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Downtown curbside parking capacity

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ABSTRACT

Current debates on downtown parking policy have been concentrating on downtown parking pricing, while overlooking downtown parking capacity. This paper focuses on how much curbside to allocate to parking when the private sector provides garage parking. In the first-best optimum, no cruising for parking occurs, and only curbside parking is provided when demand is low relative to street capacity, both curbside parking and garage parking are provided when demand in intermediate, and only garage parking is provided when demand is high. In the second-best optimum where curbside parking is underpriced, cruising for parking occurs only when both curbside and garage parking are both present. As the fee differential between garage and curbside parking increases, cruising for parking becomes more severe, and the range of demand levels over which curbside and garage parking are both present shrinks and eventually disappears.

1. Introduction

The last decade has seen a surge of interest in the use of downtown parking policy to reduce the inefficiencies associated with downtown traffic congestion. One branch of the literature has considered the second-best effectiveness of using parking pricing as a substitute for congestion pricing. Another branch of the literature has focused on remedying the ubiquitous underpricing of curbside parking downtown. The underpricing of curbside parking generates inefficiency. When it leads to the underpricing of auto trips downtown, there is excessive travel to the downtown area and excessive use of the car relative to mass transit. Furthermore, the cruising for parking that underpriced curbside parking induces is not only pure deadweight loss in itself but also exacerbates traffic congestion. Both those branches of the literature focus on pricing. This paper focuses on a different facet of downtown parking policy: *How much curbside should be allocated to parking?* The first-best theory of the optimal capacity of a congestible facility is well understood, and applies relatively straightforwardly to curbside parking. The second-best analysis, when auto traffic congestion or curbside parking or both are underpriced, is unexpectedly rich.

To our knowledge, the first paper in the literature to consider second-best curbside parking capacity – optimal curbside parking capacity with a fixed (perhaps zero) curbside parking fee – is Arnott and Inci (2006). The paper considers a stationary-state model with identical individuals and price-sensitive trip demand, where space is uniform, all parking is curbside, and all travel is by car. It obtains the simple and general result that curbside parking capacity should be chosen so that curbside parking is "just" saturated (full occupancy but no cruising for parking). The rationale is as follows. Underpriced curbside parking corresponds to excess demand, which is rationed via cruising for parking; in this situation, increasing curbside parking capacity increases throughput, and hence consumer surplus, curbside parking fee revenue, and social surplus. Meanwhile, overpriced curbside parking corresponds to excess supply (unsaturated curbside parking); in this situation, decreasing curbside parking capacity leaves more road space for traffic flow, which increases throughput and hence social surplus.

In a dense downtown area, it is implausible that all parking should be provided curbside. What is second-best curbside parking capacity when curbside and private garage parking may both be

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provided, and when, as is typically the case, the curbside parking fee is less than the garage parking fee? The difficulty of the problem is suggested by the following three observations. First, when it is second-best optimal to have only curbside parking, the result of the previous paragraph applies. Since the full price of curbside parking is then less than the full price of garage parking, how is demand for private garage parking generated when demand rises to the point where it is second-best optimal to have garage parking? Second, when only underpriced curbside parking is provided, the stock of cars cruising for parking adjusts to clear the parking market, but when both curbside and garage parking are provided, the stock of cars cruising for parking adjusts to equalize the full prices of curbside and garage parking. Third, there are two quite different ways to eliminate cruising for parking. One is to expand curbside parking capacity to the point excess demand is eliminated, which renders garage parking unprofitable; the other is to provide no curbside parking. This observation suggests that social surplus may be a nonconvex function of curbside parking capacity, which may lead to discontinuity in second-best curbside parking capacity as demand intensity increases.

The difficulty of the problem is increased when account is taken that, in downtown areas, traffic flow falls as traffic density rises above a critical level, as recently documented in a landmark paper, Geroliminis and Daganzo (2008). In terms of the conventional economic analysis, where equilibrium trip price and throughput are determined by the intersection of the trip demand and supply curve, this implies a backward-bending portion of the traffic supply curve and raises the possibility of multiple equilibria. Thus, determination of second-best curbside parking capacity requires dealing with excess demand/rationing (taking the form of cruising for parking), nonconvexity, and possible multiplicity of equilibria.

Given the intrinsic complexity of the problem, general results with general functional forms are not to be expected. As is done in new economic geography models, to make progress in analysis we adopt specific functional forms. We go further and parameterize the functional forms, except for demand intensity, essentially developing an extended numerical example. To the standard pair of dichotomies in the theory of congestible facilities: short run (capacity fixed) vs long run (capacity variable) and first best (here efficient pricing) vs second best (here inefficient pricing), we add the further dichotomy of only curbside parking vs curbside and garage parking. To aid intuition further, we develop and apply the apparatus needed to explain our results geometrically. Because the full model's behavior is complex, we first consider the model without parking, then the model with only curbside parking, and finally the full model with both curbside and garage parking.

