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Drivers' willingness to pay for curbside parking (rather than in a garage)

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Drivers' willingness to pay for curb parking

(rather than in a garage)

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Abstract. We introduce and apply an easy-to-implement methodology to estimate the effect of parking prices on drivers' choice between curb and garage parking using information about parking duration. The endogeneity of parking duration is acknowledged in the estimation procedure. We focus on an area in the CBD of a Dutch monocentric city, where cruising for parking is (almost always) absent. Curb parking is ubiquitous, but 33 percent more expensive than garage parking which is discretely located over space. We show that drivers' willingness to pay for curb parking (relative to garage parking and conditional on parking duration) is positive and about € 0.35 - 0.58. This finding is attributed to an, on average, smaller walking distance to the driver's final destination for curb parking. Our estimates imply that reductions in curb parking prices induce a strong increase in the inflow and particularly the stock of curb parking. For example, if curb parking were only 33 percent *cheaper* than garage parking, the on-street stock of cars would increase threefold. Our estimates strongly suggest that a parking regime including curb prices that are (slightly) higher than garage prices is welfare improving, in particular because drivers with longer parking durations are induced to use garage parking.

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1. Introduction

Pricing of street parking has come to the fore since the seminal paper by Vickrey (1969). Nowadays, there exists consensus among economists that street parking prices which are lower than garage prices (as is generally the case in American cities, for example) are usually not welfare improving. Lower street prices induce a strong demand for on street parking, so markets for parking on street are ‘cleared’ by congestion-induced cruising, which leads to welfare losses attributable to increased travel durations for drivers and externalities like increased carbon emissions, traffic congestion, and accidents, among others (e.g. Arnott and Rowse, 2009; Shoup, 2005). Because cruising is an (almost inherent) source of welfare loss for society, the theoretical literature suggests that street prices be set such to create a number of parking vacancies that is sufficiently high to eliminate (almost) all cruising.

In case that street and garage parking are perfect substitutes (and the garage parking market is perfectly competitive), the optimal curb parking price will be equal to the garage parking price. In reality however, street and garage parking are usually not perfect substitutes, for example because the supply of street parking is ubiquitous, whereas garage parking is discretely located over space.¹ Individual drivers may have a preference for street or garage parking. Given ubiquitous street parking and few garage parking locations in an area, one expects that most drivers strongly prefer street parking (as it is closer to their final destination), suggesting that if street and garage parking prices are equal then cruising for parking may still occur. This effect will even be stronger when garage parking also requires additional time within the parking building (although the opposite may occur when garage parking is well connected to destinations such as is common in US shopping centres). Rather surprisingly, although the growing economics of parking literature almost exclusively focuses

¹ Given cruising for parking on street, commercial garage parking operators may have monopsonistic power (Arnott, 2006). This may help to explain why in many cities in the world, the commercial garage parking market is regulated.

on the drivers' choice between on-street and garage parking (and the consequences of non-optimal pricing), we are not aware of a substantial literature of revealed-preference studies which examines this choice.² As a result, we currently have little or no knowledge to what extent differences between on-street and garage parking prices affect this choice. Based on our empirical study, we believe that economists are able to improve their policy recommendations regarding the issue whether street parking is welfare improving when the parking price is the same, cheaper, or more expensive than the price for garage parking.³

We introduce and apply an easy-to-implement methodology to estimate drivers' willingness to pay for street parking (relative to garage parking), using information from administrative data about parking choice and parking duration for one particular city. This kind of administrative data is widely available in many other cities around the world. So, one of the advantages of our methodology is that it easily be reapplied in other cities.

In essence, we estimate the effect of parking prices on parking choice (i.e. street or garage), given information about driver parking durations. Our methodology is based on the simple observation that the differences in prices for on-street and garage parking depend on parking duration. So, conditional on (anticipated) parking duration, drivers face different pricing schemes.

We apply this methodology for parking in the Central Business District (CBD) of Almere in the Netherlands. This city has about 200,000 inhabitants, and it is located about 20 km east of Amsterdam. Almere is a rather young city; it is literally built on a homogeneous plane using land gained from the sea in the 60s. It is the fastest growing city in the

² We aware of two interesting revealed preference studies on parking which make use of survey data, namely Gillen (1978) and van der Goot (1981). We are also familiar with a few stated preference studies, such as Axhausen and Polak (1991) and Hensher and King (2001). In addition, we are aware of a number of studies where on-street prices have been increased and changes in parking occupancy have been reported. Although these studies are informative, they offer no insight to what extent drivers change from on-street parking to garage parking (or the other way around).

