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Reducing dependency on special transport services through public transport

Lisa Hansson[a] and Johan Holmgren[a*]

[a]*Molde University College – Specialized University in Logistics, Britvegen 2, 6410 Molde, Norway*

Abstract

One of the official transport policy objectives in Sweden is that all citizens should have access to the transport system. The public sector is therefore required by law to provide special transport services (STS) for those who are unable to use public transport or private car. STS is often provided through public procurement of taxi services. As a response to new legislation in 2000, there have been developments in the public transport sector, making buses, trains and other parts of the system more accessible to people with disabilities. These developments have also been driven by other objectives, such as reducing costs in STS by transferring passengers from STS to regular public transport. However, so far, there is little evidence of the effects of public transport access on STS usage.

The purpose of this paper is to study the effects of public transport system design on the demand for STS permits and usage. The main focus is on how different aspects of the general public transport system (e.g. price and supply levels) affect the demand for STS permits and STS usage per permit. In addition, the analysis will control for socioeconomic and geographical variables. It is concluded that the price and supply level of public transport do affect STS travel. Public transport price affects the demand for permits as well as the demand for trips from permit holders. Public transport service level only has an effect on the demand for permits.

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Keywords: Special transport services; Public transport; Policy; Price; Service; Accessibility; Local government; Modal shift; Mobility

1. Introduction

An EU white paper has called for a more efficient use of the transport system (European Commission, 2011), emphasising a broader and more flexible use of transport instruments to manage the negative environmental effects of transport growth and costs (Hull, 2008). One of the most important aspects in this transition is modal integration and/or modal shift, such as reducing car use and increasing the use of public transport, walking and cycling. Modal integration and modal shift are core instruments in the Swedish transport policy, as well as in those of many other countries (e.g. in the UK as described by Hull, 2005) and in those of the EU.

When appropriately designed, transport policy measures can reduce levels of car use by promoting other transport modes (Banister, 2008; Holmgren and Ivehammar, 2015). An often-forgotten group in relation to modal shift is that of people with special transport needs, such as disabled or older people. Mobility studies often focus on social aspects of inclusion and accessibility regarding this group (Alsnih and Hensher, 2003, Preston and Rajé, 2007). However, special transport services (STS) are also a policy area in which modal shift and modal integration are encouraged; especially a shift from special transport, using a car, to transport within the general public transport system. A central motive for such a shift from STS is the reduction of costs in special transport (SOU, 2009).

One of the official transport policy objectives in Sweden is that all citizens should have access to the transport system. The public sector is therefore required by law to provide STS for those who are unable to use public transport or a private car. In

* Corresponding author. Tel.: +47 711 958 10, E-mail adress: johan.holmgren@himolde.no

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Sweden, there have been developments in the public transport sector, making buses, trains and other parts of the system more accessible to people with disabilities (SKL, 2014). However, in practice, STS is often provided through the public procurement of taxi services. So far, there is little evidence of the effects of public transport accessibility on special transport usage.

The purpose of this paper is to study the effects of public transport system design on the demand for special transport permits and usage. The analysis includes two related parts. The first part of the analysis examines the proportion of people in a geographical area holding a special transport permit. This reflects how public officials (who approve the permits) perceive the need for (or the option of) using STS among the population. The proportion of people having permits also reflects the perceived need for STS among the public (which applies for permits). For policy reasons, the focus is on how different aspects of the general public transport system (e.g. price and supply levels) affect the demand for special transport permits; however, the analysis will also control for socioeconomic and geographical variables. The second part of the analysis examines the actual number of trips taken by permit holders, using the same variables as before; this part reflects the actual usage of the service.

Most people using STS are elderly, and the importance of understanding the travel behaviour of this group will only grow. Several authors have acknowledged the fact that increased life expectancy will result in a growing proportion of the population being above 65 years old. This may have important implications for future travel patterns and may increase the demand for a flexible and widely accessible transport system (Alsnih and Hensher, 2003; Hjorthol et al., 2010; Shergold et al., 2015; Dejoux et al., 2010; van den Berg et al., 2011; Metz, 2000). Metz (2000) points out that having access to people and places in addition to the possibility of "getting out and about" provides a range of psychological as well as physiological benefits. It is therefore important to increase the understanding of travel behaviour among the elderly and disabled and to examine to what extent regular public transport can play a role in securing their mobility in an efficient manner.

