# PARKING AT AND AROUND DOWNTOWN SHOPPING MALLS

by

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## Abstract

This thesis focuses on the parking behaviors of individuals at and around downtown shopping malls. I express a real life parking problem where a sequential game is played between the mall and individuals, and I model the problem. In the model, the mall decides the price of the good, the parking fee, and the capacity of the mall, then individuals decide to park either at the mall or the curbside. Individuals are determined endogenously according to their valuations of the good that the monopolist shopping mall has produced. I determined the equilibrium and also solved for the social optimum where a social planner controls the parking fee. I find that both the equilibrium and social optimum parking fees are positive. Moreover, the socially optimum parking fee is higher than the equilibrium parking fee.

**ŞEHİR İÇİ ALIŞVERİŞ MERKEZLERİNDE VE ÇEVRESİNDE PARKLANMA**

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**Anahtar Kelimeler:** park ekonomisi; alışveriş merkezi; park yeri ücreti; taşan parklanma; trafik sıkışıklığı

## Özet

Bu tezde, bireylerin şehir içi alışveriş merkezlerindeki park etme davranışlarına odaklanılmaktadır. Gerçek hayatta bireyler ve alışveriş merkezi arasında ardışık bir oyun şeklinde gerçekleşen bir park etme problemi modellenmektedir. Modelde alışveriş merkezi ürün fiyatına, park yeri ücretine ve otopark alanının kapasitesine karar vermektedir, daha sonra ise bireyler alışveriş merkezine ya da yol kenarına park etmeye karar vermektedirler. Bireyler model içerisinde alışveriş merkezinin ürettiği ürüne verdikleri değere göre belirlenmektedir. Dengeyi belirlerlemekle birlikte problemi sosyal bir planlayıcının park yeri ücretini kontrol ettiği durum için de çözdüm. Sonuç olarak hem dengedeki hem de toplum için optimal olan otopark yeri ücretleri pozitif olmaktadır. Dahası toplum için optimal olan park yeri ücreti dengedekinden daha büyük bir değer almaktadır.

## Contents

## 1 Introduction

The motivation for this paper is a parking price policy enforced by the city of Istanbul and the subsequent conflict between mall owners and the city council. The city pronounced in 2007 that the first three hours of shopping mall parking must be free to prevent spillover parking and traffic congestion. However, mall owners opposed this new order since they suffer from low gain from parking space and negative externalities of residents who enjoy free parking slots. Therefore, mall owners took this case to the administrative court of Istanbul and the court decided that malls can charge a parking fee. However, the conflict had not ended yet. The state council of Turkey (DANIŞTAY) reversed the judgment and decided that the first three hours of parking spaces must be free for all people. During this decision process all approaches were from a political or legal perspective and we cannot say that there were economical analyses that affected the final judgment. Thus, throughout this paper I seek an answer of the question ”is a free parking fee at downtown malls better for society?”.

This paper examines the effects of a downtown shopping mall on the parking behavior of individuals and externalities imposed on society in various aspects. While integrating on-street parking with shopping mall parking, I also analyze the spillover parking and traffic congestion effects. In the model, where there are a residential area and a downtown shopping mall, individuals decide to park at the mall or curbside, and they come to the mall by car. First, I analyze the equilibrium parking fee without any intervention of the city council. Then, I analyze the socially optimal parking fee when the city chooses the parking fee and make a comparison between the equilibrium and socially optimal parking fees. In this paper, I determined the equilibrium parking fee and socially optimal parking fee when the city behaves as a social planner and both the equilibrium and city's socially optimal parking fees are always positive. Moreover, I show that the socially optimal parking fee is lower than the equilibrium parking fee.

Shopping mall parking is a highly new area in the economics of parking. As far as I know, Hasker and Inci (2014) is the first attempt to analyze shopping mall parking behavior. They focus on suburban shopping malls and show that providing free parking for consumers is socially optimal. Even though suburban malls allocate large amounts of space to provide parking lots, they embed the costs of parking in the prices of goods by providing parking free. In their model there is a risk-neutral monopolist shopping mall which sells a good and the only way to reach the mall is by car. Their innovation in the model is that people who cannot find their desired goods at the shopping mall go back home empty-handed. In this case, charging a parking fee becomes a punishment to people who cannot find their desired good. To insure these individuals, the shopping mall embeds the parking fee in the price of goods that it sells, and charges a zero fee for parking. They show that this result is also the second-best social optimum, and moreover it holds either that the monopoly mall has competitive monopoly power and prices competitively or there is parking validation or a trade-off between shopping and parking spaces. In the extensions section of the paper, they briefly analyze the parking fee in urban areas which is highly relevant to my research. They find that if there is a high enough probability of customers to be able to purchase the good, then the equilibrium parking fee is positive.

Ersoy, Hasker, and Inci (2015) use a similar model to Hasker and Inci (2014); however, it can be differentiated in three main aspects. Firstly, in Ersoy, Hasker, and Inci (2015) there is a mode choice to come to the mall. Individuals come to the mall either by car or public transportation. Secondly, none of the modes cause traffic congestion which implicitly assumes that the shopping mall is in a suburban area. Thirdly, unlike Hasker and Inci (2014), they guarantee that shoppers can find their desired goods at the mall with certainty. Therefore, this assumption eliminates the insurance motive of the mall and emphasizes the direct effects of public transportation that are added to the model. They find that parking again can be free. Furthermore, even in cases where the parking fee is positive, the equilibrium parking fee is always less than the marginal cost of the parking space. Therefore, whether the parking fee is zero or positive, the mall always employs loss-leader pricing, and they show that this can even be socially optimal.

There are three main differences between the model that I introduce and Hasker and Inci (2014)'s model. Firstly, in their model shopping malls have to provide parking spaces to the shoppers and the shoppers can only park at the mall's parking lot. However, in my model, the shopping mall does not have to provide a parking space. It decides the quantity of space. Moreover, individuals who come to the mall also have another option; they can park curbside and they can cause spillover parking and traffic congestion. Secondly, in Hasker and Inci (2014) all individuals who need to park are shoppers; there is no other type of individual (residents) who can use parking spaces. In my model, there are residents who can park either at the mall or curbside, and they can also prevent more shoppers from coming to the mall; therefore the mall should also consider the residents in parking fee decisions and the capacity of the parking space. The aim of these two assumptions is to represent a daily spillover parking problem in downtown areas. Shoppers who park curbside and residents who park at the mall can cause misallocation and efficiency loss. While the parking fee is increasing, individuals tend to park curbside, and while parking fee is decreasing they tend to park at the mall. In this paper I also analyze the allocations of shoppers and residents in the equilibrium. The third difference is the same as Ersoy, Inci and Hasker's (2015) model; shoppers can find the goods that they wanted for sure. Therefore, by eliminating the insurance motive of the mall, I emphasize the direct effects of the parking behavior of shoppers and residents over spillover parking traffic congestion.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 sets up the model and derives the equilibrium, the allocations of individuals and the social optimum. Section 4 concludes. An appendix contains some details and proofs.

## 2 Literature Review

The study of the economics of parking mainly started to grow in the early 1990's. Although there were several papers about parking before the 1990's, transportation economics did not pay much attention to the parking behavior of individuals. Vickrey's (1969) paper can be serve as an example of a pioneering work which introduces a time varying parking fee as a substitute of congestion pricing. In this section, I review some of the papers that create infrastructure of economics of parking.