³ We assume that the on-street regulator is not able to introduce a dynamic/flexible on-street pricing scheme as has been recently introduced in San Francisco.

Netherlands. Its urban structure deviates from most European cities with historic centres. In fact, it closely resembles the structure of the stylised monocentric city often described in urban economic textbooks. It has only one CBD, which is surrounded by a residential area where non-residential parking is prohibited (which is again surrounded by a rural area). The CBD is rather small (i.e. slightly smaller than 3 square kilometres) and contains predominantly a shopping centre which is second largest shopping centre within the Netherlands. The local government has fully regulated on-street and garage parking. Within the CBD, there is no spatial variation in parking prices, but contrary to many cities, curb parking is 33 % *more expensive* than garage parking. Almere has hardly any cruising for parking and usually there is sufficient supply of on-street and garage parking given current parking prices, except for some peak shopping hours (which we will exclude from our analysis). So it is reasonable to assume that most drivers will be able to park at their preferred location. In our application, we will focus on a part of the CBD where on-street parking is ubiquitous, whereas garage parking is discretely located over space (in the other areas, garage parking is extremely close to the shopping centre and there are only a few street parking places).

The structure of the remainder of this paper is as follows. Section 2 presents a parking choice model for individual drivers and an empirical approach to estimate the effect of parking prices on parking choice. In section 3, we discuss the Almere parking transaction data and provide descriptive statistics. Section 4 presents the empirical results and derives an estimate of the willingness to pay for street parking. Section 5 concludes.

2. The data and estimation

2.1 Theoretical model on parking choice

We focus on a driver who may choose between street and garage parking. Cruising is assumed to be absent and both parking choices (street, garage) are paid. The (indirect) utility function for parking is defined by:

$$U_i = u(p_i(d_i), d_i, \alpha_i, \varepsilon_i). \quad (1)$$

where $i = s, g$ defines street or garage parking. Here, p_i denotes the price of parking, d_i denotes the (individual-specific) parking duration and α_i is an unknown parameter which measures the type-specific benefits (costs) of parking. The error term ε is a stochastic unobserved component with expectation zero. Note that in (1) the price of parking depends on the duration of parking, so $p_i = p_i(d_i)$. We emphasise that α_i refers to benefits conditional on the price and parking duration, so it captures mainly any walking time to the driver's final destination. We assume that the derivative of u with regard to its first argument is negative (i.e., drivers dislike paying higher prices).

We will assume that the duration d_i is exogenous so we will rewrite it as d . The endogeneity of duration will be acknowledged in the estimation procedure later on using an instrumental variables approach.⁴ Furthermore, we put standard restrictions on the functional form of u . We assume that u is an additive separable function and we will rewrite u as a linear-in-parameter function, so:

$$U_i = \alpha_i + \beta p_i(d_i) + \gamma f(d) + \varepsilon_i, \quad (2)$$

where $f(\cdot)$ is a concave function and β and γ are positive. In this specification, β captures the (negative) effect of the parking price and γ captures the benefits of parking duration of type i . Note that γ does not depend on i . So, we assume that the benefits of parking longer are independent of the choice between street and garage parking.⁵ The probability of parking on-

⁴ Given this procedure we are also able to address the fundamental identification issue that d_s and d_g are never simultaneously observed.

⁵ This assumption seems reasonable, as we will focus only on short parking durations (not longer than 120 minutes), so the marginal risk effect of d_i is ignorable in this safe city.

street, P_s , depends on the difference between U_s and U_g . So, the probability of on-street parking can be written by the following function:

$$P_s = Prob(\alpha_s - \alpha_g + \beta[p_s(d) - p_g(d)] + \varepsilon_s - \varepsilon_g > 0). \quad (3)$$

This model can be estimated given assumptions on the distribution of ε (i.e. normal), and given information on d . Now, (3) can be rewritten as:

$$P_s = Prob(\alpha + \beta[p_s(d) - p_g(d)] + \varepsilon > 0), \quad (4)$$

where $\alpha = \alpha_s - \alpha_g$, and $\varepsilon = \varepsilon_s - \varepsilon_g$.⁶ In our application, p_s and p_g are both proportional to d . In this case, (4) can be written in a more straightforward form:

$$P_s = Prob(\alpha + \beta dD + \varepsilon > 0), \quad (5)$$

where D denotes the *marginal* price difference between street and garage parking. In our application, $D > 0$. Later on, we will show that when the parking duration is (almost) 0, so the difference between street and garage parking prices dD is (almost) zero, then the vast majority of drivers parks on-street. So it appears that, when street and garage prices are the same, most drivers have a preference for street parking, which implies that $\alpha > 0$. As $D > 0$ and $\beta < 0$, our model predicts that drivers with short durations are more likely to park on street, and drivers with long durations are more likely to park in a garage, *ceteris paribus*. As D is given, one may rewrite (5) as:

$$P_s = Prob(\alpha + \theta d + \varepsilon > 0), \quad (6)$$

where $\theta = \beta D$. The expectation of ε is zero, implying that for $d = -\alpha/\theta$, the average driver is indifferent between street and garage parking. We will refer to this level of d as the ‘indifference duration’. At the indifference duration, the benefits of street parking (relative to garage parking) α are equal to Dd . So, given information on α and θ , it is straightforward to calculate the willingness to pay for street parking, WTP_s :

⁶ Note that (4) can be easily generalised. It may for example be the case that α is weather specific and α and β may also be driver specific. It may also be the case that these coefficients depend on the type of activity at the destination. So, one may for example estimate different models for typical shopping hours (Thursday evening, Saturday and Sunday) and business hours (Monday to Friday until 17.00).

$$WTP_s = -\alpha D/\theta \quad (7)$$

2.2 Estimation procedure

We will use a probit model to estimate (6). As emphasised above, d may be endogenous for two reasons. First, drivers' walking distance will usually differ between parking types. When garage parking entails a longer walking distance to the final destination, a driver would park longer in garage, given equal time spent at the final destination. Second, when parking demand is elastic with regard to price, drivers will adjust their time spend at the final destinations. We deal with both issues by using an IV approach. As an instrument, we use the average duration of *both* street and garage parking in the whole area at the time of parking.

3. The data

We employ information on parking transactions that took place in the Almere CBD from January to December 2009. The data contain information on: (a) the time of inflow, (b) the price paid, and (c) parking location. Based on the price, we calculated the parking durations.

We make several data selections. First, we focus only on hours and days during which parking choices can be measured, so when parking is not free. Therefore, we select hours and days when stores are opened, and exclude Sundays and holidays. Second, we are interested in *voluntary* parking behaviour (i.e. the parking choice is the preferred option, conditional on the price). So, we exclude Saturdays, which are associated with parking-congestion.⁷ So, we focus on weekdays between 9am and 4pm. Third, we are only able to calculate duration when drivers pay for each specific parking activity, so we exclude permit parking. Forth, we focus on drivers with a parking duration up to 120 minutes.⁸ Fifth, we exclude locations where garage parking is closer to potential destinations than street parking. Hence, we exclude two of the five municipal parking zones, which consist of a shopping-mall and a hospital with

⁷ Another cause of involuntary choice outcome may have been restricted supply, for instance due to a large reconstruction project. This has also *not* occurred in the year 2009.

⁸ The reason for this is that the marginal risk effect of duration is ignorable only for short durations.

garages right next to it (and only very few street parking).⁹ Given these selections, we have information on 475,899 parking transactions over 258 days. In the area we focus on, there are 6 commercial garages with a total capacity of 2,232 places, and 1,294 street places.

Drivers park 52 minutes on average, and 43 percent of drivers park on-street. Local government established tariffs are € 0.50 per 19 minutes for garage parking, and € 0.70 per 20 minutes for street parking (so, street parking is about 33 percent more expensive).¹⁰ The probability of street parking is negatively correlated with durations. As shown in Table 1, about 55 percent of drivers with a duration shorter than 41 minutes parks on street. Of drivers with a duration longer than 120 minutes, only 9 percent parks on street. Table 1 furthermore illustrates that 47 percent of drivers park shorter than 41 minutes, and 16 percent of drivers park longer than 120 minutes. Of the drivers who park on street, only 4 percent parks for longer than 120 minutes.

Table 1: Share on street parking per duration category

| Duration | < 41 minutes | 41-80 minutes | 81-120 minutes | ≥ 121 minutes |
|--------------------------|--------------|---------------|----------------|---------------|
| Share street parking | 0.55 | 0.32 | 0.21 | 0.09 |
| Share obs. | 0.47 | 0.24 | 0.13 | 0.16 |
| Share obs. <i>Street</i> | 0.69 | 0.20 | 0.07 | 0.04 |

Note: category ≥ 121 minutes excluded henceforth.