Even though older people might experience reduced physical mobility, they have more time available for activities outside of work, which increases their demand for social trips (van den Berg et al., 2011). Hjorthol et al. (2010) and Dejoux et al. (2010) find that mobility among older people has increased substantially in comparison with the same age groups 20 years ago and that this development is likely to continue. This demand for mobility varies between different groups: higher education tends to increase mobility; women are more mobile than men; and mobility typically falls with age (Dejoux et al., 2010). Several studies point out that there is a substantial difference in behaviour between those aged 65–75 and those above the age of 75. For example, people above 75 are less mobile in general (Hjorthol et al., 2010).

Aarhaug and Elvebakk (2015) find that increasing the accessibility of public transport has a positive impact on public transport usage among the older and disabled. The main effect is caused by people who already use public transport continuing to do so for longer as they grow older. However, the overall effect is found to be lower than what was expected, and Aarhaug and Elvebakk point out that it is important to ensure that accessibility in the entire system is increased so that there are no gaps. In line with this finding, Neven et al. (2015) conclude that a good general public transport system with improved accessibility reduces the need for STS.

A vast number of studies related to travel behaviour have analysed why people choose a specific mode. Typically, these studies focus on how monetary and time costs affect mode choice and, most commonly, on the choice between private car and public transport (e.g. Hensher, 1998; Beirao and Cabral, 2007). There is also a large body of literature on the emotional aspects of travel behaviour (Anable and Gatersleben, 2005; Ellaway et al., 2003; Stokes and Hallett, 1992; Steg et al., 2001). The preferred mode of transport for those aged 65–75 and those over 75 is the car, as either driver or passenger (Alsnih and Hensher, 2003). Over the past 20–25 years, car ownership and usage among older people has increased. This development is especially prominent among women (Hjorthol et al., 2010). Feelings of control, freedom and independence are important factors that influence a choice of car as the preferred travel mode (Burns, 1999). Public transport, on the other hand, is not associated with those positive attributes (Stradling, 2011). Similar patterns are found among disabled people (Nordbakke and Hansson, 2009). Schmöcker et al. (2008) estimates a mode choice model for shopping trips by older and disabled people and concludes that the demand for taxi trips increases with age, and that disabled people and those in wheelchairs have a low probability of choosing the bus. Men are less likely to go by bus than women, and are also less likely to make complex trips with multiple purposes (Fengming and Bell, 2012).

Even though many studies exist on mode choice in general, on older people's use of public transport, and on the attitudes and experiences of disabled people, the knowledge of the demand for STS and more specifically of *how this demand is affected by the design of the general public transport system* is scarce. For this reason, this study focuses on the determinants of STS usage.

The results show to what extent different aspects of the general public transport system affect STS. The paper contributes to new knowledge that could be used in planning a transport system that is accessible to all citizens, while keeping the need for costly STS to a minimum. This paper can also be seen as a complement to the ongoing research on sustainable transport systems (e.g. Banister, 2008; Rosenbloom, 2001), in terms of analysing social (i.e. the travel demand of disabled passengers) and environmental (i.e. the shift from special transport by car to public transport by bus) aspects of public transport that are related to cost efficiency.

The analysis is performed using data from the 21 Swedish counties covering the period 1998–2014. The transport-related data is provided by the Swedish governmental agency Transport Analysis, to which municipalities and transport suppliers are required to report key statistics. The other data is provided by Statistics Sweden.

2. Special transport services (STS) in Sweden

Sweden is located in northern Europe. It is a sparsely populated country with 9,750,000 inhabitants, spread over an area of 450,000 km^2. The main population is located in three large city areas (Stockholm, Gothenburg and Malmö) and in approximately

20 mid-size towns (75,000–200,000 inhabitants). Sweden also consists of smaller towns and rural areas (SCB, 2015). The country has a unitary political system with a central government level and a local government level. The central government has a regulatory responsibility for public transport, while the operational responsibility is delegated to the local government level. This arrangement means that each county has the right to plan and provide its own public transport, and the local government has the right to collect taxes that cover part of the public transport expenses. The local government in Sweden consists of 21 counties and 290 municipalities. Within a county, responsibility for public transport is often shared between a regional transport authority (at the county level) and municipalities. The transport services are then purchased through competitive tendering. In Sweden, public transport is divided between regular public transport and special public transport. Special public transport includes school transport, STS for disabled people, and transport to/from hospitals and other health units (Hansson, 2011). Regular public transport and STS are regulated by different legislation (SFS, 2010:1065; SFS, 1997:736; SFS, 1997:735, 1991:419; SFS, 2010:800; and SFS, 1991:1110). This paper focuses on STS.

