MICROECONOMIC EXPLANATIONS FOR BETWEEN-MODES DIFFERENCES IN THE VALUE OF TIME

C. Angelo Guevara
Universidad de los Andes, Chile
San Carlos de Apoquindo 2200, Las Condes, Santiago
aguevara@uandes.cl
52-2-6189364

ABSTRACT

The subjective valuation of travel time savings (SVTTS) obtained from mode choice models is sometimes found to be larger conditional on the choice of car than conditional on the choice of public transportation. This seems contradictory from a classical micro-economic perspective since public transportation is often less comfortable, less accessible and less reliable than car and, therefore, the same individual should be willing to pay relatively more, and not less, for saving a marginal unit of travel time in public transportation. This article describes two plausible novel micro-economic explanations for this seemingly contradictory empirical finding. The first follows from noting that the marginal consumption of goods when travelling by car is usually larger than when travelling by public transportation. This effect can be explicitly accounted for with the inclusion of technical constraints relating goods consumption and time assignment in the microeconomic framework of the SVTTS. The second explanation follows from noting that the activity pattern needs not to be the same conditional on the choice of each mode. Since the car is faster and more flexible, a schedule constructed conditional on the choice of car may allow for more complex activity patterns, justifying larger values of time as a resource than conditional on the choice of public transportation. Empirical evidence for this second hypothesis is given using real data on activity patterns complexity from the city of Santiago de Chile. The article finishes summarizing the contributions of this research and proposing lines for further investigation.

Keywords: Value of Time; Mode Choice; Micro-economics

1. INTRODUCTION: A SEEMINGLY CONTRADICTORY EMPIRICAL FINDING

The subjective valuation of travel time savings (SVTTS) corresponds to individual's willingness to pay for a marginal reduction in travel time. Reductions in travel time account for about 60% of total benefits of transportation projects (Hensher, 2001). Therefore disentangling the components and determinants of SVTTS play a crucial role in transportation economics.

Since modes have different attributes, SVTTS need not to be the same between them. However, although countless studies have estimated SVTTS, only a few had made a distinction of it between modes. Wardman (2004) states that this occurs because most studies focus on a specific mode rather than on mode choices (as in, e.g. Gunn et al., 1999) and because mode choice models usually consider generic coefficients among modes, forcing the SVTTS to be the same by mode (as in, e.g. Gaudry et. al. 1989). When the model coefficients are allowed to differ by mode in mode choice models, results are sometimes contradictory. Wardman (1997) identified 20 studies in which SVTTS was allowed to differ by mode, founding that in 6 of them the SVTTS for car was larger than for public transportation.

The finding of larger SVTTS for car seems to contradict conventional wisdom and to defy the classical microeconomic framework of the SVTTS. The apparent contradiction comes from that public transportation is usually less comfortable, less accessible and less reliable than the car. Therefore, individuals should be willing to pay relatively more, instead of less, for saving a marginal unit of time spent on public transportation. Examples of other recent articles showing SVTTS that are larger for car than for public transportation are Axhausen et al. (2004) and Gutierrez and Cantillo (2012).

Although Wardman (1997) found this seemingly contradictory result for only 30% of comparable cases, the real share of this phenomenon may be much larger. It is likely that many researchers may not be interested (or willing) to report (or to accept for publishing) results that seem contradictory, unless that particular result is the cornerstone of the investigation. This suggests that many experiments for which a generic SVTTS is reported may actually implicitly have larger SVTTS for public transportation, provided mode-specific parameters had been considered.

To illustrate this statement, we estimated a Logit mode choice model using the database known as "Las Condes-Centro" (Ortuzar and Donoso, 1983). This revealed preference database considers 697 individuals from different areas of Santiago de Chile who have 9 modes on their choice-sets, including public transportation (Bus, metro, shared-taxi and combinations) and private modes (Car and Carpool). This database was used before by several researchers (see, e.g. Gaudry et al. 1989; Munizaga and Daziano, 2002; Morera, et. al. 2006) all of which considered generic coefficients for car and public transportation, forcing the SVTTS to be the same by mode.

The specification of the systematic utility used to estimate the Logit model reported in Table 1 is the same used by Munizaga and Daziano (2002) Level of service by mode include in-vehicle-travel time (IVT), walking and waiting time and cost divided by income. Besides, the model includes for the car-driver the variable Licenses, which corresponds to the number of cars divided by the number of licenses. Finally, gender (1 if it is female) is included for carpool and shared taxi.