Verhoef, Nijkamp, and Rietveld (1995) argue that the literature mainly agrees on road pricing as the first option in regulating traffic. Therefore, they introduce the possibilities of parking policies in traffic regulation as the alternatives to road pricing. They analyze the two fundamental parking policies, which are regulations on parking prices and restrictions on the supply of parking spaces, and compare them. They make three main assumptions to highlight the relationship between parking and mobility. An equal length of urban road is driven by individuals in their trips; traffic congestion is equally distributed in the urban area; and the government is the single authority in controlling parking spaces. Although parking fees and supply restrictions are not mutually exclusive, they show that time dependent parking fees are superior when these policies of parking are equivalent to road pricing. They then construct a spatial parking model and analyze the problem of constant regulatory parking policies while the lengths of trips are varied. They show that this problem can be solved when a proper spatial pattern of parking fees is specified and individuals respond to differentiation of parking fees.

Arnott and Rowse (1999) construct a simple stochastic model of parking congestion that examines the driver's search for an available parking space on a circular road. In their model, the mean density of available parking spaces is endogenously determined. The demand of individuals for parking is derived from their demand for trips, and trip opportunities are assumed to be exogenous, stochastic and time invariant. For the simplicity of the model, they do not include the flow congestion of cars and also assume spatial and temporal homogeneity. Despite these simplifications, they reach highly complex results because of the stocasticity of the model. They need stochasticity due to the existence of cruising for parking and to evaluate parking information systems that are used by many cities. They examine the equilibrium with no parking fee and the social optimum. They also examine for the equilibrium with a parking fee. They then analyze the decentralization of the social optimum by using the parking fee. In their model, each driver contributes to parking congestion externality because drivers ignore the fact that their parking affects the mean density of parking spaces, and authors find that the equilibrium parking fee is equal to the negative externality of parking congestion.

Anderson and de Palma (2004) approach parking as a common property resource and they study on the pricing of parking in various dimensions. They mainly focus on unassigned parking that individuals search around for the usage of shorter time periods. They are not interested in individuals who have long term contracts to avoid the bother of daily search of parking. Specifically, their model is designed for individuals who have less regular trips who do not have regular parking routine such as tourists or shoppers. In the model, each extra parker increases the others' search time of parking, and the number of parkers and number of parking spaces are taken as exogenous. They analyze equilibrium with underpriced parking, social optimum, and they then compare it with the price of parking by monopolistically competitive private parking lot operators. Since unassigned parking spaces are free, parking spaces that are close to the most desirable destination are over-exploited, and less desirable parking lots are under-used. Therefore, the optimal pricing includes the externalities of congestion and differentiate among closer and further locations. They show that the private ownership of parking lots in a market system can decentralize the optimal configuration under private ownership where parking lots are priced diversely and in a monopolistically competitive manner.

Anderson and de Palma (2007) extended their model in Andersen and de Palma (2004). In the model of the latter parking lands are exogenous and people have to park somewhere; walking to the desired place is not an option. In Anderson and de Palma (2007) they allow endogenously determined parking land and land rents are determined in the model. They show that again socially optimum is reached under a monopolistically competitive market. Moreover, in the equilibrium residents who are close to the city can walk directly to the desired places without using their cars, while those who come from far away, drive to a parking space and then walk the remaining distance.

Verhoef (1995), Arnott and Rowse (1999), and Anderson and Palma (2004) analyze their problem when there is no off-street parking market. Caltroph and Proost (2006) think that eliminating an alternative parking option is restrictive. They focus on regulation of on-street parking when there is a monopolistic off-street parking option. In their model, identical individuals such as shoppers or tourists driving to the urban area and search for a parking space. They have two options; they either park at a private parking facility or search for an available spot on street. When on-street parking fee is lower than the private parking fee, people want to search for cheaper spots. If the difference between two options is higher, more number of individuals want to invest for searching an available spot. They find that in the equilibrium government choose on-street parking fee equal to the private parking fee in order to minimize the search cost. Moreover, they show that this setting is socially optimal when the supply of private parking space is competitive. They also show that the optimal price of on-street parking space is equal to marginal cost of private parking space when the supply of on street parking is sufficiently low relatively to the demand and the supply of private parking space is competitive. This allocation is also optimal in first best sense.

Arnott and Inci (2006) is the first attempt to understand and analyze the cruising for parking from an economic perspective. They construct a simple downtown parking model that connects saturated (fully occupied) on-street parking and traffic congestion, so that the number of cars that search for a parking space increase traffic congestion. In their model, the number of on-street parking spaces and parking duration per trip and trip length are fixed. There is endogenously determined travel time which contains in-transit travel time and time spent cruising for parking and it is equally affected by both of them. They show that it is efficient to set the parking fee at a level where parking is fully occupied without cruising for parking. On the other hand, they also analyze the steady-state social optimum for the on-street parking when the level of parking capacity is fixed and variable. In first-best optimum, on-street parking space should be set at a level that the efficient parking fee covers the externality of traffic congestion and there is no cruising for parking whether parking is variable or fixed. In second-best optimum where there is fixed parking fee, on-street parking space should be set at a level that parking remains fully occupied where there is no cruising for parking.

According to the economic theory, residential parking permits generally increase inefficiencies except for some cases such as residents' willingness to pay for parking is greater than non-residents. Van Ommeren, Wentink, and Dekkers (2011) estimate the money that residents want to pay for parking permits and the cost of cruising for residents in Amsterdam by using the estimates of economic value of on-street private parking and the data of parking permits waiting lists. Then, they make a comparison between the estimated money and on-street parking fees that non-residents pay. Their empirical results show that, an outside parking space increases the value of houses that are close to the residential parking permits more than the value of houses that are close to the on-street parking areas. Moreover, they show the amount of money that the marginal resident wants to pay for a parking permit is approximately 10 euro per day. This is higher than the amount that residents pay for a parking permit but lower than the on-street parking fee that a non-residents pay. Therefore, there are high inefficiencies about use of on-street parking spaces.

Molenda and Sieg (2013) focus on parking behavior of individuals at crowded and central residential areas, and commercial districts of the cities. Residents who live in downtown areas (close to the shopping malls, theaters, office buildings etc.) enjoy the location advantage of their homes; however they suffer from the difficulty of finding an available parking slot. In their simple model, there are two types of individuals who are residents and visitors, and two types of parking options which are parking at parking lots that is further away from city center or on-street parking that close to residential area and all the facilities. In the model, their aim is to identify the trade-off between residents' priority on parking lots and the availability of various products in commercial districts, and examine the optimal policy of sharing of residential parking spaces from the perspective of residents and the social planner. They identify under which situations turning on-street parking spaces into residential parking spaces can be rational. Moreover, they find the optimal allocation of residential parking areas, and show that when there is privileged on-street parking for residents, economic efficiency cannot be ensured.

In the literature, downtown parking pricing has more attention than downtown parking capacity. Arnott, Inci, and Rowse (2015) approach differently and focus on the optimal downtown curbside parking allocation when private sector provides parking spaces (garage parking). They look at the optimal proportion of curbside to be allocated for parking when there is exogenous curbside parking fee. The first best-optimum results are straightforward and there is no cruising for parking. Moreover, in the low demand intensity there is only curbside parking. When demand intensity is sufficiently high i.e. intermediate, both curbside and garage parking occurs. If demand intensity is very high then there is only garage parking. In the case that where curbside parking is underpriced and there is low demand intensity, excess demand occurs. The social surplus is maximized at a point when the curbside parking capacity increases until excess demand is eliminated which makes garage parking unprofitable. If demand intensity is very high, the social surplus is so close to its maximum even there is no curbside parking, and any curbside allocated to parking increases traffic congestion. Therefore, there is no curbside parking in the second-best optimum and for the both cases where demand intensity is low or high, there is no cruising for parking.

