameter and how the effects of AVs from the literature study could impact these variables. The second section consists of the results from the interview study, which analyses the assumption from the results in the first section by investigating the likeliness for the assumptions. The tables from the literature will therefore be altered in the regards to the result from the interview study and the result will be in Table 9 for scenario POAV, Table 10 for scenario SAV and Table 11 for the real estate value factors.

5.1 Literature Results

This is the result from the literature from the table 1 and table 2 and used to construct assumptions for each of the real estate parameters.

5.1.1 Density

The real estate value factor density consists of two parameters: *layout of the streets* and *Urban activities.* In the weighting between the value adding factors density for houses is 24 percent and for condominiums 17 percent.

Layout of city streets

The parameter layout of the city streets is decided by a sub-parameter called block-index, which is a combination of two variables: the proportion of a blocks outer edges which have been built towards the street and what proportion of entrances faces towards the street (Spacescape, 2016). Higher values in either variable increases the real estate value for the area.

Currently cities are allocating excessive space for cars, which includes extra safety space. Through implementing AVs this could be impacted by improved driving accuracy which could then remove the extra safety space (Gavanas, 2019; Kellett, Barretob, Van Den Hengel, & Vogiatzis, 2019). This exesive space could in scenario POAV and SAV be used for something else.

Scenario POAV

Assumption: If space were to become available, it would be used to create more walking friendly areas

The exessive space from the reduced safety space (Gavanas, 2019; (Kellett, Barretob, Van Den Hengel, & Vogiatzis, 2019), could be used to create more walking areas. As actractivness to walk is correlated to a a higher block index, this could increase the real estate value.

Assumption: Owners will let their vehicles roam driverless

Another possible outcome of this scenario is increased congestion through more driverless cars roaming the street and an increase of the total numbers of trip per person, which could decrease the attractiveness to walk (Bahrami, Nourinejad, & Roorda, 2018). As a result, exploitation of the outward facings parts of blocks towards the streets could decrease, as it will become less desirable for stores to face such an environment. This in turn will decrease value for the real estate value.

Scenario SAV

Assumption: AVs will reduce traffic

Assumption: If space were to become available, it would be used to create more walking friendly areas

Shared AVs are estimated to reduce traffic by 62-100 percent (Ataii, Kemp, Simpson, & Zhang, 2019), this could lead to a reduction of 80 percent of all curb-to-curb parking (SOU, 2018). This is estimated to be 20 percent of the street space dedicated to transportation (SOU, 2018) and could lead to the space of two lanes per street to open up, if there was no curb-to-curb street parking on either sides. With reduced space for parking, combined witth smaller roads in general, the street layout could be constructed to become more walking and bicykle friendly. As there is a direct correlation between walkways and activity on street corners AV could have a positive effect on the block index.

Urban activities

The parameter urban activities are mainly investigating the number of different urban activities such as shops and restaurants within close vicinity of the residence. As the locations of such activities are mainly affected by where people spend their hours during the day, they generally have a much higher density in places that have a high density of workplaces or CBDs. As our study has assumed that peoples behaviour regarding work and work transportation patterns will be unchanged, it is assumed that the parameter urban activities will be unchanged as well.

5.1.2 Accessibility

Accessibility consist of two parameters, distance to the city centre or workplace, and the distance to train or express bus station.

Distance to the city centre and/or workplace

Assumption: Lower VOT with AVs

Condominiums consider the distance to the city centre as a value adding parameter, where the real estate value is decreasing for every kilometre further away the residency is located. Since AVs are not predicted to have any effect on the location of residential buildings this parameter will not be impacted.

For houses the parameter regarding distance to the workplace depends on two variables: should be within 45 minutes of commuting and the real estate value increases with access to a higher number of workplaces (Spacescape, 2016). Marchetti's constant of one hour, describes peoples maximum commuting time (Donkers & de Wit, 2018) combined with Klaesson and Pettersson (2015) graph over the declining willingness to commute over time could be used to show the real estate value changing. During the first 1-15 minutes the willingness remains consistent and unimpacted. In the interval 15-50 minutes, the willingness to commute declines, and after one hour, Marchetti's constant assert that people will move closer to the workplaces rather than remain commuting.

With VOT the value of time could be decreased with 20 percent as people could during transport do other things than driving. When combining this with the variable willingness to commute from the figure 5 it shows that the acceptable commuting time will increase with the same amount (Medina-Tapia & Robusté, 2018). The changes in the commuting variables are calculated bellow and illustrated in figure 11:

*New Marchetti's constant: 60 [minutes] * 1,2 [increase from VOT] = 72 minutes*

*New upper commuting limit: 50 [minutes] * 1,2 [increase from [VOT] = 60 minutes*

*New commuting value: 45 [minutes] * 1,2 [increase from [VOT] = 54 minutes*

*New lower commuting limit: 15 [minutes] * 1,2 [increase from VOT] = 18 minutes*

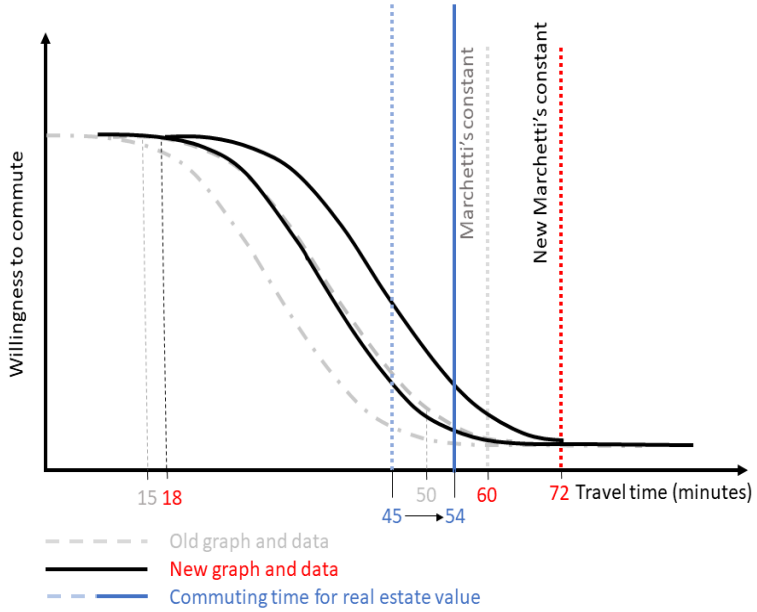


Figure 11. The change in willingness to commute, a new Marchetti's constant, and a new maximum commuting value for the real estate parameter distance to workplace.

This calculation shows that with AVs the time where the real estate value no longer is applicable is then at 54 minutes instead of 45 minutes. The new maximum commuting time would be 72 minutes and the new willingness declining interval will be starting at 18 minutes. AV are also predicted to affect the congestion, depending if there will be a reduction or increased number of vehicles, which may lead to a longer traveling time than today. Based on these calculations there will not be any major changes in the city centre, as the city centre has a higher density of workspaces (Spacescape, 2016). Most of the workplaces are in the central parts of the city. With the reduction of VOT the Marchetti's constant and the defined value variable of 45 minutes can be assumed to change, meaning people will consider commuting a longer time than before. This means that people could consider moving further away from the city centre or considered to have a workplace further outside the city. This could mean that this value parameter could be applied to a wider area. This will be the case for both scenario POAV and SAV.

Scenario POAV

Assumption: Owners will let their vehicles roam driverless

Assumption: More people will be using vehicles with AVs compared to BAU

There is a predicted increase of vehicles in traffic between 15-200 percent of the current situation. The increase of 200 percent derives from driverless cars roaming to avoid expensive parking in the city (NACTO, 2019). The lower increase of 15 percent assumes the comfort of having an AV driving, will cause an increase in travelling (Sprei, 2017). A high increase in traffic could lead to increased congestion (SOU, 2018), which would result in lower driving speeds with longer commuting times. For short commuting distances the impact of this would not really be noticed, but for people with longer commuting distances the increase in congestion could lead to considerably longer commuting times. This could mean that a large enough increase in vehicles in traffic could potentially increase the commuting time that could have been gained through the positive change in VOT, and therefore reduce the real estate value back to the current status.

For houses, the real estate value is connected to the parameter *distance to the workplace*, where the variable for this is the time commuting to the workplace. This would have both a small positive impact

from the decreased VOT and a negative impact on the real estate value from the possible congestion with the extra commuting time that could result in.

Scenario SAV

Assumption: Less vehicles with shared AVs compared to currently

Studies estimate that there could be a reduction of congestion with 25-100 percent (SOU, 2018; Archer, 2017). With less congestion, traffic flow will be smoother and it could be faster to drive. As the new acceptable commuting time is increased to 54 minutes, from the decrease in VOT, applies that the real estate value adding area could be increased for houses. The change in the real estate value is larger since there is a positive change in real estate value from the changed VOT and reduced congestion.

Distance to train or express bus station

The distance to train or express bus station is value adding for residents in both condominiums and houses. For the condominiums, the real value decrease when the distance to the nearest station increases with every kilometre. For houses, the distance needs to be within 400 meters from the house to the station. If this condition is fulfilled the real estate value will increase (Spacescape, 2016).

