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Downtown parking supply, work-trip mode choice and urban spatial structure☆,☆☆

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ABSTRACT

This paper examines the effects of changes in downtown parking supply on urban welfare, modal choice decisions and urban spatial structure using a spatial general equilibrium model of a closed monocentric city with two transport modes, endogenous residential parking and a form of bottleneck congestion at the CBD. Our analysis shows that parking reforms at the CBD that increase delay congestion costs in the short-run such as parking supply limits can be welfare improving if other commuting externalities such as air pollution can be reduced. In addition, because parking limits can also change location decisions such as where to live and invest they may complement anti-sprawl policies efforts by leading to a more compact urban spatial structure in the long run. We also show that changes in downtown parking supply can have different spatial impacts on the market supply of residential parking by affecting urban residents' location decisions. Finally, we investigate whether the self-financing theorem of transportation economics holds within the context of our spatial urban model.

1. Introduction

Economists have long recognized that traffic congestion tends to exceed economically efficient levels because auto commuters do not bear the full cost of their use of the roads and parking facilities. In heavily trafficked areas such as downtown areas, each additional vehicle imposes additional traffic delay on all the other auto users. For instance, Shoup (2005) found that, in a single year, drivers wasted 100,000 h while cruising for underpriced curb parking in a 15-block business district in Los Angeles, CA, USA.[1] Recently, Inci et al. (2015) provide evidence that the external cruising costs of parking in downtown

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[1] As vehicles cruise for parking, they remain in the traffic system and travel at a lower speed, slowing the entire system until they find a space. Where curb parking is underpriced and congested, cruising for parking can greatly increase traffic congestion (Arnott and Rowse, 1999; Arnott and Inci, 2006; Pierce and Shoup, 2013). van Ommeren et al. (2012) also estimate the cost of cruising for parking and find that cruising only takes around 36 seconds per trip in Amsterdam because, and in contrast to the U.S., on and off-street parking prices are very similar.

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areas may be substantial and even exceed the external cost of traffic congestion generated by a trip.[2] Yet no auto user is charged for the negative traffic delay externality. The result is that traffic delay slows economic activity and can reduce some of the agglomeration benefits that characterize central business districts.

In recent years planners have given increasing attention to the possibility of reducing downtown use of cars and comply with urban air quality targets by controlling parking either by restricting the number of spaces available, or by charging users to park.[3] After all, empirical evidence has shown that parking prices and parking availability are two of the key factors in auto users' decision on whether to drive to work or use public transportation (Shoup, 2005). Possible benefits of auto-restraint schemes include reductions in traffic delay costs, air pollution and energy consumption (STHC Report, 2009; Kodransky and Hermann, 2011; Weinberger et al., 2010).

Even though parking reform is an important policy topic in several parts of the world, analytical work on how parking reform affects the urban form is scarce. This gap in the literature is surprising, as parking pricing and parking supply policies may have a considerable impact on the transport and land use systems within an urban area. Moreover, advocates of parking reform have urged for the need to move away from parking minimums to parking maximums, to cap parking supply in city centers and to erase employer transportation subsidies as ways to reduce solo driving and urban air pollution, manage congestion, and achieve less dispersed urban spatial structure (Shoup, 2005, 2011; STHC Report, 2009; Kodransky and Hermann, 2011; Weinberger et al., 2010).

The purpose of this paper is to develop a spatial urban model that allows one to study the interactions between parking, mode choice and land use, with the ultimate goal of examining how changes in downtown parking supply when CBD parking is underpriced affect the urban spatial structure, welfare, modal choice and residential parking supply outside the CBD.

Our model builds on the urban yard-space spatial framework developed by Brueckner (1983) and develops a closed monocentric-city model with two transport modes (auto and public transit) and endogenous residential surface parking. All urban residents are car owners and commute to job sites in a congested downtown district. For reasons of analytical tractability, road congestion is absent from the model but we include parking congestion and parking provision at the CBD. Auto commuting also generates air pollution, which affects both auto and transit users equally. These features allow us to explore how CBD parking policies affect mode choices and in turn, some of the externalities associated with private vehicle use. Expansions of the congested downtown parking capacity are fully paid with parking fees that only cover infrastructure costs. Finally, housing is portrayed as a commodity with floor space and parking spaces, which are both choice variables of the housing developer. Residential parking consumes a fixed amount of land per parking space, a feature similar to the yard space associated with a dwelling in Brueckner (1983). Since residential floor space is endogenous and varies over space, we are able to explore how CBD congestion management strategies affect urban land use and auto use in the long run.

Within this framework we examine how changes in CBD parking supply affect residential land rents, residential parking supply, modal choice, welfare, air pollution, share of auto users, population densities and city size. The impacts are expressed in terms of behavioral elasticities. This allows for an easy interpretation, while elasticities can be linked to empirical estimates obtained from observed behavior. Furthermore, we examine how the optimal choice of CBD parking supply affects the value of a budget-balancing parking fee and explore the implications of our results for the self-financing theorem (where revenues from congestion tolls cover capacity costs).

Our analysis shows that when the auto-travel elasticity with respect to parking capacity is inelastic and financing relies on budget-balancing parking fees, an expansion in downtown parking supply in the presence of underpriced parking tends to decrease overall CBD parking congestion. However, increased parking supply also increases home-to-work car commuting and reduces transit rides and, as a result, contributes to an increase in air pollution. Provided that the direct effects dominate the effects from induced demand, an increase in CBD parking supply is welfare improving. In addition, the overall decrease in downtown parking congestion delay costs makes automobile-dependent locations in the long run more attractive to urban residents, potentially leading to an expansion in the city size.

Another interesting finding of our analysis is that when downtown parking capacity is chosen to maximize the equilibrium level of urban utility, a balanced-budget parking fee coincides with the optimal congestion toll despite the presence of environmental spillovers. Moreover, the self-financing equality remains valid even if an environmental tax is levied to internalize the air pollution externality from auto commuting.

Inci (2015) provides a comprehensive review of the literature on parking. Most theoretical studies on parking policies in downtown areas focus on how parking pricing policy affects short-run commuter decisions regarding trip scheduling and frequency, transport mode choice, and parking location. Some studies focus on the efficiency of second-best pricing of park-

[2] For a commercial street in Istanbul, Inci et al. (2015) show that a marginal car parking for 1 h induces 3.6 other cars to cruise for parking which translates into a marginal external cruising cost of about 1.2 liras per hour of parking. This external cost is substantial as it corresponds to 60% of the marginal parking fee that drivers face after parking for 1 h and 15% of the hourly wage in Istanbul.

[3] Kodransky and Hermann (2011) examine several European cities on a variety of parking measures ranging from pricing mechanisms to regulatory measures (supply caps and parking minimums and maximums). All case studies highlight that expanding the supply of free, cheap, or excessive parking has been reassessed across Europe in order to reduce the use of private motor vehicles and comply with EU ambient air quality and national greenhouse gas targets. Weinberger et al. (2010) provide an overview of the best practices in parking management in the United States. Many U.S. cities still take a passive approach to managing parking with just a few cities (Chicago, New York and San Francisco) taking steps to align parking policy with the broader city goals of accessibility, economic development and better quality of life. The overall conclusion is that dysfunction will continue as long as parking policy is viewed independent of transportation policy and curbside and off-street parking are treated independently.