Decentralisation and its efficiency implications in suburban public transport

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Introduction

Suburban public transport services are used predominantly by regular commuters living in low-density residential areas outside of the political boundaries of large cities. The provision of such services is often perceived as a substitute for car commuting when major road links heading to the centre of employment areas are heavily congested, especially in the morning peak.

One may distinguish three beneficiaries of suburban public transport provision: (1) suburban commuters who are either the actual users of the service, or drivers who enjoy lower travel time costs in the presence of substituting public transport capacity, (2) urban residents who experience less car externalities if some suburban commuters are diverted to alternative modes, and (3) the public transport provider as an individual economic agent. As the first two groups of residents usually belong to different political jurisdictions, the quality and pricing of suburban public transport supply may depend on what level of government is responsible for service provision.

In this research we investigate four service provision regimes:

1. Centralised decision making, i.e. the economic objective is to maximise aggregate social welfare, including both the urban and suburban population.
2. Decentralised decision making by an urban government.
3. Decentralised decision making by a suburban government.
4. Profit maximising (monopolistic) service provision.

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The research question here is essentially how the choice between these institutional regimes affects service quality and pricing of suburban public transport, and the economic well-being of user groups and society as a whole.

Practical experience shows that the ownership structure of suburban public transport is by far not consistent across Europe; examples can be found for all four regimes enlisted above. Moreover, the ownership of commuter services may even change over time. The direct motivation behind this research includes recent developments in London (UK) and Budapest (Hungary). In the former case Transport for London (TfL), the public transport agency of the British capital has just taken over a large portion of its suburban rail network operated as part of the national rail franchise framework up until now. Plans include further expansion by TfL in London's rail market. In case of the Hungarian capital recent policy interventions were even more drastic: the entire suburban rail network of the city of 2 million inhabitants has been overtaken by the state railway operator (MÁV) from the incumbent operator fully owned by the local government of Budapest. Note that this intervention points towards centralisation as opposed to what happened in London. In both cities the changes in ownership structure were intensively debated in the local media and caused severe debates among transport professionals as well.

This research is built on a number of earlier contributions on multimodal interaction, including Arnott and Yan (2000), Pels and Verhoef (2007) and Parry and Small (2009). The direct predecessors of this paper, such as Borck and Wrede (2008), De Borger et al. (2005), Proost and Sen (2006) and De Borger and Proost (2016), modelled public transport provision at different political levels of decision making without uncovering all relevant features of *suburban* public transport.

Modelling framework

This paper assesses the decentralization of public transport provision and pricing in a two-region federation, a city and suburb. We develop a simplified model where traffic originates from the suburb (separate administrative jurisdictions from the city) and the city and travels to the central business district (CBD) located within the city.

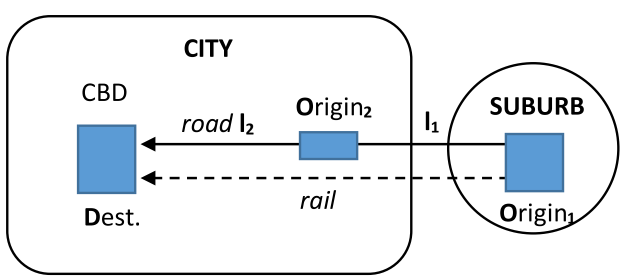

Figure 1: Network layout

While the city gains from incoming traffic in terms of employment, it also suffers from transport-related externalities. That is, private car users impose externalities (e.g. congestion, pollution, accident risk, parking.) on city residents. Suburban commuters can choose between two modes of transportation, private car and public transport, while local commuters within the city only travel via car. In addition, the road within the city's jurisdiction is subject to congestion. The topology of the overall network is reflected in figure 1.

Residents of both regions commute to the CBD which is located in the city. There are two modes of transportation, car and public transport. Given that the city network is used by local traffic as well as drivers from the suburb, we assume that the city network is subjected to congestion. As the modal choice of suburban commuters is endogenous, the price and quality of suburban public transport services may affect the magnitude of external costs imposed on city residents.

We start with the case where there is no congestion toll. First, we study the outcomes when a federal government, who takes into account society's welfare, decides on the optimal fare and supply of public transport. This serves as a benchmark. Second, we delve into the decentralization of public transport supply and pricing. Under decentralisation, we analyse the outcomes when the city and suburb are given the authority to decide on the optimal pricing and provision of public transport. In addition, we will also assess the outcomes when a profit-maximising private operator supplies public transport. This allows us to evaluate whether decentralization or privatization makes the society better off The second case involves the introduction of a congestion toll. We evaluate whether the outcomes from congestion pricing differs from the first case.