Table 1. Logit Mode Choice Model from "Las Condes-Centro" Database With and Without Mode Specific In-Vehicle Travel Time (IVT) Coefficients

	Mode Specific IVT Coefficients		Generic IVT Coefficient	
Parameter	**Estimator**	**Standard Error**	**Estimator**	**Standard Error**
Walking time	-0.165	0.0195	-0.161	0.0193
Waiting time	-0.255	0.118	-0.236	0.116
IVT private	-0.138	0.0299	-0.0824	0.0174
IVT public	-0.0818	0.0174		
Cost/Income	-0.0211	0.00875	-0.0245	0.00877
Female	-0.295	0.215	-0.295	0.215
Licences	2.36	0.420	2.36	0.422
Final log-likelihood	-946.397		-949.135	
Adjusted rho-square	0.225		0.224	
N	697		697	

Alternative specific constants by mode omitted from this summarized report
IVT: In-vehicle travel time; Private: Car and Carpool; Public: Bus, metro, shared-taxi and combinations
Soruce of data: Ortuzar and Donoso (1983). Generic specification replicates Munizaga and Daziano (2002)

Table 1 shows that, when the coefficients are not forced to be generic, the coefficient of IVT for the private transportation modes becomes almost twice the coefficient of IVT for public transportation modes. Applying a likelihood ratio test it can be shown that this difference is statistically significant. Since the SVTTS is calculated as the ratio between the cost coefficient and the time coefficient, Table 1 implies that the SVTTS for car is larger than for public transportation, even after controlling by income. Formally, the SVTTS for the problem described in Table 1 can be calculated as follows

$$SV\hat{T}TS = \frac{\hat{\beta}_{time}}{\hat{\beta}_{cost/Inc}} * Income = \begin{cases} SV\hat{T}TS_{Private} = 6.54 * Income \\ SV\hat{T}TS_{Public} = 3.88 * Income \end{cases}$$

Two types of explanations for the apparent contradiction of finding larger SVTTS for public transportation had been suggested in the literature, but both seem questionable or at least limited. The first is that public transportation has some positive attributes, relative to car and different from comfort, that may explain the difference. The principal attribute that may fall into this category is the productivity of travel time, in the sense that travel time by public transportation may not be completely wasted, but used to perform alternative activities. This assumption is plausible but arguable. Lyons and Urry (2005) indicates that travel time productivity may depend on many modal attributes and individual characteristics such as crowding, noise, temperature, availability of seating, age, and personal equipment. Consequently, travel time by car may end up being as or even more productive than travel time by public transportation. Lyons and Urry (2005, Figure 1) suggests that, although there is a range in which bus may be more productive than car, the opposite is instead more likely to occur. Furthermore, even if travel time by public transportation happens to be more productive, it is not clear that such effect may overcome other attributes that might be relatively worse than for car.

The second explanation that can be found in the literature for finding larger SVTTS for public transportation is self selection. The hypothesis is that it is more likely to find users with larger SVTTS choosing the car because it is faster. This problem is analyzed, e.g. by Mabit and Fosgerau (2008) and Mackie et al. (2003). Although this hypothesis is plausible, it cannot be used to explain why SVTTS is, for the same person, larger when using car than when using public transportation. The self-selection hypothesis holds when analyzing the SVTTS by mode users, but not the SVTTS that is obtained from mode choice models.

The purpose of the present article is therefore to offer novel micro-economic explanation for this seemingly contradictory finding. Two plausible novel explanations are proposed. The first is that the marginal consumption of goods when travelling by car is usually larger, justifying larger SVTTS when using the car. The second follows from noting that the activity pattern needs not the same conditional on each mode. Then, since the car is faster and more accessible, an activity schedule constructed conditional on the choice of car would allow for more complex patterns, implying larger values of the time as a resource for car.

The article is structured as follows. After this introduction, a review of the classical microeconomic theory for analyzing the SVTTS is presented. Then, Section 3 presents a description of an extension of this framework regarding a more proper account of the relation between time assignment and goods consumption, and the implications of considering such extension in the interpretation of the SVTTS. In Section 4, the impact of mode choice in activity scheduling is analyzed in the light of the SVTTS, and an empirical example is given. Finally, Section 5 summarizes the findings and contributions of the paper, as well as identifying future lines of research in this area.

