PUBLIC TRANSPORT QUALITY AS A TOOL FOR REDUCING CAR DEPENDENCY

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1. INTRODUCTION

"The overall objective of the Transport policy is to ensure an economically efficient and sustainable transport system for citizens and industry throughout the country." (Bill 2008/09: 93 p. 14) As part of the fulfilment of this goal for Swedish transport policy, it is said that the transport system should be (re)designed in a manner so that it contribute to reduced climate impact as well as improved health for the public. For this to be possible, a greater proportion of future travel has to be made by bicycle, by foot or by public transport.

At the local level, public transport usage has been on the decline, in absolute terms, as well as in terms of the share of total transport trips. The loss of market share has primarily been to the private car. This negative trend has been going on since the 80s. (Holmgren, 2005, Holmgren et.al. 2008).

Alongside increased levels of income and traffic volume, car ownership has also increased in Sweden. From the mid-60s car ownership has increased by 190% and it is estimated to increase by another 55% until 2030 (Dargay et.al. 2007) The importance of income for car ownership is well established in the literature (e.g. Jansson et.al. 1983, 1986, Dargay et.al. 2007, Caulfield, 2011, Holmgren, 2013). Since car owners are hard to influence into using more environmentally friendly modes of transport, breaking this link is especially important for the development of the future environmental impact of the transport sector.

In both large and medium-sized cities the living environment is negatively affected by car traffic. Noise, pollution, congestion and risk of accidents can be reduced if current drivers can be persuaded to use public transport instead of the private car and if the perceived need for owning a car at all could be reduced. The really important question in the long-run therefore appears to be whether or not we can design our cities and the public transport system in a way that makes less people feel the need to own a car in the first place.

In this context it is a problem that, despite the fact that previous studies clearly show that people having access to a car rarely use public transport, there are very few studies that explicitly incorporates the quality and competitiveness of public transport, walking and bicycling into models of car ownership.

To enable planning of a future transport system for improved health and reduced environmental impact, it is important to be aware of how car ownership is affected by the design of the public transportation system and the quality of other modes of transport.

This paper aims at contributing to the overall objective of increasing the knowledge of the conditions under which public transport can be a competitive alternative to the private car and what urban planning measures can be used to reduce long-run car dependency in favor of more sustainable modes of transport. Specifically, the purpose of this paper is to examine how car ownership is affected by the quality and cost of public transport.

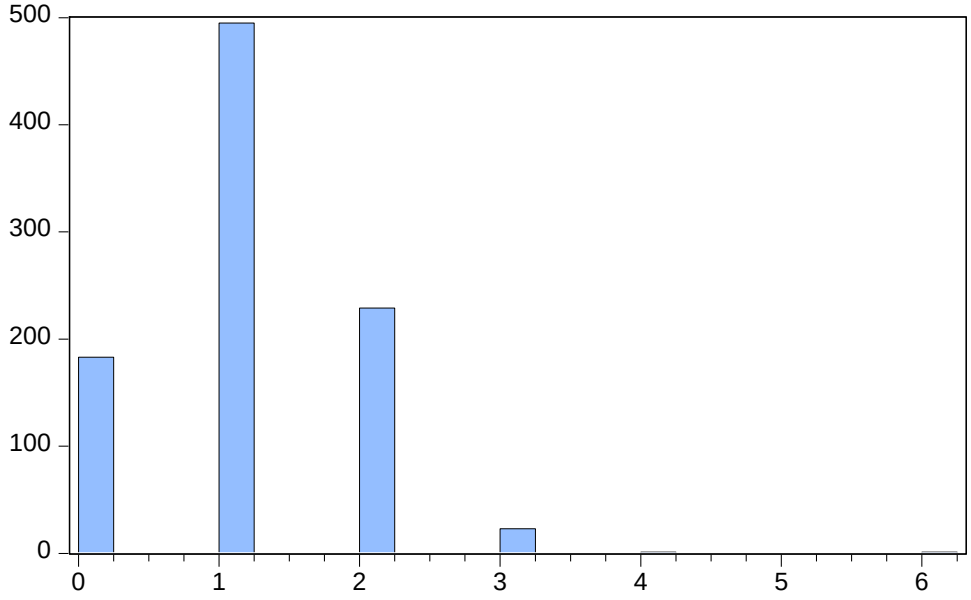
2. DATA

The data used in this study was collected by sending questionnaires to a random sample of the population. In total, 3000 questionnaires were sent, in which the respondents were asked questions concerning their travel behaviour, car ownership and socioeconomic standard. The survey was undertaken in two parts. The first was conducted during February and March 2013 and the second during August and September 2013. The samples were drawn randomly among all persons aged 20–65 years living in in the Swedish town Linköping. Linköping was selected as it is an example of a town in which walking, bicycling and public transport can be seen as realistic alternatives to the private car for commuting and everyday activities. The selected area can therefore be seen as a representative of a large proportion of mid- to small size towns, especially in northern Europe. The overall response rate was 45%.