In order to achieve modal integration, or modal shift, institutional changes in terms of cross-policy cooperation and policy coordination are needed; that is, structures encouraging horizontal work between local authority departments and service providers (Hull, 2005). Traditionally, STS and PT have been located in different policy sectors as well as being organised in separate units. PT has been part of the regular transport system and STS has been located in the social services sector. Municipalities first started to provide STS in the 1960s. Before then, special transport was often handled by voluntary organisations such as the Red Cross and the Lions. In 1969, the SKL (Swedish Association of Local Authorities) issued recommendations to municipalities on how to organise transport and in a governmental report (SOU, 2003), the SKL recommended that the state should issue subsidies to transport services for disabled passengers. According to the report, it was important that STS be available in all municipalities. The municipalities would have the main responsibility for providing STS, and state subsidies should be provided (SOU, 2003). In the 1970s, STS was implemented in all municipalities, and regulation SFS1980:620 made it mandatory for municipalities to provide STS. The STS became a task for the social services unit within the municipality.

Today, the regional transport authority (RKM) is responsible for public transport in most counties, while the organisation of STS differs. After new public transport legislation was adopted in 2010, more municipalities turned over the responsibility of providing STS to the regional public transport authority. Three organisational models of STS exist in Sweden, in which: (a) the municipality is responsible for providing STS, (b) the regional transport authority is responsible for providing STS and (c) two or more municipalities share the responsibility of providing STS. The trend is that municipalities are giving more responsibility to the county-level RKM. Data from 2013 shows that 133 municipalities out of 290 turned over responsibility for STS to the county-level RKM. The RKM has sole responsibility for providing STS in five counties (SKL, 2014).

Adjustment in PT has occurred in parallel with the adoption of STS legislation; making regular public transport services accessible for disabled passengers has been an ambition in Swedish policy for the past 35 years. In 1979, the government regulated that public transport authorities have a responsibility to adjust their service in order to meet the needs of disabled passengers (SFS, 1997:736). Numerous evaluations have also proposed ways to organise PT and STS in order to increase coordination (SOU, 2009). However, it was not until 2000 that disability questions came in focus within regular public transport planning. In 2000, the Swedish government set the goal that public transport should be fully adjusted to the needs of disabled people by 2010 (SKL, 2014).

In the regular PT system, vehicles adjusted for disabled people are increasing in number. In 2011, 67 % of regular public transport vehicles had low flooring and 60 % had audio bus-stop call-out. Nine out of ten municipalities include accessibility demands related to vehicle chairs in their competitive tendering requirements (SKL, 2014). Several municipalities have implemented “service lines”, which operate public transport buses that are adjusted to meet the needs of disabled and/or older passengers. These buses are smaller and have adjustable floors, seats and so forth. The service lines are planned according to the target group and divided between housing residences, service centres and health units. The thought is that these lines should be a compromise between general public transport buses and STS (SOU, 2009). Changes have also occurred within the STS sector in order to make STS more cost-efficient, and in several ways to make it more similar to regular public transport. Passengers travelling with STS must specify point of origin and destination. If possible, the transport is coordinated so that the passenger shares transport with others in most cases (Nordbakke and Hansson, 2009). In addition, passengers are often restricted to a certain number of STS trips per year.

There are strong efficiency arguments for developing the public transport system in a way that increases the number of passengers. Table 1 presents the cost relation between public transport and STS using data from the Gothenburg municipality.

Table 1. Cost relationships between different transport forms in the City of Gothenburg, Transport Plan 2005–2010

Travel cost	Factor
Regular public transport	1
Flexi line (service line)	7
STS with car	14
Special transport vehicles	21

Source: SKL (2014:36) and Göteborgs stad (2004)

Therefore, in Sweden today, there are clear policy ambitions to increase coordination between regular public transport and STS, as well as ambitions to move passengers from STS to regular public transport (SKL, 2014).

3. Travel behaviour and special transport needs

This section describes travel behaviour and special transport needs in Sweden. Among people with STS permits, private car is the main mode of transport. However, the use of STS is declining while the proportion of people using public transport remains constant. Fig. 1 shows the division between modes and the development over time.

