POLICIES TO CONTROL SPILLOVER PARKING[1]

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Introduction

Parking space near shops, restaurants, and other destinations is often scarce or expensive in dense urban areas. Urban shopping malls may provide little or no parking space, or charge high hourly rates. Shoppers end up searching for cheaper parking on the street, or walking to and from residential neighborhoods. Spillover parking can also be a problem near train and metro stations, sports stadiums, concert halls, public parks, and other places that attract lots of people.

Cities and towns often tackle spillover parking by enacting residential parking permit programs that ban nonresidents from parking in residential areas. Permit systems can be effective at eliminating parking problems for residents. However, like other non-price rationing tools, permit systems are generally inefficient because they allow residents to park free or for a nominal fee, and thus do not assure that parking space is allocated to those who value it the most highly.[2] Residential parking permits are also hard to enforce (Rye and Llewellyn, 2016). Yet, despite these weaknesses, local politicians prefer residential parking permits to priced-based policies because residents benefit from permits, and can express their preferences at the voting booth.

Another common policy to curb spillover parking is to impose minimum parking requirements, differentiated according to type of land use. Yet minimum parking requirements have well-studied drawbacks. Parking space is often underutilized outside regular business hours, and more generally at times of low demand. Expanding parking capacity is also unsightly, and it encourages people to travel by car (Guo, 2013ab). As Shoup (2013) argues at length, spillover parking can be addressed by better parking pricing. Priced-based policies enhance efficiency because they are demand (and thus value) driven. Their goal is not necessarily to eliminate spillover parking, but rather to maximize the combined welfare of residents, nonresidents and businesses.

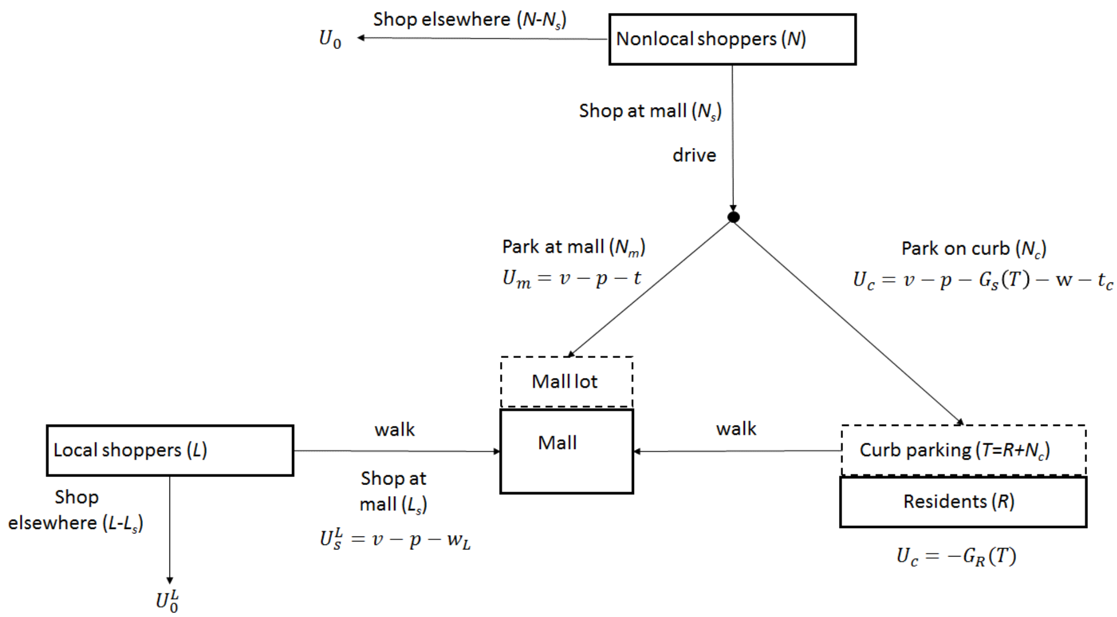
In this paper, we analyze three policies to deal with spillover parking generated by a shopping mall located in a residential area: (1) a curbside parking fee, (2) regulation of the mall parking lot fee, and (3) regulation of mall parking lot capacity. If the regulated lot capacity exceeds the mall's profit-maximizing capacity, the third policy amounts to a minimum parking requirement, but since demand is static in the model this does not result in underutilization of capacity.

