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Park-and-ride: Good for the city, good for the region?

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ABSTRACT

At the edge of cities, park-and-ride (P + R) facilities pop up with the aim to intercept motorists from traveling into the city. However, these facilities also appear attractive to public transport users who start using their cars for getting to the P + R location. This paper analyzes the overall impact of P + R on total car traffic and social welfare by means of a discrete modal choice model. The results show that the distribution of individuals' preferences for car over public transport is the main determinant of this impact. P + R has a larger traffic reducing effect if more individuals prefer their car. At the same time, the shift of traffic from city to periphery improves welfare. These effects get stronger when a P + R facility provides a superior access to the mainline public transportation network.

1. Introduction

On the edge of cities and towns, more and more parking facilities pop up with direct access to a public transport service. These so-called park-and-ride (P + R) facilities intercept motorists from traveling into the city, close to their final destination, and are popular throughout the United States and Europe. This is the most common type of P + R and sometimes referred to as "peripheral" or "local" P + R (AASHTO, 2004).[1]

The popularity of P + R among cities is not without a reason. First, it improves accessibility. Most cities suffer from congestion; they are often physically constrained to increase the capacity of the road network and the parking stock in the city center. P + R increases the number of parking places while avoiding the construction of new car parks in the urban core.

Second, by encouraging people to take public transport for part of their trips, P + R facilities help to alleviate traffic congestion and other adverse external effects of travel by private car. Any reduction in congestion from the transfer of motorists to P + R frees road space in the city and may induce further visitors that stimulate economic activity.

Third, opening P + R facilities along existing public transport networks increases public transport ridership and may improve the cost recovery of those services. For example, current fare revenues of urban public transport fall short of the operational costs by 66% in North America (Federal Transit Administration, 2008) and by an average of 48% in Europe (UITP, 2005). Moreover, increased public transport ridership allows for further improvements in quality of service.

Finally, as an urban transport policy, P + R is also generally saleable to the public. It widens the choice of transport options, not forcing people out of their cars when using a car is their preferred option. P + R facilities integrate the private car into the public transport system, allowing motorists to evade the low speeds of inner city driving, the inevitable congestion delays, and the high costs of parking in the city, while enjoying the convenience and comfort of their private car for the larger part of the journey outside the city.

Despite its popularity, P + R has drawn little scientific interest. A small body of literature analyzes the planning and the design of P + R facilities. Wang et al. (2004) and Horner and Groves (2007) analyze P + R locations with different objective functions. Wang et al. (2004) consider P + R as an investment decision and focus on profit maximization and social cost minimization. Horner and Groves (2007) take a traffic engineering approach and capture the maximum number of vehicles early in their journeys. Given a P + R location, García and Marín (2002) analyze capacity and pricing decisions that minimize total travel costs in a mathematical programming approach. Bos and Molin (2006) carry out an experiment with incentives that may increase P + R usage.

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[1] This type of P + R is in contrast to "remote" and "suburban" P + R that aim to stop drivers close to their place of origination.

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The motivation for this paper comes from another body of literature on P + R. This literature is more descriptive and policy oriented, and focuses on the objectives behind P + R and the actual realization thereof. Based on a review of policy documents and impact studies (Cairns, 1997; Parkhurst, 2000; Meek et al., 2008a, 2008b), and on the results drawn from surveys and interviews (Parkhurst, 1995 and Meek et al., 2009, 2010), this literature calls into question the role of P + R in reducing car traffic. The central argument is that the incentives offered to motorists also apply to existing public transport users. By shifting modes, they may enjoy the benefits of motoring for the P + R access trip.

The degree to which this negates mileage savings made from intercepted motorists is likely to be considerable, especially if one takes into account that access journeys are generally longer than the trip leg between the P + R location and the urban center (Parkhurst, 2000, Meek et al., 2008b). Empirical evidences show that a significant proportion of P + R users may indeed come from public transport (see Meek et al., 2008b). This has brought the role of P + R in reducing car usage into question. The American Association of State Highway and Transport Officials is critical about P + R near the place of destination and prefers to locate it close to the origin of trips (American Association of State Highway and Transportation Officials, AASHTO, 2004). This preference is also explicit in the approach of Horner and Groves (2007) and the recommendations of Parkhurst and Richardson (2002).

In this paper, we consider the most common type of P + R, which is located at the edge of the city, and analyze its impact on total car traffic and social welfare. In a discrete choice model, we analyze the effect of opening P + R on the modal choice of individuals who already travel into the city without P + R. Individuals are assumed heterogeneous in their geographical location as well as in the costs of using the private car and public transport. They choose one of the following three modes of transportation: the car, public transport, or the combination of the two with a transfer at a P + R facility. The latter is located along the existing public transport network at the edge of the city. The model accounts for the generalized transportation costs for each of these three modes. Differences in these costs characterize individuals' preferences for one mode over another.