Scenario POAV

Assumption: Existing public transport will become a less attractive transport option as POAVs emulate the benefits of public transport with lower VOT

Residents of houses prefer to take their own vehicle if the station is further away than 400 meters (Spacescape, 2016). If the VOT is lower with AVs this could mean that more people will prefer to use their own vehicle instead of using the public transportation, even within the radius of 400 meter. It could be assumed that the parameter closeness to an express bus- or train stations could have its impact on real estate value decreased as public transportation could become a less attractive travel option.

Scenario SAV

Assumption: Existing public transport will become a less attractive transport option as SAV emulate the benefits of public transport such as low cost, high efficiency

There is a possibility that AVs could provide a pick-up-drop-off service from door to door which could be combined with a CM public system (SOU, 2018). With this the impact of the real estate value parameter of having an express bus- or train-station at a close distance could become reduced, as multiple people from the same household would have the possibility to be picked-up and dropped-off at the right destinations without stations close to them. This could reduce the real estate value of having a station within a walkable distance, which should be the case for both condominiums and houses.

5.1.3 Recreation

The recreation real estate value factor consists of three parameters: *distance to parks and greeneries, distance to water* and *Peace and qui*et. Peace and quiet is affected by two sub-parameters, *distance to the closest highway and railway* and *calm street index.*

Distance to parks and greeneries

Gothenburg has stated in the green initiative strategy that it aims to have green areas in different sizes available for its residents. Small parks and greeneries that are between 0.2-2 hectares should be within 300-meter walking distance from residential buildings. District parks which are larger than 2 hectares should be within 1 kilometre of residential buildings and within 15 minutes walking distance (Park- och naturnämnden, 2014).

Since AVs are speculated to require a different need of parking, it could therefore be possible to reconstruct some parking spaces in the future as new green areas. According to Sigma (2019) 60.6 percent of available parking spaces in Gothenburg are in the city centre which can be seen in table 5 below. The city centre area covers around 3 percent of the city of Gothenburg and it is in this area the residents have one of the highest availabilities to parks, shown in figure 12 below. This indicates that there is less opportunity to develop parks in the rest of Gothenburg as 60 percent of the potential new land will become available for development in the inner city. As 40 percent of the public parking lots are still available to be developed in the rest of the city there is great opportunity to develop parks in areas to fulfil Gothenburg's green strategy vision regarding parks. And therefore, increase real estate value.

Table 5. Number of parking spaces in relation to location

Area of Gothenburg	Parking spaces	Area	Percentage area	Percentage parking spaces
Inner city	40000	75 Hectares	3.2%	60.6%
Rest of the city	26000	2340 Hectares	96.8%	39.4%
Total	66000	2415 Hectares	100%	100%

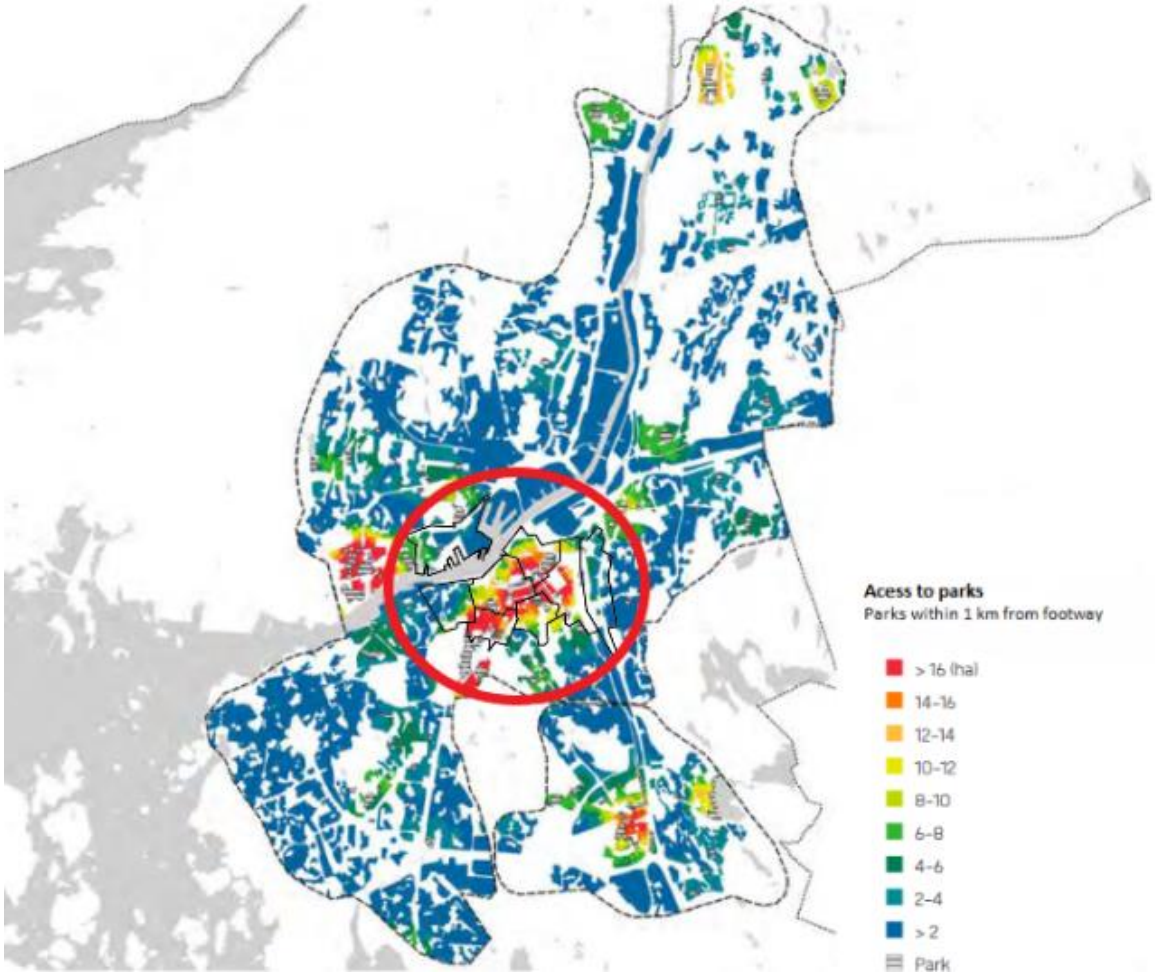


Figure 12. Parks and greeneries in the city centre area. Remade picture from Spacescape (2016).

Gothenburg's green strategy states that it is important to preserve and develop the green areas of the city (Park- och naturnämnden, 2014), but at the same time there is also a need for more residential

buildings and other facilities such as offices and commercial real estate (ÖP, 2018). This would result in land being available for redevelopment, but it is uncertain what projects will be developed in the future and how this will affect real estate value. The results are to be regarded as speculative as it is hard to assume what the prioritization for developing new projects will be, if it is parks, housing or other projects without a more in-depth study regarding this.

Scenario POAV

Assumption: There will be an effort by Gothenburg city to decrease the number of parking spaces as well as reconstruct existing ones to make them more efficient

Assumption: Gothenburg will use the developable land to construct additional green areas up to a level that satisfies the requirements for adding real estate value

There is great uncertainty among previous studies how much this scenario will reduce the need for parking. One study identified that this number could be correspond to a 10-15 percent decrease (SOU, 2018). This means that Gothenburg could reduce the number of parking spaces with between 6600 - 10000 spaces in favour of new developments. With privately owned AVs there is some possibility for city planners to affect the current situation regarding access to parks and greeneries and therefore increase real estate value in the city.

Scenario SAV

Assumption: There will be an effort by Gothenburg city to decrease the number of parking spaces as well as reconstruct existing ones to make them more efficient

Assumption: Gothenburg will use the developable land to construct additional green areas up to a level that satisfies the requirements for adding real estate value

With shared AVs studies suggest a reduction in parking spaces that ranges from 62 percent to total elimination (Ataii, Kemp, Simpson, & Zhang, 2019; Choi, 2019; Nourinejada, Bahramib, & Roorda, 2018). This means that 41000 – 66000 parking spaces could be removed in favour of new projects within the city. This indicates that large new areas could be available for redevelopment. With AVs implementation there is a large opportunity for city planners to affect and increase access to parks and greeneries and therefore increase real estate value within the city.

Distance to water

There are three parameters that affect the real estate value in realtion distance to water. Its distance to closest water area, less than 50 meters to water area and distance to the ocean. AVs could potentially make it easier to visit water areas, but it will according to the literature study, not be any impact in these parameters as a result of the implementation of AVs in scenario POAV nor in scenario SAV.

Peace and quiet

The impact of the parameter peace and quiet is decided by the distance to the closest highway and railways, and the proportion of nearby roads which have a low speed limit of maximum 30 km/h. Peace and quiet only have an impact on the real estate valuation for houses (Spacescape, 2016).

Distance to the closest highway or railway

Assumption: AVs will not impact the distance to closes highway or railway

The possible impact the implementation of AV could have on the location of highways and railways has not been discussed in the literature and there is therefore no data available of how this could change the real estate value.

Calm street index

Calm street index is measured in two variables. The length of roads within a one-kilometre radius with the speed limit of 30 km/h or lower and the proportion of low speed roads within the same radius. As AVs are claimed to be safer in traffic than MVs there are some theories that discusses the potential to increase speed limits with AVs without comprising safety and in doing so increasing efficiency on the roads (Friedrich, 2016).