The model

The model is depicted in Figure 1. It includes four types of agents: a profit-maximizing urban mall, local shoppers, nonlocal shoppers and residents.[3] The mall produces a composite good at zero cost, and sells it at a retail price of p. It can build a parking lot with capacity K at a cost $C(K)$ where $C(K)$ is strictly convex to reflect the scarcity of urban space and the increasing marginal cost of building multi-storey lots either above or below ground. The mall charges a parking fee of t.

In addition to the mall's parking lot, parking space is available on the curb in a nearby residential area. There is no residential parking permit program so that anyone can park on the curb. Curbside space is scarce, and drivers have to search for it. Cruising for parking, and entering and exiting spaces, obstruct other parkers as well as through traffic, and creates noise, pollution and safety hazards for residents. A mall shopper who parks on the curb incurs a cost of $G_s(T)$, where T is the total number of vehicles parked on the curb. There are R residents who park on the curb, and each incurs a cost of $G_R(T)$. Functions $G_s(T)$ and $G_R(T)$ are strictly convex to reflect increasing scarcity of curbside space and impediments to traffic flow. A shopper who parks on the curb also incurs a cost w to walk to the mall and back. Finally, if a curbside parking fee is introduced, it is levied at a rate t_c on all parkers.

Figure 1: Spatial representation of the model



There are two groups of shoppers: L local shoppers and N nonlocal shoppers. Every shopper consumes one unit of the composite good and decides whether to buy it at the mall or elsewhere. A nonlocal shopper who shops elsewhere earns a net utility U_o. The shopper receives an idiosyncratic gross utility of v from the mall's good. Value v has a range of $[0,\bar{v}]$, a continuously differentiable cumulative distribution function $F(v)$, and a density function $f(v)>0$. Parameter $\bar{v}$ is large enough that some shoppers patronize the mall in equilibrium. To assure that first-order conditions define global optima, the standard monotone hazard rate property holds so that $f(v)/(1-F(v))$ is increasing in v. To solve the second-best regulatory policies, the distribution $f(v)$ is assumed to be uniform. A nonlocal shopper who shops at the mall drives there, and parks either at the mall's lot or on the curb. Net utility from parking at the mall's lot is $U_m = v - p - t$. Net utility from parking on the curb is $U_c = v - p - G_s(T) - w - t_c$. The number of nonlocal shoppers who shop at the mall is $N_s = (1-F(\tilde{v}))N$, where $\tilde{v}$ is a threshold utility level from the mall's good below which a shopper chooses to shop elsewhere. The number of nonlocal shoppers who park at the mall's lot is N_m, and the number who park on the curb is N_c, where $N_m + N_c = N_s$.

Local shoppers can include residents who are inconvenienced by spillover parking as well as those who are not. Similar to nonlocal shoppers, local shoppers choose between shopping at the mall and shopping elsewhere. Net utility from shopping elsewhere is U_0^L. Gross utility from shopping at the mall, v, has a range of $[0,\bar{v}_L]$, a continuously differentiable cumulative distribution function $F_L(v)$, and a density function $f_L(v)>0$. The distribution $f_L(v)$ satisfies the same properties as $f(v)$. All local shoppers walk to the mall at a cost w_L. A local mall shopper with gross utility v thus earns a net utility of

$U_s^L = v - p - w_L$. Since no local shoppers drive, the total number of individuals who park on the curb is $T = R + N_c$.

Equilibrium with no regulation

In the unregulated regime the curbside parking fee, t_c, is set at an arbitrary level, possibly zero. Equilibrium is determined in two stages. In stage 1, the mall chooses *p*, *t* and *K*. In stage 2, local and nonlocal shoppers simultaneously decide whether to shop at the mall, and nonlocal shoppers who choose to shop at the mall decide where to park. Since mall lot capacity is fully utilized, the mall's choice of *K* is effectively determined by its choice of *p* and *t*. The mall exercises its market power in the goods market by setting *p* above the good's marginal cost (which is normalized to zero). It sets the price of parking according to the equation

$$t^n = C' + \frac{G_s' N_m}{1 + f(\tilde{v}) N G_s'} - \frac{f(\tilde{v}) G_s' N}{1 + f(\tilde{v}) N G_s'},$$

where the $'$ symbol denotes a derivative. The parking fee is set equal to the marginal cost of parking capacity, C', plus two adjustment terms that both increase in magnitude with curbside congestion, G_s'. The first additional term is a positive mark-up reflecting the fact that curbside parking is congestible, and hence an imperfect substitute for mall parking. This gives the mall market power to raise the parking fee above marginal cost. The second additional term is negative. It reflects the fact that drawing shoppers to the mall parking lot alleviates congestion on the curb, which is a cost borne by shoppers, and hence a cost that the mall operator chooses to internalize. It is straightforward to show that the amount of spillover parking is greater: (i) the higher the marginal cost of constructing lot capacity (i.e., C'), (ii) the lower the cost incurred by shoppers to find curbside parking (i.e., G_s'), (iii) the lower the cost of walking to and from the mall (i.e., *w*), (iv) the lower the curbside parking fee (i.e., t_c), and (v) the smaller the number of residents (i.e., *R*).