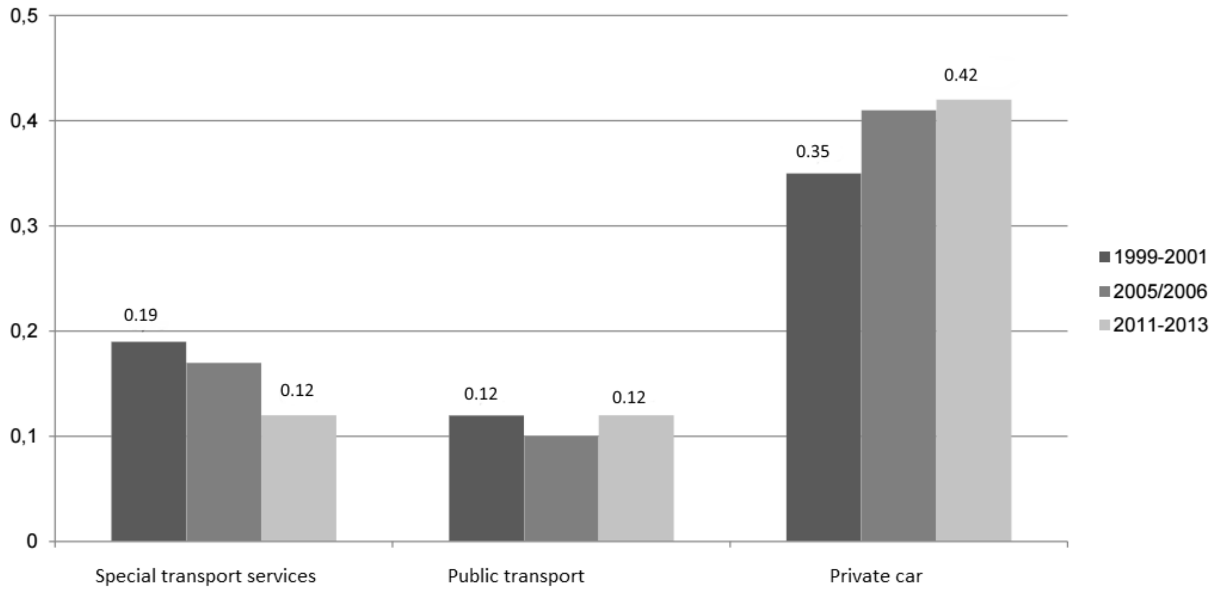

Fig. 1. Journeys per person per day, by persons with an STS permit (source: Peterson [2014]).

However, this figure may show public transport in too much of an unflattering light. The proportion of the population holding an STS permit has decreased during the period shown in Fig. 1, which may be caused by more people preferring public transport, or by authorities being more restrictive in giving out permits. If the reduction in permits is due to an increase in the proportion of people actually preferring public transport it would be a gain for society that could not be seen in figure 1.

During the relatively short period over which data is available, the total real cost of STS services in Sweden has been close to constant (up 3 %). However, total costs are kept down by a decreasing proportion of people having a permit (5 % in 1996 and 3 % in 2014), which hides the fact that the costs per permit have in fact increased by 42 %. Fig. 2 shows this development.

