The relation between perceived and actual private travel costs – a key question for efficient modal split

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Abstract

Distortions in form of misperceptions of the private transport cost may lead to more travelling by car instead of travelling by bus to work. The purpose of this paper is to study if car commuters underestimate the variable private cost of travelling by car to work and overestimate the travel time if they would travel to work by bus.

This possible market failure due to incomplete information is studied with the help of data in the form of answers from those travelling by car or by bus to work in a survey with answers from 1023 randomly selected persons in the City of Linköping travelling to work or studies within a specified area where car, bus, bicycle or walk are the available transport modes.

The results indicates that information about the actual private travel costs travelling by different transport modes may be an inexpensive way to increase economic efficiency and at the same time make transportation more environmentally friendly.

1. Introduction

An economically efficient and sustainable transport system is a goal in Sweden (The Riksdag, 2009) as well as in the European Union (European Commission, 2013). Increasing the share travelling to work by bus instead of by car may be a way to increase efficiency as well as sustainability. Internalization of external effects is a possible course of action for the Public sector to approach this goal. One example of internalisation of positive external effects is subsidies for bus transportation that can for example be motivated by the Mohring effect

(Mohring, 1972), i.e. positive returns to scale in consumption. An example of internalisation of negative external effects is congestion charges to improve the environment and decrease traffic congestion as the congestion tax in Stockholm (The Swedish Transport Agency, 2015).

Another possible market failure, not as much studied as external effects in the transport sector, is incomplete information in the form of inadequate perception of the private travel costs for different transport modes. Travellers can be assumed to choose the travel mode that gives them the highest net benefit if they have complete information about the private travel costs by using different travel modes for their trips. The total private cost of travelling by different modes consists of monetary costs as well as non-monetary costs. The monetary cost when travelling by bus is the fare. Monetary variable costs when travelling by car are the costs for the trip in fuel, as well as maintenance costs and car depreciation caused by the kilometres driven. Private fixed costs for a car as interest, insurance, taxes, vehicle inspection, parking place at home and time-dependent car depreciation should affect the decision of owning (another) car, and thereby affect the possible travel choices in the long run. It is however the private variable costs that should affect the travel choice in the short run.

Some monetary costs as fares and fuel costs are more direct and visible for the traveller (out-of-the-pocket) than other variable monetary costs, as kilometre depending car maintenance and car depreciation. A non-monetary private cost when travelling by different transport modes is the time spent travelling from door to door. If the travellers are fully aware of both the private monetary and non-monetary costs for different travel modes they can make the best choices for themselves, restricted by the current design of the transport system and the transport policy applied.

A study in Sydney (Glazebrook, 2009) revealed that the “out-of-pocket” cost of car use was only one third of the total private costs and less than one sixth of the total cost, when also including external costs. The author points out that the “out-of-pocket” cost is the cost most likely to be perceived by the traveller and which will affect travel choices. Shiftan and Bekhor (2002) studied the individual perception of car travel costs by commuters. They did found that the mean stated travel cost was too low with a large standard deviation, and concluded that travellers are uncertain about the private travel costs and may only take fuel costs into account.

In Sweden studies has found that the fuel taxes approximately covers the external costs when driving a car in the country side, but not in cities (Transport Analysis[i], 2013). The "out-of-pocket" cost when driving a car in Sweden is approximately 1 SEK per kilometre (The Automobile Association[ii], 2015, The Swedish Consumer Agency, 2015), while the full private variable monetary cost per kilometre is approximately 3 SEK per kilometre (The Automobile Association, 2015).

One part of the possible market failure due to incomplete information is that travellers may not fully be aware of and take into calculation the full private monetary cost of a transport mode they actually travel by. Another is that travellers may misjudge the size of the private non-monetary cost in form of the travel time by transport modes they not presently use.