The unregulated equilibrium suffers from three market failures. First, local residents and nonlocal shoppers compete for parking space and impose external costs on residents. As noted above, the mall takes into account the costs borne by shoppers, but not the costs of residents. Second, the mall exercises its market power by setting the retail price above the marginal cost of the good. Third, the mall generally deviates from pricing mall parking at its marginal cost.

The social optimum can be supported by pricing curbside parking, mall parking and the good at their respective marginal social costs. However, it is quite unrealistic to assume that retail prices can be regulated in a market economy. We thus treat the social optimum as a theoretical benchmark, and consider the three regulatory policies identified at the end of the introduction that each make use of only one instrument while leaving the mall free to set the retail price. The goal for each policy is to maximize social surplus: the sum of the mall's profit, consumers' surplus for local and nonlocal shoppers, and the (dis)utility of residents.

A curbside parking fee

The most direct approach to controlling spillover parking is to charge a fee for parking on the curb. Cities often avoid this option because it is politically risky to implement if parking has been free. Nevertheless, setting curbside fees to control congestion is slowly gaining credence with policy makers and it has been implemented fairly recently in several cities around the world, such as San Francisco and Istanbul. If the mall's choice of *p* and *t* were independent of the curbside parking fee, the second-best curbside fee would simply equal the marginal external cost of curbside parking borne by residents: $t_c = G_R'(R)R$. The fee would not include the external cost incurred by shoppers who park on the curb because the mall operator internalizes this cost. However, at least when the number of local shoppers is small, raising t_c induces the mall to increase the full price or generalized cost of visiting the mall, $p+t$. To curb the mall's exercise of market power, the curbside fee is set below $t_c = G_R'\left(R\right)R$. Indeed, the second-best curbside fee can be negative when the number of residents (*R*) is small although negative fees may be practically infeasible. If the second-best curbside fee is zero, a curbside fee yields no benefit at all.

Mall parking lot fee regulation

If the planner can regulate the mall parking lot fee, it chooses *t* to maximize social surplus while taking into account the effect of *t* on the mall's choice of *p*. Contrary to the curbside parking fee, raising *t* induces the mall to reduce the retail price in order to alleviate the loss of sales to nonlocal shoppers. A lower retail price benefits both nonlocal and local shoppers. However, raising *t* reduces consumers' surplus for nonlocal shoppers, and it also increases the amount of curbside parking which harms residents. Overall, it is not obvious whether the planner prefers a higher or lower parking lot fee than the mall. If the levels happen to be the same, regulating the mall parking lot fee is useless.

In general mall parking fee regulation can be either more or less effective than pricing curbside parking and it is not easy to derive general conditions under which one policy dominates the other. However, if there are no local shoppers the two instruments turn out to be equivalent. This is because the price difference between curb parking and mall parking can be controlled using either instrument, and only the price difference determines how many nonlocal shoppers park on the curb. The two policies result in different retail prices, but this does not affect shopping decisions by nonlocal shoppers because the full price, $p+t$, is the same.

Mall parking lot capacity regulation

Both the curbside parking fee and parking lot fee regulation operate through prices. Another possibility is to regulate mall parking lot capacity. The mall then effectively has only one degree of freedom because the planner's choice of *K* restricts the mall to combinations of *p* and *t* such that parking-lot capacity is fully used without inducing excess demand.[4]

It is not easy to rank the efficiency of parking lot capacity regulation against the other policies. However, unlike with the other two policies, if there are no local shoppers it is possible that parking lot capacity regulation can support the full social optimum. This happens if the mall's retail price markup happens to match the marginal external cost of curbside congestion on residents. More generally, if the mall's markup exceeds the marginal external cost of curbside congestion borne by residents, then the mall sets too high a price, and conversely if the markup is less than the marginal congestion cost.