After an initial question about current employment, the respondent answered questions about how they actually travelled to their work or place of study in the previous week. The questions were about mode choice, frequency, the specific reason for the choice, and travel time. They survey also included questions about the availability of parking facilities at work or school, distance to bus stops, whether a bus change must be made on the way, and the time and cost of different modes of travel to work or place of studies.

Figure 1 show the distribution of car ownership among the respondents that answered this question. The average number of cars per household is 1.11 and the median is 1.0.

Figure 1. Distribution of car ownership



3. CAR OWNERSHIP – A BRIEF OVERVIW OF THE LITERATURE

The choice of transport mode for different types of activities has been extensively and commuters have been a particularly common unit of study. (See, for example Espino, et.al. 2007, Bajić, 1984, Swait and Ben-Akiva 1987, Dunne, 1984) Other studies has focused on which factors affect cycling but doing so without explicitly acknowledge the influence of the conditions under which other modes of transport are operating. (Hunt and Abraham, 2007, Parkin et.al. 2007, Ortuzar et al 2000, Wardman et.al. 2007)

When it comes to car ownership, the studies have been strongly focused on the effects of (rising) income, price of petrol, and the price of new cars on car ownership. It is well established that increased income leads to higher probability of owning a car and to households owning more cars (e.g. Jansson och Shneerson 1983, Jansson m.fl. 1986, Matstoms, 2002, Dargay m.fl. 2007, Holmgren, 2013) Many authors also stress the fact that car ownership exhibits state dependency, i.e. owning a car in one time period makes it more likely to own one the next time period too. (e.g. Dargay and Hanly, 2000b)

It has also become increasingly popular to study the effects of different socioeconomic variables (other than income) on car ownership and the propensity to get a car. The effects of different family composition have for example been studied by Oakil, et.al.(2013) and Zhang, et.al. (2014). Matstoms (2002) concludes that, in addition to income and cost of cars, people living in urban areas are less likely, to own a car than those living in rural areas, women are less likely to own a car, and that age and family composition also affect car ownership. Dargay and Hanly (2000b), for example, concludes that the number of adults in the household who are employed, whether or not the household head is a senior (over age 65) and the location of the household also has an effect on car ownership.

However, when it comes to the linkages between the design and accessibility of the public transport system and car ownership the previous research is thin. The same goes for the effects of planning measures, (e.g. limiting the access to parking, constructing speed bumps, lowering speed limits and introducing one-way streets), on car ownership. In some cases, isolated aspects of the public transport system are included among potential variables for explaining people's car preferences without taking into account a broader view of the transport system. Dargay and Vythoulkas (1999) for example, include the price of public transport in their model but not other aspects such as service frequency, travel time, distance to bus stops etc.

4. CAR OWNERSHIP – A MODEL

As number of cars owned by a family (Car) takes (nonnegative) integer values it is an example of a count variable. A common assumption, used in order to ensure that the predicted values are non-negative, it is assumed that the expected number of cars E(Cars) is given by an exponential function of a set of n explanatory variables x_1 to x_n, i.e.:

$$E\left(Car\middle|e^{\beta_0+\beta_1 x_1+\beta_2 x_2+\cdots+\beta_n x_n}\right) \quad (1)$$

Table 1 show the variables tested for inclusion in the estimation of the model explaining car ownership (1). The variables include aspects of the transport system such as the time it takes to make a trip to work by different modes of transport, the cost of using car or bus for a trip to work, the proximity of bus stops and if there is a need to change bus for a trip to work. Note that there are many other reasons for making a trip and owning a car than using it for trips to and from work, the variables included in this study could be seen as proxies for general aspects of the transport system. It could also be mentioned that work trips make up a considerable proportion of the total number of trips and since it for many people is a necessary trip, those aspects of the transport system most likely affects other transport decisions as well. The explanatory variables also include socioeconomic factors describing the household. These include income, which for is assumed to have a positive effect the expected number of cars but if the household include children (of different ages), gender of the respondent and educational background. Household size, measured as the number of adults, is also included to correct for the possibility of a larger household needing to have more cars for the car level of car access to be constant.[1]