The relation between the perceived and actual private travel costs can be studied by comparing the stated monetary cost and travel time when travelling by different transport modes with the estimated actual costs. The aim of this study is to study if car commuters take the correct private monetary cost travelling by car into calculation, and if they perceive the travel time if they would travel by bus to work correctly. Data from a study about actual and potential travel to work in the midsized town of Linköping in Sweden is used for studying this.[iii]

The method in the present study will be to compare respondents' answers to questions about their actual monetary cost and travel time with car and bus when travelling from their home to work within approximately 12 km with an estimation of the actual costs for the same persons. One hypothesis is that those travelling by car might underestimate their total variable monetary cost travelling by car.[iv] Another hypothesis is that car travellers not presently travelling by bus to work might overestimate the travel time using this more environmentally friendly transport mode from their home to their workplace.

This paper aims at increase the knowledge of possible market failures in form of incomplete information in the transport sector that may distort the correct choice of transport mode and lead to travelling too much by car and too little by the more environmental friendly transport mode bus. Such possible market failures may be corrected with information from the Public.

2. The survey of travel to work or studies in Linköping

The object of the survey that collected the data used in this study was travel to work or studies when car, bus, bicycle or by foot were the possible travel mode options. Our population was defined as people who live and work or study in a delimited area where those transport choices can be relevant travel mode options. The chosen area is the 26 neighbourhoods defined as the densely built-up area in the medium-sized town Linköping in Sweden (Linköping municipality, 2013) together with four other neighbourhoods nearby.[v]

We sent questionnaires to random samples of the population on two different occasions. The first was about mode choice when travelling in the half of the year including the winter months, defined as October to March. This was conducted during February and March 2013. The second about travel mode choice during the half of the year including the summer month, defined as April to September, was conducted during August and September 2013.

The samples were drawn randomly among all persons aged 20-65 years living in a range of postcode areas in Linköping.[vi] Some of these postcode areas partly included persons who lived outside the 30 selected neighbourhoods, which lead to that some persons in the sample did not live in the selected area and thus were excluded from the sample. In addition, people not working or studying within our selected area were also excluded from the sample. Defining the correct sample size and thereby the response rate is difficult, since some of the non-respondents should have been excluded from the samples. The response rate was at least 45 % in both studies. The result of the study was in total 1023 useable responses.

After an initial question about current employment, the respondent answers questions about actual travel to work or studies in the previous week. The questions are about mode choice, frequency, reason, and travel time “from door-to-door” to and from work or studies. Then questions about parking facilities at work/studies, distance to bus stops, whether a bus change must be made on the way when travelling by bus, and the time “door-to-door” and monetary cost of different modes of travel to work/studies follow. At last two questions about mode choice after some change and questions about the respondent follow.[vii]

The answers from those travelling to work by car or by bus will be used in this study.[viii] One reason for excluding respondents travelling to studies is that a larger share of them has not access to a car or not even a driving license.[ix]

3. The private monetary cost driving by car to work

To study if the stated private monetary travel cost by car differs from the actual one, we compare car commuters stated private monetary travel cost by car with the estimated actual variable private monetary cost by car. To make it comparable, the stated monetary travel cost to work by car by the car commuters (which travelled by car to work the previous week) is measured per minute:

$$\frac{stated\ cost\ per\ single\ trip\ to\ work\ by\ car}{\frac{(stated\ time\ per\ trip\ to\ work\ last\ week + stated\ time\ per\ trip\ from\ work\ last\ week)}{2}} \quad (1)$$

The respondents state the time travelling per trip to work, as well as per trip back from work, for their actual trips the previous week. An average of the time to and the time from work is used. One possible problem is that the respondent might state the cost by car considering the trip to and from work instead of the cost single way. One way to discover this is to study the stated cost by bus for the same person. The fare for a single ticket by bus one-way in Linköping at the time of the study was 19 SEK. Those stating double that sum or more for bus are excluded (9 responses), because they are assumed to have misunderstood the questions about cost per trip correctly.[x]

The stated cost by car per minute of the trip for those of our respondents living and working in the selected area, travelling by car to work the previous week is shown in Table 1.