In the next step, we extend this basic model to accommodate for negative congestion externalities. Individuals experience instantaneous disutility from traffic at any point on their route. This converts the discrete choice model into a rational expectations model, where individuals' initial belief about traffic intensities along the route induces such a modal split that the actual realized traffic intensities equal to the expected ones.

Our results are as follows. The model identifies two reasons why individuals use a P + R facility. First, P + R may be cheaper than using the private car in the city center. This is the case when the city has all the usual problems associated with car use, such as congestion and parking problems. Second, P + R may provide a cheaper access to the mainline public transport network than the place of origination. This is the case when individuals use P + R to avoid relatively slow and low frequency local services at their home locations.

These reasons result in opposite patterns of modal split. If P + R costs less than using the car in the city center, then P + R attracts those individuals who prefer the car to public transport and who reside far from the P + R location. These individuals benefit from avoiding the congestion and parking costs in the city center, while enjoying their private car for the larger part of their journey. If, in contrast, P + R provides cheaper access to the mainline public transport network, it attracts those individuals who prefer public transport to the car and who reside close to the P + R location. These individuals enjoy P + R as a more efficient public transport access point, while not incurring too much disutility from having to drive their car to the P + R facility.

When both reasons apply simultaneously, P + R attracts individuals from all over the periphery, which yields the largest reduction in car traffic, and can be achieved by making P + R as cheap and efficient as it is ever possible. This is in contrast to the suggestion of Parkhurst (1995) and Meek et al. (2008a) to make P + R more expensive than public transport in order to prevent individuals from switching from public transport to their private car.

In the presence of congestion, P + R has yet another effect on modal split. By shifting traffic away from the city into the periphery, it reduces congestion, and makes the private car more attractive than public transport for individuals who reside next to the city border. As a result, some individuals switch directly from public transport to the car for their trip into the city center. This effect vanishes if the cost of using P + R is low. Hence, this effect constitutes another reason why P + R should be made as cheap and as efficient as possible.

P + R has a favorable effect on welfare beyond the reduction in traffic. The reason is that P + R expands individuals' choices, and, consequently, increases users' consumer surplus. Besides, a shift of traffic into the periphery is likely to have an additional positive welfare effect since in most cities the external costs of driving in the city are higher than in the periphery.

The positive effects of P + R on traffic and welfare hold under fairly general assumptions, *e.g.*, when the distribution of preferences is unimodal and the private car dominates the modal split. This latter assumption is empirically validated in most cities; see Urban Audit 2004 (Eurostat, 2008). However, an empirical study into the shape of the distribution function and the actual modal split remains useful in assessing whether a new P + R facility will indeed reduce car traffic.

The rest of the paper is organized as follows. Section 3 specifies the model, which is analyzed in Section 4. Section 5 concludes.

2. Model

We consider a city and its circular periphery (region); see Fig. 1. This city is in the form of a disk and has unit radius. The periphery has the form of a ring around the city and has an outer radius $R>1$. A unit measure of individuals lives in the periphery. Every individual i is characterized by its location at distance $r_i \in [1,R]$ from the city. The spatial distribution density function of individuals has support $[1,R]$ and is denoted by $f_r(r)$.

Each individual is a traveler who wants to reach the city center by using one of the following three transportation modes. The first mode is public transport, denoted by superscript (P). An individual i, who travels distance r_i to the city center by public transportation, gets the following utility

$$U^{(P)} = U_{0,i} - r_i t_i - \tilde{a}, \quad (1)$$

where $U_{0,i}$ is his personal gross utility of going to the city center (for work, leisure, or any other reasons), and $t_i>0$ and $\tilde{a}>0$ are the variable and fixed costs correspondingly. The variable cost t_i covers the distance related part of the tariff and an individual's valuation of in-vehicle time. The fixed cost $\tilde{a}$ is the fixed part of the tariff, the time costs associated with getting to a network access point, the waiting time for departure, *etc.*

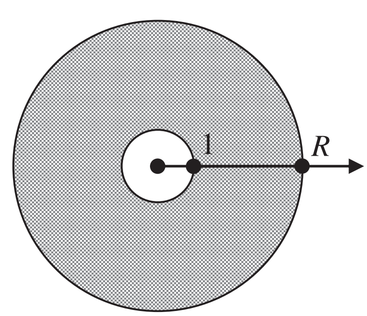

Fig. 1. The city (inner circle) and the periphery (shaded ring).