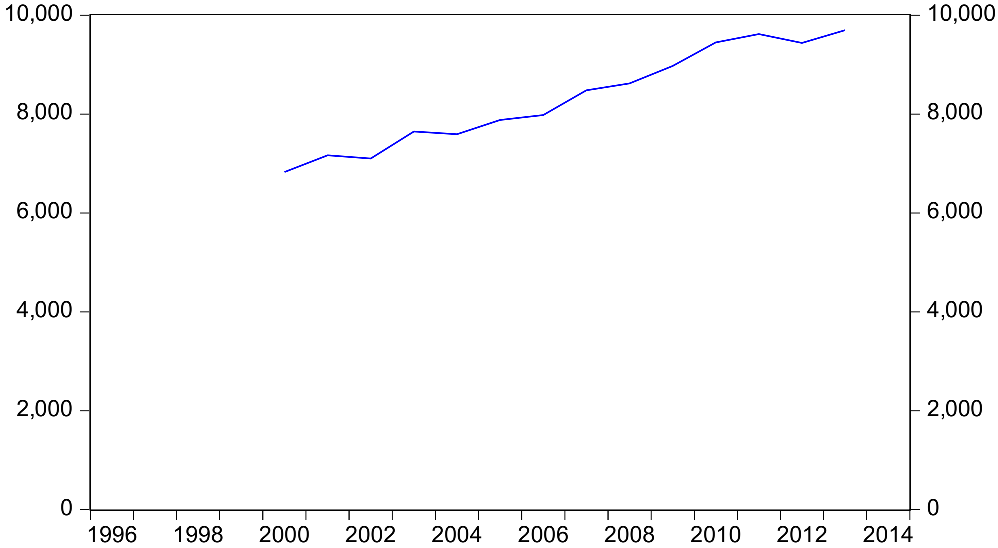

Fig. 2. Costs per STS permit in SEK, 2013 price level.

Therefore, the moderate total increase in cost is explained by a reduction in the number of permits combined with a small decrease in trips per permit. Forecasts clearly show that the population is getting older; that is, that a larger proportion of the population will be over 65 years of age in coming years. Therefore, there is concern that the proportion of people entitled to an STS permit will rise again; and if that occurs, the total cost of STS will rise rapidly.

Table 2 provides an overview of the development of STS permits and STS usage in different counties. The table also illustrates the regional differences, especially in trips per permit.

Table 2. Proportion of population with STS permits in 2014, trips per permit in 2014 and change in trips per permit from 1996–2014

County	Proportion of population (%) with STS permit, 2014	Trips per permit, 2014	Change in trips per permit, 1996–2014 (%)
Stockholm	3.1	46	–4.2
Uppsala	3.4	33	–15.3
Södermanland	3.5	16.3	–34.5
Östergötland	3.9	45.6	–15.5
Jönköping	3.4	21.2	–35.8
Kronoberg	3.5	22.3	–28.1
Kalmar	2.4	48.4	130.7
Gotland	3.5	21.7	3.3
Blekinge	3.4	16	–46.7
Skåne	2.8	50.3	2.6
Halland	3.0	40.1	8.3
Västra Götaland	3.4	29.9	–9.5*
Värmland	3.2	19.3	–19.7
Örebro	3.4	28.4	23.6
Västmanland	3.2	25.3	–25.7
Dalarna	2.9	14.2	–45.5
Gävleborg	2.8	19	–24.1
Västernorrland	4.5	21.4	–7.0
Jämtland	2.7	29.5	–7.9
Västerbotten	4.1	36.2	24.8
Norrbotten	4.3	24.7	12.2

*1998–2014

The proportion of people having an STS permit vary between 2.4 % in Kalmar to 4.5 % in Västernorrland. The variation in trips per permit is much higher, from 16 per year in Blekinge to over 50 in Skåne. The development in the number of trips also shows considerable variation, with 13 counties having fewer trips per permit now than in 1996 and seven having more trips per permit.

4. A model for STS demand

By definition, the total number of trips made by STS in county i in year t ($T_{i,t}$) can be written as follows:

$$T_{i,t} = p_{i,t} \cdot u_{i,t} \cdot I_{i,t} \qquad (1)$$

where
$p_{i,t}$ = the proportion of the population in county i with an STS permit in year t
$u_{i,t}$ = the number of trips per STS permit in county i in the year t
$I_{i,t}$ = the number of inhabitants in county i in the year t

This specification makes it possible to examine the processes affecting the distribution of permits as well as the demand for STS trips per permit.

In general terms, it is assumed that for both permits and trips, demand is a function of characteristics of the transport system (Z) and socioeconomic factors (S) so that:

$$p_{i,t} = f\left(Z_{i,t}, S_{i,t}\right) \qquad (1.a)$$
$$u_{i,t} = g\left(Z_{i,t}, S_{i,t}\right) \qquad (1.b)$$