Table 1 Travelling to work by car the previous week, stated cost by car/time by car

	Stated cost SEK per minute by car
N	228
Mean	1.6637
Median	1.3750
Std. Deviation	1.10403
Variance	1.219
Minimum	0.29
Maximum	8.00
Percentile 25	0.9238
Percentile 75	2.00

One possible problem is that those having to pay for parking at work have included the parking fee as part of the monetary cost for driving to work. In Table 2 those having free car park at work are separated from those having to pay for car park at work.

Table 2 Travelling to work by car the previous week, paying or not for car park at work, stated cost by car/time by car

	Stated cost SEK per minute by car, free car park at work	**Stated cost SEK per minute by car, not free car park at work**
N	186	38
Mean	1.6520	1.7109
Median	1.3693	1.4643
Mode	2.00	1.00
Std. Deviation	1.05885	1.35779
Variance	1.121	1.844
Minimum	0.29	0.50
Maximum	6.67	8.00
Percentile 25	0.8972	0.9706
Percentile 75	2.00	1.9063

To compare the stated cost with the actual cost, estimations must be made about the time it takes to drive one kilometre in Linköping when most people drive to and from work as well as the cost for driving one kilometre at those times in Linköping. In google maps it is possible to find out the usual travel time by car between different locations and at different times. Using this application for the study gives that 1.5 minute per kilometres seems to be a reasonable approximation. Using this together with the private variable monetary cost of approximately 3 SEK per kilometre (The Automobile Association, 2015) gives the estimation 2 SEK per minute.

A t-test is used to test the hypothesis that the mean stated cost for those travelling by car is the same as the actual average value.[xi]

$$t = \frac{|\bar{X} - \mu_0|}{\frac{s}{\sqrt{n}}}$$

$H_0: \mu = \mu_0 \qquad H_1: \mu \neq \mu_0$

For all car commuters:

$$t = \frac{|1.6637 - 2|}{\frac{1.1040}{\sqrt{228}}} \approx 4.600$$

4.600>2,576

With a significance level of 0.01 the hypothesis that the mean is 2 can be rejected.

The result implies that car commuters on average do not take the full variable travel cost into account when travelling by car to work. As shown in Table 1, the standard deviation is large. This corresponds to the findings by Shiftan and Bekhor (2002).

4. The travel time by bus to work

To study if the stated travel time by bus by those commuting by car to work differs from the actual one, we compare the stated time by car commuters with the stated time by bus commuters. The time by bus as well as the perception of the time by bus may be affected by if the respondent would have to change bus on the trip to work or not. Table 3 shows the stated travel time by bus by different categories of car and bus commuters.

Table 3 Different categories of car and bus commuters to work, time with bus

	Car	Car, change bus	Car, not change bus	Bus	Bus, change bus	Bus, not change bus
N	242	147	91	49	13	35
Mean	41.372	49.327	29.07	27.563	33.692	25.286
Median	40	50	25	28.5	35	25
Std. Deviation	19.056	17.425	14.557	11.088	11.750	10.075
Variance	363.1	303.6	211.9	122.9	130.1	101.5
Minimum	7	7	10	6	8	6
Maximum	120	120	120	50	45	50
Percentile 25	25	40	20	20	30	20
Percentile 75	75	60	30	35	45	30

A problem might be that some respondents might have answered the time to and from work instead of the time one-way. To avoid effects caused by this the quota time by bus in relation to time by car is used. The respondent should have answered the question about time by car and time by bus (that stands together in the questionnaire) the same way. A problem is that bus travellers not answering the question about time with car will be excluded. Table 4 shows the quota time by bus and time by car.

