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Parking in cities:
how essential is parking for healthy central shopping areas?

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Abstract: In this paper we analyse the effectiveness and consequences of introducing a paid parking scheme. It is argued that pricing measures are effective for combating inefficiencies in parking behaviour caused by distortions such as information problems and congestion costs. An additional distortion concerns the negative effect of parked cars on the attractiveness of areas such as cities' historical centres and residential quarters. It is demonstrated that given the structure of the marginal external costs involved, pricing measures are not attractive for addressing these problems. Since for the other distortions pricing measures are promising instruments, a mixture of pricing and quantity regulation would be called for. A possible consequence of pricing and quantity regulation of parking is that it would negatively affect the vitality of shopping areas in cities. Aggregate statistics and statistical analysis of parking behaviour in 30 municipalities in The Netherlands suggests that parking quality, including parking prices and parking capacity, not influence shopping behaviour. An important point seems to be that the introduction of a low parking charge per hour does not strongly hurt visitors, while at the same time it is effective to discourage long term parking (by residents, personnel). The introduction of low parking charges therefore appears to lead to a reallocation of parking space from long term to short term parking. Based on the literature however we have to conclude that different studies provide different insights into our problem and that. Therefore, analysis using micro-level data on the parking situation and competitiveness of inner cities would be fruitful in giving more definitive answers regarding this issue.

1. Introduction.

Cities are places where people live, work and meet. These activities give rise to large transport flows. Among the various motorised and non-motorised transport modes, the car plays a dominant role. Adequate parking infrastructure for cars is one of the necessary elements of a well functioning city. Given the lack of space in cities and the high costs of building parking garages one may expect bottlenecks in parking. A basic fact is that an average car is only used during 1 hour per day. This implies that it needs a parking place during the remaining 96% of the day. The problem is that these parking places are needed at various locations (for example, during daytime in the work areas and near shopping centres, during the evening and in the weekends near recreational destinations, during the night in the residential areas). Therefore it is no surprise to so that there are many more parking places than there are cars. It is conventional wisdom that for every car in a country there are about three parking places. Given the importance of cities as destinations of trips, a substantial part of these parking places will be located in cities. The 24-hour average occupancy rate of parking places will be around 33% according to this figure. But in cities it will be considerably higher implying various frictions in waiting and searching for parking places.

Policies to improve the environmental quality of cities often aim at restricting car use in cities. Given the high densities of land use, cities are a favourable place for non-motorised transport and public transport (Rietveld, 2001). The reason is that within short distances many opportunities exist for spatial interaction so that non-motorised transport modes have a natural advantage. In addition, the high densities offer opportunities to exploit economies of scale in public transport operations. One of the policies to reduce the role of the car in the city is to apply restrictive parking policies.

A reason of concern with restrictive parking policies is that the cities will become less attractive as a destination of various trips so that some activities will relocate to other places. This holds true for example for shopping. When central shopping areas are difficult to visit, customer expenditures may go down and shops may relocate to places at the fringe of the large cities or even further away.

In this paper we will discuss these issues from a mainly economic perspective. We start with an economic analysis of the market of parking services and possibilities of government intervention (section 2). In section 3 the theme of parking and shopping will be discussed. In section 4 we present empirical results of a cross-section study on the impact of parking on central shopping areas after which a survey is given of more detailed studies on the effects of parking in Section 5. Section 6 will empirically investigate the price elasticity of parking demand and focus on the relation between paid parking and shop sales, using panel data for several city parts of Amsterdam for 1990 to 2000. Section 7 will provide a discussion.

2. An economic analysis of the market for parking services.

Parking has received relatively little attention in the transport research literature (Young, 2000). This is rather surprising since parking is a major policy issue in many cities. The background is that the market for parking space is characterised by various distortions so that one may expect non-optimal policies from the demand and the supply side. Examples of such distortions are externalities, lack of information, monopoly power of the owner of private parking places, and high transaction costs. We will discuss some of these in more detail here.

Parking and market distortions.

Parking is an activity that may easily give rise to *externalities*. A well-known example is a lorry parked on a street to be loaded or unloaded in a city centre, which blocks the way for other road users. A less extreme example is that parking a car on a parking place may have an effect on the time other road users need to find a parking place. Also non-road users may be affected by parked cars: parked cars reduce the scenic quality of the city centres for both visitors and residents and they reduce the opportunity to use the road for other purposes like a playground for children. Indirectly parking is also related to the externalities of car traffic such as noise, emissions, accident risks, etc. Another market imperfection with parking is the *lack of information* on demand and supply. This may lead car drivers to look for a parking place implying search and waiting costs that could be avoided if adequate information had been available. The *monopoly pricing* issue is relevant because parking facilities usually serve a very local market and within many cities it is difficult for entering suppliers on the parking market to find a place for a new parking garage. *Transaction costs* relate to the costs of letting car users pay for the use of parking places (for example by introducing metering for on the street parking). These costs may be so high that the authority taking care of the parking places may decide to offer them free. This is an example of the non-excludability property. The problem with free parking places is illustrated in figure 1.

<<< Figure 1. Demand and supply of parking space >>>

In the short run the volume of parking places is given. When the downward sloping demand curve intersects the supply curve a positive parking charge (p) would be needed to arrive at the market equilibrium, but with a price equal to zero there will be excess demand leading to queues and waiting costs. Another possible distortion is that private suppliers of parking space provide the parking for free, for example in the case of parking provided by employers to employees (see for example Shoup, 1997, Rietveld and Van Ommeren, 2001). This would imply that workers that commute by car would not pay for part of the inputs of their trip: so that they are charged a price that is too low.

Approaches to deal with market distortions.

Several approaches exist to address these market imperfections. Part of the problems can be overcome by using *new technologies*. For example, ICT can be used to develop dynamic parking information systems so that unnecessary search for parking places can be avoided. Also the transaction costs in parking can be reduced by using ICT.