The economic study of parking has been hampered by a lack of systematic data.[1] With few empirical regularities to guide the economic modeling of downtown parking, there has tended to be a proliferation of models, each addressing a different subset of features of downtown parking. These features include: (1) parking and rush-hour traffic dynamics (Arnott et al., 1991; Qian et al., 2012), (2) curbside parking (Arnott and Inci, 2006, 2010; Arnott and Rowse, 2009), (3) off-street/garage parking, including spatial competition between parking garages (Anderson and de Palma, 2004, 2007; Calthrop and Proost, 2006; Arnott and Rowse, 2009; Inci and Lindsey, 2014), (4) parking and land use, including minimum parking requirements (Shoup, 1999; Anderson and de Palma, 2007; Cutter and Franco, 2012; Hasker and Inci, 2014), (5) cruising/searching for parking (Arnott and Rowse, 1999; Calthrop, 2001; Anderson and de Palma, 2004; Shoup, 2005, Part II; Arnott and Inci, 2006, 2010), (6) parking and traffic congestion (Arnott and Inci, 2006, 2010; Arnott and Rowse, 2009), (7) the subsidization of parking, including employer-provided parking, validated parking, shopping mall parking (Hasker and Inci, 2014), and resident parking (Molenda and Sieg, 2013),[2] (8) parking and modal choice, including the treatment of mass transit (Arnott and Rowse, 2012), (9) parking as a source of local public revenue (Shoup, 2005, Ch. 19), (10) parking and visit duration (Glazer and Niskanen, 1992; Calthrop and Proost, 2006), (11) curbside parking time limits (Calthrop and Proost, 2006; Arnott and Rowse, 2013), and (12) the political economy of downtown parking (Russo, 2013).

Following Vickrey (1954), the primary theme of the literature on parking economics has been that efficiency requires that parking be priced at its social opportunity cost, just like any other commodity. Most models have assumed identical individuals, though Arnott and Rowse (2013) considered some complications arising from heterogeneity. Some models have considered an isotropic downtown area (e.g., Calthrop and Proost, 2006; Arnott and Inci, 2006); others have considered parking relative to a central location (e.g., Arnott et al., 1991; Anderson and de Palma, 2004; Qian et al., 2012); and none to date has considered parking on an explicit street network. All models have ignored aggregate uncertainty. Among those papers that treat traffic congestion, some have assumed bottleneck congestion (e.g., Arnott et al., 1991; Qian et al., 2012), and others classic flow congestion (Arnott and Inci, 2006, 2010; Arnott and Rowse, 2009, 2012, 2013).

The paper is organized as follows. Section 2 sets the stage by adapting Walters' (1961) treatment of highway traffic congestion to downtown traffic without parking. Section 3 adds curbside parking but not garage parking, considering both the first best and the second best, and both the short run and the long run. Section 4 extends the analysis to the simultaneous provision of curbside parking and private garage parking. Section 5 briefly discusses directions for future research, and Section 6 concludes. An online appendix treats the stability of the various equilibria, presents the numerical deadweight loss of second-best compared to first-best equilibria, and discusses the generality of the paper's results.

2. Downtown traffic congestion with no parking

To set the stage for further analysis, we start by adapting Walters' (1961) familiar steady-state diagrammatic analysis of highway congestion to downtown traffic. For the moment, we ignore downtown parking, essentially assuming that parking is costless and uses no street space. We assume that downtown is isotropic; one can imagine a boundless Manhattan network of one-way streets. We also assume that all travel is by car.

We use the term *user cost* to refer to the user's travel time cost on a trip (ignoring the money costs of travel, such as gasoline and depreciation), which equals trip length, m, times travel time per mile, t, times the value of time, ρ:

$$UC = \rho m t. \tag{1}$$

Travel time per mile is an increasing function of V, the density of traffic per unit area: $t = t(V)$, with $t' > 0, t'' > 0$, and with $t(0) > 0$ being free-flow travel time. We define the full price of a trip, F, to equal the user cost plus the toll, τ:

$$F = UC + \tau; \tag{2}$$

user cost is a real resource cost, whereas a toll is a transfer from the user to the government.

[1] Some recent empirical papers that make use of comprehensive parking data include van Ommeren et al. (2011), van Ommeren and Wentink (2012), van Ommeren et al. (2012), Kobus et al. (2013), Pierce and Shoup (2013), Chatman and Manville (2014), and Millard-Ball et al. (2014).

[2] Van Ommeren et al. (2011) provide an empirical estimation, based on social surplus analysis, of the deadweight loss due to resident parking. Van Ommeren and Wentink (2012) estimate the welfare loss due to free employer-provided parking.