## 3 The Model

In this section, I describe the model and its assumptions. There is a monopolist shopping mall in a downtown area, and it is owned by a monopolist and risk-neutral mall owner. The mall sells one good, which has no cost, and at a non negative price, $P$. Only vehicle that can be used to come to the mall is a car. The shopping mall provides parking spaces for shoppers and residents who can use these parking spaces for errands other than shopping.

The mall decides on the capacity of the parking space, $Q$. The cost of parking spaces is defined by a functional form $c(Q)^2$ where $c > 0$ is a constant coefficient of the cost function. The intuition behind this cost function depends on the assumption that the cost of an extra parking space increases with an increasing rate because land is expensive in downtown areas. The parking fee charged by the mall is $t$; and all $t$, $P$, and $Q$ are common knowledge; and the mall decides on them.

There are two groups of agents in this model. The first group is consumers who come for shopping, and the second one is residents. Intuitively, residents are people who come to the residential area but use parking spaces of the shopping mall. The consumers' only aim is to shop and go back to their homes after that. For both groups there are two places to park: they can either park at the shopping mall or curbside. Therefore, there are four types of individuals according to their parking forms: shoppers who park at the shopping mall, $S_M$ and curbside, $S_C$, and residents who park at the shopping mall, $R_M$ and curbside $R_C$. There is no capacity limit for outside parking area; however, there is an increasing cost function $k(S_C + R_C)^2$ for both shoppers and non-shoppers where $k > 0$ constant coefficient of cost function. When the number of individuals increases in traffic, both traffic congestion and time spent for cruising for parking increases. Moreover, this increase in cost is not linear with the increase in the number of individuals; cost rather, increases at an increasing rate. Lastly, there is a walking cost w for shoppers who park outside and residents who park at mall. Intuitively, shoppers who park curbside walk to the mall, and they consider this cost in the parking decision. For example, a family who comes to buy some furniture from Ikea takes this cost into account. On the other hand, residents who suffer from cruising for parking may choose to park at the mall, but I cannot ignore the fact that they have to walk to their home. For example, after a busy day people may pay a parking fee, and they do not want to deal with traffic congestion. However, if they consider the distance they will walk, they can change their mind and they may not want to pay a parking fee and walk after that. Therefore, I include this cost to express this real life situation.

The value of the good to a shopper is $v$, which has the cumulative distribution function $F(v)$ with support $[0; v]$ and the probability density function $f(v) > 0$. The residents have the constant utility of $D$ from their activities. Therefore, the utility of a shopper who parks at the shopping mall is the difference between his valuation to the good and price of the good, and the parking fee $i.e.$ $V - P - t$ and that for a shopper who parks curbside is the difference between his valuation to the good and the price of the good and the cost of cruising for parking and traffic congestion, and the walking cost $i.e.$ $V - P - k(S_C + R_C)^2 - w$. The utility of a resident who parks at the shopping mall is the difference between his utility $D$ and the parking fee, and the walking cost $i.e.$ $D - t - w$ and that for a resident who parks curbside is the difference between his utility $D$ and the cost of cruising for parking and traffic congestion $i.e.$ $D - k(S_C + R_C)^2$. There is $N$ mass of individual in this model. $N$ can be identified as people who has car and people have not parked yet at or around the shopping mall. Since people who come to the mall by walking do not effect traffic congestion or spillover parking, there is no need to include them. Therefore, this model focus on decisions of people who have not park yet and make a decision between parking residential area (curbside) or at the shopping mall, and outcome of their decisions in various aspects. Overall, the model can be thought as a sequential game. In the first stage, the shopping mall decides on the price of the good, the parking fee, and the the capacity of parking space. Then, in the second stage, shoppers and residents choose to park at the shopping mall or curbside.

### 3.1 Equilibrium

In this section, I determine the equilibrium price of good, $P$, the equilibrium quantity of parking space, $Q$, and the equilibrium parking fee, $t$. Furthermore, I determine the distribution of $N$ mass of individual according to their parking decisions in the equilibrium. Since, it is a sequential game I will start with the problem of individuals and then continue with the problem of the mall by applying the backward induction.

#### 3.1.1 Individuals

There are two groups of individuals who are shoppers and residents and they are determined endogenously. These individuals choose to park at the mall or curbside. A shopper parks at the mall if his utility of parking at the mall is greater than the utility of parking curbside, $i.e.$ $V - P - t > V - P - k(S_C + R_C)^2 - w$. Similarly, he parks curbside if his utility of parking curbside is greater than the utility of parking at the mall, $i.e.$ $V - P - k(S_C + R_C)^2 - w > V - P - t$. He is indifferent between parking at the mall and parking curbside if he has same utilities from both of them, $i.e.$ $V - P - t = V - P - k(S_C + R_C)^2 - w$. A resident parks at the mall if his utility of parking at the mall is greater than the utility of parking curbside, $i.e.$ $D - t - w > D - k(S_C + R_C)^2$. Similarly, he parks curbside if his utility of parking curbside is greater than the utility of parking at the mall, $i.e.$ $D - k(S_C + R_C)^2 > D - t - w$. He is indifferent between parking at the mall and parking curbside if he has same utilities from both of them, $i.e.$ $D - t - w = D - k(S_C + R_C)^2$.

For the equilibrium, there are two possible equilibrium allocations such that either shoppers or residents are indifferent between parking at the mall and parking curbside, $i.e.$ either $V - P - t = V - P - k(S_C + R_C)^2 - w$ or $D - t - w = D - k(S_C + R_C)^2$. If neither of the two groups are indifferent, people want to move to other option. Therefore, there are four possible cases when there is no indifference.

For the first case, if the utility of parking at the mall is higher than the utility of parking curbside for a shopper $i.e.$ $V - P - t > V - P - k(S_C + R_C)^2 - w$ and the utility of parking curbside is higher than the utility of parking at the mall for a resident $D - t - w < D - k(S_C + R_C)^2$, then shoppers want to park at the mall and residents want to park curbside. Therefore, there will be a reallocation of parking spaces. Thus, this cannot be an equilibrium.

For the second case, the exact opposite of the previous one, if the utility of parking at the mall is lower than the utility of parking curbside for a shopper $i.e.$ $V - P - t < V - P - k(S_C + R_C)^2 - w$ and the utility of parking curbside is lower than the utility of parking at the mall for a resident $i.e.$ $D - t - w > D - k(S_C + R_C)^2$, then shoppers want to park curbside and residents want to park at the mall. Therefore, again there will be a reallocation of parking spaces between individuals. Thus, this cannot be an equilibrium.

For the third case, if for both of the shoppers and residents, the utility of parking at the mall is higher than the utility of parking curbside $i.e.$ $V - P - t > V - P - k(S_C + R_C)^2 - w$ and $D - t - w > D - k(S_C + R_C)^2$, then all individuals who park at the mall want to park curbside. Therefore again here we cannot talk about an equilibrium.