An entirely different approach would be to use *Coasian negotiations* between the victims and the causes of the externalities. However, in the case of many actors this is not a feasible option. Also some kind of *rationing* may be introduced. For example, restrictions on the duration of parking may help keep some of the parking problems manageable. Or giving parking rights to only some categories of users (for example residents) may help to solve the mismatch between demand and supply.

The *supply of adequate parking infrastructure* is also a policy often used by local governments to reduce some of the related problems. For example, in order to overcome negative external effects of car traffic and of parking in historical cities, parking may be concentrated at the fringe of the cities after which public transport services are offered to bring visitors to their final destination. In this policy the location of parking facilities as well as the function of parking in multi-modal transport chains play a central role.

Pricing measures to optimise parking congestion.

Pricing measures are another way to deal with the externality problems mentioned. We will discuss these in some detail below. Figure 2 gives an illustration of the externality problem in the case of stochastic arrivals and stochastic parking duration at a parking place.

<<< Figure 2. Average waiting time at a parking place as a function of demand >>>

This figure is based on operations research modelling of queuing systems (M/M/N) where N parking places are available in the situation with exponentially distributed arrivals and service times of cars. When b is the arrival rate, d is the service rate and N=1 the average waiting time AW in the queue equals:

$$AW = [b/d]/[d-b] \qquad (1)$$

Note that as demand b increases, the average waiting time before a parking place is found also increases. From the formula it is clear that b should be smaller than d, otherwise, there would never be sufficient capacity to serve the demand for parking space. The total waiting time TW per unit of time equals

$$TW = [b^2/d]/[d-b] \quad (2)$$

The elasticity of total waiting time with respect to demand E^{TW}_b can be shown to be:

$$E^{TW}_b = [2d-b]/[d-b] \quad (3)$$

Consider for example a shopkeeper who has reserved one parking place for customers coming by car. When the arrival rate is 1 per hour (b=1) and the duration of the visit is ½ hour (d=2) the average waiting time AW of a visitor equals ½ hour. This illustrates that even when the capacity is large enough there may be substantial waiting times due to the fact that there may be two or more subsequent visitors that happen to arrive at about the same time. The elasticity E^{TW}_b of total waiting time with respect to demand equals 3 in this case. This means that when demand increases with 1% the total waiting time would increase with no less than 3%. This means that a small increase in demand has a more than proportional effect on total waiting time. This implies that an additional customer imposes costs on all other customers. Another way to illustrate this point is to consider the gap between the average waiting time and the marginal waiting time (i.e., the change in total waiting time) when there is a small increase in demand. The marginal waiting time MW can be derived from TW to be:

$$MW = [b/d]/[d-b] * [2d-b]/[d-b] \quad (4)$$

This means that the ratio of marginal waiting time and average waiting time equals

$$MW/AW = [2d-b]/[d-b] \quad (5)$$

which is exactly equal to the elasticity mentioned above. The gap between marginal and average waiting time equals

$$MW\text{-}AW = b/[d-b]^2 \quad (6)$$

In the present example with b=1 and d=2 this gap appears to be double the value of the average waiting time. The gap can be interpreted as an externality. When the capacity is given, an additional parking car imposes costs on other drivers that want to park. These additional costs may be considerably higher than the average waiting time experienced by the parking drivers.

When the number of parking places N is larger than 1 more complex formulas are found for the queuing time. But the line of reasoning remains the same. When demand is far below the capacity the waiting time is negligible, but as demand comes close to the capacity (taking into account the average duration) it increases to very high levels. The central point is that an extra car that arrives (a slight increase in b) has an effect on the average queuing time of all cars. A similar result holds for a

decrease in the service rate d. In a way similar to the literature on congestion pricing a gap can be observed between the average queuing time of an individual car driver and the marginal queuing time for all drivers. A parking charge r being equal to be difference between the two may be levied to confront the car driver with the externality costs (see Figure 3).

<<< Figure 3. Imposition of a parking charge to correct for waiting externalities >>>

This would bring back the use of parking space from Q_0 to Q_1, implying that a larger part of the capacity remains vacant. This reduction in the intensity of use of the parking facility can be shown to be outweighed by the decrease in queuing time so that the imposition of the parking charge is welfare increasing. Thus, from the viewpoint of efficiency a parking charge in the case of a congested facility can be fully justified. Another point is the equity problem, because the imposition of the parking charge leads to a decrease of welfare of car drivers: the parking charge they have to pay is higher than the value of the gain in queuing time. On the other hand, the government benefits because it now receives the parking charges. This may make parking charges sometimes difficult to accept, but as indicated by Rietveld and Verhoef (1998), there are various ways to compensate the losing groups without corrupting the efficiency of the parking charge.

Pricing of parking to protect the historical attractiveness of cities.
As mentioned above another externality problem with parking may be that on the street parking negatively affects the scenic attractiveness of older cities and makes the street useless for other purposes such as a playground for children. In figure 4 we sketch how the marginal external costs will look like. The striking point is that as the number of parked cars increases, the marginal costs involved decrease: when a street is already rather full with parked cars the additional negative effect on the attractiveness of the street will be very small. This has some interesting implications for the use of parking charges to arrive at the optimal balance between the benefits and costs of parking. As figure 4 demonstrates there may be two or more points of intersection between then curves related to the marginal costs and benefits of parking (the analysis below is to some extent related to Rouwendal et al., 2001).

<<< Figure 4. Pricing policies addressing the negative effect on historical cities by parked cars >>>

Case A in Figure 4 implies that the optimum is found near the full use of the parking space. In this case the marginal costs are low. In the case of B the volume of parking cars is low; the marginal costs and benefits are both high. However, this cannot be an optimum since moving away from B to the left will lead to an allocation where the benefits will decrease less than the gain in environmental quality. A closer inspection of point B reveals that this relates to minimum in stead of maximum net benefits.