2. MICROECONOMICS OF SVTTS AND DISCRETE CHOICE MODELING

This section describes the classical microeconomic framework of the SVTTS proposed by DeSerpa (1971), and its extension to discrete choice modeling, what allows the estimation of the SVTTS from observed modal choices.

DeSerpa (1971) considers that the individuals determine their daily activity (T_i) and consumption (X_i) patterns by maximizing a utility function U that depends on the time T and X, subject to three types of constraints, as shown in Eq. (1). There is first a monetary budget constraint, with LaGrange multiplier λ, which indicates that individuals use all their income I in consuming the goods X_i with prices P_i. There is also a time budget constraint, with LaGrange multiplier μ, which states that the sum of the time assigned to all activities T_i should be equal to the total time available τ. Finally, there is a technological constraint associated to each activity i, with LaGrange multiplier K_i, which states that the time assigned to activity i should be enough to consume the goods X_i associated to it. Note that, for simplicity, DeSerpa's (1971) framework considers that goods are specific to activities.

$$
\begin{aligned}
& Max_{X,T} U(X_1,...,X_n,T_1,...,T_n) \\
& s.t \quad \sum_{i=1}^{n} P_i X_i = I \qquad (\lambda) \\
& \qquad \sum_{i=1}^{n} T_i = \tau \qquad (\mu) \\
& \qquad T_i \geq a_i X_i \qquad (K_i) \quad \forall i = 1,\cdots,n
\end{aligned} \tag{1}
$$

The optimal utility level U^* attained by resolving Eq. (1) is called the indirect utility. This utility depends on the exogenous variables *I*, τ and the prices. If this optimization problem is non-degenerate (see, eg. Luenberger, 2003), the LaGrange multipliers at the optimal point will correspond to the marginal impact in the indirect utility of increasing the right-hand side of each constraint. Consequently, λ is the shadow price of income or its marginal indirect utility of income ($\partial U^* / \partial I$), μ is the marginal (indirect) utility of time as a resource ($\partial U^* / \partial \tau$), and K_i is the marginal (indirect) utility of being required to assign more time to activity *i*. It follows directly that if $T_i^* > a_i X_i^*$, then K_i should be zero. Also, since the problem is non-degenerate, when $T_i^* = a_i X_i^*$, K_i will also corresponds to the marginal utility of saving time at activity *i*. Therefore, K_i/λ corresponds to the willingness to pay for a reduction in the minimum time required to perform activity i.

For discrete choices, such as the selection of a transportation mode, the behavioral model implied by Eq. (1) has to be slightly adapted. Following McFadden (1981), consider that traveling is a particular activity that can be performed by different modes, e.g., car and bus, with respective travel times t_{car}, t_{bus} and travel costs c_{car}, c_{bus}, which are exogenous. To decide between car and bus, the individual determines the optimal set of consumption levels of *X* and *T* for all other activities, such that utility is maximized. This problem is summarized in Eq. (2).

$$
\begin{aligned}
& Max_{X,T} U(X_1,...,X_n,T_1,...,T_n \mid t_{mode}, c_{mode}) \\
& s.t \quad \sum_{i=1}^{n} P_i X_i + c_{mode} = I \qquad (\lambda) \\
& \qquad \sum_{i=1}^{n} T_i = \tau \qquad (\mu) \\
& \qquad T_i \geq a_i X_i \qquad (K_i) \quad \forall i = 1,\cdots,n; i \neq travel \\
& \qquad T_{travel} \geq t_{mode} \qquad (K_{travel})
\end{aligned} \tag{2}
$$

The maximum level of utility attained, conditional on the choice of each mode U^*_{bus}, U^*_{car}, is known as the indirect conditional utility. The behavioral assumption is then that the individual chooses the alternative with the largest indirect conditional utility.