For the fourth case, when for both of the shoppers and residents, the utility of parking at the mall is lower than the utility of parking curbside $i.e.$ $V - P - t < V - P - k(S_C + R_C)^2 - w$ and $D - t - w < D - k(S_C + R_C)^2$. This situation cannot occur since a shopping mall wants to maximize its profit. In this case, the mall has the chance of increasing the parking fee without losing any customer because even if parking fee is higher individuals who park at the mall do not want to move by reason of they are still better off. Thus, this cannot be an equilibrium.

After showing any of the four cases cannot be an equilibrium , I go back for the two possible equilibrium allocations. The one where shoppers are indifferent between parking at the mall and curbside $i.e.$ $V - P - t = V - P - k(S_C + R_C)^2 - w$, and the utility of parking curbside is greater than the utility of parking at the mall for a resident $i.e.$ $D - t - w < D - k(S_C + R_C)^2$ is the only equilibrium. In Appendix A I show why the other one cannot be an equilibrium. I find the optimal parking fee $t^*$ in terms of $k$, $w$, $S_C$, $R_C$ by the help of equation

$$V - P - t = V - P - k(S_C + R_C)^2 - w, \tag{1}$$

and equilibrium parking fee, $t^*$ in terms of $k$, $w$ and $S_C$, $R_C$ is

$$t^* = k(S_C + R_C)^2 + w. \tag{2}$$

Notice that I have not determined the equilibrium fee yet. I only find the structure of $t^*$.

$\tilde{v}$ is the point that individuals are indifferent between shopping and going home and $\tilde{v} = D+P-w$. It can be also thought as the utility of marginal individual who is indifferent between parking at the mall and curbside. In the equilibrium, $F(\tilde{v})N$ individuals are residents since $F(\tilde{v})N$ represents the ratio of individuals who have less utility than the marginal individual, $\tilde{v}$. Therefore,

$$R_C + R_M = F(\tilde{v})N. \tag{3}$$

Since utility of parking curbside is higher than parking at the mall for residents, none of the residents park at the mall $i.e.$ $R_M = 0$, and thus,

$$R_C = F(\tilde{v})N. \tag{4}$$

$(1-F(\tilde{v}))N$ individuals are shoppers since $(1-F(\tilde{v}))N$ represents the ratio of individuals who have more utility than marginal individual, $\tilde{v}$. Thus,

$$S_C + S_M = (1 - F(\tilde{v}))N. \tag{5}$$

Therefore (2), (4) and (5) are the three equilibrium conditions.

### 3.1.2 The Mall

After finding the three equilibrium conditions by solving the problem of individuals, I now go back and solve the problem of the mall. The objective of the mall is maximizing its profit, and its profit is equal to difference between its gain from selling the product to shoppers and the parking fee from individuals who park at the mall, and the cost of building parking space. Therefore, the profit function is

$$\Pi(P, t, Q) = P(S_C + S_M) + t(Q) - c(Q)^2. \tag{6}$$

by using equilibrium condition (5), $\Pi(P, t, Q)$ becomes

$$\Pi(P, t, Q) = P(1 - F(\tilde{v}))N + t(Q) - c(Q)^2. \tag{7}$$

The first order condition with respect to $P$ is

$$\Pi_P : (1 - F(\tilde{v}))N + Pf(\tilde{v})N. \tag{8}$$

Equating the first-order condition with respect to P to zero gives the unique equilibrium price of the good implicitly, $P^*$.

$$P^* = \frac{(1 - F(\tilde{v})}{f(\tilde{v})}. \tag{9}$$

When $P$ increased $\frac{(1-F(\tilde{v})}{f(\tilde{v})}$ decreases and when $P$ decreased $\frac{(1-F(\tilde{v})}{f(\tilde{v})}$ increases, since the equality of $P^* = \frac{(1-F(\tilde{v})}{f(\tilde{v})}$ holds, this yields a contradiction. Therefore, there is a unique $P^*$. The first-order condition with respect to $t$ is

$$\Pi_t : Q. \tag{10}$$

Since $Q > 0$, the mall wants to increase the parking fee as much as possible, however, I have already found that the only possible structure of the equilibrium parking fee is $t^* = k(S_C + R_C)^2 + w$. Therefore, after finding the allocation of shoppers and residents in the equilibrium, I can determine the equilibrium parking fee, $t^*$ in detail. Lastly, the first-order condition with respect to $Q$:

$$\Pi_Q : t - 2cQ. \tag{11}$$

Equating first-order condition with respect to Q, to zero gives the equilibrium capacity of parking space $Q^*$:

$$Q^* = \frac{t^*}{2c}. \tag{12}$$

After finding the equilibrium allocation of individuals, I can determine the equilibrium capacity of parking space in detail, $Q^*$.

### 3.1.3 The Allocation of Individuals at the Equilibrium

The distribution of shoppers and residents are determined in the problem of individuals part. In this subsection I calculate the proportion of shoppers and residents who park at mall or curbside. The individuals who park curbside is equal to difference between $N$ mass of individual and individuals who park at the mall $i.e.$

$$S_C + S_M = N - Q. \tag{13}$$

By inserting equilibrium condition (2) into expression for equilibrium capacity (12) I get

$$Q^* = \frac{k(S_C + R_C)^2 + w}{2c}. \tag{14}$$

Then, I rewrite equation (13) as

$$S_C + R_C = N - \frac{k(S_C + R_C)^2 + w}{2c}. \tag{15}$$

By solving this equation I get individuals who park curbside:

$$S_C + R_C = \frac{\sqrt{c^2 + 2ckN - kw} - c}{k}. \tag{16}$$

Since the structure of the equilibrium parking fee is $t^* = k(S_C + R_C)^2 + w$, the equilibrium parking fee is

$$t^* = \frac{2c}{k}(c + kN - \sqrt{c^2 + 2ckN - kw}). \tag{17}$$

By using the equilibrium parking fee $t$, I also get the equilibrium capacity of parking space since $Q^* = \frac{t^*}{2c}$. Then, $Q^*$:

$$Q^* = \frac{c + kN - \sqrt{c^2 + 2ckN - kw}}{k}. \tag{18}$$

By using equilibrium conditions (4) and (5), and equations (16) and (18) I determine the equilibrium allocation of individuals. The quantity of shoppers who park at the mall is equal to the capacity of the mall since there are no residents who park at mall in the equilibrium, $S_M$ is

$$S_M = \frac{c + kN - \sqrt{c^2 + 2ckN - kw}}{k} = N - \frac{\sqrt{c^2 + 2ckN - kw} - c}{k}. \tag{19}$$

The quantity of shoppers who park curbside is equal to difference between the total quantity of shoppers and the quantity of shoppers who park at the mall (capacity of the mall), $S_C$:

$$\begin{aligned} S_C = (1 - F(\tilde{v}))N - \frac{c + kN - \sqrt{c^2 + 2ckN - kw}}{k} = \\ \frac{\sqrt{c^2 + 2ckN - kw} - c}{k} - F(\tilde{v})N. \end{aligned} \tag{20}$$

The quantity of residents who park at the mall, $R_M$ is equal to zero, and quantity of residents who park curbside, $R_C$ is equal to $F(\tilde{v})N$.