Scenario POAV and Scenario SAV

Assumption: Increased speeds on low speed roads

As AVs could potentially increase the speed limits due to their increased safety standards it is therefore expected to have a negative impact on real estate value (Gavanas, 2019; Greiwe, 2017). Since this is affected by the technical specification of the vehicles and not with the ownership this is estimated to have the same valuation impact in both scenarios.

AVs are expected to be programmed to never go above the speed limit (Gavanas, 2019; Greiwe, 2017), which could give a positive impact on the parameter calm street index. But as the parameter only considers the proportion of low speed roads and not if the speed limits are obeyed this is considered to have little or no impact on the real estate valuation.

5.1.4 Summary result for scenario POAV and SAV

Tables 6, 7 and 8 provide summaries of the results presented above. A comparison between the effects of AV and the factors of real estate value shows values depending on how significant an impact they could potentially have. As there are many different effects that are caused by AVs and since scenario POAV and SAV could have different impacts there are five categories of effects chosen that try to encompass as much as possible of the effects.

Scenario POAV

Table 6. The assumed positive or negative impact on each real estate value parameter for scenario POAV and on which AV effect this is based on.

Factors	***Density***		***Accessibility***		***Recreation***			
Parameters / ***Effects of AV***	*Urban activities*	*Layout of city streets*	*Distance to the city centre and/or workplace*	*Distance to train or express bus station*	*Calm street index*	*Distance to closest highway or railway*	*Distance to park and greeneries*	*Distance to the water*
Parking							+	
Roads		+						
Traffic flow		– –	–		–			
VOT			+	–				
Total	**NA**	– – +	– +	–	–	**NA**	+	**NA**

Scenario SAV

Table 7. The assumed positive or negative impact on each real estate value parameter for scenario SAV and on which AV effect this is based on.

Factors	***Density***		***Accessibility***		***Recreation***			
Parameters / ***Effects of AV***	*Urban activities*	*Layout of city streets*	*Distance to the city centre and/or workplace*	*Distance to train or express bus station*	*Calm street index*	*Distance to closest highway or railway*	*Distance to park and greeneries*	*Distance to the water*
Parking							+ +	
Roads		+ +						
Traffic flow		+	+		–			
VOT			+	–				
Total	**NA**	+ + +	+ +	–	–	**NA**	+ +	**NA**

Higher real estate value **Lower real estate value**

+ - *Small positive outcome*

+ + - *Intermediate positive outcome*

+ + + - *Significant positive outcome*

– - *Small negative outcome*

– – - *Medium negative outcome*

– – – - *Significant negative outcome*

Summary of the result from the scenarios

Table 8. The assumed positive or negative impact on each real estate value factor for both scenario POAV and SAV.

Factors	***Density***	***Accessibility***	***Recreation***	***Total***
POAV	+ – –	+ – – –	+	+ + + – – – – –
SAV	+ + + –	+ + – –	+ +	+ + + + + + + – – –

5.2 Interview Study Results

The results of the interviews are presented in the paragraphs below. The results from the literature study were acquired by making assumptions regarding how AVs could potentially impact Gothenburg and its citizens. The assumptions were speculative, and the interviews were thus used as a counterbalance to determine the probability of the assumptions made in this study. The interviews were made with several different experts in areas such as real estate, mobility and city planning area, the questions with answers is included in Appendix 2. In the end of this section the final result will be summarised in Table 9 for scenario POAV. This is an altered version of Table 10 for scenario SAV that will take into consideration the outcome of the result from the interview study and questionnaire. Table 11 represents the final conclusion on the impact on the real estate factors divided into the two scenarios.

5.2.1 Density

The factor density is based on two real estate value adding parameters: Layout of city streets and Urban activity. Since Urban activity was assumed to not be impacted by AVs this is not included in the interview result.

Layout of city streets

Layout of city streets was determined by four assumptions: *If space assigned to cars would decrease, walking friendly sidewalks would be created, Owners will let their vehicles roam driverless, POAV causes increased congestion* and *AVs will reduce traffic.*

If space assigned to cars would decrease, walking friendly sidewalks would be created instead

The responses from the questionnaire and interviews was divided with approximately 60 percent of the participants likely or highly likely while 40 percent thinking it is unlikely to highly unlikely. One participant that thought this was very likely mentioned that pedestrians and green areas have been given a higher priority in city planning in recent years, and that this trend is likely to continue. Another participant mentioned how the space distribution on the street between the different transport modes favours cars unproportionally. To redistribute more of the road space for other transport modes, such as walking and cycling, would thus be equalizing this ratio.

One participant that thought this was an unlikely scenario since roads are dimensioned to also support large vehicles, such as trucks, busses and fire trucks. These vehicles will continue to need a large space to maneuverer and any argument that roads could be constructed with smaller dimensions need to take this fact in consideration. One of the participants explained that even if the AVs could use less space,

this space would be too small to be able to redevelop in a manner that would yield positive results regarding real estate value. Another participant pointed out that this depends on which scenario that will occur and who will be in charge when debating on this. This would be the case for both scenario POAV and SAV.

Assessment: ***Slightly likely***

Owners will let their vehicles roam driverless

For scenario POAV the assumption was that there would be an increased number of vehicles driving around. The results from the questionnaire indicated that most of the participants thought that this would be a likely scenario, if parking and driving continued to be priced and regulated as the current state. This possibility was describing as "*one of the biggest threats with AV*" and that "*this would be a step in the totally wrong direction*". The participants did however think that regulations and prices would change, as driverless vehicles would be detrimental to current trends. Suggestions for control through congestion taxes, increased driving costs or simply forbidding using the vehicles in such a manner. The assumption that in the POAV scenario vehicle owners would let their vehicles roam driverless are quite likely if the regulations remain the same. But since the majority answered that there needs to be regulations in place that prevent this, the final answer for this assumption is therefore that this would be unlikely.

Assessment: ***Unlikely***

POAV causes increased congestion

The participants thought it was a likely outcome that there would be an increased usage of cars with POAV. Many of the participants agreed that a higher level of comfort with AVs compared to MVs would increase of usage compared to the current state. Some of the participants also mentioned that more people will be eligible to travel by themselves that cannot do so today, such as elderly, children and disabled, which would increase the total number of users.

But the participants also suggested that this could be avoided as longs as policies was set up that would prevent AVs of driving with only one passenger. The increased number of vehicles might increase the level of congestion which would make the time for transportation longer than the current state. This might make some people choose other transportation alternatives to avoid being stuck in congestion.

Assessment. ***Slightly Likely****. Even though policies could be implemented to prevent this it is unsure how likely this is to occur.*

AVs will reduce traffic

For scenario SAV the biggest reduction would be not only through sharing the vehicle, but to increase ridesharing. The results from the questionnaire deemed it more likely that people would choose to share rides instead of traveling by themselves. Some of the answers suggested however that sharing rides depends on the economical aspect. How much more the traveling fee alone compared to how much longer time the trip will take if ridesharing. One explained this as "people will always value their own time higher" and that it also may be based on how frequent these vehicles will go. One participant also mentioned that using CM would maybe be an even more attractive option, if you could ride alone, and you did not have any or minimal waiting time during the trip. During one interview the interviewer said that the culture of sharing might also have an impact. If the people who are sharing the ride feel like they have to interact with the other passengers, this might lower the willingness to travel with other people. The change with Covid-19 and social distancing could also affect people's future willingness to ride together.

Still a majority of the participants thought that it would be likely to share rides in the future, but that it might still be different levels of service, where the premium might be having the vehicle by yourself and for the lower levels to share the ride with a lower paying rate.

Assessment: ***Likely***

5.2.2 Accessibility

The factor accessibility had two real estate value parameters that were according to the results impacted by AVs: Distance to the city centre/workplace and distance to train or express bus station

Distance to the city centre/workplace

Lower VOT with AVs

The assumption that people will in general have a lower VOT was deemed uncertain or slightly likely. The answers differed very much with some of the participants thinking it would likely increase and some thinking it would decrease. Some did not choose to answer this question, since they either did not understand the question or did not feel like they had enough knowledge. Those who answered during the interviews mostly agreed that VOT would slightly decrease. Some participants mentioned however that it would not be much difference from taking the bus or the train, when comparing what you could do during the transportation time. So even if there is a decrease in VOT it may not be big enough to have any impact on the commuting time.

Assessment: ***Uncertain*** *or* ***slightly likely***

POAV causes increased congestion

The assumption that POAV causes increased congestion was elaborated earlier on in section 5.2.1 *Layout of city streets*. It was deemed likely as increased comfort and increased number of eligible car users would put additional stress on the infrastructure with the increased traffic.

Assessment: ***Likely***

AVs will reduce traffic

How the number of vehicles will change in scenario SAV is based on how many that would consider sharing the ride compared to having the vehicle to themselves for the ride. This was discussed further above in Section 5.2.1 *Layout of city streets*. The number of vehicles depends on both the cost and the policies, and how many that uses ridesharing or take a vehicle alone. But it was still considered likely that more people will start ridesharing, thus reducing the number of vehicles.