Solving the first order conditions of Eq. (2), it can be shown that $K_i = \mu + \partial U / \partial T_i$. Consequently, considering that activity *i* corresponds to traveling on a given mode, the following three definitions of the SVTTS can be postulated:

$SVTR = \frac{\mu}{\lambda}$	**Subjective Value of Time as a Resource**: Opportunity cost of time. Money equivalence for the change of indirect utility that would be attained if τ is marginally extended.
$SVTA_{\text{travel}} = \frac{\partial U / \partial T_{trip}}{\lambda}$	**Subjective Value of Time Assigned to Travel**: Money equivalence for the marginal *direct* utility of assigning time to travel
$SVTTS = \frac{K_{\text{travel}}}{\lambda} = \frac{\mu}{\lambda} - \frac{\partial U / \partial T_{travel}}{\lambda} = SVTR - SVTA_{Travel}$	**Subjective Value of Travel Time Savings**: Money equivalence for the marginal indirect utility of saving travel time.

The implementation of this behavioral model into a method that allows the estimation of the SVTTS from observed modal choices follows from considering what is known as the Random Utility Model (RUM). The first step is to recognize that the researcher can measure only a part of the indirect conditional utility. The measureable part is called the systematic utility $V^*_{\text{mod}e}$ and what remains is an error term $\varepsilon_{\text{mod}e}$. Then the probability that the individual choose, e.g., the bus will correspond to

$$P_n(bus) = P_n\left(U^*_{bus} \geq U^*_{car}\right) = P_n\left(\varepsilon_{car} - \varepsilon_{bus} \leq V^*_{bus} - V^*_{car}\right) = F_\varepsilon\left(V^*_{bus} - V^*_{car}\right),$$

where F_ε is the cumulative distribution of $\varepsilon = \varepsilon_{car} - \varepsilon_{bus}$. If ε is distributed Extreme Value I, the choice probability becomes a Logit, and if it is distributed Normal, the model becomes a Probit. To estimate the model what remains to be determined is a specification of the systematic utility $V^*_{\text{mod}e}$. If $V^*_{\text{mod}e}$ is assumed to be linear in $c_{\text{mod}e}, t_{\text{mod}e}$ and ε follows an Extreme Value I distribution, the choice model becomes

$$P_n(bus) = \frac{e^{V_{bus}}}{e^{V_{bus}} + e^{V_{car}}} = \frac{e^{\beta_{bus} + \beta_t t_{bus} + \beta_t c_{bus}}}{e^{\beta_{bus} + \beta_t t_{bus} + \beta_t c_{bus}} + e^{\beta_{car} + \beta_t t_{car} + \beta_t c_{car}}},$$

where the *β's* are parameters which can be estimated, e.g., maximizing the likelihood of observed choices.

The link between parameters of the choice model and the SVTTS can be established by noting first in Eq. (2) that $\partial U^* / \partial I = -\partial U^* / \partial c_{\text{mod}e} = \lambda$. Equivalently, $-\partial U^* / \partial c_{\text{mod}e} = K_{trip}$ assuming that the actual time spent travelling T_{travel}, is equal to the minimum possible t_{mode}, which is set exogenously by the transportation system in the respective mode.

The next step is to consider that the model does not suffer of endogeneity, that is, that the error terms $\varepsilon_{car}, \varepsilon_{bus}$ are independent from t_{mode}, and c_{mode}. This assumption is also critical for discrete choice model estimation (Guevara and Ben-Akiva, 2006, 2012), but in this case it has a critical implication in establishing the link between mode choice models and DeSerpa´s (1971) model. Without endogeneity $\partial U^*/\partial c_{\text{mode}} = \partial V^*/\partial c_{\text{mode}} = \beta_c$ and $\partial U^*/\partial t_{\text{mode}} = \partial V^*/\partial t_{\text{mode}} = \beta_t$, what allows the estimation of $SV\hat{T}TS = \frac{\hat{\beta}_t}{\hat{\beta}_c}$ in the binary choice model example deployed. Different SVTTS by mode can be obtained by considering β_s that are not generic by mode. That was the approach used to estimate the SVTTS reported in Table 1.

The estimation of the components of the SVTTS is possible by the joint estimation of the choice model, from which SVTTS is obtained, and a time assignment model, from which $SVTR = \frac{\mu}{\lambda}$ is obtained (Jara-Díaz and Guevara, 2003).

Under this framework it is clear how to justify finding larger SVTTS for car in mode choice models. Since $SVTTS = SVTR - SVTA_{trip}$, the only term that seems to depend on the mode is the SVTA to travel. Then, the result would appear only if the SVTA to travel by car is more negative that when travelling by public transportation. Although it can be argued that the travel time by public transportation is more productive, in the sense of allowing e.g. reading, the hard fact is that public transportation is almost always less comfortable, less accessible and less reliable than the car. In the following sections we will propose novel micro-economic interpretations that may justify this seemingly counterintuitive result.