### 3.2 The Social Optimum

In the previous section, I find the equilibrium parking fee, the capacity of parking space and the price of good, moreover I determine the allocation of individuals in the equilibrium. Next question is what will be the second-best socially optimal parking fee that is chosen by the city in order to maximize social welfare. I use the notion of second-best for the social optimality because city can only control the parking fee and cannot control the capacity of parking space at the mall and the price of good. Since the city maximizes the welfare of the society, the welfare function consists of the summation of the utilities of individuals, $i.e.$ $\int_{\tilde{v}}^{\bar{v}} (V - P - t) dF(v)$, $F(\tilde{v})N(D - t + w)$, and the profit of the mall $i.e.$

$P(1 - F(\tilde{v}))N + t(Q) - c(Q)^2$:

$$W(t) = \int_{\tilde{v}}^{\bar{v}} (V - P - t)dF(v) + (R_C + R_M)(D - k(S_C + R_C)^2) + P(S_C + S_M) + t(Q) - c(Q)^2. \tag{21}$$

Using equilibrium conditions (4) and (5) from problem of the individuals, and optimality of the parking space (12) from the problem of the mall, the welfare function becomes

$$W(t) = \int_{\tilde{v}}^{\bar{v}} (V - P - t)dF(v) + F(\tilde{v})(D - t + w) + P(1 - F(\tilde{v})) + \frac{t^2}{2c} - \frac{t^2}{4c}. \tag{22}$$

Since the city controls the parking fee, first-order condition with respect to $t$, is

$$W_t = -\int_{\tilde{v}}^{\bar{v}} dF(v) - F(\tilde{v})N + \frac{t}{c} - \frac{t}{2c}. \tag{23}$$

Equating first order condition with respect to $t$ to zero I get second-best socially optimal parking fee,

$$t_{SO} = 2cN. \tag{24}$$

## 4 Extensions

The subsections 3.1 and 3.2 derive the main results. In this extension section I differentiate the base model in some dimensions to argue that there can be alternative policies for the city, instead of interfering in the shopping mall parking fee. As a first extension I analyze the parking validation. The parking validation case allows the mall to identify the type of individuals. Therefore the mall can charge different parking fees. In this case I determine the parking fees; however, I need to the data to compare with the socially optimal case where the city decides on the parking fee because change in the parking fee changes the distribution of individuals unlike the base model. Although I do not use the data, I reach some important preliminary results for further research. Then, I analyze the situation where curbside parking is not free and it is controlled by the city. In this second extension section the city charges a parking fee to individuals who park curbside instead of deciding the shopping mall parking fee. In this section I show that the city can also reach the socially optimal parking fee by using curbside parking fee. Lastly, I extend the base model by adding a private parking company that provides parking spaces for individuals. In this last case, I find that although the welfare of the city's socially optimal case higher than the private parking company case, the private parking company makes individuals better off.

### 4.1 Parking Validation

In this extension part, now the mall can distinguish shoppers and residents. Therefore, the mall charges two separate parking fees, one for residents $t_R$ and one for shoppers $t_S$. The utility of a shopper who parks at the mall is difference between his valuation to the good and cost of the good, and parking fee $i.e.$ $V - P - t_S$. The utility when he parks curbside does not change and it is same as the base model $V - P - k(S_C + R_C)^2 - w$. The utility of a resident who parks at the mall is difference between his constant utility and parking fee, and walking cost $i.e.$ $D - t_R - w$, and the utility when he parks curbside again does not change from the base model and it is $D - k(S_C + R_C)^2 - w$. The indifference point $\tilde{v}$ changes in this setting and it becomes $\tilde{v} = D + P + t_S - t_R - w$. Notice that now $\tilde{v}$ also depends on parking fees. Thus a change in parking fees can change the allocation of individuals. Here, the profit of the shopping mall is

$$\Pi(P, t_S, t_R, Q) = P(S_M + S_C) + t_S S_M + t_R R_M - cQ^2 \tag{25}$$

The first-order conditions with respect to $P$:

$$\Pi_P : (1 - F(\tilde{v}))N + Pf(\tilde{v})N. \tag{26}$$

Equating the first-order condition with respect to $P$, to zero gives the unique equilibrium price of the good:

$$P^* = \frac{1 - F(\tilde{v})}{f(\tilde{v})}. \tag{27}$$

The first-order conditions with respect to $t_S$:

$$\Pi_{t_S} : P(-f(\tilde{v}))N + S_M. \tag{28}$$

By using $P^* = \frac{1-F(\tilde{v})}{f(\tilde{v})}$, $\Pi_{t_S}$ becomes

$$\Pi_{t_S} : (F(\tilde{v}) - 1)N + S_M < 0 \tag{29}$$

Since $(F(\tilde{v}) - 1)N + S_M$ is negative, parking fee for shoppers is equal to zero $i.e.$ $t_S = 0$. Therefore, the shopping mall charges no parking fee to the shoppers. Then, the first-order conditions with respect to $t_R$:

$$\Pi_{t_S} : P(f(\tilde{v}))N + R_M. \tag{30}$$

By using $P^* = \frac{1-F(v)}{f(v)}$, then $\Pi_{t_R}$ becomes

$$\Pi_{t_R} : (1 - F(\tilde{v}))N + S_M > 0. \tag{31}$$

Since $(F(\tilde{v})-1)N+S_M$ is positive, the mall wants to increase parking fee for residents as much as it can. The only possible equilibrium situation is where residents are indifferent between parking at the mall and curbside $i.e.$ $D - t_R - w = D - k(S_C + R_C)^2$ and utility of parking at the mall is greater than utility of parking at curbside for the shoppers $i.e.$ $V - P - t_S > V - P - k(S_C + R_C)^2 - w$. Since the shopping mall parking fee is zero the second one is trivial. For the indifference of residents, if the mall chooses parking fee such that the utility of parking curbside is greater than the utility of parking at the mall, then no resident park at the mall. Therefore, the mall cannot gain any fee from residents and this cannot be an equilibrium. If the utility of parking curbside is greater than utility of parking at the mall then, this means that the mall does not maximize its profit since it can increase parking fee without losing any individual. Thus, this cannot be an equilibrium. Therefore the structure of $t_R$ is $k(S_C + R_C)^2 - w$. I rewrite the profit function of the mall by using $t_S = 0$ and writing $Q - S_M$ instead of $R_M$ to find the capacity. Then, $\Pi(P, t_S, t_R, Q)$ becomes $\Pi(P, t_R, Q)$:

$$\Pi(P, t_R, Q) = P(S_M + S_C) + t_R(Q - S_M) - cQ^2 \tag{32}$$

The first-order conditions with respect to $Q$:

$$\Pi_Q : t_R - 2cQ. \tag{33}$$

Equating the first-order condition with respect to $Q$, to zero I get equilibrium capacity

$$Q^* = \frac{t_R}{2c}. \tag{34}$$

Summation of shoppers who park at the mall and curbside is equal to total number of individuals $N$ $i.e.$

$$\underbrace{\frac{k(S_C + R_C)^2 - w}{2c}}_{S_M + R_M} + S_C + R_C = N. \tag{35}$$

Then, I get people who park curbside;

$$S_C + R_C = \frac{\sqrt{c^2 + 2ckN + kw} - c}{k}. \tag{36}$$

Parking fee for residents $t_R$ is

$$t_R = \frac{-2c\sqrt{c^2 + 2ckN + kw} + 2c^2}{k} + 2w + 2cN. \tag{37}$$

For a detailed analyze of the parking validation and comparison of it with the socially optimal case where the city decides parking fee, I need the data. Therefore, I end this part with some important results that can help a further research. Firstly, when the mall can identify the individuals as shopper and resident, it does not charge any parking fee to shoppers. Only residents who park at the mall pay the parking fee. Secondly, the parking fee for residents is lower than the socially optimal parking fee for high enough $N$. Thirdly, when there is parking validation, there are more shoppers in the society when it compared with the socially optimal case. Intuitively, free parking for shoppers promote people to shop. Lastly, in the parking validation case the capacity of the mall is smaller and there are more individuals who park curbside. Intuitively, when the parking fee decreases the mall need to decrease the cost of parking space. Therefore, the capacity of the mall decreases and more people park curbside.

