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**Parking fees in Gothenburg: Effectiveness and Consistency with
Traffic Planning Goals**

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Abstract

In 2009 the city of Gothenburg adopted a new parking policy which, among other things, aims to reduce long term parking and encourage short term parking in urban areas. This thesis provides an analysis of parking fees in Gothenburg, where emphasis lies on the city center, using off street data from Parkeringsbolaget and on street data from Trafikkontoret. One of the main factors that affect parking accessibility is the parking price. Thus, the dynamics of the price elasticity of parking demand, the length of parking time, and the intensity of use, such as daily and seasonal variation, are studied to examine if the fees are in line with the policy objectives. The results show that the current parking fees are too low to reduce long term parkers and to encourage rotation. Hence, the parking policy should be modified if a significant change in parking demand is to be achieved.

Key words: parking policy, on and off street parking, parking fees and price elasticity.

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1. Introduction

Private vehicle travel has increasingly become an integrated part of everyday life and has offered a great improvement of personal mobility; we use the car to get to and from work, to shop and to drive our children to different activities. The rising car ownership, i.e. there are about 4.4 million private vehicles in Sweden, combined with the growing population in urban areas has created a greater demand for parking (Trafikanalys, 2012). However, this increased mobility should be put in relation to an array of negative consequences that car ownership has created.

Vehicles are a major source of pollution across the world, mainly in urbanized areas, where the vehicle density is the most extreme and where pollution in general is most grave (EPA report, 1998). The transport sector contributes to 23% of global CO₂ emission and almost three-quarters of these are caused by road transports (Hulme-Moir, 2010; Ribeiro and Kobayashi, 2007). Besides these issues, the transport sector imposes costs on the environment that are not covered by fuel taxes and other vehicle levies and the environment loses green spaces such as recreation areas to highways and parking lots in the city. In addition, the transport sector contributes to accidents and several negative impacts on e.g. public health (Hulme-Moir, 2010).

A study conducted among residents in Gothenburg in 2010 showed that almost half of the respondents used the car as their main mode of transport to and from work. The number of car trips can partly be explained by an increase of commuters from municipalities surrounding Gothenburg (Trafikkontoret, 2011). Parking problems have increased during peak hours in most parts of the city, resulting in both increased traffic and increased unauthorized parking. In addition, many parking spaces in the inner city are extensively used by people who either work or live there, which has led to a lack of short term parking (Parkeringspolicy Göteborgs stad, 2009).

Municipalities therefore have great potential to contribute to correct for the factors that currently impair the parking market's ability to function optimally, (Svensson and Rhedström, 2010). The municipality can through parking policies e.g. restrain traffic, control supply and the location of parking spaces. Well-designed parking policies can be an instrument to effectively control urban traffic and can, among other things, encourage change of transport, carpooling, lower emissions and discourage commuters from driving to work (Verhoef et al., 1995; Shoup 2005, Cost, 2005; Marsden, 2006).

In this regard, Gothenburg adopted a new parking policy in 2009 that aims to discourage car commuters and thereby reducing long term parking in urban areas. To achieve this objective parking fees on street in the city were increased from 20 to 25 SEK per hour and from 8 to 10 SEK per hour off street (Trafikkontoret, 2011). On street parking aims to provide short term parking, thus, these parking fees are in general much higher so that long term parkers are encouraged to use off street parking, which in turn is intended for those that park for a longer time but still high enough to prevent employees from blocking them (Adiv and Wang 1987; Litman, 2011).

With this in mind the purpose of this study is to evaluate the parking demand and the parking behavior in the city center. Possible changes in frequency can give an indication of a change in parking related traffic, whereas possible changes in parking time show a behavioral change (Clinch and Kelly, 2009). Therefore, the increases in parking fees give an indication of whether the policy aims are reachable.

1.2 Objective

This thesis aims to study parking demand, on and off street, in the city center of Gothenburg, as to location, amount and intensity of use. More precisely, the duration of parking and daily variation, e.g. comparisons among days of the week and among months of the year are studied. Additionally, a price analysis is conducted to compare data from three different high fee parking locations (on street) to a low fee parking location (off street) to see whether demand for parking is price elastic.

1.3 The research question

The main research question of the thesis is:

Are the current parking fees in line with the policy aim?

1.3.1 To answer the main question, the following sub questions are asked:

- Are there variations in parking demand through days and time?
- Are there variations in duration between on and off street parking?
- Is demand sensitive to parking fees?

1.4 Limitations

The data only gives a limited view of parking demand, since the variation in the parking fee is not large and the sample size is small. Moreover, since the idea is to study visitors parking demand, the focus is on the inner city as it seems as a natural place to study visitors demand

elasticity and parking behavior, which consequently means that parking outside the city center is excluded from the analysis. Additionally, the price variation is too small to develop a proper econometric analysis; therefore the analysis is based on simple statistics.

1.5 Outline of the study

The paper is organized as follows. The next section presents the literature review on parking demand. This section is followed by a background on parking policy in Gothenburg and parking fees in Gothenburg. Section 4 presents the methodology used for examining the influences on parking demand and parking behavior. The main findings are discussed in section 5. The final section presents the conclusions of the paper.

2. Literature review

Parking fees is one of the most common strategies to regulate parking in the city and refers to motorists paying directly for using parking facilities (Litman, 2011). According to the municipal law of fees (Avgiftslagen) a municipality may charge fees for parking to the extent necessary to organize traffic in public places that are under municipal administration [SFS 1957:259 2 §]. If parking is free, it leads to a situation where individuals park for a long time which reduces access for everyone else. Parking pricing can therefore provide accessibility by limiting the length of parking time, reduce traffic and influence mode shift (Ibid, 2011). With this in mind the main findings from the literature review on parking demand and parking behavior are presented and discussed.

The section begins with a review of studies that have looked at the effects of parking frequency and parking duration. Next, the effects of parking pricing on transportation mode are revised. Lastly, short reviews on seasonal and daily variation effects on parking demand are analyzed.

It is argued that parking has the characteristics of a private good, meaning that only one person can use the parking space at a given time and, therefore, market price should be applied to adjust the parking supply (Vickrey, 1954; Roth, 1965). Similarly, it is argued that parking should be priced, since parking spaces ought to be seen as “short-term rentals of land” (Shoup, 2003).

However, the difficulty is setting the correct price. If the price of parking is too high, many parking spaces will be underused and there is a waste of valuable resource e.g. land. Instead,

if the price is too low, individuals are encouraged to take the car, cruising for the most desirable parking spaces (Ibid, 2003). This, in turn, causes congestion traffic and air pollution. This externality occurs because motorists only consider their own travel time and do not consider the fact that they will increase the search cost for all other drivers trying to find a parking space (Hindrik and Myles, 2006).

The total cost associated with parking at any location is the parking price and the walking time to and from the final destination¹ (Shoup, 1999). If market prices were to assign parking spaces, the most desirable parking spaces should be allocated to those that park for short term, carpool, walk slowly and place a high value on reducing walking time (Ibid, 1999). Hence, if the parking fee is the highest where the parking demand is the largest, individuals will tradeoff between money and walking time. This allocation will clearly induce efficiency as the most convenient parking places would be used by those who value them highly (Ibid, 1999). Additionally, by pricing parking correctly and thereby eliminating cruising for parking, the full cost of a trip will be reduced without affecting the consumer surplus and in addition revenue will be generated for the government (Arnott and Inci, 2005).