Table 4 Different categories of car and bus commuters to work, time by bus/time by car

	Car	Car, change bus	Car, not change bus	Bus	Bus, change bus	Bus, not change bus
N	242	147	91	38	10	29
Mean	3.047	3.564	2.246	2.190	2.5	2.094
Median	3	3.25	2	2	3	2
Std. Deviation	1.481	1.479	1.092	1.037	0.7071	1.112
Variance	2.193	2.188	1.193	1.074	0.5	1.237
Minimum	0.67	1	0.67	1	1	1
Maximum	11.25	11.25	8	7	3	7
Percentile 25	2	2.5	1.5	1.5	2	1.5
Percentile 75	4	4	3	2.542	3	2.417

A t-test is used to test the hypothesis that the mean for those travelling by car is the same as the mean for those travelling by bus. An F-test showed that it cannot be assumed that the standard deviation differs.

$$t_{obs} = \frac{|\overline{X_1} - \overline{X_2}|}{\sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$s_p^2 = \frac{\left((n_1 - 1)s_1^2 + (n_2 - 1)s_2^2\right)}{(n_1 + n_2 - 2)}$$

Comparing all respondents commuting by car with all respondents commuting by bus:

$s_p^2 \approx 2.0441$

$t_{obs} \approx 3.4352$

3.4352>2.576

With a significance level of 0.01 the hypothesis that the means are the same can be rejected.

Having to change bus would probably lead to increased travel time by bus in relation to the travel time by car. Since a majority of the car travellers would have to change bus on the way to work while a majority of the bus traveller do not have to change bus on the way to work this may affect the comparison. Therefore those who have to change bus and those who not have to change bus are also compared separately.

Comparing car commuters and bus commuter that have to change bus on the way to work:

$s_p^2 \approx 2.0900$

$t_{obs} \approx 2.2521$

2.2521>1.96

With a significance level of 0.05 the hypothesis that the means are the same can be rejected.

Comparing car commuters and bus commuter that do not have to change bus:

$s_p^2 \approx 1.2240$

$t_{obs} \approx 0.6443$

0.6443<1.645

With a significance level of 0.01, 0.05 or 0.1 the hypothesis that the means are the same cannot be rejected.

A possible problem is that car travellers might actually have longer travel time door-to-door on average by bus than those travelling by bus even though all respondents live and work within approximately 12 kilometres in the town of Linköping and do not for example live in the countryside with poor bus connection. This possible problem is decreased by using the quota time by bus in relation to time by car because it is a way to make the comparisons less affected by the distance to work.

A longer travel time door-to-door might also depend on car travellers having a longer distance to a bus stop from home or from the workplace than those travelling by bus. Table 5 shows the stated distance in metres to bus stop from home as well as from bus stop to work for those travelling by car and by those travelling by bus.

Table 5 Stated distance in metres to bus stop from home and at the workplace

	By car to work, home to bus stop	By bus to work, home to bus stop	By car to work, work place to bus stop	By bus to work, work place to bus stop
N	286	47	273	46
Mean	268	258	295	233
Median	200	200	250	200
Std. Deviation	203	225	226	191
Minimum	5	20	5	10
Maximum	1000	1000	1000	800
Percentile 25	100	100	100	50
Percentile 75	350	300	400	350

In table 6 the time by bus is net of walking time to and from bus stops for each respondent. It is assumed that it takes 1 minute to walk 100 metres.

Table 6 Time by bus without walking time/time by car

	Car	Car, change bus	Car, not change bus	Bus	Bus, change bus	Bus, not change bus
N	233	140	89	35	9	26
Mean	2.630	3.201	1.761	1.813	2.186	1.684
Median	2.325	2.942	1.56	1.733	2.4	1.625
Std. Deviation	1.455	1.413	1.053	0.871	0.6283	0.916
Variance	2.177	1.996	1.109	0.759	0.395	0.839
Minimum	0	0.85	0	0.6	0.79	0.6
Maximum	11.03	11.03	7.63	5.4	2.77	5.4
Percentile 25	1.625	2.202	1.144	1.15	1.838	1.081
Percentile 75	3.35	3.792	2.175	2.4	2.633	1.893

Comparing all respondents commuting by car with all respondents commuting by bus:

$s_p^2 \approx 1.9958$

$t_{obs} \approx 3.1901$

3.1901>2.576

With a significance level of 0.01 the hypothesis that the means are the same can be rejected.