A third candidate would be the extreme zero parking solution C. Whether C is more attractive than A depends on the exact form and location of the curves. This leads to an interesting conclusion. When one would like to correct for parking externalities by means of prices, the charge will be either very small (case A), or very high (case B). This means that prices are probably not a good means to solve this type of parking externality. When case A would be the optimum a much more straightforward solution would be to impose the physical constraint that parking is forbidden. This is what many old cities indeed do: the introduction of a car free zone, or the construction of underground parking space so that parking does not spoil the historical centre of the city. When on the other hand case C would be optimal it would most probably be better not to impose a parking charge since the welfare loss compared with a very low charge would most probably be smaller than the transaction costs of collecting the money.

Tradable parking permits.

A possibility that has not received much attention thus far is a combination of rationing and pricing in the form of *tradable parking permits.* For example, in a certain area with 50 parking places and 100 dwellings a limited number of parking permits may be distributed among the households such that for example each household receives 0.5 permit. Then trading will lead to the situation that half of the households with a low willingness to pay for the permits will sell the permit to the other half that have a higher willingness to pay. This ensures that total parking remains within the capacity, so that unnecessary search costs are avoided. Households for whom the availability for parking space is most important indeed get a place. The advantage for the other households is that they get an additional source of income. Almost all households will benefit. The most extreme benefits accrue to those with the highest willingness to pay (their consumer surplus is highest) and those with the lowest willingness to pay: they sell the permit at a price that is much higher than the benefits they would have by using it themselves. For the intermediate households the benefits are smaller. In the current example the median household would be indifferent between selling the permit or using the permit itself: its willingness to pay happens to be equal to the market price.

Other versions of the tradable parking permit system could be applied to the case of parking at the place of the employer. When there are capacity problems, employers sometimes distribute parking permits according to some hierarchy rules. The distribution of tradable parking permits among employees would be an interesting and more efficient and equitable alternative to ensure that the scarce parking places will be used by those who need it most. Tradable parking permits might also play a role in the so-called ABC parking policies in the Netherlands. Rather than imposing constraints on the number of parking places per employer a constraint could be imposed on a collective of employers in a certain zone.

Other dimensions.

We finish this section by discussing a number of other dimensions that matter for the performance of the parking market. *Travel motives* deserve attention in parking since they have strong implications for the timing and duration of parking as well as for the willingness to pay for a parking place. These differences sometimes enable one to make use of parking place in an efficient way. For example, commuters who use their car to go to work make available a parking place to car using commuters from other places who work near the residences of the first mentioned group of commuters. However, in other cases there may be an immediate conflict in the interest of different groups of car users. For example, workers in the retail sector usually arrive earlier than the customers. Hence they can park at the parking locations nearby forcing shoppers to walk longer distances.

This conflict is aggravated by the occurrence of differences in the *duration of parking.* Employees usually have a longer parking duration than customers so that one parking place taken by a worker during a whole day means that 10 customers may be forced to park the car at a more distant parking place. The duration of parking is also important in the case of pricing. Pricing per time unit will affect long-term parking much more than short-term parking. Pricing is therefore almost certainly beneficial for very short term parking since it reduces the costs of waiting and search at a low cost. Note however, that an unintended side effect of pricing parking places may be that the shift from long duration parking to short duration parking implies that more traffic is generated. This has an adverse effect on noise and emissions in the city.

Timing of parking and the spatial dimension of parking have already been mentioned in the above points. The most important behavioural alternatives for car drivers who are confronted for parking problems at a certain place are parking at another place and arriving at another moment (see Arnott and Rowse, 1999). When pricing schemes are imposed to arrive at an optimal use of the parking space, systems with spatially differentiated parking prices will emerge where parking prices are lower the further way they are from large destinations of car traffic. An example of the temporal dimension of parking is that car drivers depart earlier from home in order to be sure that there will still be a free parking place at their destination. This has the possible unintended side effect that congestion on the road gets worse. Thus there is a clear interrelationship between parking problems and congestion problems.

The pricing of parking is sometimes advocated as a *second best policy for road pricing*: pricing parking in urban areas indeed affects commuters that are airing congestion. However, it is only a rather crude pricing measure since a parking charge does not differentiate according to the origin of the trip: it may be charged to car drivers who were not involved in congestion. An additional problem is that a parking charge does not address through traffic (Glazer and Niskanen, 1992), and that part of the cars

that were involved in congestion will park on private parking places. Hence, the pricing of parking places is in general a rather ineffective way to address congestion problems.

3. Paid parking and shopping behaviour.

As mentioned in the previous section, charging parking fees to resolve problems in a city's central business area may not be optimal from an efficiency point of view. A possible negative effect not discussed so far is that putting a price on parking in a city's centre may decrease sales and profits of incumbent shops. In other words, instead of shopping in the city's central area, consumers may shift to shopping locations at for instance the fringe of the city. Besides the possible redistribution of sales and profits between different shopping locations, this may also give rise to some negative welfare effects. To illustrate this, it is very likely that for most people central business districts are areas where a symbiosis exists between shopping, cultural activities, sightseeing and other leisure activities. Such a symbiosis is likely absent or at the least much less present in shopping locations at the fringe of the city. In this sense, shopping in the historical centre of a city has an added value – or in other words has a positive welfare effect – over shopping at locations at the fringe of a city.

In order to investigate whether putting a price on parking will actually lead to a decrease in sales and profits of shops, we will have to take account of the complexity of consumer choice analysis. First of all we have to realise that in reaction to priced parking in a central business district, consumers may change their shopping behaviour in several ways:

- A *change of parking location* within the same shopping area: this will be especially relevant if there are no-parking zones nearby the paid-parking zones;
- A *change of transport mode*: if the price of shopping by car increases, shopping by using other transport modes will become more attractive;
- A *change of shopping location*: if at other shopping areas parking is free, these areas will become more attractive. However, we can also imagine that shopping through Internet increases;
- A *change in parking period:* the result of this change may either be that people shop more effectively, i.e. the same amount of shopping is done in less time, or that people shop less resulting in a decrease in sales.

A second observation is that the choices consumers actually make, depend not only on the fact that parking fees are being charged or increased, but on several other factors as well. We will discuss the most important ones below.