As the curbside meters do not give change, 66 percent of drivers incur excess payment when parking on-street (€0.23 on average). As most drivers are probably aware of this, we will interpret this excess payment as an additional transaction cost for street parking.¹¹

⁹ In these zones, garage parking is always preferred (i.e. cheaper *and* closer by). Interested readers can view an interactive map of the Almere street- and garage parking places via: <http://www.google.com/maps/ms?ie=UTF8&hl=en&oe=UTF8&msa=0&msid=202358016036145748697.0004b06a6a82dd1714b26>.

¹⁰ So, street parking is € 1.20 more expensive for a driver who parks 119 minutes, but only € 0.20 more expensive for a driver who parks 15 minutes.

¹¹ For garage parking, there is hardly any excess payment: more than 99.9 of drivers pays the exact money. Almere is not a touristic city, so most drivers probably live or work in Almere and go to the CBS more often, and are aware that the curbside meters do not give change due to previous experience

4. Estimation results and interpretation

3.1 Main results

We have estimated probit models on the choice between street and garage parking as a function of parking duration where we control for heterogeneity in demand by including five dummies for the day of the week (Monday, .., Friday), 52 week dummies and 27 time of the day dummies (measured in quarters of an hour). Furthermore, we control for weather conditions which may influence the parking choice.¹² We control for weather influences by including 7 temperature dummies (< 0 °C, 0-5 °C, .., 20-25 °C, > 25 °C), and a dummy variable that indicates whether precipitation has occurred during the hour of observation.¹³ To account for snowfall, we include a dummy for temperatures lower than 2 °C in combination with the occurrence of precipitation. As explained above, we use the average duration of *both* street and garage parking in the whole area at the time of parking as an instrument.¹⁴ This instrument is strong (the F-test is 3,384).

Table 2 reports the effect of parking duration in minutes (d) on the probability that a driver parks on-street (rather than in a garage) for several specifications. In column [1], we show the results of a standard probit specification where we only include d (not instrumented). The coefficient is equal to -0.0115 (s.e. 0.0001), and the constant is equal to 0.4018. In addition, column [2] also includes weather dummies. To facilitate interpretation, we report the *mean α* which is the constant accounting for the mean values of the control variables. The coefficient of d and the constant are identical to column [1].¹⁵ In addition to weather dummies, column [3] also includes time-, day-, and week dummies, which results in

¹² For instance, when it rains, car drivers are thought to prefer to park in a garage rather than on-street, because in a garage one may leave the car without getting wet. Weather may also influence parking durations, for example when people who are shopping go home earlier when it rains. Not taking these weather influences into account may therefore potentially result in an omitted variable bias.

¹³ The weather data are obtained via the Royal Netherlands Meteorological Institute (KNMI).

¹⁴ To be precise, we use the average duration over a 60 minutes time-interval.

¹⁵ We find that cold weather increases the probability of *street* parking, and rain increases the probability of *garage* parking. Both effects are significant at the 99 percent level in all specifications. The effect of snow is not significant in specifications [3] -[4].

a coefficient of -0.0114 (s.e. 0.0001) and an α of 0.3961. These coefficients are also almost identical to columns [1] and [2]. In column [4], d has been instrumented (same control variables), which results in a higher coefficient of -0.0166 (s.e. 0.0007). The strong absolute increase in the coefficient of d indicates that d is indeed endogenous to parking choice. The value of α in column [4] is also much higher, and is equal to 0.6721. This is our preferred estimate.

The probability that an individual parks on-street is reported in the same table for different levels of d . According to column [4], the probability that an individual parks on street is 72 percent at a duration of 5 minutes, but only 9 percent given a duration of 120 minutes. It appears that drivers are indifferent at a duration of 40 minutes (with a standard error of 0.48). We have also calculated the implied marginal effects of the parking duration on the choice of parking on-street for different levels of parking duration. The marginal effect (when duration is measured in minutes) is between -0.003 and -0.006.

One may obtain the willingness to pay for street parking as the price difference between street and garage parking given a parking duration where drivers are indifferent between street and garage parking (on average, about 40 minutes). This difference between street and garage parking prices is about € 0.0087 per minute. The latter indicates a willingness to pay for street parking of about € 0.35 per parking activity. However, given a mean excess payment of € 0.23 that drivers pay when they park at the curb, it appears that drivers' willingness to pay for street parking is equal to €0.58.¹⁶ When we assume a car drivers' value of time of € 5.00 per hour, our results imply that drivers save about 4 - 7 minutes when parking on street. This seems a reasonable result.