The Z variables tested in this case include the price of making an STS trip, the price of making a public transport trip, the service level of public transport and car availability. The price variables are quite straightforward; it is expected that the price of an STS trip may negatively affect the demand for permits as well as the demand for actual trips. Since public transport is a substitution good for STS, it is expected that the price of public transport will positively affect permit demand and trip demand; that is, if public transport price goes up, the demand for permits and the demand for trips will increase.[1] Rye and Scotney (2004) and Rye and Mykura (2009) show that public transport fare has an effect on public transport usage among the elderly (but not where these passengers come from) and it is therefore reasonable to assume that the price of using STS may affect STS demand. A similar argument can be made for including the service level of public transport in the demand function for STS. Public transport service levels have been found to have an effect on the probability of older people choosing public transport when travelling (e.g. Rye and Scotney, 2004; Schmöcker et al., 2008). The service level of public transport is expected to have a negative impact on STS permit demand as well as on STS trip demand because increased service levels provide better accessibility and/or shorter waiting times for public transport. The effect of the number of cars available is somewhat unclear. At a first glance, one might expect a region with high car density to have a lower demand for STS permits and STS trips since there might be more opportunities for people to get a ride with someone else who is able to drive. However, high car density might also be an indicator of an area in which the demand for mobility in general is high and/or in which the general accessibility of different activities and public services without a car is low. It is well known that owning a car reduces the probability of using public transport, and this is also true among the elderly (e.g. Schmöcker et al., 2008; van den Berg et. al. 2011). In addition, studies show that car ownership and car use among older people has been rising for the past 20–30 years and that this trend is likely to continue (Hjorthol et al., 2010). Knowledge of the effect of car ownership on STS demand is therefore important for future planning.

The S variables tested include income, population, population density and the proportions of the population that might be defined as “older” and as “very old”[2] (Schmöcker et al., 2008; van den Berg et. al. 2011). In this setting, income is expected to increase the demand for mobility as well as the ability to pay for more trips. However, higher income may also result in an increased demand for regular taxi services as a substitute for STS trips. Therefore, the expected effect of income is unclear. Higher population in an area might result in a person having a larger number of places to visit and might therefore result in higher STS demand. On the other hand, higher population density usually implies that activities are more concentrated in space, which should reduce the need for STS services. Van den Berg et. al. (2011) finds that travel behaviour among the elderly differs between areas with different density. It is known from previous studies that travel behaviour changes with age and it is common

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[1] See for example Gravelle and Rees (2004) for a general textbook discussion on the effects of prices on demand and for example Oum et al. (1992) for a discussion on price effects in transport.
[2] As mentioned earlier, data on these variables is acquired from Statistics Sweden, which publishes official Swedish statistics (www.scb.se).

to differentiate between old people and very old people (Alsnih and Hensher, 2003; van den Berg et al., 2011; Hjorthol et al., 2010; Dejoux et al., 2010). Two age-related variables are tested in this study: one indicating the proportion of the inhabitants in the county from 65–79 and one indicating the proportion above the age of 80. The expected effect of these variables is unclear. In the first group, although the individuals might exhibit a high demand for mobility, a large proportion of them might still be able to drive themselves and use public transport. In the older group, there is likely to be a higher proportion in need of STS services when travelling, but also a lower level of mobility demand in general.

Table 3. Variables tested for inclusion in the empirical estimates of (1.a) and (1.b)

Variable	Description	Expected effect on STS demand
F^{sts}	Price of using STS	–
F^{pub}	Price of using PT	+
V	Vehicle kilometres of PT service	–
C	Car ownership level	?
Y	Average income	?
I	Population	+
d	Population density	–
$S1$	Proportion of population aged 65 –79	?
$S2$	Proportion of population aged above 80	?

For the empirical application, it is assumed that (1.a) and (1.b) take a multiplicative form[3] so that:

$$lnp_{i,t} = \gamma_i + \delta_t + \alpha_0 lnF_{i,t}^{sts} + \alpha_1 lnF_{i,t}^{pub} + \alpha_3 lnV_{i,t} + \alpha_4 lnC_{i,t} + \alpha_5 lnY_{i,t} + \alpha_6 lnI_{i,t} + \alpha_7 lnd_{i,t} + \varepsilon_{i,t} \quad (2.a)$$

and

$$lnu_{i,t} = \theta_i + \mu_t + \beta_0 lnF_{i,t}^{sts} + \beta_1 lnF_{i,t}^{pub} + \beta_3 lnV_{i,t} + \beta_4 lnC_{i,t} + \beta_5 lnY_{i,t} + \beta_6 lnI_{i,t} + \beta_7 lnd_{i,t} + \sigma_{i,t} \quad (2.b)$$

Both equations (2.a) and (2.b) include county-specific effects (γ_i and θ_i) as well as time-specific effects (δ_t and μ_t). The county-specific effects are included in order to account for variables not specifically included in the model (but affecting STS demand) that differ between counties but are constant over time. For example, these might be geographical factors or differences in culture (if they are reasonably constant over time). These effects are sometimes referred to as "unobserved effects". The time-specific effects are present to account for variations in time that are constant between counties. Such effects might include general economic shocks or other events affecting all counties in a similar way (Baltagi, 2001; Wooldridge, 2002).