Table 1. The explanatory variables tested in the car ownership model

Variable	Description
Age	Age of the respondent
Cost buss	Cost of taking the bus to work
Cost car	Cost of taking car to work
Change bus	Dummy variable, =1 if respondent have to change bus for a bus trip to work
Distance bus stop	Meters to the closest bus stop at home + meters to closest bus stop at workplace
High school	Dummy variable, =1 if respondent have attended high school as the highest form of education
University	Dummy variable, =1 if respondent have attended university as the highest form of education
Gender	Dummy variable, =1 if respondent is a woman
Children 1	Dummy variable, =1 if respondent have at least one child of age 8-17 living at home
Childern 2	Dummy variable, =1 if respondent have at least one child under the age of 8 living at home
Household size	Number of persons, 18 years or older, in the household
Time bicycle	Time it takes to travel to work by bicycle
time buss	Time it takes to travel to work by bus
Time car	The time it takes to travel to work by car
Time walking	The time it takes to walk to work
Income	After tax income for the household

Since number of cars owned by a family takes relatively few values, including zero (see distribution in figure 1), assuming that the variable (Car) follows Poisson distribution is a reasonable starting point. The model (1) could then be estimated by maximum likelihood but since the variance assumptions of the Poisson distribution might be too restrictive, quasi-maximum likelihood is used (QMLE). (Wooldrige, 2002)[2]

Table 2. The result from the QMLE estimation of equation (1) including all explanatory variables.

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Constant	-1.494712	0.151252	-9.882286	0.0000
AGE	0.011941	0.001857	6.430791	0.0000
Cost bus	0.003714	0.002843	1.306103	0.1915
Cost car	-0.000763	0.001127	-0.677399	0.4982
Change bus	-0.008313	0.041389	-0.200837	0.8408
High school	-0.037647	0.090110	-0.417784	0.6761
University	-0.154428	0.090990	-1.697198	0.0897
Gender	-0.024894	0.035995	-0.691582	0.4892
Child age 8-18	-0.024156	0.052018	-0.464387	0.6424
Household size	0.121779	0.023913	5.092635	0.0000
Children < age 8	-0.050889	0.050840	-1.000959	0.3168
Time bicycle	0.008979	0.003040	2.954162	0.0031
Time bus	0.002337	0.001290	1.811068	0.0701
Time car	-0.005642	0.004027	-1.401267	0.1611
Time walking	0.000194	0.001090	0.178330	0.8585
Income	1.64E-05	1.47E-06	11.14997	0.0000

Although several variables appear statistically significant, not all are. It is e.g. interesting to note that among the variables describing the transport system, none of the cost variables and only two of the time variables (not including Time_Car) appear

significant at any reasonable level (10% or less). The change_bus variable is also not significant, indicating that this does not affect the decision on how many cars to get.

Eliminating non-significant variables result in a smaller model, which is shown in table 3.[3] All remaining variables are significant on the 10% level

Table 3. The results of estimation of the smaller model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Constant	-1.340946	0.102577	-13.07252	0.0000
Cost bus	0.004910	0.002849	1.723544	0.0848
Time bicycle	0.008301	0.001588	5.226632	0.0000
Time bus	0.002584	0.001169	2.210083	0.0271
Income	2.03E-05	1.31E-06	15.50062	0.0000
University	-0.156192	0.039348	-3.969553	0.0001
Age	0.009358	0.001629	5.745168	0.0000

It can be seen that the (perceived) cost of riding the bus[4] affects the expected number of cars owned positively, i.e. if bus fares are increased car ownership will also increase. The same goes for the time it takes to go by bus which can also be seen to have a positive effect on car ownership. In order to get some perspective on the size of the effect, it is useful to interpret the results in terms of elasticities. In this case, the (point) elasticity of car ownership (Car) with respect to bus fare (cost_bus) is:

$$E_{Car|Cost\_bus} = \frac{\partial Car}{\partial Cost\_bus} \cdot \frac{Cost\_bus}{Car} \qquad (2)$$

Since the elasticity in this case will vary with the level of the bus fare (Cost_bus) it is evaluated at the average level. It is then found that the elasticity of car ownerchip with respect to bus fare is 0.1, meaning that if the bus fare increase one percent the expected number of cars owned increase by 0.1 percent. The elasticity with respect the time of a bus ride (time_bus) is found to be 0,079 while the elasticity with respect to income is 0,7.

Another interesting finding is that the time it takes to go by bicycle also affects car ownership, in this case the elasticity is found to be 0,15, meaning that a one percent increase in the time it takes to go by bicycle from home to the workplace increase the expected number of cars owned by 0,15 percent.