With this in mind, there have been several studies that have examined how the introduction of parking charges affects parking demand. A summary of the results that will be described in this section can be found in Table 1. For instance, a study conducted in Oregon, United States, looked at the effect of street parking by non-residents. They used three parking zones in which residents could park unlimited whereas non-residents (commuters, students etc.) were restricted to a two hours limit. In two of the three zones non-residents could buy a daily or a monthly permit in order to park unlimited, at a cost of between US\$10 to US\$17.50 per month, and US\$1.50 per day. The results showed that parking duration in all three zones were reduced by 30%, 39% and 36%, respectively and frequency went down by 50%, 33% and 22% respectively, due to the combination of time restriction and the increased parking fees (TCRP report, 95).

Similarly, Clinch and Kelly (2009) used the revealed preference method (RPM) to evaluate trends from parking meters ex ante and ex post of a parking fee increase from £1.27 to £1.90 per hour, in Dublin, to estimate the short run parking price elasticity of demand. The results showed a drop of average parking duration of 16.5% and an aggregate 4.18% drop in

¹ “The value of time is the price you are willing to pay to reduce the time spent walking between your parking space and your final destination. It will depend on whether you are in a hurry, how tired you are, packages you are carrying, the weather, and many other circumstances that can vary greatly from trip to trip” (Shoup, 1999).

frequency. Although, these papers provide evidence that parking pricing has effects on parking duration, Niskanen and Glazer (1991) argue that parking pricing can allow more turnovers than intended and thereby increasing the amount of traffic. On the other hand, parking pricing has been argued to have effects by reducing the number of short trips, which represents a high share of total trip cost (EPA report, 1998).

Furthermore, Shoup (1999) argues that market price forces individuals to alter their behavior and economize their costs e.g. carpool in order to reduce their individual cost or use other transport modes. This will also reduce the demand for parking. Market prices induces those who want to park for a longer time to use the cheaper and underused peripheral spaces and those who want to park for a short time to use the higher priced central spaces. Therefore, it is recommended that parking fees should have higher rates during peak periods and lower rates during off-peak period, thereby discouraging commuter parking and long term parking and improving overall utilization, (Shoup, 1999; Shoup, 2005).

For example, a study conducted in Haifa, Israel, used Stated Preference Method (SPM) to contrast the potential effect of parking tolls and congestion tolls (Albert et al., 2006). They used four different fees 2, 4, 8 and 10 New Israeli Shekels (NIS), where the cost of public transport was 4 NIS. The results showed that the introduction of parking fees would lead to 29% of the drivers shifting to public transport in order to avoid the fee. Moreover, another study conducted in Portland, United States, by Hess (2001), who used a multinomial logit model to evaluate and interpret daily commuting behavior. The model predicted that free parking, among other things, would lead to 22% using public transport but, after introducing a daily parking charge of US\$6.46, 50% of the commuters would use public transport.

Additionally, although few researchers have studied seasonal and daily variation in parking demand those that have, found that most parking lots and garages, in Connecticut, United States, have their peak during pre-Christmas shopping. The cycle for the daily variation shows a low demand on Sundays, high demand on Saturdays and a constant level on weekdays (Ricker, 1948) and that parking density is overall greater in the spring and fall months in New York (Roth, 2004). As mentioned above, Table 1 shows different studies that have examined parking demand and parking behavior. In order to make the parking fees and the fees of public transport comparable they were converted into Swedish Kronor. We can see that in general the fees in United States are much lower than the fees in European countries. Further, it can be seen from the table that the parking fees in Hong Kong are the highest; the high fee

in combination with a low charge on public transport has led to a decrease in car dependency. Whereas in United States, where 99% of all parking is free and those parking spaces that are chargeable have very low prices, has not discouraged extensive car use².

Additionally, a comparison between Gothenburg and Stockholm shows a very large difference in parking fees; the lower parking fee in Gothenburg in combination with a low frequency of bus and tram services and low comfort has resulted in longer parking time and a higher parking demand (Glans and Eliasson, 2011). Thus, for example in Stockholm the higher parking fees, (the highest parking fee is 39% higher than the highest fee in Gothenburg) in combination with better public transport has decreased parking demand (Personal interview, Jonas Nilsson). For example, in Gothenburg 25% of all journeys are made by public transport whereas in Stockholm it is approximately 40% (Göteborg Stad, 2012).

Study	Parking Fees	Income per capita	Fee of public transport	Effects on duration	Effects on transport use	Effects on frequency
Washington, Frank et al (2011)	2 to 8SEK	47153	15 SEK and 17SEK	11.52 % Reduction in VMT		
Dublin, Clinch and Kelly (2009)	14 to 21 SEK	50034	24SEK	16.5% drop in duration		4.5% drop in frequency
Oregon, TCRP report 95 (2005)	67 - 118 SEK/month or 10 SEK/day.	42569	No information	30%, 39% and 36%		50%, 33% and 22%
Gothenburg, SWECO (2008)	4 to 6 SEK	52731	20SEK	No effect on duration		No effect on frequency
Copenhagen, Transportrådet (2002)	8,14 and 24 SEK	32344	24SEK	Average duration 1h 21min, 2h, 2h 45min, respectively		
Stockholm	15, 26 and 41 SEK	48897	36 SEK			
Haifa, Albert et al (2006)	4, 7, 14 and 18 SEK	20676	7 SEK		29% switch to public transport	
Portland, Hess (2001)	43 SEK/day	35912	12 SEK		50% use transit	
Washington, Everett et al (1982)	Between 67-219 SEK	13933	No information		Overall increase in transit	
Hong Kong, Cullinane (2003)	Between 26-87 SEK	23559	Between 2-10SEK			Drop in car dependency

Table 1 shows a summary of the results from different studies.

² This part of the global transportation policy in United States, where the political parties gain a lot of popularity from opposing fuel taxes. In combination with absence of alternative travel substitute together with an uneven income distribution it makes fuel taxation particularly sensitive for low income groups (Sternier and Coria 2012).

3. Parking policy in Gothenburg

This section presents a review of the parking policy in Gothenburg and background information about the current parking situation.

3.1 Parking policy in Gothenburg

As of 2009 Gothenburg adopted a new parking policy, which was developed on behalf of the Planning committee and Traffic committee, in conjunction with the parking company Real Estate and Environment Department. The essential feature of the policy is to maintain the current number of parking spaces, but to redistribute them to make space for new public transportation, improved bicycle paths, bicycle parking and to reward carpooling through better parking terms. Moreover, increasing parking fees and limiting parking time may be used to lead parking behavior in to a more sustainable direction (Parkeringspolicy Göteborgs Stad, 2009).

Currently, parking spaces take a large amount of space in the city, both visually and physically and in order to enhance the city's attractiveness and create opportunities for recreation in the inner city, the usage of land must be used more effectively. Furthermore, in order for the city to grow in a sustainable manner the municipality argues that a certain proportion of on-street parking in the city needs to be replaced (e.g. shared facilities, preferably underground ones) to expand the public transportation i.e. set new tram-lines and bus-lines (Ibid, 2009). Further, it is argued that the mobility that the cars offer must be replaced by some other accessibility e.g. bicycle paths (Ibid, 2009).

The main problems now emerging from the parking situation are that many parking spaces in the inner city are extensively used by people who either work or live there, which has led to a lack of short term parking. Thus, the policy aims for a change from long term parking in urban areas to short term (e.g. visit an event) parking in urban areas and half day parking (e.g. for longer visits, issues such as commerce and services). This means that workplace parking on street will be replaced by parking for residents, commerce and services. In other words, the policy aims to encourage city employees to change to other transportation services and to deter commuters from taking parking places intended for visitors and consumers (Ibid, 2009). Furthermore, it is argued that residents' parking should be available, so that residents are not forced to take the car to work and thereby avoiding parking fees. In areas where residents' parking is available the municipality wants to move the cars from the street to adequate

parking facilities that can meet the demand on daily parking for residents. This also provides parking space for short term and half day parking, as well as making way for new public transport and bicycle paths (Ibid, 2009).