3. DIFFERENCES IN GOODS CONSUMPTION AS A POSSIBLE CAUSE FOR FINDING LARGER SVTTS FOR CAR

The first novel explanation for finding larger SVTTS conditional on the choice of car, results from an extension of the microeconomic framework for the SVTTS. Jara-Díaz (2003) proposed a sophistication of DeSerpa's (1971) technological constraints for better capturing the interrelations between goods and time consumption. The main implication of that work regarding the SVTTS comes from the inclusion of the set of inequalities shown in Eq. (3), which account for the minimum goods consumption imposed by the assignment of time to activities.

$$x_k \geq g_k(T) \quad (\psi_k) \quad \forall k \tag{3}$$

Guevara (1999) showed that, when considering the set of technological constraints shown in Eq. (3), the SVTTS is compounded, besides the terms described by DeSerpa (1971), also by an additional term. This additional term accounts for the impact that traveling has in the minimum requirement of goods' consumption, as it is shown in Eq. (4). This result is also shown later by Jara-Diaz (2003).

$$SVTTS = \frac{K_{\text{travel}}}{\lambda} = \frac{\mu}{\lambda} - \frac{\partial U/\partial T_{Travel}}{\lambda} + \sum_k \frac{\psi_k}{\lambda}\frac{\partial g_k}{\partial T_{travel}} \tag{4}$$

Equivalently to the SVTTS, the term ψ_k/λ can be interpreted as the subjective value of saving consumption of good *k*, the willingness to pay for a marginal reduction in the requirement of consuming *k*. The whole term $\sum_k \frac{\psi_k}{\lambda}\frac{\partial g_k}{\partial T_{travel}}$ can be interpreted as the subjective value of saving consumption of goods *k* when travel time is reduced.

The multiplier ψ_k will be positive if the good *k* is consumed at its minimum, and zero otherwise. The term $\partial g_k / \partial T_{travel}$ corresponds to the change in the minimum consumption requirements because of the change in travel time. It will be positive if an increase in travel time induces an increase in the consumption of good *k*, and it will be negative in the contrary situation.

Under the framework summarized by Eq. (4), a larger SVTTS for car can be explained by the additional requirements for the consumption of, for example, fuel, oil, or car maintenance when traveling by car, all goods that are not required when traveling by public transportation. Assuming that those goods are consumed to their minimum required levels, the respective term ψ_k / λ will be positive, and then the positive sign of $\partial g_k / \partial T_{travel}$ will trigger a larger SVTTS for car. In turn, this effect will not be present when travelling longer by public transportation because, in that case, the passenger is not the operator.

Although including the impact that traveling has in the consumption of goods allows justifying larger SVTTS for car, it is unclear so far how to disentangle this effect from others. Guevara (1999) proposed a method to measure the term $\sum_k \frac{\psi_k}{\lambda}\frac{\partial g_k}{\partial T_{travel}}$, a method that includes the estimation of a discrete choice model for restricted goods consumption and set additional assumptions. Further analysis of this line of research is required to establish the feasibility of implementing such a procedure in practice.

4. ACTIVITY SCHEDULING DIFFERENCES AS A POSSIBLE CAUSE FOR FINDING LARGER SVTTS FOR CAR

Extending and re-interpreting the micro-economic framework allows elaborating a second alternative explanation for the finding different SVTTS for car than for public transportation. The random utility model under which the SVTTS is estimated from observed choices considers that users compare optimal arranges of activities and goods' consumption, conditional on a given mode. This means that the activity pattern and the overall consumption need not to be the same conditional on each mode. Then, since the car is faster and more accessible, a schedule constructed conditional on the use of the car would probably allow more complex activity patterns. This fact has a relevant implication for the interpretation of the SVTTS.