¹⁶ We approximate the drivers' expected excess payment by its mean value, because we do not find it realistic that drivers inspect their coins before choosing to park.

| | [1] Probit | [2] Probit | [3] Probit | [4] IV probit |
|-----------------------------|----------------------------|------------------------|------------------------|------------------------|
| Duration in minutes (d) | -0.0115*** (0.0001) | -0.0115*** (0.0001) | -0.0114*** (0.0001) | -0.0166*** (0.0007) |
| Time-dummies (27) | No | No | Yes | Yes |
| Day-dummies (5) | No | No | Yes | Yes |
| Week dummies (52) | No | No | Yes | Yes |
| Weather dummies (9) | No | Yes | Yes | Yes |
| α | 0.4018*** (0.0037) | 0.4015*** (0.0037) | 0.3961*** (0.0037) | 0.6721*** (0.0355) |
| Observations | 475,899 | 475,899 | 475,899 | 475,899 |
| Level of d | Street parking probability | | | |
| 5 | 0.6347 | 0.6346 | 0.6327 | 0.7221 |
| 30 | 0.5226 | 0.5225 | 0.5216 | 0.5691 |
| 60 | 0.3866 | 0.3865 | 0.3867 | 0.3730 |
| 90 | 0.2633 | 0.2632 | 0.2644 | 0.2056 |
| 120 | 0.1640 | 0.1639 | 0.1656 | 0.0934 |
| Level of d | Marginal effect of d | | | |
| 5 | -0.0043 | -0.0043 | -0.0043 | -0.0056 |
| 60 | -0.0044 | -0.0044 | -0.0044 | -0.0063 |
| 120 | -0.0028 | -0.0028 | -0.0028 | -0.0028 |
| Indifference duration | 34.9453 (0.1796) | 34.9304 (0.1797) | 34.7426 (0.1821) | 39.9407 (0.4802) |

Note: the constant has been adjusted to the mean value of control dummies; *** $p < 0.001$

3.2 Parking choices in hypothetical pricing schemes

Figure 1 provides information about the probability that an individual chooses to park on-street given our estimates and hypothetical pricing schemes. Our calculations are based on two assumptions made for convenience only. First, we ignore restrictions in supply (so, we assume that supply of parking is infinite and there is no cruising). Second, we assume that *total* demand for parking is perfectly *inelastic*, so neither drivers' decision to park, nor their durations are influenced by changes in prices.¹⁷ The probability of choosing to park on-street, given hypothetical pricing schemes and parking durations, are presented in Figure 1.

¹⁷ Note that if parking demand is elastic, the hypothetical pricing schemes that we present in Tables 3 and 4 are an *underestimate* of demand for on-street parking.

Figure 1 shows the results for the current pricing scheme, so when street parking is € 0.0087 more expensive for every 10 minutes parked. The probability of street parking falls from 0.75 when the duration is (close to) zero, to 0.50 when the duration is 40 minutes and to 0.09 when the duration is 120 minutes. In another scenario, we assume that street and garage parking have the same price. In this case, parking choice does not depend on the duration, so the probability of street parking increases to 75 percent. In a third scenario, street parking is 33 percent, so € 0.087 (per 10 minutes), cheaper than garage parking. The probability of choosing street parking is then 0.91 given a duration of 40 minutes, and almost 1 given a duration of 120 minutes. In the last scenario, street parking is for free and garage parking prices remain the same price (€ 0.50 per 20 minutes). The probability that a driver chooses to park on-street is then essentially one for a driver with a parking duration of 40 minutes (or longer).