Assessment: ***Likely***

Distance to train or express bus station

Decreased value of express bus or train station

When asked if the value of an express bus or train station being close to the residency, a majority of the participants thought that the real estate value would increase and the majority of the rest that the value would remain the same. Public transportation is capable of transporting multiple personsand are relatively cost efficient. The participants thought that AVs would not be able to compete with this. One participant mentioned that if more people would take the SAVs instead of public transport this could lead to more congestion, that in turn would decrease the efficiency of AVs and make public transport the more attractive option. Therefore, most stated that with the higher capacity of trains AVs will not be able to replace this means of transportation. Therefore, the value of having an express station will

continue to increase in the future. One participant mentioned that this would be especially true with CM, if AVs could take them the first part of the trip.

Assessment: ***Unlikely***

5.2.3 Recreation

The factor recreation had two value adding parameter defined as distance to parks and greeneries, and calm street index that were impacted by AVs according to the results.

Distance to parks and greeneries

The value adding parameter distance to parks and greeneries continued two assumptions: *Reduced numbers of parking spaces* and *new parks and greenery in Gothenburg*

Reduced numbers of parking spaces

With parking spaces most of the interviewees thought that there might be a reduction, especially in the scenario with SAV. Still there is a need for pick-up and drop-off areas, and space for more public transportation and delivery services. In the case of POAV, where regulations discussed earlier in section 6.1.1, it is assumed to be in place, there will still be a need of parking spaces. But that the parking spaces could be constructed smaller, since they no longer need to be designed for human height or the possibility of exiting the vehicle when it is already parked. In total the interviews indicated that there would most likely be a reduction of parking spaces or at least a more efficient usage of the parking areas, with fewer parking spaces in scenario SAV than POAV.

When then looking on the assumption that redeveloped parking spaces would be constructed to establish more parks and green areas the answer from the interview showed that this was neither unlikely nor likely. Instead, it depended on the housing situation in the future and the agenda of who will be in charge at the time. When redeveloping an area, the residents explained that it is easier to calculate the real estate value and profit on a built property rather than having a park. Therefore, redeveloped areas become housing instead of green areas to a higher degree. Also, by looking at the current situation, when parking lots are redeveloped this is to build new housing and not new parks. Furthermore, the participant still thought that the regulations and guidelines of how much green areas the city aim to have will still be followed. But if it has enough green area as it is, new land will not be used to create more parks.

Assessment: ***Likely***

New parks and greenery in Gothenburg

The results from the interview study indicated that the participants thought it was either no change or unlikely that parks would be prioritized. The majority answered uncertain and elaborated that other parameters may impact on the outcome. Some participants assumed that it depended both on how the housing market looks like in the future, but that it will most likely be a political question as well of what is valued the highest, parks or available housing. One participant mentioned that a privately owned area might not see the same value for investing in parks as someone from the public sector does. One of the participants mentioned that when the city develops a parking space it almost always becomes a living area instead, but that this is also according to Gothenburg's Green strategy and the city still makes sure to keep the guidelines that is set for the level of green areas in the city.

Thought, one of the questions was if the participants thought it was enough green area in the current state most participants who lived in Gothenburg thought that it did not have to add any extra parks or green areas. Instead it was just important to keep and protect the parks that Gothenburg has as of today, and make sure that none of them get redeveloped into something else.

Assessment: ***Uncertain or slightly unlikely***

Calm street index

Calm street index had one assumption: higher speed on low speed roads for both scenarios.

Assumption higher speed on low speed roads with AVs

The results from the interview study indicated that this assumption was very unlikely to happen. A majority of the answers was on the very unlikely or unlikely side. Some participant answered in the middle, since they were uncertain about the question or they felt like they did not have enough knowledge regarding the subject. It was mentioned that even if AVs could make this possible, people will generally resist such changes since they would not approve of high-speed roads in a living area. Many of the interviewees suggested that the pros of having increased speeds on low speed roads would go against current trends, which are to lower speeds on roads to increase safety. One of the participants explained that if a higher allowed speed limit would be implemented then the feeling of safety and security for the pedestrian or cyclist would decrease in that area. Another interviewee said that the speed limit that is set is decided by a person's capability to withstand physical impact. If the speed limit is above 30 kilometre per hour this would result in more severe injuries in accident. Even if AVs have a higher level of safety and less accidents would happen, the set speed limit is still based on the capability of the human body and therefore the speed limits are very unlikely to change. Two interviewees instead suggested that there could be a reduction of the speed limit from the current situation to further increase the safety and calm neighbourhoods.

Assessment: ***Very unlikely****, AVs could potentially slightly increase real estate value for the parameter calm street index*

5.2.4 Summary Interviews

The interviews made it possible to assess the likeliness of the assumptions based on a colour scheme, shown in figure 13.

Figure 13. The colour schematic for the likelihood of the assumptions

Green plus or minus means that it is an added impact from the literature results while a red plus or minus is a removed impact from the literature result. If the colour of plus and minus is black, it means that there is no change in the results from the interview study.

Summary result Scenario POAV

Table 9. The confirmed likelihood of each impact from AVs on each factor. If the sign at the bottom is read it is deemed unlikely and removed as a possible impact on the real estate value for the scenario POAV.

Factors	***Density***		***Accessibility***		***Recreation***			
Parameters / ***Effects of AV***	*Urban activities*	*Layout of city streets*	*Distance to the city centre and/or workplace*	*Distance to train or express bus station*	*Calm street index*	*Distance to closest highway or railway*	*Distance to park and greeneries*	*Distance to the water*
Parking							+	
Roads		+						
Traffic flow		– –	–		–			
VOT			+	–				
Total	**NA**	– – +	– +	–	–	**NA**	+	**NA**

Summary result Scenario SAV

Table 10. The confirmed likelihood of each impact from AVs on each factor. If the sign at the bottom is read it is deemed unlikely and removed as a possible impact on the real estate value for the scenario POAV

Factors	***Density***		***Accessibility***		***Recreation***			
Parameters / ***Effects of AV***	*Urban activities*	*Layout of city streets*	*Distance to the city centre and/or workplace*	*Distance to train or express bus station*	*Calm street index*	*Distance to closest highway or railway*	*Distance to park and greeneries*	*Distance to the water*
Parking							+ +	
Roads		+ +						
Traffic flow		+	+		–			
VOT			+	–				
Total	**NA**	+ + +	+ +	–	–	**NA**	+ +	**NA**

Table 11. The conclusion of the impact from AVs on the different real estate value factors by the two scenarios POAV and SAV.

Factors	***Density***	***Accessibility***	***Recreation***	***Total***
POAV	+ –	+ –		+ + – –
SAV	+ +	+ +	+	+ + + + +

Higher real estate value	**Lower real estate value**
+ - *Small positive outcome*	– - *Small negative outcome*
+ + - *Intermediate positive outcome*	– – - *Medium negative outcome*
+ + + - *Significant positive outcome*	– – – - *Significant negative outcome*

6 Discussion

The results from the literature study and the interviews are analysed to examine how the likeliness of the assumptions will impact on the real estate value. Eventual shortcoming of the study is discussed, and further research is recommended.

6.1 Density

When examining the results only layout of the city streets is assumed to affect real estate value by implementing AVs. This parameter account for houses 10 percent of the total weighting, and for condominiums is 17 percent, which will create a bigger impact for real estate value on condominiums than housing.

Layout of city streets

For POAV there is both a positive and a negative impact on real estate value within the parameter layout of city streets. This does not mean that the total impact from AVs in the perimeter is net zero as the two impacts within layout of city street are most likely not equal. For SAV there is only a positive impact that is a result from two variables, which means that for this factor it could result in increased real estate value for condominiums and houses. This is only an indication however and does not provide and quantitative data. It does say however that there are many opportunities in scenario SAV to increase real estate value.

The assumptions in scenario POAV with driverless cars roaming the streets was likely to happen if no laws or regulations would forbid this. But a majority of the participants in the interview study thought that policies would most likely be adopted to prevent an unreasonable increase in traffic. Potential future traffic policies were not examined in the study. But it raises an important shortcoming of this study which is what policies are probable to be implemented as a result of AVs and how will these policies affect how AVs are used.

The potential positive impacts in scenario SAV on layout of city from a potential redevelopment of excessive roads space were reduced as a result of the interview study. The reason for the reduction was that of the potential positive impact from redeveloping road was most likely overestimated in the literature study. It is not unreasonable to assume that city street will be redesigned if there is opportunity to, but opportunity does not mean it will automatically occur. Thus, background studies will be needed to investigate the viability and possible gains of each area to be redeveloped. There is an issue with how excessive space will be redeveloped, which would depend on prioritizations. When comparing the value that is created from establish a more walking friendly area compared to investing in a new building, then the latter is more profitable and provides sure profits. This means that even if attractiveness to walk may cause an increase in real estate value for existing residential buildings it is often more attractive for a developer to construct additional housing.

Layout of city streets was defined by the block-index, which in this study was connected to the variable of how attractive it is to walk in the surrounding streets. This is a simplification and the block-index are defined by other variables as well. These other factors which could be related to business saturation and perceived safety are not analysed. It is thus important to note that simply because walking attractiveness increases does not mean that the block index will.

Urban activities

In the result it was assumed that the number of urban activities would not be impacted through the implementation of AVs. This might be shortcoming that is dependent on the limitations set in this study. This study stated that it would assume that work patterns, would remain the same as they currently are. Thus, no effort was made to investigate how AVs could potentially impact workplaces, which is the main variable in determining the factor urban activities.