Comparing respondents commuting by car that would have to change bus with respondents commuting by bus that have to change bus:

$s_p^2 \approx 1.8960$

$t_{obs} \approx 2.9313$

2.9313>2.576

With a significance level of 0.01 the hypothesis that the means are the same can be rejected.

Comparing respondents commuting by car that would not have to change bus with respondents commuting by bus that do not have to change bus:

$s_p^2 \approx 1.0665$

$t_{obs} \approx 0.3345$

0.3345<1.645

With a significance level of 0.01, 0.05 or 0.1 the hypothesis that the means are the same cannot be rejected.

The results indicate that car commuters that would have to change bus on their way to work overestimate the travel time by bus to work.

5 Concluding remarks

The results in this study indicates that car commuters might underestimate their private variable monetary cost travelling by car to work and as well overestimate their travel time by bus to work when they have to change bus on their way to work by bus.

Respondents misunderstanding some of the questions in the questionnaire and failure of taking account of actual differences when comparing might have affected the result. A better way to test the difference between perceived and actual travel costs would be to actually measure time and cost for each respondent travelling to work with “a chip” in the car and data of each respondent’s car etc. We have though tried to make the comparisons as comparable as possible by using for example quotas of values.

If correct, our findings leads to that information from the Public sector to citizens could be an inexpensive way to decrease these possible distortions and increase the share travelling by bus instead of travelling by car to work, at the same time achieving improved economic efficiency and a more sustainable transport system.

Something that would be interesting to study if the perceived and actual travel time by foot or by riding a bicycle to work by car commuters differ.

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[i] Transport Analysis is a Swedish government agency providing decision-makers in the sphere of transport policy with policy advice.

[ii] The Automobile Association (Motormännens Riksförbund) is an interest organization for Swedish car owners.

[iii] The study is part of a project financed by the Swedish Energy Agency, aiming at finding measures to increase energy efficiency in the transport sector. The project studies under which conditions individuals are willing to use environmentally friendly modes of transport in urban areas and which policy measures could be used to stimulate a switch from private car to other modes.

[iv] Since those travelling by car have a car available, the fixed monetary costs of owning a car are not considered at all in this study.

[v] The 26 neighbourhoods are Berga, Ekholmen, Ekkällan, Garnisonen, Gottfridsberg, Hackefors, Hejdegården, Hjulsbro, Innerstaden, Johannelund, Jägarvallen, Kallerstad, Lambohov, Mjärdevi, Ramshäll, Ryd, Skäggetorp, Tallboda, Tannefors, Tornby, Ullstämma, Vasastaden, Vidingsjö, Vimanshäll, Västra Valla and Östra Valla. The other 4 neighbourhoods are Ekängen, Malmslätt, Slaka and Tokarp.

[vi] The chosen postcode areas are 580 02-589 57.

[vii] The survey is furter described in Holmgren, Ivehammar (forthcoming)

[viii] Due to being a distance of 12 kilometres or more between some areas the combinations of living and working in them are excluded. Those are Ekängen in combination with Ekholmen, Hjulsbro, Jägarvallen, Lambohov, Malmslätt, Slaka, Tokarp, Ullstämma and Vidingsjö, as well as Malmslätt or Tokarp in combination with Hackefors, Hjulsbro, Tallboda, Vidingsjö and Ullstämma. Those who have more than 1000 metres to a bus stop from home are also excluded due to not being part of the population studied.

[ix] 82 % of those working both have a driving licence and access to a car for private use, while the same apply for 27 % of those studying.

[x] The most expensive ticket by bus at the time of the study was to buy a ticket by SMS for 30 SEK.

[xi] The statistics used in this paper is for example explained in Helbaek (2014)