The *existence and attractiveness of alternative shopping locations* can have a large influence on consumer choice. Attractiveness incorporates factors such as the diversity, quality and price of the goods and services offered, the accessibility of the location by different transport modes and the distance to the location.

Secondly, the *existence and attractiveness of alternative transport modes* to a city's centre will influence the degree of substitution between the car and for instance the bicycle or public transport. Usually city centres are fairly well accessible by several transport modes, so existence will not be much of an issue. However, when many products are purchased, the car is obviously more attractive for transport than a bicycle or public transport. Furthermore, public transport is inflexible in the sense that there are fixed times of departure. Especially with busses this may lead to waiting time if shopping, certainly if shopping isn't planned in advance.

Third, the characteristics of the consumer population in a local economy can be important for several reasons. First, behaviour of part of the consumers will be unaffected by a parking fee, for instance because they do not travel by car to go to the city's centre for shopping. The larger this part of the population, the smaller the sensitivity to changes in parking prices. Second, the distance that consumers travel to get to the shopping location will differ. This is of some concern since demand elasticity with respect to the price of parking will likely be different for consumers with different travel distances. For instance, someone who goes shopping in a city relatively far away from home, will likely react less to (an increase in) parking fees than someone who lives close by the city and drives downtown to do his or her groceries there. Third, an aspect closely related to that of travel distance is the issue of shopping motives. It is possible to distinguish a continuum of shopping motives with fun shopping on the left and daily groceries on the right. This continuum is useful in that one may expect that when going from the left to the right of the continuum we see an increase in the price sensitivity of demand for parking. The remaining question is then how and how much the price elasticity changes as we go from the left to the right of this continuum. In other words, do consumers react more heavily to an increase in parking fees when they go fun shopping or when they go and do their (daily) groceries.

Finally, *local suppliers of goods and services may react to change in parking fees* in several ways. For instance, they may change their prices (certainly in an imperfect market) in reaction to an expected decrease in demand to again optimise their profits, or they may offer parking discounts to consumers who buy at their shop[1]. Another possibility, already mentioned earlier, is that they relocate to other locations at for instance the fringe of the city. What is furthermore important in a more dynamic analysis of changes in shopping behaviour is the interplay between producer and consumer reactions.

The outcome of this process can be largely different from the initial consumer reaction to a change in parking prices.

We have discussed possible consumer reactions to an increase in parking prices as well as the factors, besides parking price changes, that may influence them. One of the possibilities is that sales and profits of incumbent shops decrease because of an increase in parking prices in a city's centre. Furthermore, we have tried to illustrate that social welfare may be negatively influenced by a substitution between shopping locations. However, the complexity of the analysis on changes in consumer choice renders any theoretical conclusion unwarranted, thereby making the central issue in this paper an empirical one. In the next section we will present figures on transport and shopping behaviour in The Netherlands before turning to some empirical evidence on the relation between shopping behaviour and parking prices sections 5 and 6.

4. Parking and the demand for shopping in cities: a cross-sectional analysis.

Parking is one of the determinants of the success of shopping areas. In this section we give an investigation of the role of parking for a specific class of shopping areas, i.e., central shopping areas in a number of municipalities in The Netherlands (for an operational definition of central shopping areas see Locatus, 2001). Given the fact that these shopping areas attract people from relatively long distances and that many of them will come by car it may be expected that parking facilities will contribute to the attractiveness of these shopping areas.

The success of a shopping area can be defined in terms of the total sales. It will be measured by its size in terms of the number of m^2 used for sales activities. The use of the size as a success indicator seems to be a reasonable proxy because in the long run if there would be a disappointing level of sales some of the shops will be forced to close. Similarly, when sales would be high given the size of the shopping area this would induce an expansion of the shopping area.
For 30 Dutch municipalities (mainly cities) we have data on the size of the central shopping area (see Althuisius, 1998). We propose the following explanatory variables:

Pop_m: Number of inhabitants in the city *(source: CBS).*
$Popn_m$: Number of inhabitants in municipalities within a distance of 15 km *(source: CBS).*
$Comp_m$: Size of competing shopping centres in the same municipality measured in m^2 *(source: Locatus, 2001).*
$Park_m$: Number of parking places within walking distance *(source: Althuisius, 1998).*

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[1] For an analysis of the effectiveness of parking discounts, see Lan and Kanafani (1993) and Lindsey and West

PT_m : Indicator of quality of public transport facilities *(source: Hoofdbedrijfschap Detailhandel, 1999).*

The results of a regression model explaining the size of central shopping areas based on a double log specification are presented in Table 1. The elasticity of the central shopping area with respect to the own population is estimated to be almost 0.7. The responsiveness with respect to population in neighbouring centres is clearly lower (the elasticity is about 0.2). Competition by other shopping areas in the city is rather limited (the pertaining elasticity is only -0.08). A rather surprising result can be found in the lower two lines of the table: the accessibility of the central shopping area does not play a significant role. For public transport even a negative (but very small) elasticity is found. For Parking space the elasticity is 0.05, implying that an increase in the number of parking places with 10% leads to an increase in the size of the shopping area of 0.5%. However, the coefficient is not significantly different from zero. Hence we cannot reject the null hypothesis that parking does *not* matter as a determinant of the size of central shopping areas. In some additional regressions, a number of additional explanatory variables have been added, such as an index of the historical character of the city, the presence of a pedestrian area, etc, but also these variables were not significant. The conclusion is that with the given data set of only 30 Dutch municipalities it is not possible to demonstrate that parking really matters as a determinant of success of shopping centres in central cities. It is not impossible that with data on more cities and with more refined data we would arrive at other, more definite results. The least we can say is that from the available cross section data the importance of parking is not as clear as is sometimes claimed. Other types of data would be needed to arrive at more definite results.