6.2 Accessibility

The factor accessibility accounts for 29 percent for houses and 27 percent for condominiums in the weighting of the real estate value. The only parameter that is affected in the scenarios POAV or SAV is distance to the city centre or workplace, which accounts for 20 percent for houses and 17 percent for condominiums of the total real estate value. But as mentioned in the results, condominiums are not assumed to be affected by the implementation of AVs therefore only houses will impact both on this parameter and to an extent to this factor.

From Table 11 from scenario SAV there are two positive impacts. With the weighing it would therefore mean that there is a large potential real estate value increase for housing side in scenario SAV. For POAV there is a positive and a negative impact. If the positive impact from a reduced VOT is greater, equal or smaller the negative impact from increased congestions is hard to predict. It is possible to influence the outcome however by pushing towards policies that reduce congestion as well as increase the positive impact from VOT.

Distance to train or express bus station

A majority of the answers indicated that public transport would not lose its value which therefore makes the result from the literature study ill grounded. The reasoning for the assumption speculated that people would prefer to be transported by AVs instead of busses or trams. This reasoning however disregarded other factors such as policies and transportation needs. Even though many would prefer to travel by AVs this would create a scenario where more vehicles would be on the roads as fewer people would be traveling by conventional public transport which is more space efficient. Such an outcome will most likely not be attractive for the city of Gothenburg and it is thus more likely that a scenario where conventional public transport is still a major transportation mode which is then complemented by AVs.

A limitation of this study is that the set scenarios may have been a bit to narrow. As an example, is that with POAV there could be the possibility of taking their own vehicle to the closest express bus or train station and then letting the vehicle drive back to the residency. If the distance from the end station to the end destination is not too long this could mean that there could be an increase of users of public transportation. This could be described as a CM system and will probably be a big part even in scenario POAV, even if it has not been elaborated in this study, for limitation reasons. For a real estate perspective this could, instead of the negative outcome from the result, be a positive outcome. With AVs there could be an easy way for the first transportation this could mean that the value of having a station close could increase, but also that the acceptable distance to these could be extended.

Distance to the city centre or workplace

Scenario POAV experience a positive impact from VOT and a negative impact by the increased congestion. The total impact from the factor *Density could* thus become either a positive, negative or no change. Similar to the reasoning from layout of city streets, a positive impact and a negative impact does not become net zero. It only indicates that there is a potential for positive and negative change in real estate values.

The reason that the assumption of reduced VOT is questionable or uncertain following the interviews is largely dependent on the source material used in the literature study. There was a dissonance between the source material and the participants in the interview study. The participants in the interview study had concerns that not everyone would be able to adapt to conducting tasks in AVs or that they would not value transportation in AVs if it would mean potentially slower trips than MVs. Such concerns were not addressed in the literature study, but as the raise valid concerns regarding how VOT will change should be addressed in further studies.

As stated earlier, SAVs could mean a scenario where AVs are part of a combined mobility system. In such a case there would not be much difference between SAVs and current public transport in terms of VOT. Thus, VOT would not be any different than it is today. Public transport today makes it possible to perform tasks while being transported and for longer routes, people do according to some of the participants of the interview study. For shorter trips in the city however, it is usual for busses and trams to be crowded and there will often be a need to change busses along the trip to get to the destination. Such interruptions and the limited space can make productive work difficult. If SAVs instead are configurated to be used as its own shuttle service VOT could potentially increase. There would be no need to leave the vehicle until the destination is reached which would mean it would be easier to start a task and not be interrupted by change of vehicles. For POAVs, VOT would likely be reduced as POAVs emulate the benefits of a privately owned MV and offer the advantage of being able to perform other tasks while being transported.

The assumptions regarding and increase of congestion with SAVs and a decrease of congestion with POAVs were deemed likely according to the interview study. How much either of them will increase or decrease is speculative, and it will depend how the scenarios are specifically implemented and how regulations and laws are formed.

6.3 Recreation

The factors Recreation is based on the distance to parks and greeneries and distance to water. From table 9 for POAV there will be no impact at all from AVs, while for SAVs there will be a small positive increase in real estate value

Distance to parks and greeneries

From the literature result it was assumed that if more parking lots would be redeveloped to parks it would increase the real estate value for the residential buildings in the neighbourhood. But from the interviews it could be concluded that there was no need to increase the number of parks and greeneries. This could therefore be assumed that the set regulations in the Green strategy for Gothenburg has set their level of green areas in the city at a good level and that the need for more residential buildings is higher than the need for parks. It is important to note that the need to create more residential buildings are often very complex and can depend on number of parameters such as living shortage and economic development. Therefore, any outcome of will depend on the current needs and prioritisations based on the current situation's prioritizations.

A flaw in this study was how the data regarding parking spaces was used. To directly assume that the number of parking spaces in Gothenburg is converted into area is a simplification of reality. It disregards several aspects when determining how much impact AVs could have on the real estate value parameter distance to green areas. There is underground parking, multiple stories parking houses and built-in parking spaces into houses. These elements are not considered here which means that the actual area that could be used for redevelopment if parking space were to be eliminated would be smaller than what was first speculated. This means that the magnitude of the impact this could have is still to be debated and should be analysed further in future studies. The difference between the scenarios will remain with SAV having a larger positive impact on real estate value the POAV. A disadvantage of using this data is that it might give readers a false context in how much the parameter could impact the real estate value. It does however offer an insight in the possibility for positive real estate value change, but the result should be regarded as that, potential positive change without and specific quantitation.

How parks per capita would change with AVs is something that could have been examined further. This study as of now does not investigate that with more residential buildings and a higher density of people, there will be more people sharing the same parks and green areas. If the parks become overcrowded, they could potentially become less attractive to visit, something that was no considered in either this study, or the report by Spacescape (2016).

Distance to water

In the result it was stated that the implementation of AVs would not have any impact on this value parameter. There could however be some positive indirect effects from AVs that may have an impact on this parameter. There may become land available for redevelopment close to the water as a result of obsolete parking spaces which can be redeveloped into new real estate that would be accessible to increase their real estate value through this parameter. This would however not mean that existing residences would be impacted, only that new developments could be built which would have this value adding parameter.

Distance to the closest highway and railway

Nothing regarding the potential effects of AVs indicated any impact on the parameter distance to the closest highways or railways. However, the parameter derives from the reluctancy of living close to highways and rails because of the excessive noise. AVs could potentially, depending on the implementation, either decrease or increase noise and thus not affect the parameter directly but affect the variable noise indirectly. This is not something that was analysed in this study as only effects that directly impacted the parameters or their variables were investigated.

Calm street index

It was speculated that the increased safety of AVs would increase the speed limits. This, according to the results from the interview study was very unlikely to occur which means there was a discrepancy between the literature study and the interview study regarding speed limits. The literature study assessed that AVs have the capability to travel faster speeds compared to MVs, if they are in a controlled environment. However, an eventual shortcoming with this reasoning was that there are disadvantages with higher speed that outweigh the gains.

The interview study and questionnaire indicated a high possibility of more roads being redesigned into low speed areas with the implementation of AVs. According to Spacescape (2016), a reason value adding qualities add value is because they are not part of the norm. If any of the value adding parameters would become part of the norm it could lose its value adding qualities. If the norm for residential buildings becomes a high saturation of low speed roads it could lead to the parameter losing its value adding qualities.

According to theory, calm street index real estate value is impacted by having a good network for transportation. This was not elaborated upon in the results since it was not mentioned as the main variable for this real estate value. However, it was mentioned in the background that AVs could result in more direct paths to every residency to be able to pick-up and drop-of directly at the entrance. This might not come true if less space in the road net will be assigned to vehicles and more would be redistributed for other means of transportations. If an increase of roads would happen in the future it would most likely require for the AVs to be smaller and low speed transportation pods, that would fit onto walking and biking lanes. Thus, the roads would not occupy unnecessary space and the real estate value from having a better designed road network would increase.

7 Conclusion

For scenario POAV and SAV, the parameters with the biggest potential to be affected by AVs are *layout of city streets* and *distance to the city centre/workplace*. As the real estate value adding parameter *distance to city centre/workplace* is only applicable for houses and not condominiums, the parameter that has the highest potential impact to real estate value is layout of city streets. It can thus be concluded that the real estate value factor with the highest potential impact is Density.

For scenario POAV there are two minuses which indicates a potential for negative change in real estate value and two pluses that indicates a potential positive change on real estate value. It could thus be concluded that with the usage of POAV there are an equal number of potential positive and negative impacts with regards to the value parameters defined by Spacescape (2016). This indicates that the changes of real estate valuation in Gothenburg will either be affected negatively, stay the same or increase. For scenario SAV there are five pluses which indicates five potential positive changes in real estate valuation for the city of Gothenburg. As there are no negatives it can be concluded that by implementing SAVs, real estate value in Gothenburg will either increase or stay the same. Thus, when comparing the outcomes from the two scenarios, SAV is more attractive scenario from a real estate value perspective.

A final conclusion that can be made is that the usage of AVs itself will not affect real estate value within Gothenburg, but it is the response by the city towards the effects of AVs that will affect it. POAVs will create possibilities to increase real or decrease real estate value and SAVs will create possibilities to increase it and it is up the city to seize these prospects in respective scenario.