In the estimation of (2.a) and (2.b), a stepwise procedure was used to exclude variables not found to be statistically significant (e.g. Neter et al., 1996). The models are estimated using the fixed effects (FE) estimator (Wooldridge, 2002). Table 4 shows the results of the final equation for the number of permits per person in a county (2.a).[4]

[3] Linear and semi-logarithmic functional forms were also considered and tested but the multiplicative functional form performed better in terms of the Akaike criterion and resulted in plausible parameter estimates.
[4] County-specific effects and time-specific effects are not shown.

Table 4. Results from estimation of (2.a): factors found to affect the number of STS permits per person

Variable	Coefficient	Std. error	t-Statistic	Prob.
Constant	–39.19	7.10	–5.52	0.0000
LnF^{sts}	–0.15	0.02	–7.64	0.0000
LnV	–0.15	0.03	–4.44	0.0000
LnC	2.06	0.57	3.61	0.0004
LnI	1.92	0.32	6.06	0.0000
LnS1	–0.83	0.19	–4.44	0.0000
LnS2	0.62	0.18	3.39	0.0008
Cross-section fixed (dummy variables)				
Period fixed (dummy variables)				
R-squared	0.91			
Adjusted R-squared	0.89			

From Table 4, it can be seen that the price of making an STS trip (F^{sts}) affects the demand for permits as expected. The estimated elasticity is –0.15, meaning that a 1 % increase in STS fare reduces the number of permits by 0.15 %. Public transport supply, in terms of vehicle kilometres, has a negative impact on the demand for permits. In this case, the elasticity is also –0.15. This result implies that it would actually be possible to reduce the number of STS permits by increasing PT service. Car ownership is found to have a positive effect on the number of permits, thus indicating that people living in counties with high car ownership levels are used to a high level of mobility and/or that the geographic structure of the county is such that a car is necessary to access different kinds of services.

Population is found to have a positive effect on the number of permits *per person*. This indicates that in areas with a larger population, there is a higher demand for permits, perhaps because the presence of more people results in larger networks of people. The proportion of people in the first age category (65–79) appears to have a negative effect on the number of permits, while the proportion of people in the other age group (> 80) has a positive effect on the demand for permits. This result might be interpreted as the younger group still being able to use other forms of transportation to a high degree,[5] while people in the older group require more assistance when travelling.

Table 5 presents the results from the estimation of the final equation for the number of trips per permit. In this case, the price of STS has a negative effect on the number of trips. The elasticity is found to be –0.03; that is, an increase in STS price by 1 % reduces the number of trips per permit by 0.03 %. Income is found to affect travel positively, with an elasticity of 1.89, which is reasonable because once a person needs a permit, income will increase the demand for mobility. A larger proportion of people in the oldest age category is found to reduce the number of trips per permit. In this case, population in itself is not found to be significant; rather, it is population density (I/A)[6] that has a negative effect on the demand for STS trips. As mentioned earlier, this might be because more amenities are located close together, thereby reducing the need for transport.

[5] This might also be due to counties having many people in that group being more committed to making their PT system more elderly friendly.
[6] A is area of the region

Table 5. Results from estimation of (2.b): factors found to affect the number of trips per STS permit

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	–19.11	8.88	–2.15	0.0324
Ln*PS*	–0.03	0.01	–3.52	0.0005
Ln*Y*	1.89	0.69	2.72	0.0070
Ln*S*2	–1.05	0.39	–2.69	0.0078
Ln(*I*/*A*)	–1.19	0.35	–3.43	0.0007
Cross-section fixed (dummy variables)				
Period fixed (dummy variables)				
R-squared	0.86			
Adjusted R-squared	0.84			

Using the results presented in Tables 4 and 5, together with equation (1) for the total number of trips, the total effect of different variables on the number of STS trips can be calculated. Elasticity can be defined in several different ways (e.g. Webster and Bly, 1980), but the definition that is by far most common defines the point elasticity as:[7]

$$E_{T,x_i} = \frac{\partial T}{\partial x_i}\frac{x_i}{T}$$

Table 6 shows the (point) elasticities of STS trips with respect to different variables x_i.