3.2 Parking in Gothenburg

Currently there are approximately 158, 000 parking spaces in Gothenburg which the municipality is responsible for. The municipal parking is divided between two different owners; Trafikkontoret who is responsible for on street parking and Parkeringsbolaget who is responsible for off street parking (Göteborgs Stad, 2012). Trafikkontoret manages approximately 11,000 chargeable parking spaces and 15,000 time regulated parking spaces. Parkeringsbolaget on the other hand is in charge of 132,000 parking spaces off street (Ibid, 2012).

Trafikkontoret has over the past years gradually increased the parking fees, particularly in the inner city, in order to provide accessibility. For instance, in February 2010 the City Council decided to increase the parking fees and table 5 in the appendix shows the different parking fees during different times of the day³. On street parking is mainly conceived for short term parking and the fee is generally more expensive e.g. 20 and 25 SEK per hour. During nights and Sundays i.e. off peak hours, the on street parking fee is either 1 or 2 SEK per hour (Trafikkontoret, 2011). There are also special parking permits, such as residents parking which cost, depending on the area, between SEK 190-630 per month (Ibid, 2011).

After the increase from 20 to 25 SEK, Trafikkontoret conducted a before and after study in the city center. Before the increase, 90% of the paying vehicles in the inner city parked for more than an hour and between 40-70% parked for more than two hours. For example, in Grönsakstorget and Kungstorget it was found that 25-40% park more than five hours. The after study showed that the increase in parking fee reduced the number of cars that parked for more than 2 hours from 33 % to 28% i.e. a marginal change in parking time (Ibid. 2011).

³Note that the full range of parking fee values is not observed in the sample used to analyze the price elasticity, mainly because this study focuses on the city center, where parking fees are the highest, thus in the sample 1,5,15 and 20 SEK per hour are not used.

4. Method

This section describes the quantitative method employed in this paper. Raw data on parking frequency and duration was provided by Trafikkontoret and Parkingsbolaget in order to elicit the necessary information.

This thesis uses actual parking data in order to answer the thesis question. From this raw data a lot of transformations and calculations had to be done in order to create variables in Excel and STATA. Trafikkontoret provided data from five different machines from three different locations in Gothenburg; Avenyn, Kungstorget and Pustervik, i.e. there are 15 machines in total. This data of 470,986 observations contained information on each individual's parking transaction that took place over the whole year of 2011, the parking fee is either 2 (off peak hours) or 25 SEK per hour. Whereas, Parkeringsbolaget has provided data from six different machines at Heden, from the 17th to the 23rd for February, May, August and November in 2011. The parking price in February, May and August was either 2 or 8 SEK per hour. In November the parking fee was increased from 8 to 10 SEK per hour. These four months represent the four different seasons, this data contains 51,259 observations.

The raw data provided by the Trafikkontoret and Parkeringsbolaget required intensive transformation to provide detailed information on different types of parking demand, such as the duration, seasonal and daily variation. The changes in frequency give an indication of change in parking related traffic, whereas changes in parking time show a behavioral change. Moreover, given this data an approximation construction of the price elasticity of demand for parking in the city center is calculated.

The parking areas analyzed present different conditions such as degrees of accessibility, frequency and duration. The difference between short term and long term parking is not a clear cut one. In this paper, however, parking over four hours is considered long term parking and parking less than two hours is considered short term parking.

5. Empirical Analysis

The following sections show the results from the analysis of on street and off street parking data on parking demand and parking behavior.

Parking demand refers to the quantity of parking that would be used at a certain time, place and price and it is an important issue when trying to assess what impairs and enables the parking market. The demand is affected by parking length, the quality of other modes and location (Victoria Transport Policy Institute, 2011). The first aspect of the parking demand analyzed is the seasonal, which is examined to see whether the demand-supply equilibrium changes over the year, such as during pre-Christmas times. This is followed by the daily variations throughout the year. Next, the parking duration in the city center is examined and lastly the time interval is studied to analyze during which hours the driver's park most frequently. The outline of the second section is the same as the previous section although instead results from off street data are provided.

The analysis is separated in on and off street parking because the locations differ in frequency, parking fees and have different aims. The on street parking aims to provide short term parking, whereas the off street parking fees are lower and intended for those that park for a longer time. The third and last section combines the on street and off street data to evaluate the price elasticity.

5.1 Results and Analysis

Data from Trafikkontoret and Parkeringsbolaget are used to study the parking demand and parking behavior. The result contains data from on street and off street from four different locations in the city center. The data from, Avenyn, Kungstorget and Pustervik represents on street parking and the data from Heden represents off street parking. Four different parking fees are used in this paper 2, 8, 10 and 25 SEK per hour, where 2 SEK is the off peak fee applied in all four parking sites. Parking meter results are displayed below in a variety of graphs.

5.2 On street

The outline of this section begins with the results from the seasonal variation, this is followed by the daily variations. Next, the results on parking duration are examined. The section ends with a presentation of the results from the time interval.

5.2.1 Seasonal variation

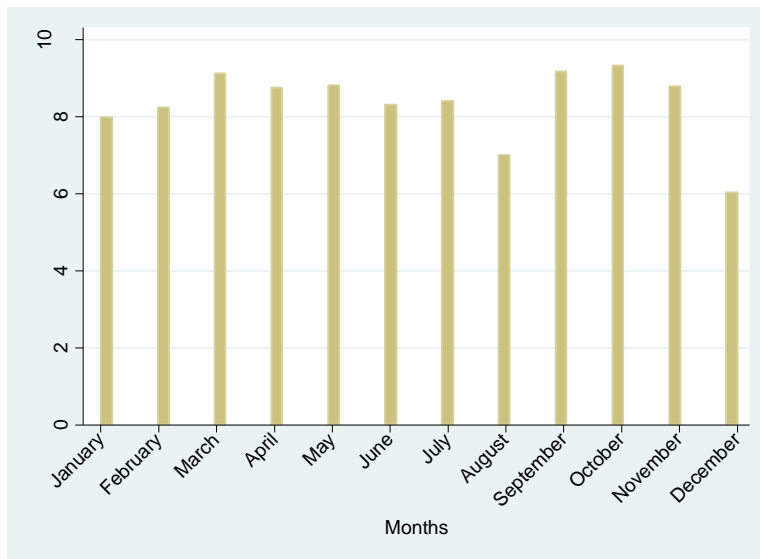


Figure 1. Seasonal variation in frequency of cars parked.

Figure 1 illustrates seasonal variations by months and gives an indication of visitors parking demand for e.g. leisure activities and shopping. The results are based on the records of the three on street parking sites which principally serve short term parkers. We can see that the parking demand varies considerably by time of the year. The results show that the parking density has seasonal variation which is greater in spring, where it peaks, and autumn months. These results are in line with those found in the literature (see Roth 1948).

Moreover, based on statistical tests when comparing the use of parking across paired seasons showed that they are significantly different, i.e., there are fewer cars parked in winter than in autumn and spring respectively, at a 5% significance level. The same test was conducted for summer, which showed that summer was significantly different from autumn and spring respectively, i.e. there are less cars parked in summer than in autumn and spring respectively, at a 5% significance level. Hence, there are fewer cars parked both in summer and winter compared to autumn and spring.

It can be perceived that drivers alter their behavior during the different seasons. One can argue that people use alternative modes during winter and summer; which can be partly explained by weather circumstances; perhaps people switch to cycling and walking during the summer and use the public transport more during winters. Additionally, it is surprising that the lowest numbers of cars are parked during December, since other studies have found that most of the cars are parked during pre- Christmas shopping (see Ricker 1948). Another issue besides the weather could be that many offices are closed during Christmas times, which can

explain why the overall demand is less during this period. Moreover, the results for the seasonal variation with respect to duration, shows no variation in mean hours parked (see figure 15 in the appendix). The parking duration is about 2.6 hours throughout the year. Indicating that on average the motorists parking in the city center are half day parkers, i.e. they park between 2 and 4 hours.