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9. Appendix I. Real estate parameters, variables and weighing from Spacescape (2016)

Condominiums

Variables	Weighing against each other	Assumed change	Price increase kr/square metre
Distance to the city centre	17%	Reduction with 1 kilometre	700
Distance to closest train or express bus station	10%	Reduction with 1 kilometre	1600
Number of urban activities within 1 kilometre	24%	Increasing with 100%	2200
Park within 1 kilometre	16%	Increasing with 10 hectar	3300
Distance to closest water area	7%	Reduction with 1 kilometre	1200
Less than 50 meters to water area	9%	Yes	7800
Block-index	17%	10	950
Socioeconomical-index	NA	5	4600

Houses

Variables	Weighing against each other	Assumed change	Price increase kr/square metre
Accessible workplaces within a driving distance of 45 minutes with a car	20%	Increase with 10 000 st	2100
A maximal distance of 400 meter to the closest train or express bus station	9%	Yes	4300
The total number of different urban activities within 500 meters	8%	Increase 1 st	1100
To what degree the surrounding area has been exploited	10%	Decrease 10 000 square metres	600
Distance to the closest green area with recreation qualities	14%	Decrease with 1 kilometre	2000
Distance to the ocean	24%	Decrease with 1 kilometre	600
Calm street index	5%	Increase with 0.1	390
Distance to the closest highway and railway	9%	Increase with 1 kilometre	600

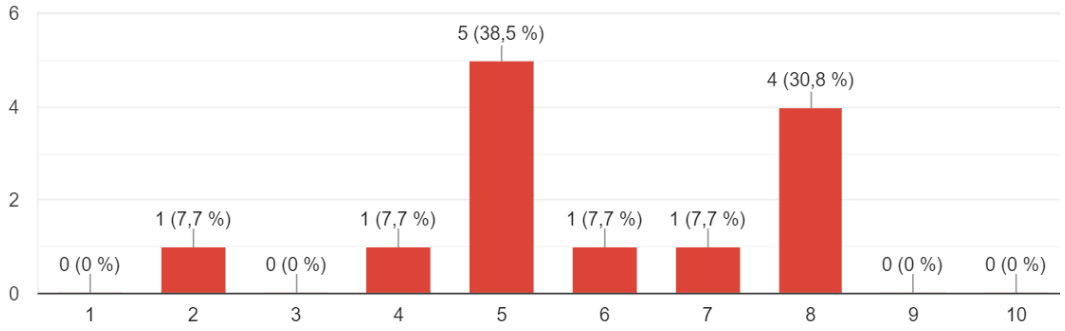
Socioeconomical-index	NA	5	2100

10. Appendix II. Interview question and answers.

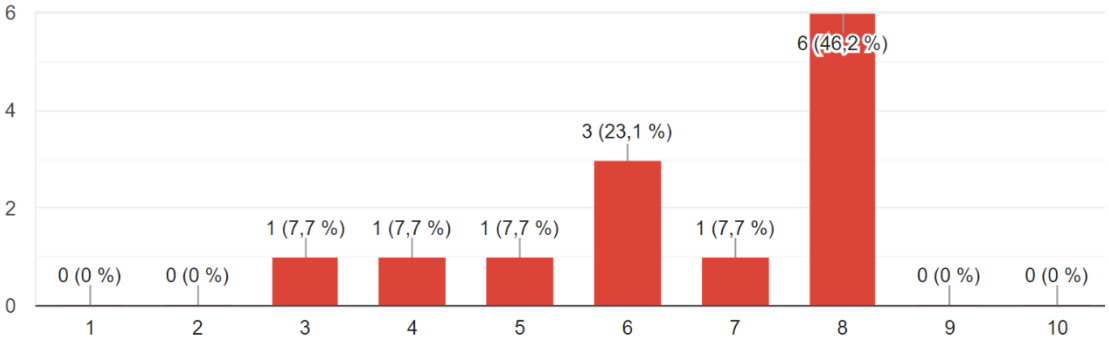
Each participant also got to answer with their own thoughts after each question. These will not be included in this Appendix to not reduce the anonymity. There was also four question in the beginning of the questionnaire that was taken away since they were personal question regarding the participants and was therefore removed to keep the answers anonymous.

Accessibility

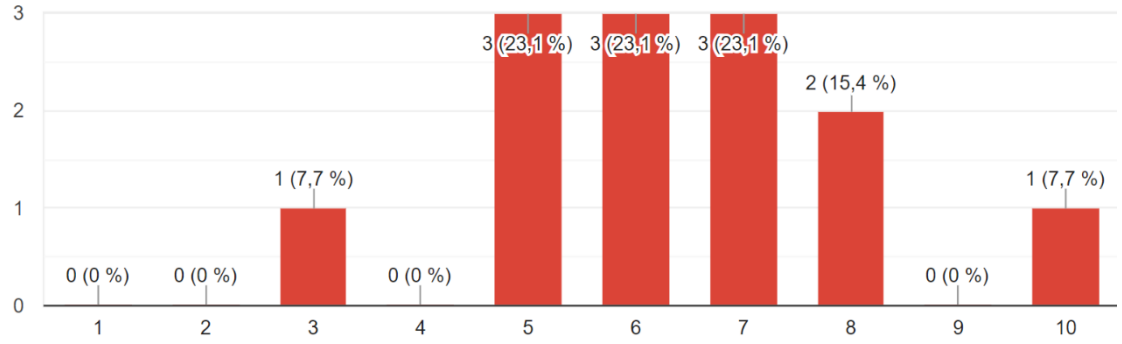
1. In the shared vehicles scenario, there are two possible transportation usages when it comes to public transportation. The first usage is where you will be sharing a ride with several others and with this have slightly longer trips, but it will be cheaper. The second usage is where you will be the only one riding the AV and therefore have a shorter ride but instead pay more. How likely do you think that people will prefer the first usage?



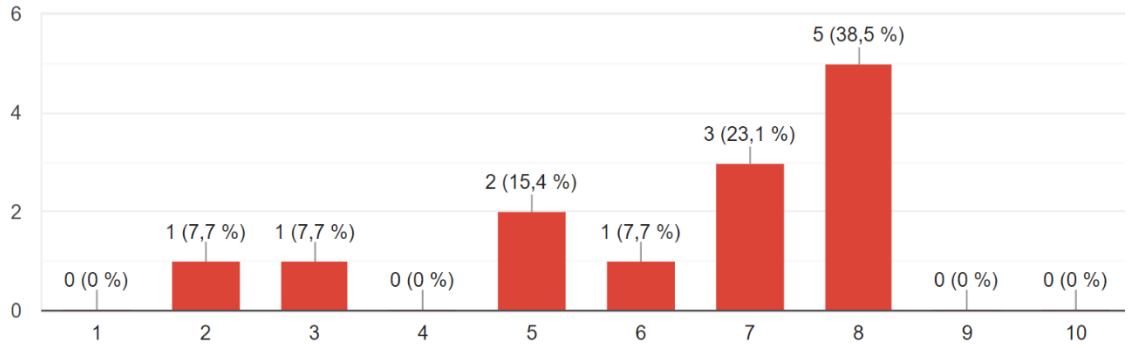
In the scenario of shared vehicle there is a possibility to use a Combined Mobility service, of having a AV-shuttle services to pick you and other at your home and then transport to closest train or express bus station for the majority of the transportation and then a new autonomous shuttle to transport the last distance. How likely is it that people would use this method of transportation instead of having one AV take you all the way in one ride?



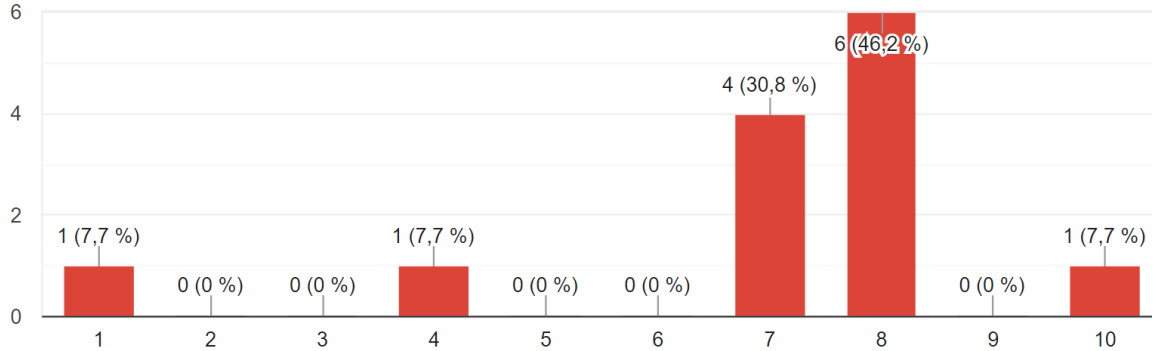
If Autonomous vehicles gets implemented this could result in a change transportation behaviour. Do you think that most of the people will decrease or increase the usage of transportation with vehicles through autonomous vehicles?