Table 1. Estimation of contribution of explanatory factors to success of central shopping areas (ln surface of area).

variable	coefficient	t-statistic
constant	.707	0.45
ln Pop	.682**	3.42
ln Popn	.192**	3.12
ln Comp	-.084**	-3.39
ln Park	.054	0.32
ln Public Transport	-.010	-0.07
R^2	.892	

* = Significant at a 5% level of significance.
** = Significant at a 1% level of significance.

(1997 and 1998).

5. Survey of empirical studies on parking and shopping.

The main question we are addressing in this paper is what effects parking conditions have on consumer behaviour. The analysis of the previous section produced results that seem to suggest that the influence of *the number of parking spaces* on size of the shopping centres is rather limited or absent. Below we will address results from Dutch studies that empirically test the effects of *increasing parking prices*. Subsequently we will discuss studies tat find a negative relation and studies that find no relation between (the magnitude of) parking prices and sales of shops. In interpreting the results it is important to realise that some studies use Revealed Preferences and some use Stated Preferences as their research method. Both methods have their specific problems. The Revealed Preferences method has the disadvantage that one cannot tell whether a certain observed reaction is actually *caused* by the variable under investigation. This type of analysis may therefore suffer from omitted variable bias. The Stated Preferences method avoids this problem because of its experimental setting in which the relevant variable is isolated from other variables. The respondent thus reacts to a hypothetical increase in parking prices while assuming that other variables stay constant. However, the problem is that since the change in a certain situation is a hypothetical one, so is the reaction to it. This weakens the credibility of the answers given by the respondents.

5.1 Significant negative relation between paid parking and sales.

In a survey of the empirical literature on the consequences of paid parking, Hulsbeek and Tchang (1996) mention only one case that reports a negative relation. The study was conducted in multiple cities in The Netherlands such as, Beverwijk, Drachten, Rijswijk and Leeuwarden, and reports a decline in retail sales after parking fees are first charged or increased. The figures reported a decline in sales in the range of 2% (Drachten) to 10% (Leeuwarden).

Broekhuijzen (1998) points to the empirical studies reporting a negative effect of paid parking on the sales of supermarkets (groceries). It appears that this effect can be of a fairly structural nature and as high as 15%. Unfortunately, the individual studies aren't mentioned, which casts some doubt on the mentioned results.

Van der Waerden et al. (1996) study both the choice of parking location and shopping location in the city of Eindhoven using the stated preference method. They find that when parking fees are increased at just one parking location, most people substitute between *parking locations* at the same shopping location or do not change their parking behaviour. When parking fees are increased at every parking location at a shopping location, a large number of people indicated that they would change *shopping*

frequency or *shopping location*. In addition, the magnitude of the increase in parking fee and the duration of parking appeared to be important moderators influencing the stated behavioural reaction.

5.2 No relation between paid parking and sales.

There are many studies that investigate the issue and find no relation between paid parking and sales. Some of them deserve some specific attention. Meurs et al. (1997) find that in reaction to parking policies (such as increasing parking prices) people first change their parking location, secondly they change their shopping location and thirdly they substitute between transport modes. In general, parking quality[2] appears to be of minor importance in shopping location choice. When parking fees are doubled at a certain shopping location and kept constant at others, the former location is calculated to experience a decline in number of customers of one percent. Of much greater importance are issues such as relative quality and accessibility of a shopping location. From this study we can conclude that the more homogeneous shopping locations are, the more paid parking influences the choice of shopping location. Furthermore, the choice of transport mode is hardly influenced by the increase in parking fees[3].

A survey performed in The Hague (Ten Heuvelhof, 1990) finds a decrease in frequency and duration of parking but an increase in consumer spending (even when corrected for a general increase in spending), the year after parking prices are increased. Moreover, when asked for the reasons for the decrease in frequency and duration, not so much the magnitude of parking fees but rather the lack of parking spaces was mentioned. Another salient result of the latter study is that a large part of the respondents estimated the parking fees to be higher than they actually were.

Similarly, Jägers and Jansen (1995) and D&P onderzoek en advies (1995) find that the quality of parking was of minor importance in the shopping location choice of consumers. Moreover, shopping motive (e.g., fun shopping versus doing groceries) and size of a city were found to be important variables that influenced the relevance of the parking situation in the choice of shopping location. Consumers appear to be more sensitive to paid parking when doing groceries than in the case of fun shopping. Furthermore, the parking situation in large cities was far more relevant for the choice of shopping location than it was in medium sized cities.

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[2] Parking quality includes the magnitude of parking fees, amount of time spent on searching and waiting for a parking place, maximum parking duration, etc.

6. Parking tariffs, parking demand and employment in the retail sector

In order to investigate the demand for parking on the one hand and the influence of parking prices on the retail sector on the other, we have gathered data on several variables for the city of Amsterdam. The data are annual and gathered at the city-district level. The data-set comprises data on 11 city-districts from 1990 to 2000 implying a total of 121 observations before correction for missing data etc. The variables used for analysis are described below.

$EMPL_{i,t}$: Number of employees in the retail sector in city-district i at year t.
$POP_{i,t}$: Population in city-district i at year t.
Source: O&S (1990-2000)

$TAR_{i,t}$: Level of the parking tariff in city-district i at year t.
$PPP_{i,t}$: Number of paid parking places in city-district i at year t.
$REV_{i,t}$: Parking revenue per parking place per week in city district i at year t.
$DEM_{i,t}$: Index for parking demand in city-district i at year t.
Source: Stadstoezicht (1993, 1996, 1997 and 2000)[4]

6.1 Demand for parking

In this section we will investigate the price elasticity of the demand for parking. The model we will estimate will use fixed effects per city-district. The dependent variable is $DEM_{i,t}$. The index for parking demand $DEM_{i,t}$ was calculated from $PPP_{i,t}$, $TAR_{i,t}$ and $REV_{i,t}$ in the following manner:

$$DEM_{i,t} = \frac{PPP_{i,t} * REV_{i,t}}{TAR_{i,t}}.$$

This index[5] is obviously not a good measure of actual demand for parking because it is not corrected for the increase in paid parking places over time. In a regression setting it can however serve as a good index of parking demand since we can consistently control for the influence of the increase in number of paid parking places. The standard explanatory variables are $TAR_{i,t}$, $PPP_{i,t}$ and $POP_{i,t}$. All the previously mentioned variables are included in logarithmic format so that the resulting coefficients may be interpreted as elasticities.