### 4.2 Curbside Parking Fee

I consider a situation where there exists a curbside parking fee $t_C$, and it is controlled by the city in order to maximize the social welfare. The utility of residents and shoppers who park at the mall does not change from the base model, and the utilities are $D - t - w$ and $V - P - t$. Since residents and shoppers who park curbside pay a curbside parking fee, their utilities become $V - P - k(S_C + R_C)^2 - w - t_C$ and $D - k(S_C + R_C)^2 - t_C$.

Firstly, problem of the individuals is same as the base model (see section 3.1.1). Adding $t_C$ to curbside cost does not change the equilibrium structure. Therefore, the only possible equilibrium is where shoppers are indifferent between parking at the mall and curbside $i.e.$ $V - P - t = V - P - k(S_C + R_C)^2 - w - t_C$ and the utility of parking curbside is greater than parking at the mall for residents $i.e.$ $D - t - w < D - k(S_C + R_C)^2 - t_C$. Thus, the structure of equilibrium parking fee, $t^*$ in terms of $k$, $w$ and $S_C$, $R_C$, $t_C$ is:

$$t^* = k(S_C + R_C)^2 + w + t_C, \tag{38}$$

$\tilde{v}$ does not change since it depends on $D$, $P$, and $w$ $i.e.$ $v = D + P - w$. In the equilibrium, $F(\tilde{v})N$ individuals are residents $i.e.$

$$R_C + R_M = F(\tilde{v})N, \tag{39}$$

and since utility of parking curbside is higher than parking at the mall, none of the shoppers park at mall $i.e.$ $R_M = 0$, and thus

$$R_C = F(\tilde{v})N, \tag{40}$$

and $(1 - F(\tilde{v}))N$ individuals are shoppers $i.e.$

$$S_C + S_M = (1 - F(\tilde{v}))N. \tag{41}$$

Secondly, problem of the mall, follows the same path as the base model since the profit function does not change $i.e.$ $\Pi(P, t, Q) = P(1-F(\tilde{v}))N + t(Q) - c(Q)^2$. Therefore, first-order conditions have same results as the equilibrium and $P^*$ is unique, the mall wants to increase $t^*$ as much as it can, and the capacity of the mall is $Q^* = \frac{t^*}{2c}$. Lastly, I analyze the allocation of individuals to determine the parking fees. Summation of individuals who park at the mall and curbside is equal to the total quantity of individuals $N$, $i.e.$

$$S_C + R_C + Q = N. \tag{42}$$

By using $Q^* = \frac{t^*}{2c}$ I get

$$S_C + R_C + \underbrace{\frac{k(S_C + R_C)^2 + w + t_C}{2c}}_{S_M + R_M} = N. \tag{43}$$

From the equation, individuals who park curbside are

$$S_C + R_C = \frac{\sqrt{c^2 + 2ckN - kw - kt_C} - c}{k}. \tag{44}$$

Since the structure of the equilibrium parking fee is $t^* = k(S_C + R_C)^2 + w + t_C$, the equilibrium parking fee, $t^*$ is

$$t^* = \frac{2c}{k}(c + kN - \sqrt{c^2 + 2ckN - kw - kt_C}. \tag{45}$$

Notice that I find the equilibrium parking fee in terms of curbside parking fee $t_C$. The equilibrium capacity of parking space in terms of $t_C$ is

$$Q^* = \frac{c + kN - \sqrt{c^2 + 2ckN - kw - kt_C}}{k}. \tag{46}$$

I need to analyze the social optimum to determine curbside parking fee $t_C$. The welfare function that includes the summation of the utilities of individuals, $i.e.$ $\int_{\tilde{v}}^{\bar{v}}(V - P - t)dF(v)$ and $F(\tilde{v})N(D - t + w)$, and the profit of the mall $i.e.$ $P(1 - F(\tilde{v}))N + t(Q) - c(Q)^2$

is

$$W(t,t_C) = \int_{\tilde{v}}^{\bar{v}} (V - P - t)dF(v) + F(\tilde{v})(D - t + w) + P(1 - F(\tilde{v}))N + tQ - cQ^2. \tag{47}$$

I use $t^*$ and $Q^*$ to write the welfare function in terms of $t_C$ and maximize welfare function with respect to $t_C$ since the city controls $t_C$, and it wants to maximize the welfare of society. The welfare function in terms of $t_C$ is

$$\begin{aligned} W(t_C) = & \int_{\tilde{v}}^{\bar{v}} (V - P - \frac{2c}{k}(c + kN - \sqrt{c^2 + 2ckN - kw - kt_C}))dF(v)) \\ & + F(\tilde{v})N(D - \frac{2c}{k}(c + kN - \sqrt{c^2 + 2ckN - kw - kt_C}) + w) \\ & + P(1 - F(\tilde{v}))N + \frac{(\frac{2c}{k}(c + kN - \sqrt{c^2 + 2ckN - kw - kt_C}))^2}{4c}. \end{aligned} \tag{48}$$

First-order condition with respect to $t_C$ is

$$\begin{aligned} W_{t_C} = & -\frac{c}{\sqrt{c^2 + 2ckN - kw - kt_C}} \int_{\tilde{v}}^{\bar{v}} dF(v) \\ & - \frac{c}{\sqrt{c^2 + 2ckN - kw - kt_C}} F(\tilde{v})N \\ & - \frac{c}{k} + \frac{c}{k} \frac{(c + kN)}{\sqrt{c^2 + 2ckN - kw - kt_C}}. \end{aligned} \tag{49}$$

By equating the first-order condition with respect to $t_C$, to zero I get

$$0 = -\frac{cN}{\sqrt{c^2 + 2ckN - kw - kt_C}} - \frac{c}{k} + \frac{c}{k} \frac{(c + kN)}{\sqrt{c^2 + 2ckN - kw - kt_C}}. \tag{50}$$

The curbside parking fee $t_C$ is

$$t_C^* = 2cN - w. \tag{51}$$

and the shopping mall parking fee $t^*$ is

$$t^* = 2cN. \tag{52}$$

When the city charges curbside parking fee in order to maximize the social welfare, the shopping mall parking fee is equal to $2cN$ which is same as the socially optimal parking fee.

### 4.3 Private Parking Facility

In this extension part I enlarge the base model by adding an alternative private company that provides parking space. I analyze the situation where the city controls none of the parking fees. Then, I compared the welfare under this situation with the socially optimal case to see that the society is better off or worse off. In this extension model individuals have three options to park. They can either park at the mall or curbside or the private parking space. $\tilde{v}$ does not change since it depends on $D$, $P$, and $w$ $i.e.$ $\tilde{v} = D + P - w$. There are two types of parking fees. First one is the mall's parking fee that is charged to individuals who park at the mall, $t_M$, and second one is the private parking fee, $t_P$, that is charged to individuals who park at the private parking space, and curbside has no parking fee. The utility structure of residents and shoppers who park at the mall and curbside are same with the base model, $i.e.$ $D - t_M - w$, $V - P - t_M$ and $V - P - k(S_C + R_C)^2 - w$, $D - k(S_C + R_C)^2$. Individuals who park at the private parking space pay $t_P$ but they do not suffer from cruising for parking $i.e.$ $k(S_C + R_C)^2$. Therefore, utility of a resident who park at the private parking space $R_P$ is $D - t_P$ and utility of a shopper who park at the private parking space $S_P$ is $V - P - t_p - w$.