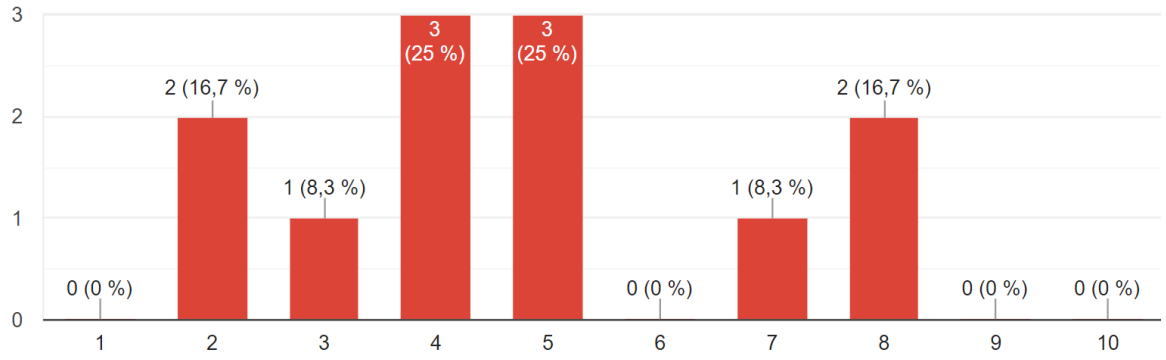
With AV there is an assumption that your perceived value of time will decrease as you can do other things than drive. How likely do you think that more people will be willing to take the car as a result?



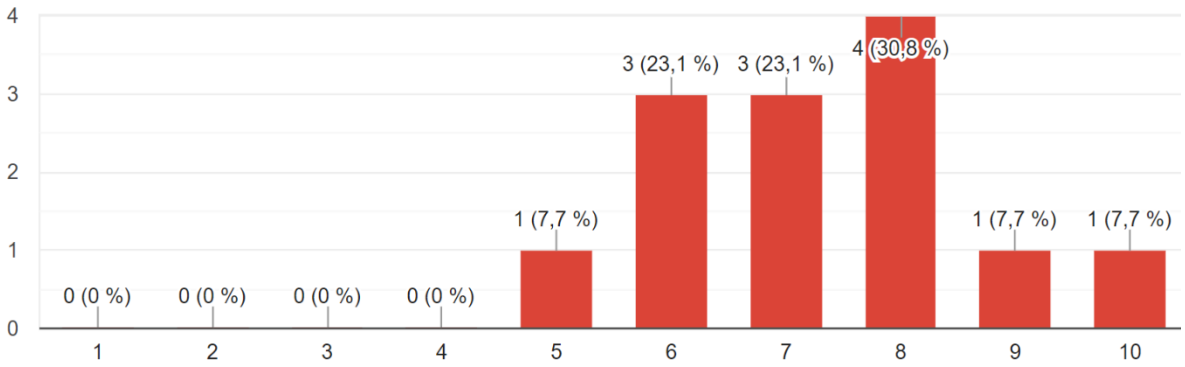
Do you think it is likely that people will drive longer distances when using autonomous vehicles instead of manual vehicles?



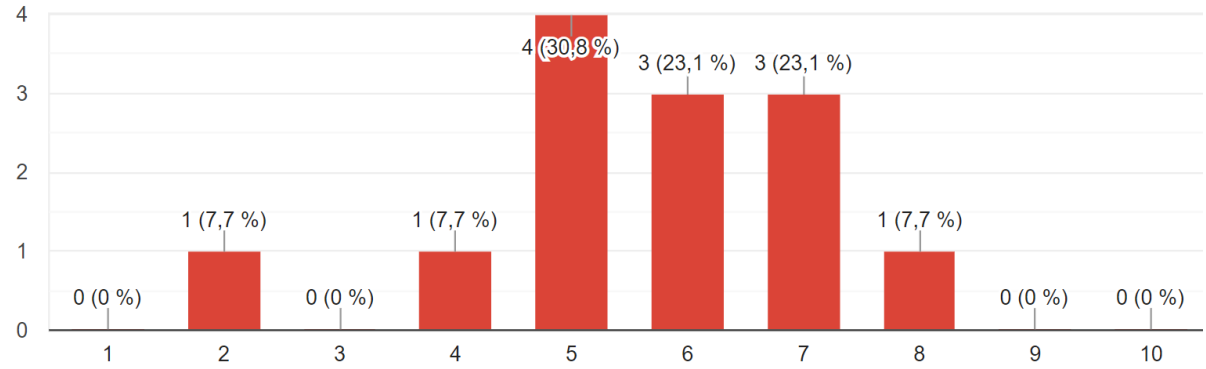
We have in our study speculated that the perceived value of time will decrease with the implementation of AV. Meaning that when you can do other things when driving, then you could also consider traveling longer distances. How and if do you think the value will change?



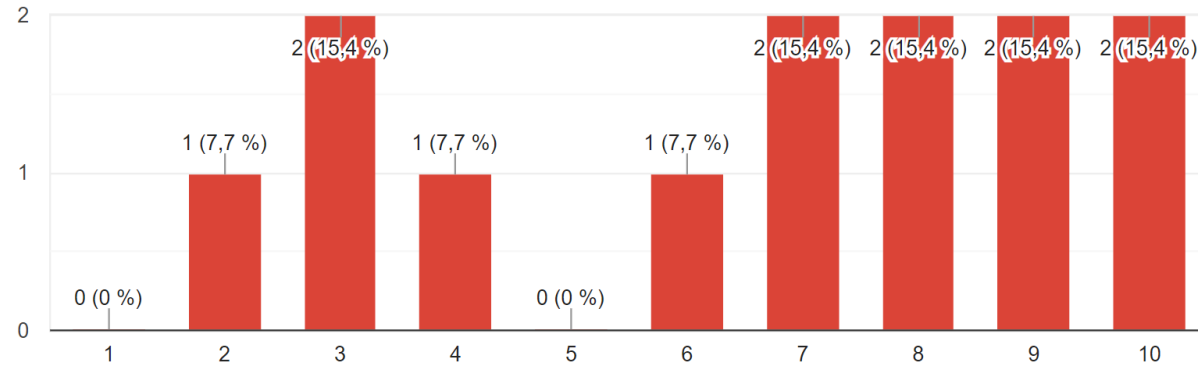
With shared autonomous vehicles, there is potential to make it more convenient to travel to the city centre compared to manual vehicles as you then do not have to find parking and they are assumed to be faster than current public transportation. Do you think that this aspect could increase the value of living in the suburbs compared to how it is today?



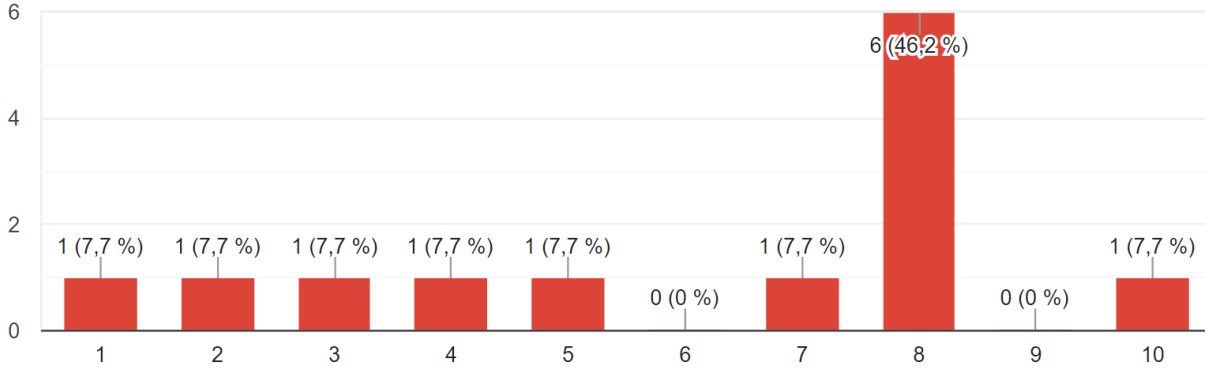
Closeness to express bus or train station is a factor that adds value in real estate. Do you think this value adding factor will decrease/increase with the implementation of autonomous vehicles?



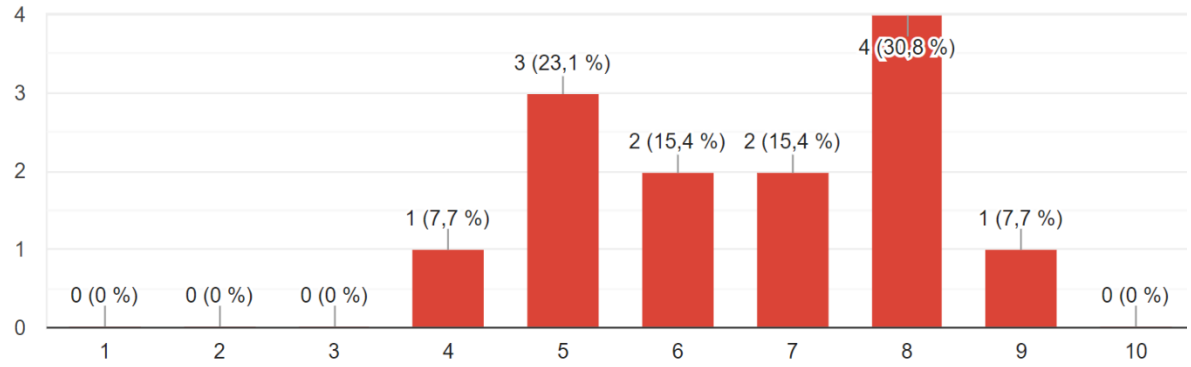
There is a theory that is used in our thesis that suggests that there is a high risk that privately owned self-driving cars will be driving around empty part of the time. People taking the car to work will send their cars back home to park or simply driving around the city as it is a cheaper option than parking in the city. This would mean an increase in congestion levels. How likely do you think this scenario is to occur?