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[3] Van Dinteren (1991) and Flier (1992) find similar results. Flier (1992) furthermore provides evidence of substitution between parking locations. See also Zwart (1995) for reactions to paid parking by commercial enterprises.

[4] We want to express our sincere gratitude to Theo Schroots from 'Stadstoezicht' who provided us with the data.

Table 2 shows the results for two different models. In general it is clear that due to missing data the number of useable observations is limited[6]. In order to increase efficiency we excluded insignificant fixed effects until the included ones were all significant at the 5% level. One other variable that was used as a control variable, for reasons we will discuss in a moment, is the lagged dependent variable LnDEM(t-1).

Table 2. Demand for parking (dependent variable is LnDEM; t-values in parentheses)

variable	Model I	Model II
Constant		
LnDEM(t-1)		
DUMpijp[7]		
DUMowm[7]		
DUMoudw[7]		
LnTAR		
LnPPP		
LnPOP		
R^2 (adjusted)		
NOBS (DOF)		
Durbin-Watson		

* = Significant at a 5% level of significance.
** = Significant at a 1% level of significance.

The first model excludes LnDEM(t-1) as an explanatory variable. At first sight the results look fine. A closer look shows us two main flaws in the results. First of all, the coefficient on LnPOP is fairly high; a result that does not make sense intuitively. There is therefore an indication that one or more

[5] The precise dimension of the index is number of paid parking hours per city-district per week.
[6] Largest consequence is that all observations from 1990, 1991, 1992 and 1993 are excluded as well as all observations regarding the city-district 'Buitenveldert'.

important variables are missing, which casts doubt on the reliability of the model and its results. The second flaw is that the Durbin-Watson statistic points to the presence of auto-correlation in the data. This is another possible source of bias in the model.

We have therefore included the lagged dependent variable in the second model to take care of the auto-correlation. It should come as no surprise that the number of observations decreases. The results indicate that the second problem has been solved. The Durbin-Watson statistic shows that the auto-correlation inherent in the data has been sufficiently controlled for. Moreover the coefficient on LnPOP has decreased by a great deal. We can furthermore see that indeed the coefficients on LnTAR and LnPPP, although they are of the right sign, were biased upwards in absolute magnitude in the first model. The short run price elasticity of the demand for (paid) parking is now estimated to be -.44 and is highly significant. Because of the inclusion of the lagged dependent variable we can also calculate the long run price elasticity by the equation $\beta_1/(1-\beta_2)$, where β_1 is the coefficient on LnTAR and β_2 is the coefficient on LnDEM(t-1). The long run elasticity in Model II is estimated to be –0.44/(1 – 0.56) which is equal to –1, i.e. perfectly elastic.

Concluding, there appear to be no major flaws in Model II. The coefficients on the control variables are all of the right sign, have plausible magnitudes and are significant at the 1% level. The relation between parking demand and parking price appears significant and inelastic; the short term and long term price elasticity of parking demand are estimated to be –0.44 and –1 respectively.

6.2 Influence of parking tariffs on retail sector

An issue often discussed throughout this paper is the relation between shop sales and parking tariffs. Although in a partial analysis tariffs can be shown to be an efficient measure for fighting parking externalities, a detrimental effect can be their negative influence on shop sales and profits. In the previous sections the existing empirical literature is shown to be rather shaky and highly inconclusive regarding this issue. We have therefore gathered data for the city of Amsterdam so as to test the relation in a more rigorous fashion.

The model we will estimate will again make use of fixed effects per city-district and the dependent variable is now $EMPL_{i,t}$. We think this is a reasonable proxy for shop sales, since as shop sales decrease, so will employment (on average). We could have used data on total employment per city-district but we will use data on the retail sector only, since this is the sector we think will react most

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[7] DUMpijp, DUMowm and DUMoudw are the fixed effects for city-district ‘De Pijp’, ‘Oost-Watergraafsmeer’ and ‘Oud-West’ respectively.

heavily to increases in parking tariffs. Identical to the previous section we use $TAR_{i,t}$, $PPP_{i,t}$ and $POP_{i,t}$ as the standard explanatory variables. These variables are again included in logarithmic format so that the resulting coefficients may be interpreted as elasticities. Next to these we will also include the lagged dependent variable LnEMPL(t-1) as an explanatory factor. The number of useable observations is limited so in order to increase efficiency we again excluded insignificant fixed effects until the included ones were all significant at the 5% level.

Table 3 shows results of models identical to those we used in the previous section. To save space we have not reported coefficients on the fixed effects per city-district. We can however state that in both models all fixed effects are included in the final specification because they were all significant at a 5% level of significance.

Table 3. The influence of parking tariffs on employment in the retail sector (dependent variable is LnEMPL; t-values in parentheses)

variable	Model I	Model II
Constant		
LnEMPL(t-1)		
LnTAR		
LnPPP		
LnPOP		
R^2 (adjusted)		
NOBS (DOF)		
Durbin-Watson		

* = Significant at a 5% level of significance.
** = Significant at a 1% level of significance.

First, Model I again has a fairly low Durbin-Watson statistic. We have therefore included the lagged dependent variable in the second model. As we can see the statistic has improved in Model II. Furthermore, the coefficient on the lagged dependent variable is large and significant at the 5% level. Including LnEMPL(t-1) in the model therefore appears preferable.

Second, the coefficient on LnTAR is very small and statistically insignificant in both models. An effect of parking tariffs on employment in the retail sector appears absent. Another important issue is

that an increase in a city-district's population appears to have a highly significant and large positive effect on the city-district's retail sector. Moreover, the magnitude of the elasticity is of a plausible level, though somewhat low in Model II. Despite the fact that these results were to be expected, they give us some confidence about our model specifications and results.