5.2.2 Weekdays and weekends

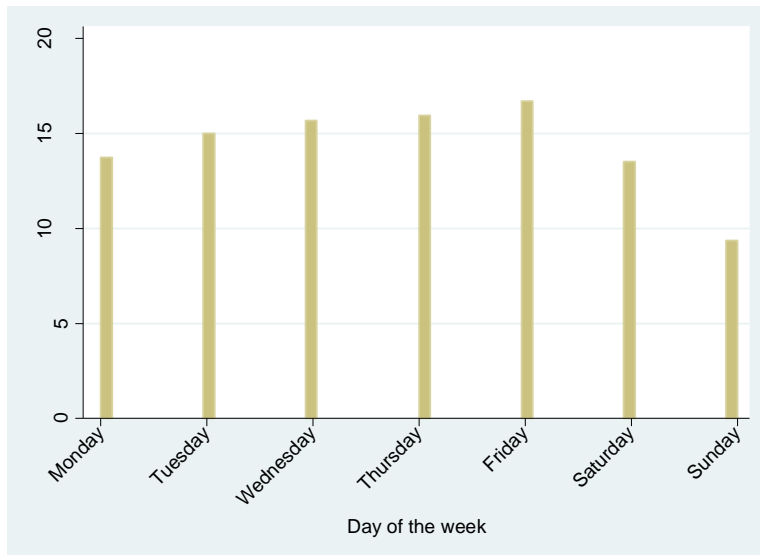


Figure 2. Daily variations in frequency of cars parked.

Figure 2 shows the frequency of cars parked and how it varies depending on the day of the week. The frequency of parked cars increases as the week goes and peaks on Friday. Indeed, the statistical test showed that Fridays are significantly different from Saturdays and Mondays are significantly different from all other days except for Saturdays, at a 5% significance level. This means that for instance, there are more parked cars during Fridays than on any other day of the week, and that there are less cars parked on Monday than any other weekday, at a 5% significance level.

Furthermore, the demand for on street parking is lower on weekends than on any other day during the week, which is an interesting finding as we are analyzing visitors, whose theoretical purpose is e.g. leisure activities and shopping. An explanation for the lower frequency on weekends could be that individuals choose to shop outside the city center during the weekends, where the parking is free. Another reason could be that individuals do their errands during the weekdays as they are already in the city center and spend their weekends outside the city center.

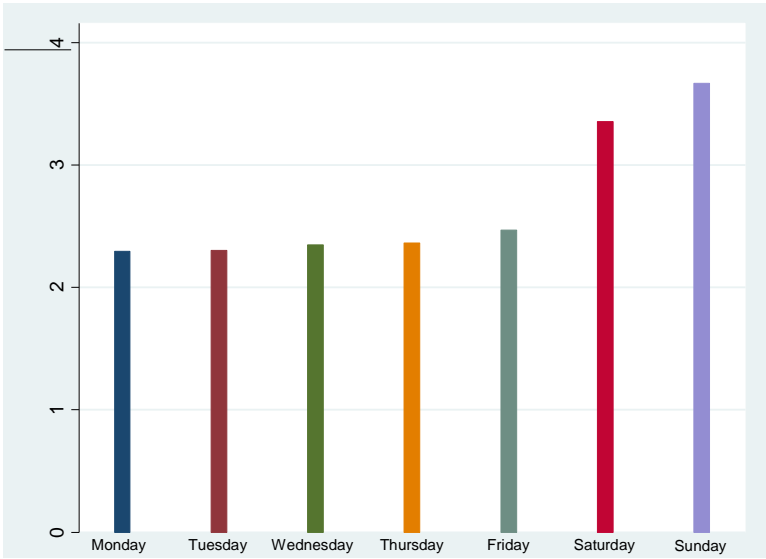


Figure 3. Daily variations in mean hours parked.

Figure 3 shows how the parking duration varies during the week, we can see that the parking duration remains almost constant from Monday to Friday but then shows a vast increase during the weekend. Although, the frequency of cars is lower on weekends, the length of parking is on average longer. Thus, those that take the car to the inner city stay for a longer time. The results deviate from earlier literature (see Ricker 1948) perhaps those motorists that chose to park on street during weekends value to park as close as possible to the destination goal over cheaper parking. However, the off street data shows otherwise, parking demand peaks on Saturdays which could be because a fraction of the weekend parkers are more price sensitive and park for a longer time and therefore use cheaper off street parking.

5.2.3 Parking duration

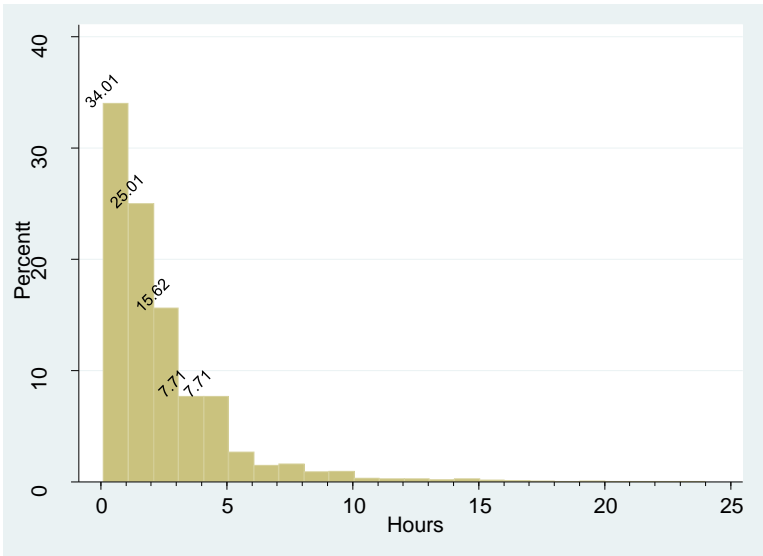


Figure 4. Distribution of parking duration.

Figure 4 illustrates the on street parking duration for the three locations. The results show that 60% of the cars are parked for 2 hours or less and that 23.3% are half day parkers (2-4 hours). This consequently means that 16.7% of the parked vehicles are parked for 4 hours or more. The high frequency of long term parkers strongly suggests that the users of the parking locations are not very sensitive to price as there are off street parking available nearby the parking locations; it is clear that the visitors prefer closeness to the destination regardless of the price of parking.

Thus, this evidence seems to indicate that the most desirable parking spaces are not being allocated to those that they are intended for, i.e. short term parkers. Notably, the price signal to the driver to alter behavior is disregarded and possibly causing a situation where motorists cruise in order to find the most convenient parking spaces. In addition, it seems that the parking fees in Gothenburg do not create neither a substitution nor an income effect on drivers, in comparison to the e.g. parking fees in Stockholm. However, a possible increase in parking fees could lead to an increase in unauthorized parking, thereby reducing circulation and thus leading to even bigger shortage of short term parking. Therefore, to ensure that the parking fees have the desired effect, i.e. providing turnovers, the possible increase in parking fees may have to be compensated by for example an increase in enforcement and fines. Thus, by monitoring the violations more closely this could pay off in terms of increase in capacity, i.e more short term parking spaces.

Although there are a lot of long term parkers, the amount of motorists that are parked during working hours (e.g. 07:00-17:30), is only 1.35%, indicating that employees are price sensitive and discouraged from parking on street. However, the low number of employee parking could be due to employees being offered parking spaces at the working site for free or at more convenient cost, but this cannot be seen in the data. For example, studies have found that 90% of all workers in Sweden have access to free or cheap parking close to the workplace (Svensson and Hedström, 2010).