Preliminary insights

Preliminary numerical analyses have been conducted with the following specification. For the sake of simplicity we assume inelastic demand, N_L and N_S representing the number of local (urban) and suburban users, respectively. The values may be considered as hourly flows. User costs on the rail link (c_r) are specified as

$$c_r = v_w\, 0.5F^{-1} + vt_r\Big(1 + \varphi\frac{q_r}{FS}\Big), \tag{1}$$

where the two additive components are the cost of waiting and in-vehicle travelling, respectively, the latter being multiplied by a crowding dependent factor. Notation: v_w and v are the value waiting and in-vehicle travel time, t_r is the exogenous train running time, and $q_r(FS)^{-1}$ denotes the occupancy rate. F and S are the two capacity variables, frequency and vehicle size, set by the public transport operator.

Road user costs on link l comes as

$$c_l = vt_l^0\Big(1 + \alpha\frac{q_l}{K_l}\Big), \tag{2}$$

in which t_l^0 is the free-flow travel time, q_l represents the number of users on link l, as K denotes an abstract capacity variable which allows travel times to increase linearly in demand. On the operational and investment cost side we assume that road capacity is exogenous and rail costs are simply linear in the frequency provided, $C_{op}(F) = zF$. In this preliminary model we keep vehicle size constant. In other words, the only decision variable in this setting the frequency of suburban rail services affecting operational costs on the one hand and waiting time as well as crowding costs on the other hand.

Even though the number of suburban users is inelastic, their mode choice is of course endogenous. We apply the simplest Wardrop equilibrium conditions, i.e. users are distributed in such a way that user costs get equalised on the two modes ($c_r = c_1 + c_2$), except if one of them is not used at all. With our basic set of parameters[1] this specification leads to zero rail market share below around 1 train per hour, and full rail market share above 8 trains per hour.

For the first three ownership regimes – centralised decision (3a), local urban supplier (3b), and suburban supplier (3c) – one can define the following objective functions:

$$\min_F C_W = N_L c_2 + q_r c_r + (N_S - q_r)(c_1 + c_2) + C_{op}(F), \tag{3a}$$

$$\min_F C_L = N_L c_2 + C_{op}(F), \tag{3b}$$

$$\min_F C_S = q_r c_r + (N_S - q_r)(c_1 + c_2) + C_{op}(F). \tag{3c}$$

Our preliminary simulation results are summarised in Table 1. Under the current set of parameters the local (urban) government would not supply suburban public transport at all. In case of a suburban supplier service quality would remain lower than what is socially optimal. The deadweight loss of decentralised decision making is moderate under suburban supply and significant (around 20%) with no public transport option at all.

Table 1: Baseline simulation results

Scenario	F	Rail share	C_L	C_S	C_{op}	C_W
Social	6.49	86.8%	17,149	22,811	6,487	**33,473**
Local	0	0	**15,000**	25,000	0	40,000
Suburban	4.75	72.5%	16,119	**22,491**	4,746	33,864

By changing certain key parameters we have identified the following interesting features of the mechanism:

- Local users are interested in public transport provision as we reduce K_2, i.e. the capacity of the urban road section. At $K_2 = 800$, for example, the optimal frequency set by a local operator is 3.19 trains per hour.
- Interestingly, the above mentioned capacity reduction leads to *less* congestion on the urban road section. As some of suburban road users switch to public transport, the user cost on the urban section drops from $c_2 = 15.0$ to 13.6.
- Similarly, a reduction in operational costs (z) also makes public transport provision

[1] Preliminary analyses were conducted with the following set of baseline parameters: $N_l = N_s = 1000$ users/h; $v = 20$ \$/h; $v_w = 30$ \$/h; $z = 1000$ \$/h; $\varphi = 0.15$; $\alpha = 1$; $K_1 = K_2 = 1000$; $t_1 = t_2 = 0.25$ h; $t_r = t_1 + t_2 = 0.5$ h, and finally $S = 50\,m^2$

attractive for local users. Increasing vehicle size (S) has the same effect, because the same frequency implies more modal shift due to reduced crowding costs for rail users.

- Capacity reduction on the suburban road section (K_2) does not imply higher than socially optimal frequency provision by the suburban operator. This suggests that frequency under decentralised decision making cannot exceed the social optimum, which may be explained by the importance of how operational costs as split between the two groups.

Upcoming research agenda

The preliminary analysis presented above will be extended in multiple directions. Introducing pricing is the first priority on our agenda, in case of the public transport service as well as on road sections. To make this possible we need elastic demand either in the form of a global elasticity with respect to the equilibrium user cost or as a result of a quadratic utility specification. Pricing will allow us to introduce revenue generation considerations into the existing objective functions, and to investigate the behaviour of a private operator.

From a methodological point of view, our plans include a thorough analytical investigation of the economic rationale behind supply-side decisions. Later on the analytical models can be calibrated to derive meaningful conclusions for the case studies of London and Budapest.

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