If the activity pattern differs by mode, the value of time as a resource might also differ by mode. For example, consider that commuting by car allows stopping at a coffee shop. Time assignments and good consumptions for the unconstrained activities (leisure) of "being at home" and "being at the coffee shop" will not be the same conditional on the choice of car or of public transportation. Equivalently, the marginal utility of the time assigned to these leisure activities needs not to be the same. Consequently, the value of re-assigning time from travel to leisure, that is, the value of time as a resource, will generally differ by mode. When, conditional on choosing car the time assigned to "being at home" happens to be shorter than the time assigned to it conditional on the choice of public transportation, the value of time as a resource, and then the SVTTS, will be larger for car because of the law of diminishing returns.

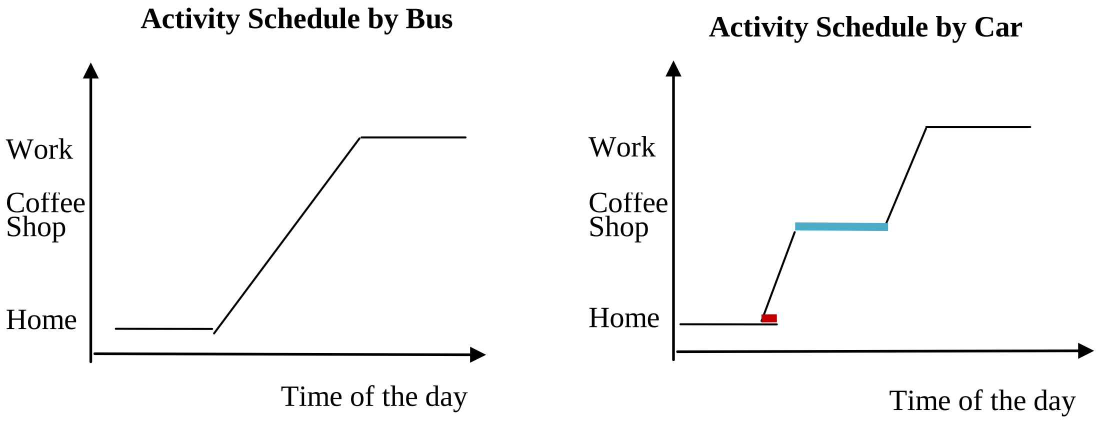

Figure 1. Different Activity Schedules Conditional on the Modal Choice

The impact of the mode choice on the value of time as a resource can be described by the example shown in Figure 1. The left plot in Figure 1 describes the optimal activity schedule that the individual can perform, conditional on the choice of bus. In this case, visiting the coffee shop is not possible because the bus speed is not enough to perform such activity between "being at home" and "being at work". The plot in the right of Figure 1 describes the optimal schedule conditional on the choice of car. In this case it becomes possible to visit the coffee shop. Note that in this example, the indirect utility should be larger for the choice of car because, otherwise, the activity "being the coffee shop" would not be performed at all. Furthermore, since the individual leaves home a little earlier in this case (time marked in red in Figure 1) than what was done conditional on the choice of bus, also the marginal indirect utility should be larger conditional on the choice of because of the law of diminishing. In other words, for this example, the value of time as a resource is larger conditional on the choice of car than on the choice of bus.

To support the fact that scheduling differences might play a role on the empirical finding of larger SVTTS for car users, we analyze real data on daily activity scheduling from Santiago de Chile, obtained from the 2001's Mobility survey reported by Sectra (2003). In this case, individuals were classified in Private (Car and Carpool) or Public (Bus, metro, shared-taxi and combinations) transportation users based on the commuting mode. Then, we use a measure of the complexity of the daily activity schedule that was proposed by Cartes et al. (2012), which corresponds to a variation of the measure of complexity used by Hidalgo and Hausmann (2009) on other framework.

The measure of complexity K_n of the activity schedule of individual n corresponds to the number of different activities performed, each one weighed by the inverse of the number of individuals that perform such activity. The intuition for this definition of complexity is that activities that are more ubiquity performed are those that are less complex and, on the contrary, the more complex activities are only performed by fewer individuals. For example, going to work or going back home are less complex activities than leisure in a weekday. Formally, this measure of complexity K_n can be stated with the following expressions

$$K_n = \sum_{i \in Activities} \frac{1}{\sum_{n \in Individuals} y_{in}} y_{in} , \qquad (5)$$

where y_{in} is equal to 1 if individual n performs activity i and zero otherwise.