I solve problem of the individuals in two parts. First part is the parking of individuals between the mall and curbside. This part is same as the equilibrium solution and I reach the same conclusion. Shoppers are indifferent between parking at the mall and curbside, and utility of parking curbside is greater than utility of parking at the mall for a resident $i.e.$ $V - P - t_M = V - P - k(S_C + R_C)^2 - w$ and $D - t_M - w < D - k(S_C + R_C)^2$. Therefore, there is no resident who parks at the mall as the equilibrium. Then, I analyze the parking of individuals between curbside and the private parking space. Only possible equilibrium is where both shoppers and residents are indifferent between parking curbside and at the private parking space $i.e.$ $V - P - k(S_C + R_C)^2 - w = V - P - t_p - w$ and $D - k(S_C + R_C)^2 = D - t_p$. If the utility of parking curbside is greater than the utility of parking at the private parking space, then no one parks at the private parking space. Thus this cannot be an equilibrium. If the utility of parking curbside is lower than the utility of parking at the private parking space, this means that private parking company does not maximize its profit because it can increase its parking fee without loss of any customer. Thus, again this cannot be an equilibrium. Therefore, private parking fee $t_P$ is equal to $k(S_C + R_C)^2$ and shopping mall's parking fee $t_M$ is equal to $k(S_C + R_C)^2 + w$ in the equilibrium.

I move on the problem of the mall and profit function of the mall $\Pi(P, t_M, Q_M)$ is

$$\Pi(P, t_M, Q) = P(S_C + S_M + S_P) + t_M(Q) - c(Q)^2. \quad (53)$$

I rewrite it by using equilibrium condition of shoppers, $i.e.$ $S_C + S_M + S_P = 1 - F(\tilde{v})$:

$$\Pi(P, t_M, Q) = P(1 - F(v))N + t_M(Q) - c(Q)^2. \quad (54)$$

The first order condition with respect to $P$ is

$$\Pi_P : (1 - F(\tilde{v}))N + Pf(\tilde{v})N. \quad (55)$$

Equating the first-order condition with respect to $P$ to zero gives the unique equilibrium price of the good,

$$P^* = \frac{1 - F(\tilde{v})}{f(\tilde{v})}. \quad (56)$$

The first-order condition with respect to $t_M$ is

$$\Pi_t : Q_M. \quad (57)$$

Since $Q_M > 0$, the mall wants to increase parking fee as much as possible, however, the structure of equilibrium parking fee for the mall is $k(S_C + R_C)^2 + w$. Therefore, after finding the allocation of shoppers and residents in the equilibrium, I can determine the equilibrium parking fee, $t_M^*$ in detail. Lastly, the first-order condition with respect to $Q$:

$$\Pi_{Q_M} : t_M - 2cQ. \quad (58)$$

By equating first-order condition with respect to $Q_M$, to zero gives the equilibrium capacity of parking space $Q_M^*$ is

$$Q_M^* = \frac{t_M^*}{2c}. \quad (59)$$

Now, I move on the problem for private parking company. The profit function of private parking company $\Pi(t_P, Q_P)$ is

$$\Pi(t_P, Q_P) = t_P(R_P + S_P) - c(Q_P)^2. \quad (60)$$

The first-order condition with respect to $t_P$ is

$$\Pi_t : R_P + S_P. \quad (61)$$

Since $R_P + S_P > 0$, the private parking company wants to increase parking fee as much as possible, however, the structure of equilibrium parking fee for the company is $k(S_C + R_C)^2$. Again, I need to find the allocation of individuals to determine the parking fee, $t_P^*$ in detail. The first-order condition with respect to $Q_P$ is

$$\Pi_{Q_P} : t_P - 2cQ_P. \quad (62)$$

Equating first-order condition with respect to $Q$, to zero gives the equilibrium capacity of private parking space $Q_P^*$ is

$$Q_P^* = \frac{t_P^*}{2c}. \tag{63}$$

The summation of shoppers and residents who park at the mall and curbside and at the private parking space is equal to total number of individuals N. Since there is no resident who parks at the mall, then I have the equation:

$$\underbrace{\frac{k(S_C + R_C)^2 + w}{2c}}_{S_M} + S_C + R_C + \underbrace{\frac{k(S_C + R_C)^2}{2c}}_{S_P + R_P} = N. \tag{64}$$

By solving the equation, individuals who park curbside are

$$S_C + R_C = \frac{\sqrt{-2wk + c^2 + 4ckN} - c}{2k}. \tag{65}$$

Then, the shopping mall parking fee and the private parking space fees are

$$t_M^* = \frac{-c\sqrt{-2wk + c^2 + 4ckN} + c^2 + wk + 2ckN}{2k}. \tag{66}$$

$$t_P^* = \frac{-c\sqrt{-2wk + c^2 + 4ckN} + c^2 - wk + 2ckN}{2k}. \tag{67}$$

Now I need to compare the welfare when the city decides the shopping mall parking fee and when there is a private parking company. After this comparison I can argue how a private parking company affect the society. To make a comparison, I analyze the change in the welfare between two cases. The change in the welfare, $W$ is equal to difference between the utilities of shoppers $\Delta U_S$, residents $\Delta U_R$, and the mall $\Delta U_M$ when the city decides the shopping mall parking fee and when there exists a private parking company. In addition to the differences between the two cases, now I add the profit of private parking company for the private parking company case. Therefore $\Delta W$ is

$$\Delta W = \Delta U_S(1 - F(\tilde{v})N + \Delta U_R F(\tilde{v})N + \Delta U_M + U_P. \tag{68}$$

The change in the utility of a shopper $\Delta U_S$, is equal to difference between utilities in the two cases $i.e.$ $V - P - t_{SO} - (V - P - t_M)$ thus $\Delta U_S$ is equal to $t_M - t_{SO}$. Then, similarly the change in the utility of a resident $\Delta U_R$, is equal to difference between utilities in the two cases $i.e.$ $D - t_{SO} + w - (D - t_P + w)$ thus $\Delta U_R$ is equal to $t_P - t_{SO}$. The change in the profit of the mall, $\Delta\Pi$, is equal to difference between profits in the two cases $i.e.$ $P(1 - F(\tilde{v}))N + \frac{(t_{SO})^2}{2c} - c(\frac{t_{SO}}{2c})^2 - [P(1 - F(\tilde{v}))N + \frac{(t_M)^2}{2c} - c(\frac{t_M}{2c})^2]$ and $\Delta\Pi$ is equal to $\frac{t_{SO}^2 - t_M^2}{4c}$. Lastly, the profit of private parking company $\Pi_P$ is $t_P(R_P + S_P)$. I rewrite the welfare function and it is

$$\Delta W = (t_M - t_{SO})(1 - F(\tilde{v}))N + (t_P - t_{SO})F(\tilde{v})N + \frac{t_{SO}^2 - t_M^2}{4c} + t_P(R_P + S_P). \tag{69}$$