Numerical examples

We now turn to numerical examples to explore further the determinants of spillover parking and the relative performance of the regulatory policies. To enhance computational tractability, the parking capacity construction and curb parking congestion cost functions are assumed to have quadratic forms:

$$C\left(K\right) = c_1 K + c_2 K^2,\ G_R\left(T\right) = k_R T^2, \text{ and } G_s\left(T\right) = k_s T^2 .$$

Parameter values are listed in Table 1.They are chosen to explore a range of possible market settings and performance levels for the regulatory policies.

Table 1: Parameter values

N	L	R	$\bar{v}$	$\bar{v}_L$	U_0	U_0^L	w	w_L	k_R	k_s	c_1	c_2
10,000	0-2000	0-3500	\$8	\$8	\$0	\$0	\$2	\$2	1.25^{-7}	6.25^{-8}	\$2	1.25^{-3}

We begin by considering a case with no local shoppers and *R*=2000. Equilibrium values for the unregulated equilibrium, the social optimum and the three regulatory regimes are shown in Table 2. With no regulation, the mall sets a retail price of *p*=\$2.98, and charges shoppers *t*=\$2.93 to use its parking lot. It builds the lot with a capacity of *K*=735 stalls at a marginal cost of $C'(K)$=\$3.84 to accommodate N_m =735 shoppers. A much larger number of shoppers park on the curb (N_c=1867). The cost of curbside congestion is G_s=\$0.93 per shopper and G_R=\$1.87 for residents.

The social optimum entails a zero retail price, a much higher price of \$5.51 for parking in the lot, and a curb fee of \$2.65. The parking lot is nearly twice as large as in the unregulated equilibrium, and fewer shoppers park on the curb despite the fact that the full price of the good, $p+t$, drops modestly from \$5.91 to \$5.51. The welfare gain relative to the unregulated equilibrium is \$684. The relative gain is normalized to 1 for comparison with the other regimes.

In the curbside parking fee regime, the curbside fee is set at a modest level of \$0.61. Compared to no regulation, this induces a moderate increase in parking lot capacity and an appreciable drop in curbside parking. However, the full price of the good increases from \$5.91 to \$6.06, and the welfare gain relative to the social optimum is only 0.138. The mall parking fee regulation supports the same equilibrium as the curbside parking fee although the values of *p*, *t* and t_c all differ. By contrast, parking lot capacity regulation achieves a relative efficiency of over 90%. It does so by mandating a lot capacity of 1356, which is nearly as large as in the social optimum, and reducing curbside parking to the lowest level of the five regimes.

Table 2: Numerical example (*L*=0, *R*=2000)

		Regime				
Variable	Unit	*U*	*SO*	*CPF*	*MPFR*	*MPCR*
p	\$	2.98	0	2.65	3.26	2.95
t	\$	2.93	5.51	3.41	2.8	2.77
t_c	\$	0	2.65	0.61	0	0
K	#	735	1404	846	846	1356
$C'(K)$	\$	3.84	5.51	4.12	4.12	5.39
N_m	#	735	1404	846	846	1356
N_c	#	1867	1710	1581	1581	1503
N_s	#	2602	3114	2428	2428	2859
G_R	\$	1.87	1.72	1.6	1.6	1.53
G_s	\$	0.93	0.86	0.80	0.80	0.77
Profit	\$	7775	2462	6729	7688	7163
Welfare	\$	6745	7429	6839	6839	7366
eff	%	0	1	0.138	0.138	0.907

Notes: U : Unregulated. *SO* : Social optimum. *CPF* : Curb parking fee. *MPFR*: Mall parking fee regulation. *MPCR*: Mall parking capacity regulation. *eff* : relative efficiency

The results in Table 2 pertain to a specific set of parameter values. As the number of residents increases, curbside congestion becomes more severe. The optimal parking lot fee increases in all regimes, and the optimal curbside fee increases in the social optimum and curbside parking fee regimes. Correspondingly, in all regimes parking lot capacity increases and curbside parking decreases. When *R* is below about 400, mall parking fee regulation cannot be fully exploited without inducing the mall to abandon its lot.

The relative efficiency of the three regulatory policies is shown in Figure 2. As expected, the policies tend to perform better when curbside congestion is severe (i.e., *R* is large), but they exhibit different patterns. The curbside parking fee and parking lot fee regulation curves follow a U-shape, dropping to zero at about *R*=1500 where the potential benefits from reducing spillover parking and restraining the mall's exercise of market power offset each other. By contrast, the mall capacity regulation curve has a reverse U-shaped pattern: rising from near zero at R=0 to full efficiency at R=2411. At this point, the mall's retail mark-up matches the marginal external cost of curbside congestion on residents, and mall capacity regulation achieves full efficiency. The efficiency curve then falls, and drops below the curve for the other two regimes when R exceeds about 3300. Figure 2 highlights sharply the importance of selecting the appropriate policy to address spillover parking.