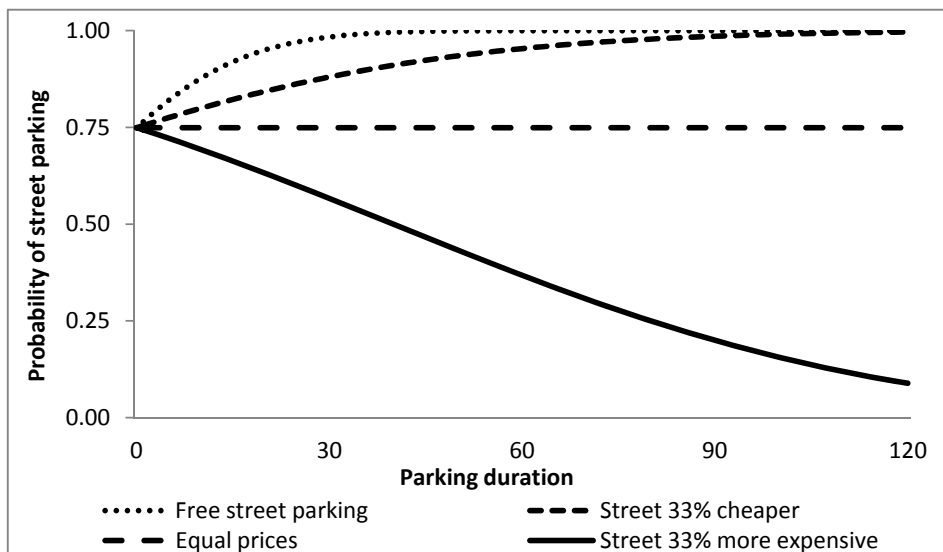


Figure 1: The probability that a driver chooses to park on-street (for hypothetical pricing schemes)

Given the probability of street parking provided in Figure 1, we have calculated how the inflow into curb places as well as the stock of cars on street changes at different hours of the day for different pricing schemes. As can be seen from Table 4, reducing on-street prices (relative to garage prices) strongly increases the inflow into street parking resulting in an even stronger increase in the stock of cars parked on-street (because drivers with long durations have a disproportionately large influence on the stock of cars parked). For example, if street parking were 33% cheaper than garage parking, street inflow would increase by about 204 percent, but the stock of cars being parked on street would increase by about 293 percent.¹⁸

Table 4: Inflow and stock in hypothetical pricing schemes

| | | 9:00 - 10:00 hrs | 10:00 - 11:00 hrs | 11:00 - 12:00 hrs | 12:00 - 13:00 hrs | 13:00 - 14:00 hrs | 14:00 - 15:00 hrs | 15:00 - 16:00 hrs | Mean hourly inflow | Increase compared to current scheme (%) |
|--|--------------------------------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|---|
| Total current inflow (street and garage) | | 214 | 299 | 290 | 327 | 402 | 349 | 321 | 315 | |
| Inflow street | | | | | | | | | | |
| Scheme # | Label | 94 | 132 | 128 | 144 | 177 | 154 | 141 | 139 | |
| 1 | Current scheme | 157 | 220 | 213 | 240 | 296 | 257 | 236 | 231 | |
| 2 | Equal prices garage and street | 193 | 270 | 262 | 296 | 363 | 316 | 290 | 284 | 167% |
| 3 | 33% cheaper on-street parking | 209 | 293 | 284 | 320 | 393 | 341 | 314 | 308 | 205% |
| 4 | On-street for free | 94 | 132 | 128 | 144 | 177 | 154 | 141 | 139 | 222% |
| Stock of cars parked on-street | | | | | | | | | | |
| Scheme # | Label | 52 | 78 | 77 | 86 | 105 | 94 | 86 | 83 | |
| 1 | Current scheme | 108 | 174 | 179 | 197 | 239 | 220 | 200 | 188 | |
| 2 | Equal prices garage and street | 137 | 224 | 231 | 253 | 307 | 284 | 258 | 242 | 227% |
| 3 | 33% cheaper on-street parking | 146 | 236 | 243 | 267 | 324 | 299 | 272 | 255 | 293% |
| 4 | On-street for free | 52 | 78 | 77 | 86 | 105 | 94 | 86 | 83 | 308% |

¹⁸ Note that Table 4 probably *underestimates* the real changes in parking stock that would occur, because we have ignored drivers with durations longer than 120 minutes (who are likely to react even more strongly to above changes in pricing schemes).

5. Conclusion

This paper shows that car drivers have a rather strong preference for street parking in the case that the supply of street parking is ubiquitous, whereas garage parking is discretely located over space, because street parking is on average closer to drivers' final destinations (e.g. a shop). We find that the average driver willingness to pay for street parking is between €0.35 and €0.58, which we attribute to the smaller walking distance to the final destinations. Our results imply that car drivers are rather sensitive to small price differences between street and garage parking, which makes sense as both are close substitutes. Given a distribution of parking durations of otherwise homogeneous car drivers (and no systematic relation between the parking duration and the location of the final destination of the driver), it is optimal that drivers with longer durations park in a garage rather than on-street, so the supply of street parking can be used by car drivers with short parking durations. In this way, the walking distance between the parking location and the final destination is minimised in the economy. The latter equilibrium outcome can be easily achieved by ensuring that street parking is slightly more expensive than garage parking (per unit of time), and definitely not *cheaper* (as is often the case).

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