Furthermore the results show that the coefficient on LnPPP is rather small in both models and significant only in Model II (although the insignificance of the coefficient in Model I is probably largely due to the small number of observations). At first sight it seems to be of the wrong sign since we would expect that if the number of parking places increases, then retail sales and retail employees will either increase or stay constant.
However, the variable PPP does not represent the number of parking places but the number of *paid* parking places. Theoretically, there are two opposite effects of an increase in the number of paid parking places. First, assuming the total number of parking places constant, an increase in the number of paid parking places will increase parking costs, decrease the demand for parking and thereby possibly decrease the amount of shopping time and shop sales. Second, as already set out in section 2, paid parking will lead to a decrease in parking congestion, thereby decreasing the time spent waiting for a parking place and increasing the probability that a parking place is actually found. Since paid parking will negatively influence long term parking most heavily, the according this line of reasoning there will be an increase in short term parking. Since parking for shopping purposes will mainly be short term parking, an increase in the amount of time spent shopping and shop sales can be expected.

Since we have two possible opposite effects the sign of the relationship between the number of paid parking places and retail employment has to be determined empirically. Our data and model suggest that the former effect slightly dominates the latter. The short term and long term elasticities are estimated to be –0.024 and –0.038 respectively. A remaining question is whether this effect has had a large impact in Amsterdam or not. An interesting illustration in this respect is the increase in number of paid parking places in the inner city of Amsterdam in 1994 and 1995.

Table 4. Estimated impact of increase in paid parking on retail employment in the inner city of Amsterdam in 1994 and 1995

Year	Δ PPP	Empl	Δ Empl Short Run	Δ Empl Long Run
1994	21.06%	7763		
1995	11.37%	7573		

As Table 4 shows, the increase in number of paid parking places in 1994 of 21.06% will lead to an estimated decrease in retail employment of 40 people in the short run and 62 in the long run. For 1995

the short and long run decrease in retail employment are estimated to be 21 and 34 respectively. We can therefore conclude that increasing parking tariffs does not appear to have had an important influence on the retail sector in Amsterdam. However, although the estimated elasticity is small, increasing the number of paid parking places does seem to have had important negative consequences.

7. Discussion.

The market for parking is characterised by various distortions. We demonstrate that congestion costs and information problems lead to substantial inefficiencies in parking behaviour (search, waiting). It is argued that pricing measures are effective to address these problems. An additional distortion concerns the negative economic effect of parked cars on cities with an attractive historical centre. Also in residential quarters, parked cars will have a negative effect on the attractiveness of the area. We demonstrate that given the structure of the marginal external costs involved, pricing measures are not attractive. Limitations on parking places are a more favourable candidate to address this specific problem. Since for the other distortions pricing measures are promising instruments, a mixture of pricing and quantity regulation would be called for.

A possible consequence of pricing and quantity regulation of parking is that it would negatively affect the vitality of shopping areas in cities. In this paper we have indicated that the possible reactions of consumers and the factors influencing them are so numerous, that general inferences from theoretical models are not warranted. The actual relation between paid parking and sales and profits of shops therefore has to be determined empirically.

A first finding is that the aggregate statistics on shopping trips in the Netherlands do not reveal trends in terms of longer distance shopping patterns, or a shift away from the car during the last decade. Yet, the last decade was characterised by a large scale introduction of paid parking in shopping areas. A possible explanation is that with the current levels of prices for parking the positive effects for visitors (less uncertainty about parking opportunities, less waiting time, less search) dominate the negative budgetary effect. An important point seems to be that the introduction of a low parking charge per hour does not strongly hurt visitors, while at the same time it is effective to discourage long term parking (by residents, personnel). Thus the introduction of low parking charges leads to a reallocation of parking space from long term to short term parking.

Furthermore, an analysis on 30 municipalities in The Netherlands shows that the influence of the *number of parking places within walking distance* has a small positive and insignificant effect on the *performance of central shopping areas*. The analysis uses fairly aggregated data. Therefore, a set of studies using micro-level data was retrieved from the literature in the hope that it would provide more

insight. Based on this set we have to conclude that different studies provide different insights into our problem and that, largely in accord with the discussion provided in section 3, the specific context in which the introduction of a paid parking scheme takes place is crucial. Based on the fact that the larger part of the existing studies finds no relation between paid parking and sales, we could state that the effect of introducing paid parking schemes on the sales and profits of incumbent shops in Dutch inner cities is on average small and insignificant. The number of studies and the number of cities investigated is however too small to warrant such a general conclusion. Analysis using micro-level data on the parking situation and competitiveness of inner cities would be fruitful in giving more definitive answers regarding this issue.

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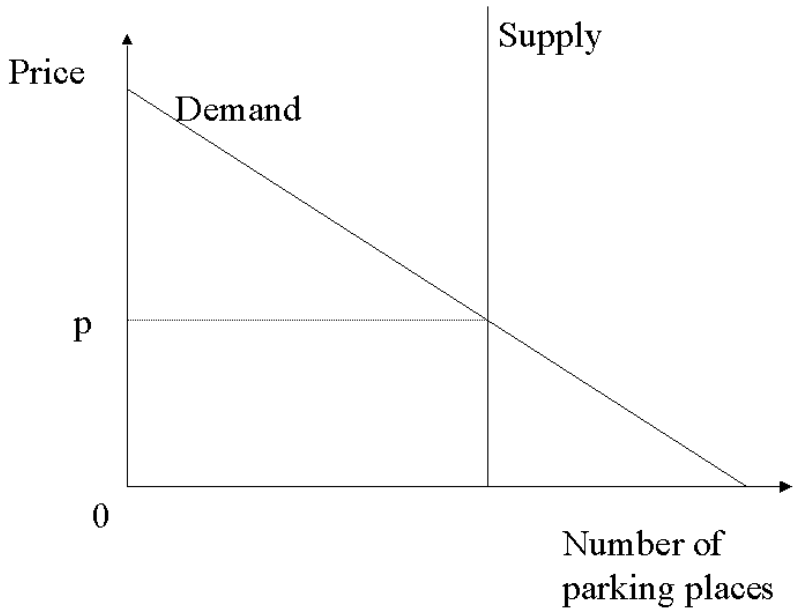