Figure 2: Relative efficiency of regulatory policies (no local shoppers)

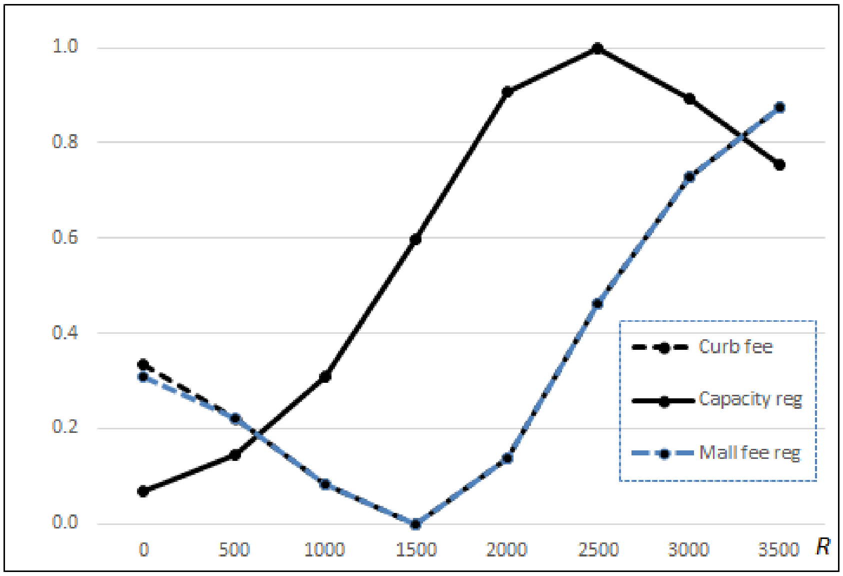


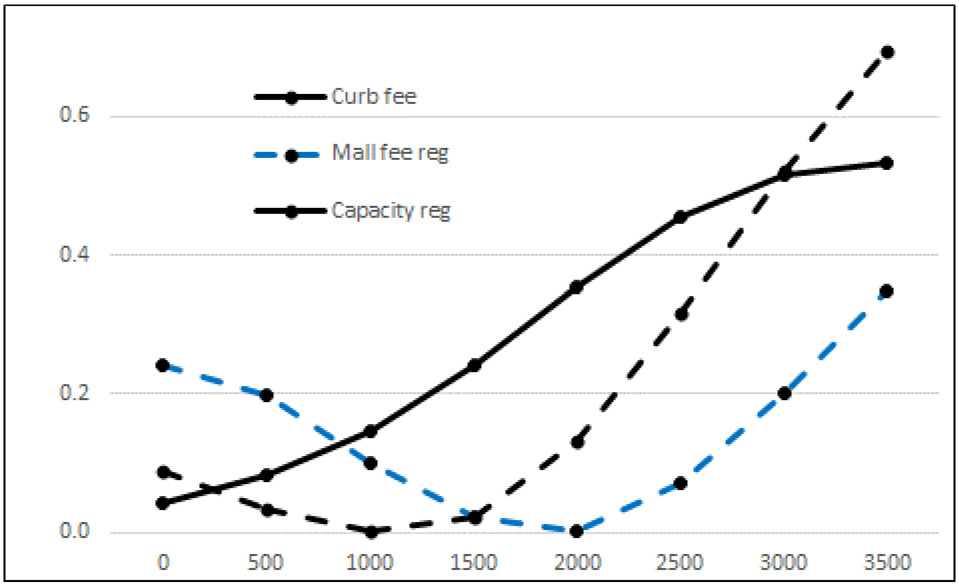
Table 3: Numerical example (*L*=2000, *R*=2000)