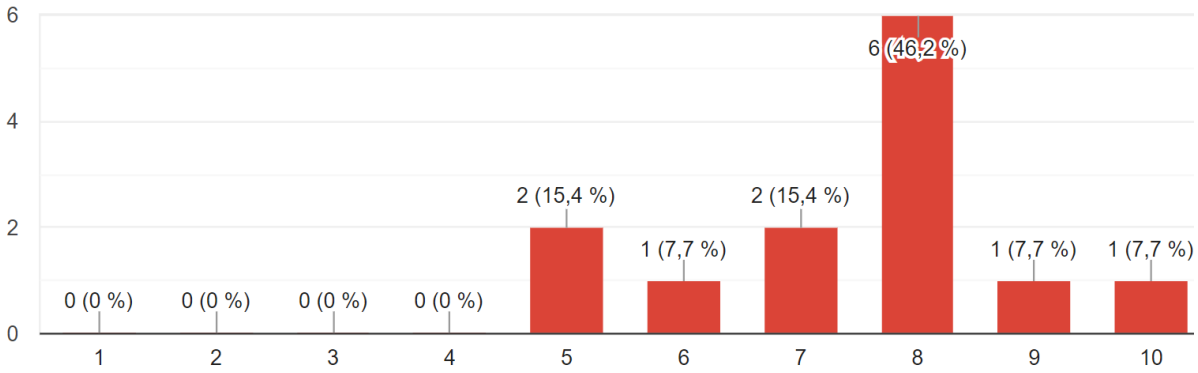
Since autonomous vehicles are speculated to be needing less safety distance and that they will be driving more accurate there is also a prediction that the space needed for the driving lanes could become smaller. With this extra space there is a possibility that this instead could be used to increase both the numbers of pedestrian and bicycle lanes and also give them more space in the street. How likely do you think that this will be?



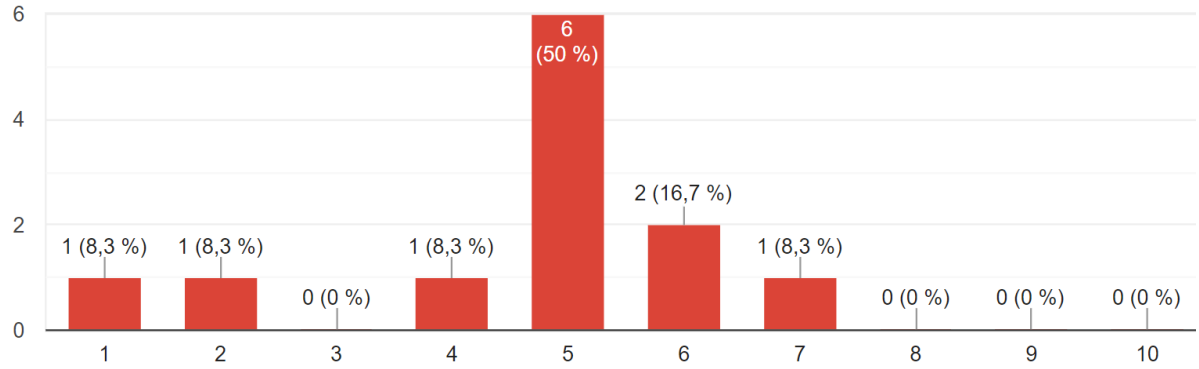
One major parameter in real estate value is how much of the outer edges of a block is facing towards the street (for example entrances and stores). We have speculated that if streets became less car focused this proportion would increase. How likely do you think this is?



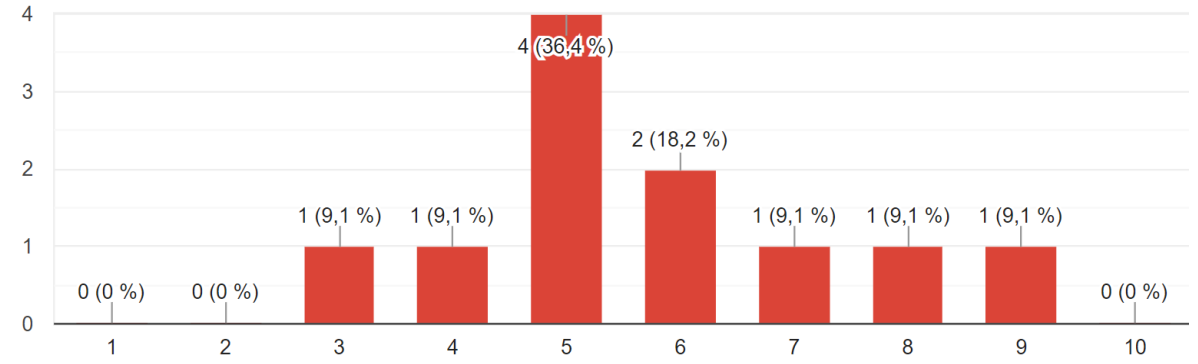
With shared autonomous vehicles are allowed much of the curb-to-curb parking could be eliminated. This in turn could make walking a more attractive option as walkways become larger and more accessible. If this were the case how likely do you think it is that walking would become more prominent within the inner city?



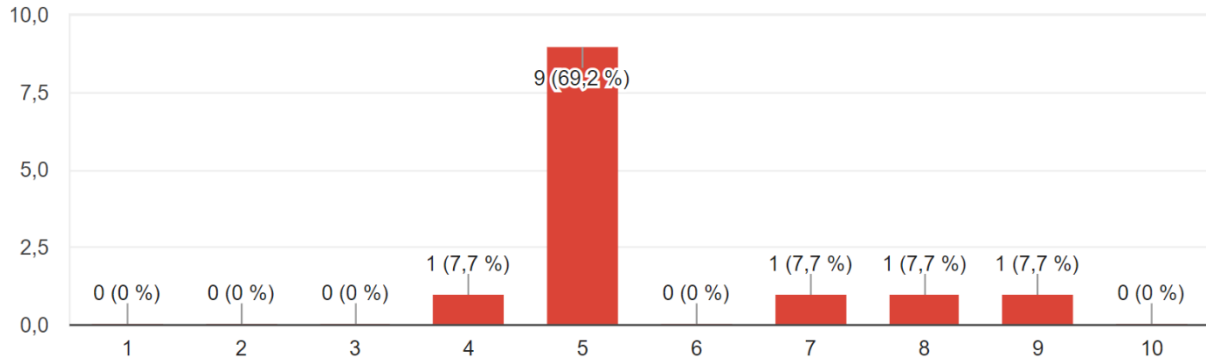
With AVs there is a possibility that land that today is used for parking that can be reconstructed to be used for something else, for example to create new apartments or parks and green areas. How likely do you think it is that cities will priorities to invest in new parks instead of apartments?



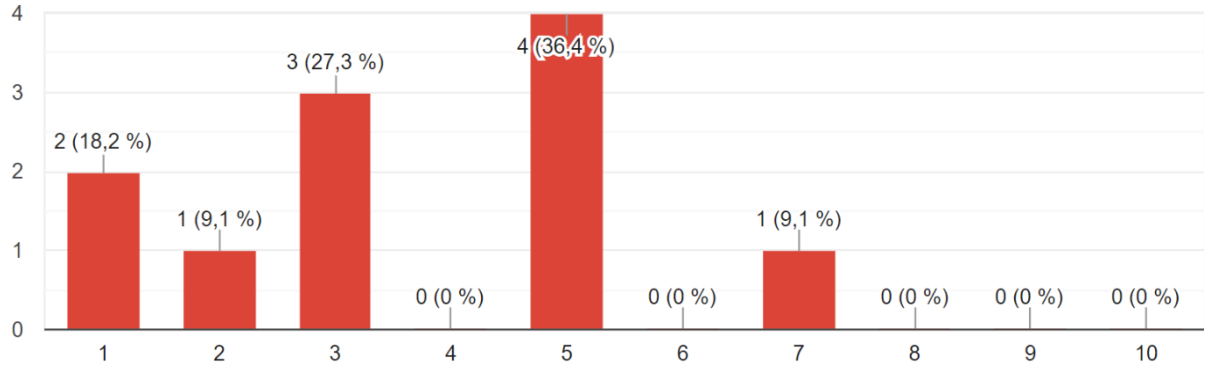
Do you currently think there is a need for more green areas such as parks, greeneries and green and green passages within Gothenburg? (or other cities if you do not live in Gothenburg)



If the perceived value of time will decrease through the implementation of autonomous vehicles, do you think that parks which are located within the city will become less or more attractive, compared to visiting green areas outside the city?



Autonomous vehicles are speculated to be safer than manual vehicles, as they react to dangerous situations faster, have even driving speed and a less unpredictable driving pattern. How likely do you think that this will increase speed limits on low speed roads?



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