Table 6. Estimated elasticities of STS trips with respect to different variables

Variable	Elasticity
STS fare	–0.16
PT service level	–0.15
Car ownership	2.06
Income	1.89
Population	2.92
Proportion aged 65–79	–0.82
Proportion aged > 80	–0.43
Population density	–1.19

Looking specifically at the variables that might be directly influenced by transport policy, it can be seen that the STS fare affects the total number of trips by an elasticity of –0.16; that is, an increase in STS fare will reduce the total number of STS trips by 0.16 %. At the same time, an increase in the supply level of public transport by 1 % reduces the total number of STS trips undertaken by 0.15 %. Therefore, the results support the hypothesis that the number of STS trips could be reduced by increasing service levels in general public transport. This effect occurs through a reduced demand for STS permits, but does not affect the number of trips per permit.

5. Conclusions

The main conclusion is that local transport policy can affect STS demand, firstly through the pricing of STS services and secondly through the service level in the regular public transport system. In the case of STS pricing, it is found that the price level affects both the demand for STS permits and the demand for STS trips. The overall elasticity of STS trips with respect to price is estimated at –0.16. The public transport service level, on the other hand, is found to affect the total number of STS trips by lowering the demand for STS permits but not the number of trips per permit. The overall elasticity in this case is found to be –

[7] See Cowie (2010) for a basic introduction to demand elasticities and Oum et al. (1992) for a discussion on elasticities in transport demand analysis.

0.15. It might therefore be possible to keep travellers within the regular public transport system by providing good service levels and by influencing their propensity to obtain a permit for STS services. This is in line with the findings of Aarhaug and Elvebakk (2015) who conclude that good public transport accessibility could result in people who have been using public transport continuing to do so as they grow older. Public transport service levels do not, however, appear to have an effect on those who already have a permit.

From a long-term perspective, the finding that increased population density decreases the demand for STS services might have important implications. A successful policy for increasing population density could therefore result in a lower demand for STS services. In this case, the effect occurs through the demand for trips per permit and not the demand for permits. This result indicates that people living in densely populated areas may still like to have the opportunity to use STS, perhaps due to the distant locations of some desired destinations.

It is also found that income has a positive effect on STS trips. This effect occurs through an increase in the number of trips per permit. This result provides a future challenge, as incomes are expected to keep rising. If authorities want to avoid rising STS usage, this link must be broken or other measures must be large enough to compensate for this development.

In summary, a policy aimed at reducing STS usage should include access to affordable public transport with good service levels. In order to strengthen such a policy, future planning should also involve policies aimed at increasing city density.

5.1 A wider perspective: barriers to a modal shift from STS to public transport

Based on these conclusions, one might ask, on a more general level: What further reasons exist for people not using public transport instead of STS? Interviews with STS passengers show that they have mixed feelings regarding PT use. Some believe they have more freedom when using PT; however, many experience infrastructural hindrances to using PT. For example, high curb stones and other aspects of the physical environment may make it difficult to get to and/or board the bus. Nordbakke and Hansson's (2009) interviews with STS passengers indicated that STS is still seen as a taxi mode/service. Historically, passengers received their own vehicle when travelling with STS in Sweden. Thus the STS was very similar to regular taxi services, but with a lower price. Now passengers going in the same direction share a car. The STS is also stricter in planning routes – passengers need to state their start and end points, and cannot change them once the car is underway. The STS passengers in the study were not happy with the changes. The interviews indicated that STS passengers do not view STS as part of the public transport system; instead, they see STS as a mode within the taxi system. They do not view themselves as public transport passengers when using STS.

This attitude among STS users indicates that many of them do not perceive PT as an alternative to STS in the form that they think it should be. However, if policymakers stand firm in the changes made to the actual workings of STS, this attitude might actually be an advantage, since STS will then be seen as a less favourable alternative to PT; especially if regular PT is provided at low cost and with good service. These findings also make it clear that a successful strategy includes policy aimed at keeping people from having to apply for a permit in the first place.

Therefore, in addition to the previous policy recommendation, a successful policy for reduced STS usage should probably include distributing information about the actual workings of the STS, with a focus on sending the message that STS is not a taxi service but part of the public transport system.

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