Further, my results show (see figure 16 in the appendix) that about 17% of the drivers at Kungstorget, which is a very desirable parking place in the city center due to its closeness to e.g. commerce, park for more than five hours. These results are lower than the previous study conducted by Trafikkontoret, which found that 25-40% park for more than five hours. This could possibly be explained by the size of the sample or a delayed reaction to the higher parking fees.

Variable	Observations	No Parking spaces	Mean Hours parked
Pustervik	98105	193	2.34
Avenyn	32854	121	2.28
Kungstorget	340027	379	3.73

Table 2 shows the frequency of cars, number of parking spaces and mean hours parked at Pustervik, Avenyn and Kungstorget.

Table 2 illustrates the frequency of parking between the three locations in the sample. We can see that parking frequency is the highest at Kungstorget; 72% of the 470,986 drivers park there and Avenyn is the area with the lowest frequency of parked cars where only 7% park. This could probably be explained by the fact that there are more parking spaces at Kungstorget. However, there is also a difference in parking duration, the cars park on average for a longer time on Kungstorget than in any of the other two locations. The longer parking duration at Kungstorget than at Pustervik could possibly be explained by the closeness to e.g. more commerce and leisure activities. The low amount of parking on Avenyn can perhaps be due to the longer peak hour parking pricing lasting until 22:00, instead, the other locations have peak parking until 18:00. It could also be because off street parking is located nearby and it is possible that people chose the peripheral cheaper parking as the difference in distance is trivial.

5.2.4 Time interval

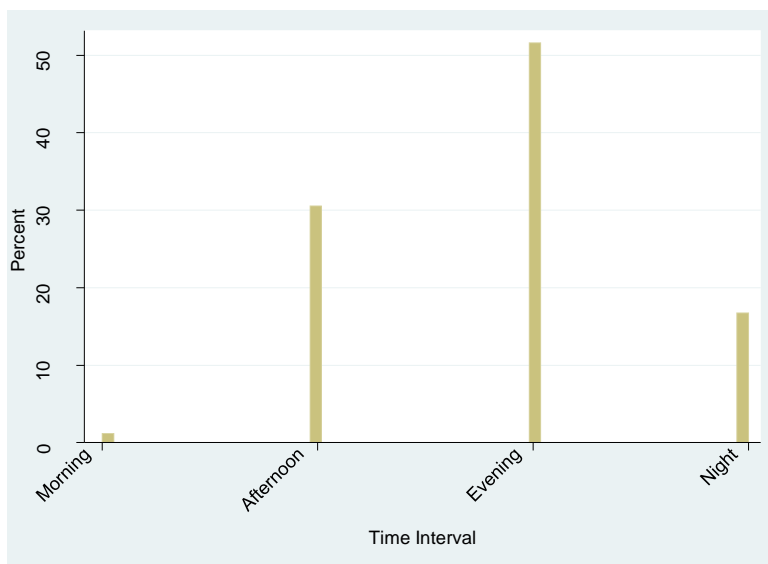


Figure 5. The frequency of different time intervals.

Figure 5 shows the frequency of cars that are parked during four different time intervals, which I have decided to call morning, afternoon, evening and night. The first column shows the cars that start to park between 00:00-05:59, the second those that begin parking between

06:00-11:59, the third 12:00-17:59 and the fourth those that begin parking between 18:00-23:59. The effects of duration on start time choice shows that the peak accumulation occurs for those cars that begin parking in the evening (12-17:59), they make up more than 50% of the observations. Additionally, more than 80% of the cars start to park between 06:00 and 17:59 and only about 2% start to park in the night. Moreover, the statistical test showed that the time intervals are all significantly different from each other at a 5% significance level. This means for example, that the numbers of cars that begin parking in the afternoon are significantly more than those parked during the night, at a 5% significance level.

Hence, most of the cars are parked during peak hours, which show that there is an issue of first come first served, meaning that parking spaces favors those motorists who arrive early, and this leads to a situation where the most preferable parking spaces are filled first and later arrivers are forced to park further from their desired destination (Arnott and Rowse, 1999). Consequently, parking places intended for visitors and consumers are not accessible. Although there is a big difference in the start time of parking there is no difference in parking duration, on average the cars are parked for 2.6 hours.

5.3. Off street

The outline of this section is the same as the previous section although instead results from off street data are provided, as such, the section begins with the results on seasonal variation, followed by daily variation, parking duration and time interval.

5.3.1 Seasonal variation

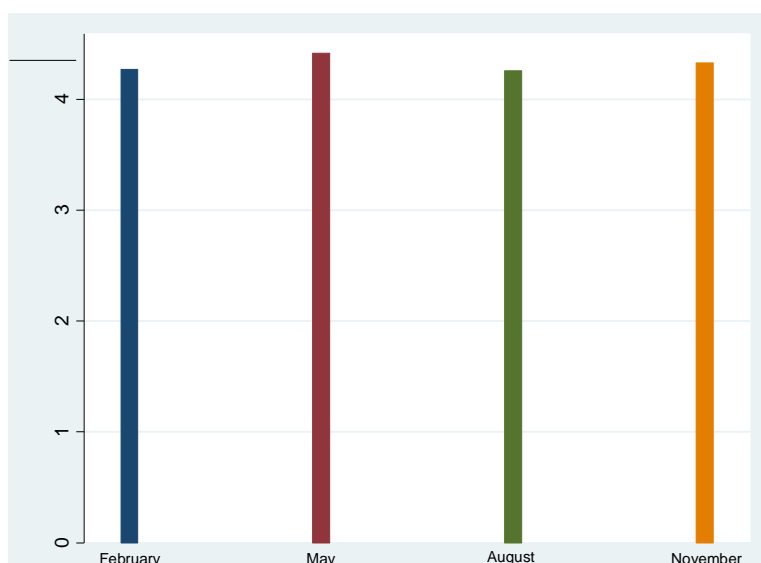


Figure 6. Mean hours parked during four different months.

Figure 6 illustrates how the duration of parking varies during the four different seasons. The graph shows no seasonal variations in the length of parking; it seems that on average the cars are parked for slightly more than 4 hours. This indicates that the motorists that park on Heden are on average long term parkers i.e. that they park for more than 4 hours, throughout the year. Although, there is no seasonal variation in the duration of parking, Table 6 in the appendix shows a slight indication of seasonal variation in terms of frequency; the frequency is marginally greater in the spring and autumn months. Thus, the results are similar to those found on the on street data and the literature (see Ricker, 1948).

5.3.2 Weekday and weekend

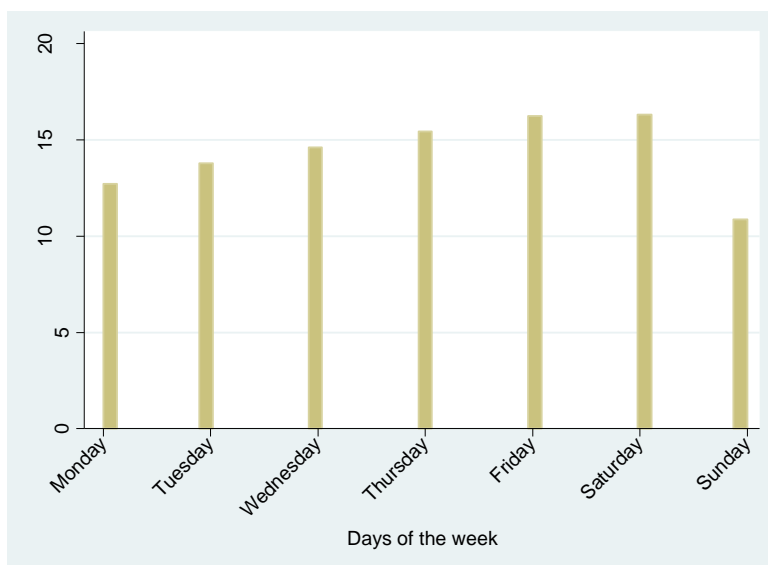


Figure 7. Daily variations in frequency of cars parked.