The null hypothesis that communing by private modes does not allow performing more complex activity-schedules can be tested by performing an ordinary least squares (OLS) regression of the schedule complexity on individuals' characteristics and a dummy variable indicating whether or not commuting was performed by car. If the estimator of the parameter of private mode commuting is positive and statistically different from zero, it can be affirmed that commuting by private modes does has a positive impact on schedule complexity.

The OLS regression was done considering $\ln(K_n)$ as the dependent variable. The independent variables considered were the natural logarithm if the per-capita familiar income, the logarithm of individuals' age and dummy variables indicating whether or not commuting was performed in a private mode, the individual is a male, a full time worker and if he or she belongs to a family with kids. The regression considered 3750 adults that belonged to households with at least one car.

Table 2. Activity Schedule Complexity as a Function of Household Characteristics and Commuting Mode

	Estimator	**s.e.**	**t-test**
Intercept	-8.81	0.556	-15.8
ln(Per Capita Income)	0.217	0.0371	5.84
Private mode commuting	0.868	0.0615	14.1
Household with minors	0.363	0.0635	5.71
Male	0.108	0.0619	1.74
ln(Age)	-0.252	0.0949	-2.66
Full time worker	-0.471	0.0833	-5.65
Adjusted R^2 0.0822 N=3,750			

Data Source: 2001's Mobility survey reported by Sectra (2003)

The results are summarized in Table 2 were it can be noted that income, belonging to a family with minors, being a male and commuting by a private mode have a positive impact on scheduling complexity. In turn, age and being a full time worker have a negative impact on the complexity. All estimators are significantly different from zero. The one with the lower significance is whether or not the individual is a male. The more significant is whether or not the commuting trip was made using a private mode, what finally sustains the hypothesis under study.

5. CONCLUSION

This article describes two plausible novel micro-economic explanations for finding larger SVTTS for car than for public transportation, a seemingly contradictory empirical finding that had been unsatisfactorily explained by previous literature.

The first micro-economic explanation is that the marginal consumption of goods when travelling by car is usually larger, justifying larger SVTTS when using the car. The second follows from that the activity pattern and the overall consumption need not to be the same, conditional on the choice of each mode. Since the car is faster and more accessible, an activity schedule constructed conditional on the choice of car is likely to be more complex, what would explain finding larger SVTTS for car.

Regarding lines for further research in this area, the principal is to develop methods to measure and to distinguish each of the potential sources for differences in the SVTTS between modes. To measure the impact of the productivity of time by mode, a potential argument for finding this difference, it would be interesting to survey the use of time by mode and to design stated preference surveys asking explicitly for the valuation of the time assigned to travel by different modes. The idea would be develop quantitative measures to the qualitative analysis developed by Lyons and Urry (2005). Regarding the measurement of the impact of goods consumption by mode on the SVTTS, besides the method suggested by Guevara (1999) one alternative would be to measure differentiated income effects by mode using, e.g, the method proposed by Jara-Díaz and Videla (1989). At last, regarding the impact of scheduling complexity by mode in the value of time a resource, it would be interesting to apply the method proposed by Jara-Díaz and Guevara (2003) but differentiated by mode. Besides, to disentangle the true impact of commuting by car in schedule complexity it would be interesting to test and to correct for endogeneity in the model described in Table 1. That final effort could be performed by the joint estimation of a mode choice and schedule complexity model.

Finally, it should be noted that this alternative approach to understand the value of time described in this paper as a resource also allows justifying different SVTTS along the day. Re-assignments of marginal savings of travel time are only possible among those activities that are within the relevant chain of activities to which the trip belongs. Then, time saved from midday trips could only be re-assigned to a different set of leisure activities, than commuting trips, explaining the differences in the value of time as a resource. From a modeling perspective, this means that, instead of considering a daily time constraint (as in DeSerpa, 1971, Guevara, 1999; or Jara-Diaz, 2003), it would be more precise to consider a time constraint for the set of activities in the relevant chain. Differently from money, a unit of time saved cannot be stored and re-assigned to any activity during the day. Furthermore, given that the activity schedule needs not to be the same by mode, the relevant chain that might be affected by variations in travel time needs not to be the same conditional on the choice of each mode, justifying again a different SVTTS.

REFERENCES

Axhausen, K., A. König, G. Abay, J. Bates, and M. Bierlaire (2004), “Swiss value of travel time savings”, European Transport Conference 2004.