These are important findings from a policy point of view as it indicates that public transport policy will actually affect car ownership (although the elasticities are small). In line with previous studies and what could be expected, income has a positive effect on expected number of cars. Increased income will therefore increase the expected number of cars owned and equivalently, households with higher income are expected to own more cars. Older people are more likely to own more cars which is logical from two points of view. First of all, cars are capital goods with long use time making it likely that some people keep their old car when getting a new one, making car ownership a cumulative process (see also Dargay and Hanly (2000b) and the discussion on state dependency). Secondly, older people might have a harder time

getting around using other means of transportation and could therefore be more likely to own a car. The question of how age affects car ownership is however complex, where young people have a higher propensity to enter the into car ownership than older people but at the same time have a higher propensity of exiting. (Matstoms,2002). Higher education reduces the expected number of cars owned, which might be due to them being more aware of the environmental stress caused by car use (see Shen et al. (2009) for a discussion on the effects of information environmental effects on transport choices).

Some words have to be said about the non- significant variables. Most surprising is perhaps that the variables describing the monetary and time costs of using car were found to be non-significant. This might be due to the public transport variables already capturing the effects of the relative competitiveness of the transport modes. It is also somewhat surprising that the change bus variable is not significant but one should remember that car ownership and car use, in addition to the factors discussed here, is affected by psychological and social factors not being captured in this study, which might affect the results. (Steg, 2005)

5. CONCLUDING DISCUSSION

The aim of this study was to draw conclusions as to what extent the design of the public transport system might affect car ownership. This is an important question as car owners are hard to influence into using more environmentally friendly modes of transport, thus making it harder to reduce the environmental stress caused by the transport system. Therefore, future policy aiming in this direction should most likely include measures that reduce the relative attractiveness of *owning* a car, as well as measures reducing the attractiveness of *using* the car.

It was found that the monetary- as well as the time cost of public transport do have an effect on car ownership thus making it possible to affect car ownership through public transport policy. This finding is important as it makes it enhances the short run effects such measures have on mode choice. The elasticities for car ownership with respect to bus fare was found to be 0,1 while the elasticity with respect to bus time was is 0,079 (evaluated at the average level of the variables). A one percent increase in bus fare will then result in a 0,1 percent increase in expected car ownership and an increase in bus ride time of one percent will result in an increased expected car ownership of 0,079 percent. This could be compared to an elasticity with respect to income of 0.7.

Even though public transport can be an instrument in reducing future car dependency, this study also shows that the effects on car ownership are quite small. Therefore, such policy should be combined with other measures in order to be effective. Car use can often be linked to other motives than getting from A to B in the most efficient way. Status and other social motives may also affect mode choice and the choice to own a car (Steg, 2005). As argued by Gärling and Schuitema (2007), in order to be effective, policies aimed at reducing car dependency may have to be coercive (see also Nurdden et al., 2007a; 2007b). Combining improved functionality of public transport and reduced fares with other measures aimed specifically at reducing the attractiveness of car use is required in order to achieve significant

results. Such measures might include road pricing and increased parking fees (Ryley, 2008) as well as restricting access to parts (or even the whole) of the city.

An even broader take on the issue would include stressing environmentally friendly mobility in urban planning so that the constraints on mode choice (the need to transport children, running errands etc.) discussed by O'Fallon et al. (2004) could be relaxed. This method might also include improved maintenance of infrastructure for bicycles as a means to reduce car use, as suggested by Bergström and Magnusson (2003). Information and campaigns to influence attitudes might also be part of a successful policy to reduce car use, as these might affect the social motifs for using a car as mentioned above. In addition, Shen et al. (2009) show that people experiencing deterioration in the environment are more likely to use public transport. Making the link between traffic and environmental problems clearer to travellers might therefore also affect behaviour, in the long run. Promoting bicycle use (Wardman et al., 1997; 2007) and walking (Ryley, 2008) or the use of bicycles in combination with public transport (Martens, 2004, 2007) might be particularly successful if combined with information and restrictions on car use.

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Notes

1) One might also consider modelling the number of cars per person but such variable could would no longer be a count variable as it would not be limited to integers.

2) For a textbook introduction to Poisson regression see e.g. Griffiths et.al. (2008)

3) The elimination is performed through a stepwise procedure where the variable with the smallest (in absolute values) z-statistic is removed first. After each step, previously removed variables are tested for re-entry into the model. (See e.g. Neter et.al (1996) for a discussion on stepwise elimination)

4) In reality, the respondents all face the same fare system and the only cost of traveling by bus that vary is due to travelers choosing different methods of payment. However, the respondents have been asked about what they think it costs to go by bus which is what influences decisions.