Figure 7 shows the weekly pattern over a period of four different months, during the year 2011. The weekly cycle follows a general pattern of low Sundays and high Fridays and Saturdays, and an increasing frequency level as the week goes by. This daily variation seems to be somewhat consistent with that observed for on street parking, but more in line with the earlier studies conducted on daily variation on parking demand (see Ricker 1948). To verify, statistical tests were conducted which showed that Sundays are significantly different from all other days, at a 5% significance level and Fridays are not significantly different from Saturdays, at a 5% significance level. Thus, there are for example fewer cars parked on Sundays than on any other day of the week at a 5% significance level. The high parking demand during Fridays and Saturdays could be explained by different activities having different peaks of demand and as such people do more after work activities such as visit the theater, restaurants or the movies on Friday and Saturdays. However, this is not statistically significant at a 5% significance level.

Moreover, in comparison to the on street data, the demand and the duration is much higher on off street data on Saturdays, this could be because motorists know that they are going to park for a longer time and therefore use the cheaper and peripheral parking spaces. Thus, it could be considered that weekend parkers are more price sensitive and prefer to pay the lower fee and park for a longer time. Additionally, it could be argued that the higher parking fees on the on street affects the driver’s decision, therefore when choosing parking space on Saturdays motorists prefer saving money over saving walking time. It seems that Saturday parkers respond to their price sensitivity by altering their behavior accordingly. This also induces efficiency as the most convenient parking places are used by those who value them highly, and parking type plays a significant role in duration.

5.3.3. Parking duration

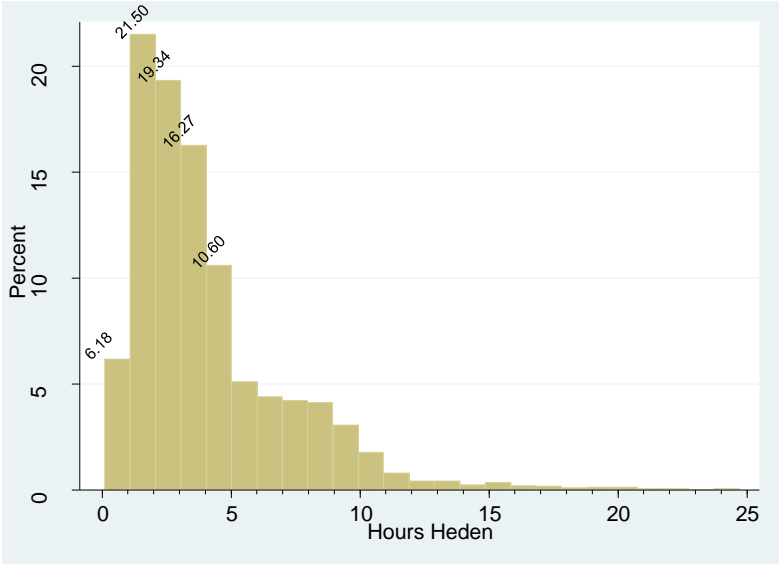


Figure 8. Distribution of parking duration.

Figure 8 illustrates the variation of duration for the off street data. From the figure it can be found that more than 36.7% of the parkers on Heden are long term parkers, which also means that the parking turnovers are low. Although, it is expected that off street parking will experience more long term parkers, due to the lower parking fees, the situation at Heden limits access for consumers and visitors. In addition, the low prices at Heden will remain cheap and only a 10% increase in price annually is expected (personal interview, Jonas Nilsson). Further, the longer parking duration on Heden can also be due to the shortage in residents parking in some areas, which forces some individuals to take the car to work in order to avoid the possibly higher parking fee in their neighborhoods. But, the municipality is aware of this and is planning to build adequate parking facilities that can meet the demand on daily parking for residents.

Furthermore, besides causing an overgrazing of resource space, the underpriced parking likely leads to congestion traffic, accidents and increases in trip costs (Shoup, 2003). Hence, the drivers do not have to economize in order to reduce their costs, which give little incentive to motorists to use parking facilities efficiently, or shifting to alternative modes. However, comparing these results to those of the on street results shows that parking duration decreases with the parking fee, hence, the results are in line with earlier studies (see for instance, Transportrådet, 2002).

5.3.4 Time interval

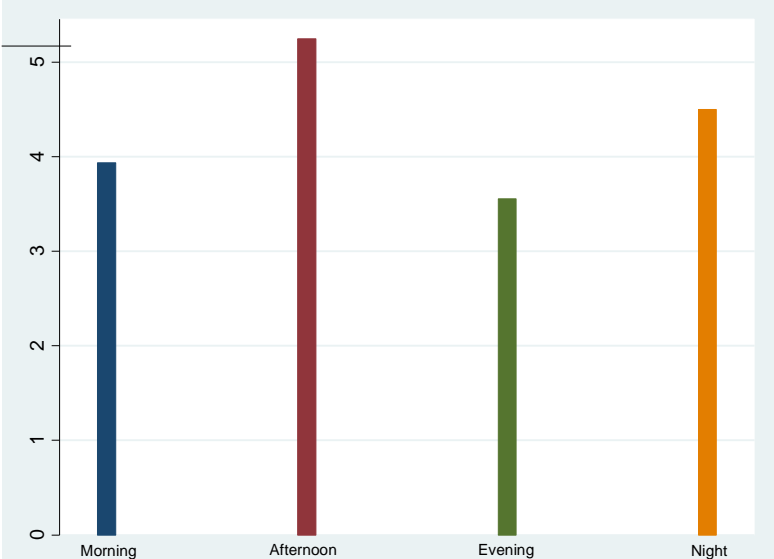


Figure 9. Mean hours for the four different time intervals, for the four different months combined.

Finally, figure 9 shows the average hours of parking duration for the different time intervals for the four months combined in 2011. We can see that those that start to park in the afternoon (06:00-11:59) park for more than five hours, meaning that the peak hour fee is not high enough to discourage drivers. In addition, although those that park during the other three time intervals park for a shorter time on average, they still park for almost four hours. These results indicate that those that park on Heden are on average long term parkers. Moreover, the statistical test showed that the time intervals are all significantly different from each other at a 5% significance level. This means for example, that the numbers of cars that begin parking in the afternoon are significantly more than those parked during the morning, at a 5% significance level.

Furthermore, the frequency of the time intervals during (see figure 17 in the appendix) the four different seasons shows that the peak frequency occurs for those that begin parking in the evening (12-17:59), they represent more than 40% of the observations. Additionally, more

than 70% of the cars start to park between 06:00 and 17:59. The high amount of parkers and the length of parking on Heden during the night (18:00-23:59) could imply parking demand for leisure time (e.g. cinema visits, football) parking. Thus, the results are similar to those of the on street data, indicating that most cars are parked during peak hours, and hence, the peak hour fees seem to be too low to discourage long term parkers.

5.4 Price analysis

This section presents a price analysis of on and off street data; four different parking fees are examined 2, 8, 10 and 25 SEK. 2kr⁴/h is the off peak parking fee at the different locations and 2, 8, 10 and 25 SEK are the peak hour fee.