Figure 1

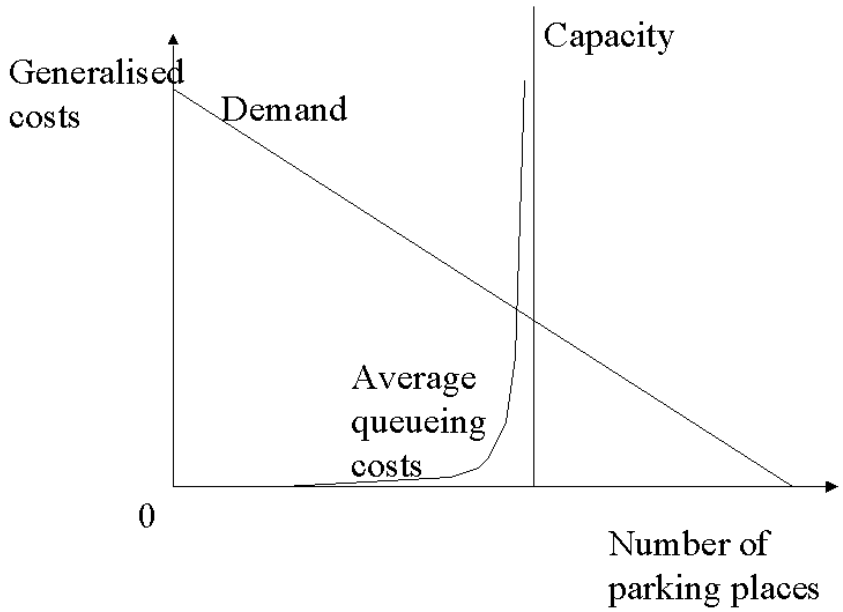
Capacity
Generalised
costs
Demand
Average
queueing
costs
0
Number of
parking places

Figure 2

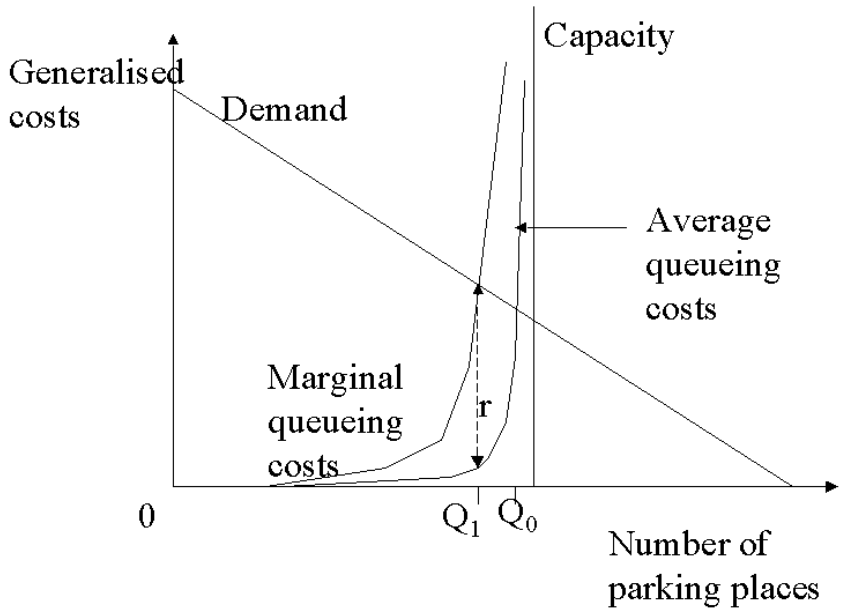
Capacity
Generalised costs
Demand
Average queueing costs
Marginal queueing costs
r
0
Q_1
Q_0
Number of parking places

Figure 3

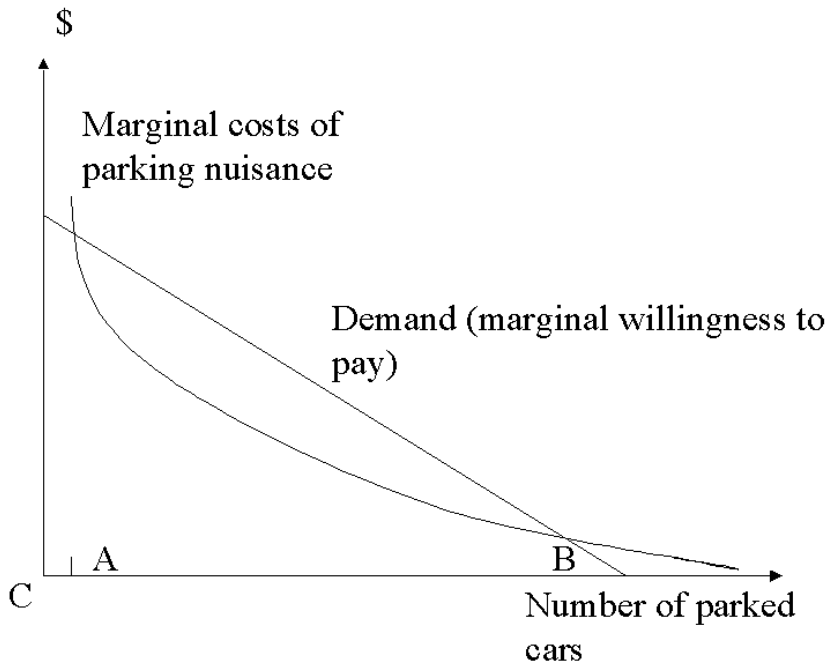
$
Marginal costs of parking nuisance
Demand (marginal willingness to pay)
A
B
C
Number of parked cars

Figure 4