By using $t_P^* = \frac{-c\sqrt{-2wk+c^2+4ckN}+c^2-wk+2ckN}{2k}$, $t_M^* = \frac{-c\sqrt{-2wk+c^2+4ckN}+c^2+wk+2ckN}{2k}$, and $t_{SO} = 2cN$ the welfare function becomes

$$\begin{aligned}\Delta W = &(\frac{-c\sqrt{-2wk+c^2+4ckN}+c^2+wk}{2k} - cN)(1-F(\tilde{v}))N \\ &+(\frac{-c\sqrt{-2wk+c^2+4ckN}+c^2+wk}{2k} - cN)F(\tilde{v})N \\ &+\frac{(cN - \frac{-c\sqrt{-2wk+c^2+4ckN}+c^2+wk}{2k})(3cN + \frac{-c\sqrt{-2wk+c^2+4ckN}+c^2+wk}{2k})}{4c} \\ &+\frac{-c\sqrt{-2wk+c^2+4ckN}+c^2+wk+2cN}{2k} \\ &(\frac{-c\sqrt{-2wk+c^2+4ckN}+c^2+wk+2cN}{4ck}).\end{aligned} \tag{70}$$

$lim(W) \to +\infty$ when $N \to +\infty$. This results show that for high enough $N$, the welfare when there is a private parking company is lower than the welfare when the city decides on the parking fee. Therefore we can say that for high enough population a private parking space is not a better alternative. Moreover, for high enough N, the shopping mall parking fee $t_M$ is smaller than the socially optimal parking fee, $t_{SO}$, and the private parking fee, $t_P$, is smaller than the shopping mall's parking fee, $t_M$ $i.e.$ $t_P < t_M < t^* < t_{SO}$. Although the private parking space is not socially optimal, it makes individuals better off.

## 5 Conclusion

I construct a model that represents a real life problem between the city, individuals, and shopping malls. I argue this conflict in an economical perspective and find an alternative policy. In the model that I constructed, individuals make a decision about where they park their cars and the shopping mall controls the parking fee, the good that it produced, and the capacity of the mall. I reach three main results in this paper. Firstly the equilibrium parking fee when there is no intervention by the city is positive and it is equal to $\frac{2c}{k}(c + kN - \sqrt{c^2 + 2ckN - kw})$ which depends on $c$, $k$, $N$, and $w$. Secondly, when the city decides on the parking fee in order to maximize social welfare as in real life case, the socially optimal parking fee is positive and it is equal to $2cN$ which depends $c$ and $N$. This shows that socially optimal parking fee should be positive unlike the city's free parking fee policy in the real situation. Moreover, for high enough $N$ the socially optimal parking fee is higher than the equilibrium parking fee. Therefore, this result suggests that instead of decreasing the parking fee, the city should increase it to make the society better off.

In the extensions part, I extend the model in various ways to see are there any possible alternative policies to improve the social welfare. I find the last main result by adding a curbside parking fee to the base model. When the city controls the curbside parking fee in order to maximize social welfare, the shopping mall parking fee is same as the socially optimal parking fee $i.e.\ 2cN$. Therefore, the city does not need to force the shopping mall for any certain parking fee. By controlling the curbside parking fee, the socially optimal parking fee can be reached without any intervention.

## Appendix A

There are two possible cases for the equilibrium structure. The first case is where shoppers are indifferent between parking at the mall and curbside $i.e.$ $V-P-t = V-P-k(S_C+R_C)^2-w$, and the utility of parking curbside is greater than the utility of parking at mall for a resident $i.e.$ $D-t-w < D-k(S_C+R_C)^2$ , and the second case where residents are indifferent between parking at the mall and curbside $i.e.$ $D-t-w = D-k(S_C+R_C)^2$, and the utility of parking at the mall is greater than the utility of parking curbside for a shopper $i.e.$ $V-P-t > V-P-k(S_C+R_C)^2-w$. To see the superiority I compare the profits of the mall for the two cases. The structure of parking fee is $k(S_C+R_C)^2+w$ for the first case and $k(S_C+R_C)^2-w$ for the second case, $i.e.$ $t^{e1} = k(S_C+R_C)^2+w$ and $t^{e2} = k(S_C+R_C)^2-w$. The capacities for the two cases are in the structure of $Q^* = \frac{t}{2c}$, $i.e.$ $Q^{e1} = \frac{t^{e1}}{2c}$ and $Q^{e2} = \frac{t^{e2}}{2c}$. Then the profit of the mall is

$$\Pi(P,t,Q) = P(1-F(\tilde{v}))N + t(Q) - c(Q). \tag{71}$$

By using $Q^{e1} = \frac{t^{e1}}{2c}$ and $t^{e1} = k(S_C+R_C)^2+w$, profit of the mall for the first case is

$$\begin{aligned}\Pi^{'}(P,t,Q) = P(1-F(\tilde{v}))N + (k(S_C+R_C)^2+w)(\frac{k(S_C+R_C)^2+w}{2c})\\ - c(\frac{k(S_C+R_C)^2+w}{2c})^2.\end{aligned} \tag{72}$$

From the section 3.1.4 $S_C+R_C = (\frac{\sqrt{c^2+2ckN-kw}-c}{k}$

$$\Pi^{'}(P,t,Q) = P(1-F(\tilde{v}))N + \frac{(k(\frac{\sqrt{c^2+2ckN-kw}-c}{k})^2+w)^2}{4c}. \tag{73}$$

Before writing the profit of the mall for the second case, I need to find the quantity individuals who park curbside for the second case. Individuals who park curbside is equal to difference between $N$ mass of individual and the capacity of the mall $i.e.$

$$S_C+R_C = N - \frac{k(S_C+R_C)^2-w}{2c}. \tag{74}$$

From equation 74, $S_C+R_C = \frac{\sqrt{c^2+2ckN+kw}-c}{k}$. Then, the profit of the mall for the second case is

$$\Pi^{''}(P,t,Q) = P(1-F(\tilde{v}))N + \frac{(k(\frac{\sqrt{c^2+2ckN+kw}-c}{k})^2-w)^2}{4c}. \tag{75}$$

Now I can prove that the first case is the equilibrium $i.e.$

$$\Pi^{'}(P,t,Q) > \Pi^{''}(P,t,Q), \tag{76}$$

and

$$P(1-F(\tilde{v}))N+\frac{(k(\frac{\sqrt{c^2+2ckN-kw}-c}{k})^2+w)^2}{4c} > P(1-F(\tilde{v}))N+\frac{(k(\frac{\sqrt{c^2+2ckN+kw}-c}{k})^2-w)^2}{4c}. \tag{77}$$

Since valuation for the good $V$, constant utility of not shopping $D$, and the walking cost $w$, do not change for the two cases, also price of the product $P$, and indifference point $v$, do not change. Therefore inequality 77 becomes

$$\frac{(k(\frac{\sqrt{c^2+2ckN-kw}-c}{k})^2+w)^2}{4c} > \frac{(k(\frac{\sqrt{c^2+2ckN+kw}-c}{k})^2-w)^2}{4c}. \tag{78}$$

When the inequality 78 is simplified it becomes

$$\sqrt{c^2+2ckN+kw} > \sqrt{c^2+2ckN-kw}. \tag{79}$$

Inequality 79 shows that Inequality 76 holds and the first case has higher profit for the mall. Therefore the first case is the equilibrium and the mall determines the parking fee as $k(S_C+R_C)^2+w$.

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