5.4.1 Difference in parking demand between on and off street

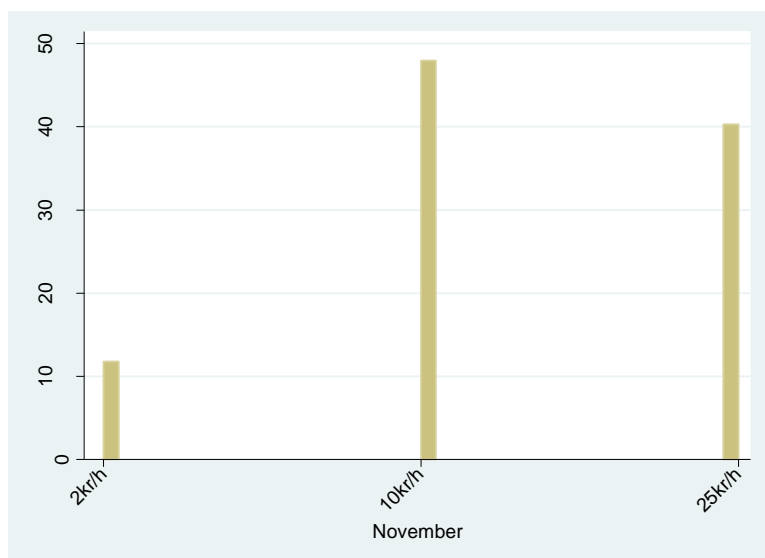


Figure 10. Mean hours for November 2011.

Figure 10 illustrates how the frequency varies between the three different parking fees in November 2011. The distribution shows a low demand during the off peak hours (2kr/h) and a high demand during the peak hours (10kr/h and 25kr/h). In November there was an increase in the parking fee at Heden from 8kr/h to 10kr/h. Although the amount of data is less in November we can see that the demand is slightly lower after the increased parking fee, when comparing with before the increase (see figure 18 in the appendix)⁵. Hence, there is a minor effect of the increase in parking fee.

⁴ Kr is an abbreviation for SEK.

⁵ The figure in the appendix is for February, but the results are very similar for May and August.

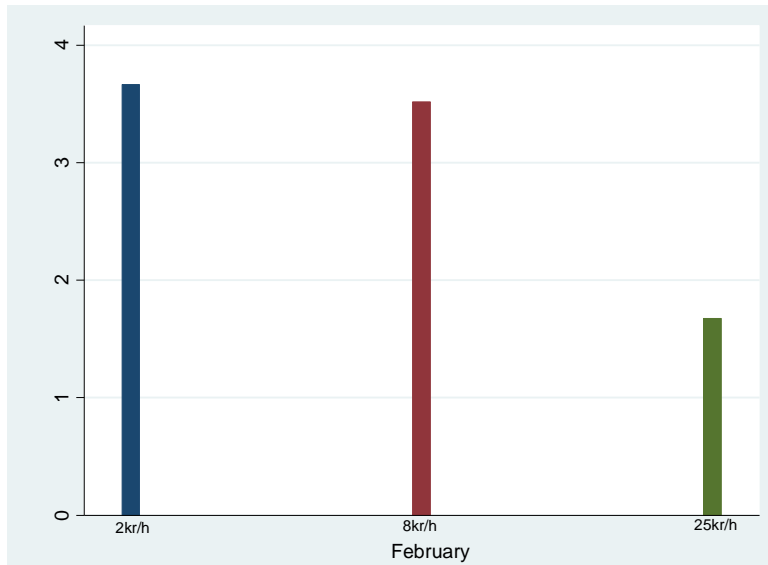


Figure 11 mean hours parked in February if you pay 2, 8 or 25kr/h.

Figure 11 shows how the duration varies for the three different parking fees in February. We can see that drivers are price sensitive between on and off street. The length of parking is shorter for those that park on street. It can also be found that drivers are not price sensitive between 2kr/h and 8kr/h but this is not giving the true picture as very few individuals park during the off peak hours. But still it can be argued that in general the duration is the same. However, in November there is larger difference in duration between those that park for 2kr/h and those that park for 10kr/h (see figure 19 in the appendix).

5.4.2 Price elasticity

Kr February	Frequency	Percent
8	9,427	58.55
25	6,675	41.45
Total	16,102	100.00

Table 3 shows the frequency and percent of cars parked that have paid either 8 or 25 SEK per hour, in February.

From table 3 the price elasticity can be calculated and we can examine how parking demand changes in response to the change in parking price. The parking price elasticity is calculated using the equivalent on street and off street peak hour prices. The estimated parking price elasticity is found to be -0.19, i.e. a 10% increase in parking price reduces parking demand in the city center by 1.9%. The price elasticity is in line with what Litman (2011) argues should be used as a benchmark (-0.2) for visitors parking in the medium and large cities. However, it should be clarified that due to the nature of the data this is just an approximation assuming a linear demand curve, with a point estimate using two values, keeping everything else

constant. Ideally, the price elasticity is calculated using a before and after study of an increase in parking fee at the same location, however this calculation is based on two different parking fees from two different parking places. Therefore, the results could be an overestimation, as Heden is assumed to be a substitute to the on street parking; however, drivers do not necessarily have to perceive it in this way. Thus, the price elasticity should be used with caution and is most likely an overestimation, since Heden is not a perfect substitute.

6. Conclusion

In 2009 Gothenburg adopted a new parking policy which, among other things, aims to change the structure of the parking charges faced by motorists and thereby reducing long term parking and encouraging short term parking in urban areas. The intention is to improve the parking situation and encourage drivers to alter their behavior by e.g. reducing the number of long term parkers, changing parking location, reducing car trips. In an effort to identify the parking choice and parking demand, this thesis analyzed parking fees in Gothenburg, where emphasis lies on the city center as it is a natural place to study visitors parking behavior.

The results showed that there are seasonal variations on street and daily variations on both on and off street for parking demand. The parking demand is highest during spring and autumn months. The daily variations showed an increase in parking demand as the week goes and peaks on Fridays for on street and on Saturday for off street. It can be concluded that the activities that people do on Fridays and Saturdays such as cinema visits, restaurant visits and shopping have different frequency peaks in demand than weekday activities.

From the analysis, as well as earlier studies developed for other cities, it can be concluded that the parking fees are too low to reduce the number of long term parkers and to encourage rotation. The parking fees do not create incentives to the individual to alter behavior; drivers are not being attracted from their cars. Although they are put in a situation where they have to choose between more convenient and costly parking (on street) or a cheaper parking and a further distance away from the location (off street), the fees are too low to have the effect of the policy. The motorists face the choice of either parking for 25kr/h or 10kr/h and according to theory, long term parkers should choose to park for 10kr/h i.e. off street; however, the motorists do not seem very sensitive to this price difference. However, the difference in the price between on and off street showed that the higher the parking fee per hour, the shorter each motorist's parking duration. Thus, the effects of parking pricing point that, motorists are

encouraged to more restricted parking and reduced parking time and impacts on parking location when the fee is higher. Hence, it is evident that parking pricing can be an influencing policy tool to discourage long term parkers. However, the on street parking fees are not affecting the demand for off street parking in the manner the policy aims to.

The choice of parking is based on the parking options available, which in turn may influence decisions such as duration and choice of transport mode. For instance, for an average, long term parker on Heden, the monthly cost of parking, only working days considered, would be about 1700 SEK per month only on parking fees. If this commuter lives outside the municipality's border, public transport would cost him 840, 1085 or 1365 SEK per month depending on how far outside the municipality he lives. It can be argued that due to the high number of long term parkers on Heden, taking the car is still a very good option as public transportation cannot compete with e.g. the convenience and reliability that a car provides, thus, motorists are not attracted from their car.

Moreover, since, the low prices at Heden will remain cheap the low parking price at Heden has limited possibilities to influence drivers to switch to public transportation. However, this could be because Parkeringsbolaget does not aim for profit but in the case of profit it is used to develop Gothenburg, for example they are planning to build an underground parking facility at Heden. With this in mind, Trafikkontoret is also aiming to increase the parking fees in a few places in the inner city to 40kr/h. In addition, they are planning on increasing the number of time restrictions, in order to express that it is not profit they are aiming for but to grant accessibility i.e. more short term parking spaces. However, this could lead to an increase in unauthorized parking and thereby leading to even larger shortage of short term parking. Therefore, to ensure that the parking fees have the desired effect, i.e. providing turnovers, the possible increase in parking fees may have to be compensated by for example an increase in enforcement and fines. This is perhaps a matter for further research.