		Regime				
Variable	Unit	*U*	*SO*	*CPF*	*MPFR*	*MPCR*
$\tilde{v}$	\$	5.92	5.51	6.16	5.95	5.72
$\tilde{v}_L$	\$	4.99	2	4.66	5.05	4.96
p	\$	2.99	0	2.66	3.05	2.96
t	\$	2.93	5.51	3.51	2.9	2.76
t_c	\$	0	2.65	0.78	0	0
K	#	735	1404	875	766	1361
$C'(K)$	\$	3.84	5.51	4.19	3.91	5.40
N_m	#	735	1404	875	766	1361
N_c	#	1864	1710	1421	1800	1490
N_s	#	2599	3114	2297	2565	2851
L_s	#	753	1500	836	739	761
G_R	\$	1.87	1.72	1.46	1.80	1.52
G_s	\$	0.93	0.86	0.73	0.9	0.76
Profit	\$	10025	2462	8681	10020	9403
Welfare	\$	10128	11929	10364	10134	10767
eff	%	0	1	0.131	0.003	0.355

Notes: U : Unregulated. *SO* : Social optimum. *CPF* : Curb parking fee. *MPFR*: Mall parking fee regulation. *MPCR*: Mall parking capacity regulation. *eff* : relative efficiency

Table 3 presents another instance of the model with L=2000 local shoppers and R=2000. Because local shoppers incur lower transport costs to the mall than nonlocal shoppers, in each regime a larger fraction of local shoppers patronize the mall (i.e., $\tilde{v}_L < \tilde{v}$). Most of the results are very similar to those in Table 2, and the social optimum is identical because the presence of local shoppers does not alter the optimal pricing strategy for p, t or t_c. There are two notable differences between Tables 2 and 3. First, the curbside parking fee and parking lot fee regulation are no longer equivalent. Second, parking lot fee regulation and parking lot capacity regulation are both much less efficient because they only directly affect nonlocal shoppers.

Figure 3: Relative efficiency of regulatory policies (L=2000)



The relative efficiency curves shown in Figure 3 are quite different from those in Figure 2. Parking lot fee regulation performs better than the curbside fee at low levels of R, and worse at high levels. As in Figure 2, both curves drop to zero, but at different levels of R. The parking lot capacity regulation curve rises monotonically, but it is superseded by the curbside parking fee for R>3000.Overall, the three regulatory policies achieve a lower relative efficiency when local shoppers are present. This shows that the effectiveness of parking congestion policies depends not only on the severity of congestion, but also on the proportion of trips taken by other modes.

Conclusion

In this paper we study how to deal with spillover parking generated by an urban shopping mall. We analyze and compare three policies: charging a curbside parking fee, regulation of the mall parking lot fee, and regulation of mall parking lot capacity. Except in isolated cases, none of the policies can support the social optimum. Their effectiveness depends, inter alia, on the severity of spillover parking externalities, and on the proportion of mall business from local shoppers who walk to the mall rather than drive.

Several results stand out. First, if there are no local shoppers setting a curbside parking fee and regulating the mall parking lot fee are equivalent because the price difference between curbside parking and mall parking can be controlled either way, and the difference in retail prices does not affect shopping decisions by nonlocal shoppers. Second, both policies involve a trade-off between alleviating spillover parking and reducing the retail markup set by the mall. If the two incentives happen to balance at the unregulated equilibrium, the policies are useless. Third, the second-best optimal mall parking fee can be above or below the mall's profit-maximizing level depending on the number of local residents who are inconvenienced by spillover parking. Fourth, with no local shoppers regulation of the mall parking lot capacity achieves the first-best optimum. Otherwise, capacity regulation falls short of being first-best although a numerical example suggests it can outperform the other two policies over a wide range of residential parking levels.

A general lesson from the study is a familiar one to economists: policies designed to target one market failure should take into account the presence of other failures. In our setting the target is spillover parking, and the other failures are the exercise of market power by the mall in setting retail prices and the mall parking lot fee. Policies should also take into account effects on all economic agents and not just those directly affected by the primary market failure. Local shoppers are affected by changes in retail prices induced by spillover parking policies. Complete elimination of spillover parking may not be warranted. Residents who continue to be inconvenienced by parking could perhaps be compensated by using revenues from curb parking fees or some other source for neighborhood improvements.

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[1] Regular paper. This is an abridged version of Inan, Inci, and Lindsey (2016) which provides a more general and formal treatment.

[2] Several recent studies have demonstrated this inefficiency including Molenda and Sieg (2013), van Ommeren, Wentink and Dekkers (2011), van Ommeren, de Groote and Mingardo (2014) and Bakis, Inci and Senturk (2016).

[3] The behaviour of shops or other tenants at the mall is not modeled separately.

[4] If the planner mandates a lot capacity much greater than what the mall would prefer, it is possible that the mall will choose not to use all the capacity. However, this did not occur in any of the numerical examples described below.