Cartes, C., Guevara, C.A. and J. Cadena (2012) “Medidas de Complejidad para Programas de Actividades” Working Paper, Universidad de los Andes, Chile.

DeSerpa, A. (1971) A theory of the economics of time. **The Economic Journal** 81, 828-846.

Guevara, C.A. and M. Ben-Akiva (2012) “Change of Scale and Forecasting with the Control-Function Method in Logit Models” **Transportation Science** 46(3), 425–437.

Guevara C.A. and M Ben-Akiva (2006) “Endogeneity in residential location choice models.” **Transportation Res. Record,** 1977, 60–66.

Guevara, C. A. (1999), “Valor Subjetivo del Tiempo Individual Considerando las Relaciones entre Bienes y Tiempo Asignado a Actividades”, Tesis, Departamento de Ingeniería Civil, Universidad de Chile.

Gunn, H.F., Tuinenga, J.G., Cheung, Y.H.F., Kleijn, H.J., (1999). “Value of Dutch Travel Time Savings in 1997”, in: Meersman, H., Van de Voorde, E., Winkelmans, W. (Eds.), **Proceedings of the Eighth World Conference on Transport Research Transport Modelling/Assessment**, 3, Pergamon, Amsterdam, 513–526.

Gutierrez, M. and V. Cantillo (2012) “Estimación del Valor Subjetivo del Tiempo en un Contexto Urbano: Nuevas Evidencias.” Proceedings XVII Panamerican Conference in Transportation Traffic and Logistics, Universidad de los Andes, Chile.

Hensher, D.A., 2001. Measurement of the valuation of travel time savings. **Journal of Transport Economics and Policy** 35 (1), 71–98.

Hidalgo, C., and R. Hausmann (2009), “The building block of economic complexity” **Proceedings of the National Academy of Science of the United States of America PNAS** 106 (26) 10570–10575 .

Jara-Díaz, S. (2003) “On the goods-activities technical relations in the time allocation theory” **Transportation** 30: 245,260.

Jara-Díaz, S. R. and C. A. Guevara (2003). Behind the subjective value of travel time savings: the perception of work, leisure and travel from a joint mode choice - activity model. **Journal of Transport Economics and Policy** 37, 29-46.

Jara-Díaz, S. and J. Videla (1989) “Detection of Income Effect in Mode Choice: Theory and Application.” **Transportation Research B**, 23, 393-400.

Luenberger, D. (2003) **Linear and Nonlinear Programming**. Second Edition. Kluwer Academic Publishers, The Netherlands.

Lyons, G. and J. Urry (2005) “Travel Time use in the Information Age” **Transportation Research** Part A, 39, 257–276.

Mabit, S. and M. Fosgerau (2008) “Self-selection and the value of travel time,” European Transport Conference, Leeuwenhorst, Netherlands.

Mackie, P. J.,Wardman, M., Fowles, A. S.,Whelan, G., Nellthorp, J. & Bates, J. (2003) "Value of travel time savings in UK", Institute of Transport Studies, University of Leeds, Working paper 567.

McFadden, D. (1981) "Econometric Models of Probabilistic Choice." In: Structural Analysis of Discrete Data with Economics Applications. C. Manski and D. McFadden, eds. MIT press, Cambridge.

Morera, A., Gonzalez, R. and Ortuzar, JdD (2006)"Variación en los Gustos y Efecto Ingreso en Modelos de Elección Discreta. Una Aplicación a la Elección de Modo de Viaje al Trabajo" Congreso ASEPELT. La Laguna.

Munizaga, M. and R. Daziano (2002) "Evaluation of Mixed Logit as a practical modelling alternative." Proceedings European Transport Conference, Cambridge, U.K.

Ortúzar, J de D y Donoso, P. C. F., (1983) Survey design, implentation, data coding and evaluation for the estimation of disaggregate choice models in Santiago, Chile. 2nd International Conference on Survey Methods in Transport, Septiembre, Hungerford Hill Village, Australia

Sectra (2003).Santiago de Chile 2001 Mobility Survey: Final Report. MIDEPLAN, Chile.

Wardman, M. (2004) "Public Transport Values of Time", **Transport Policy** 11, 363–377

Wardman, M. (1997) "A Review of Evidence on the Value of Travel Time in Great Britain." Working Paper 495, Institute for Transport Studies, University of Leeds.