Currently there is no balance between the parking policy and the parking fee. The low parking fees are limiting the effectiveness of parking demand as a policy tool, and thereby encouraging drivers to maintain their existing supply of long term parking and parking behavior. The results of the thesis shows that there are good opportunities to improve the parking market in Gothenburg, i.e. reduce long term parking and for this to be achieved the parking policy should be modified.

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8. Appendix

Taxa	Fee (including VAT)
A	12 kr/30 min 8-22 (8-22) max 30 min , other time 2 kr/h
1	25 kr/h 8-22 (8-22), off peak hour 2 kr/h
2	25 kr/h 8-18 (8-15), off peak hour 2 kr/h
3	20 kr/h 8-22 (8-22), off peak hour 2 kr/h
4	20 kr/h 8-18 (8-15), off peak hour 2 kr/h
5	15 kr/h 8-18 (8-15), off peak hour 2 kr/h
6	10 kr/h 8-18 (8-15), off peak hour 1 kr/h
7	5 kr/h 8-18 (8-15), off peak hour 1 kr/h
22	25 kr/h 8-18 (8-15) max 2 hours, off peak time 2 kr/h

Table 5. The different parking fees in Gothenburg (Göteborgs Stad, 2012).

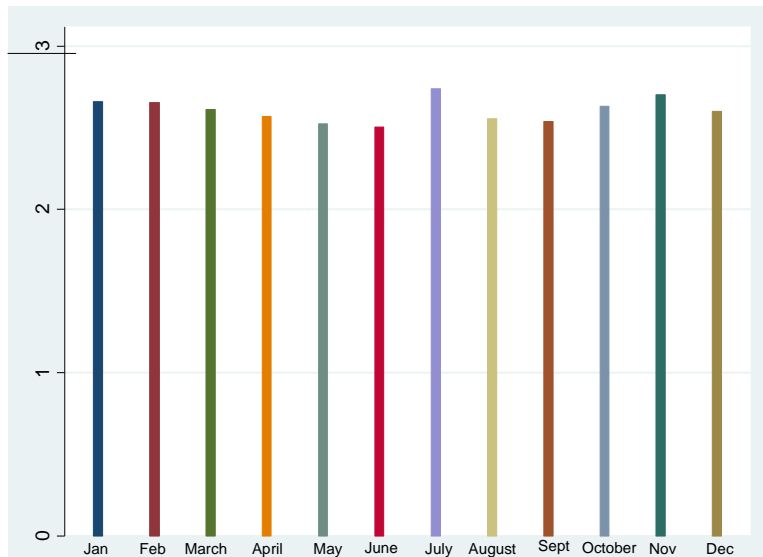


Figure 15. Mean hours parked during the twelve different months.

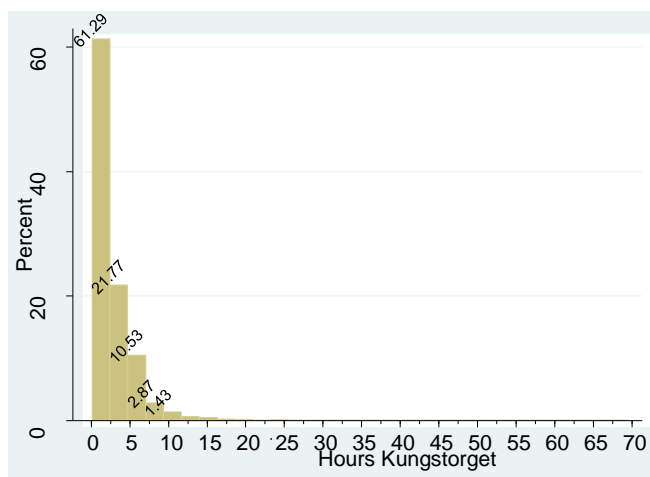


Figure 16. Distribution of parking duration in Kungstorget.

	Spring	Summer	Autumn	Winter
Frequency of cars parked	11693	13092	15794	10664

Table 6 shows the frequency of cars parked during the different seasons.

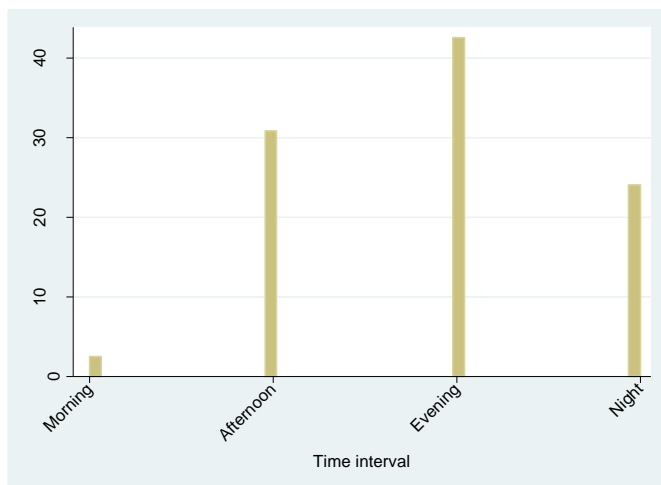


Figure 17. Distribution of frequency of cars parked hours during the four time intervals.

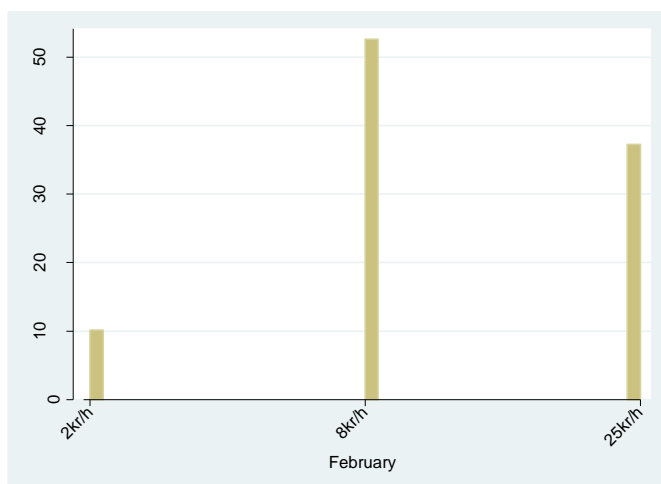


Figure 18. Frequencies of cars parked that pay 2, 10 or 25kr per hour.

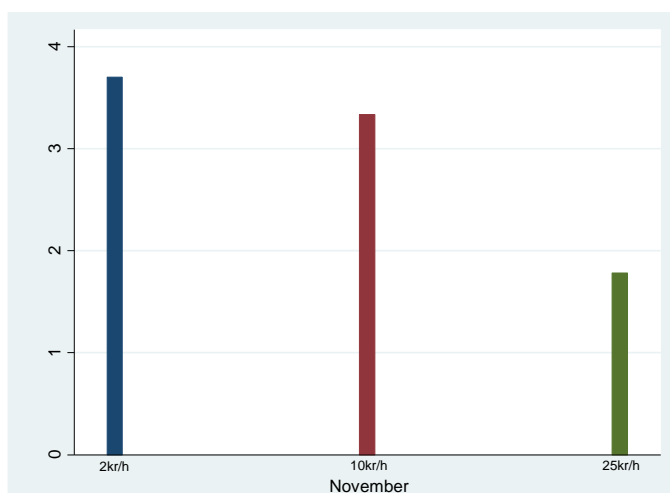


Figure 19 mean hours parked in November if you pay 2, 10 or 25kr/h.