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Laboratoire d'Economie Appliquée de Grenoble

TEST OF THE RELATION BETWEEN TRAVEL AND ACTIVITIES TIMES

DIFFERENT REPRESENTATIONS OF A DEMAND DERIVED

FROM ACTIVITY PARTICIPATION

JOLY Iragaël

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INRA

Institut National de la Recherche Agronomique - Université Pierre Mendès France
Unité Mixte de Recherche 1215
Domaine Universitaire - BP 47 - 38040 GRENOBLE Cedex 9
Tél. : 33 (0) 4 76 82 54 39 - Fax : 33 (0) 4 76 82 54 55
E-mail : vertier@grenoble.inra.fr - http://www.grenoble.inra.fr

upmf Grenoble
Université Pierre Mendès France
Sciences sociales & humaines

Test of the relation between travel and activities times - Different representations of a demand derived from activity participation

Joly Iragaël
INRA, UMR 1215 GAEL, F-38000 Grenoble
Grenoble Polytechnics Institute, F-38000 Grenoble
CNRS, UMR 5593 LET, F-69007 Lyon, France,
Tel: +33 476 828 336, iragael.joly@grenoble.inra.fr

Abstract

The paper tests linear and non-linear specifications of the relationship between travel times and activity times, in 4 four French and three Swiss cities, observed at two different periods. First, following Kitamura *et al*. (1992), we test proportional assignment of total daily available time to activities (including transport). Second, proportionality is tested between (1) daily travel time associated with a given purpose with respect of the daily activity duration and (2) the travel time associated with the duration of the activity at destination. This last specification tests the travel time ratio proposed by Dijst and Vidakovic (2000). Third, because of the non appropriateness of the OLS method for analysing non-normally distributed duration data, we estimate travel time budgets in the duration model framework. We obtain non-linear relation between travel time and activity times. Only daily leisure time and daily travel time are fixed proportion of total daily available time. At disaggregated level, the trip duration do not show proportionality with activity duration. Leisure and shopping activities exhibit increasing and convex relation with travel time.

Keywords: time use, travel time, activity-based analysis

1. Introduction

Many studies have analysed travel times and activity times. For example it seems natural to observe a positive correlation between travel time and the time of activity at a given destination. The search for simplified representations of travel times began with the stability hypothesis in the 1970's, known as the "Travel-Time Budgets paradigm" (Goodwin, 1981), the "Brever law" (Hupkes, 1982), or the "Zahavi's hypothesis" (Zahavi, 1979). Less restrictive hypotheses have been proposed on travel times. Some of them assume that travel time can be viewed as a characteristic of activity. Therefore travel times are fully determined by activity times, mostly through a proportionality relationship. Hence, travel time can be viewed as the "price time of activity" (Chen and Mokhtarian, 2002). First, it has been examined at the daily level of time expenditures. Using for a given activity type, the sum of activity duration during the day, Kitamura *et al*. (1992) test the "principle of proportional assignment" (Beckmann and Golob, 1972). Under this principle, each daily activity time represents a fixed proportion of the total daily available time. "The ratio of the amounts of time assigned to two activities is invariant regardless of the total amount of time available" (Kitamura *et al.*, 1992, p.135). Their results support that total daily travel time is proportional to the amount of daily available time (24 hours less the work time).

More generally, relationships between travel time and activity duration have been analysed and estimated in different estimation frameworks, such as linear model, structural equations model, duration model, etc (Hamed and Mannering, 1993; Golob and McNally, 1997; Goulias *et al.* 1998; Kitamura *et al.*, 1998; Ma and Goulias, 1998; Bhat and Misra, 1999; Lu and Pas, 1999; Bhat *et al*., 2004; Srinivasan and Guo, 2007). Depending on the applied framework, impacts of activity duration on travel times are supposed to be linear or not. Models estimate travel time intensity: the supplementary travel time associated to supplementary activity time. The linear form, constant travel time intensity, being a particular case of the possible travel time intensity forms.

In this context, Dijst and Vidakovic (2000) and Schwanen and Dijst (2002) propose and analyse travel-time ratio for work activities. The constant travel time ratio assumes constant travel time intensity and linear relationship between travel time and activity time. This behavioural regularity reinforced the rational locator hypothesis (Levinson *et al*., 2005) or the co-location hypothesis (Kim, 2008). Under the travel time ratio hypothesis, travel time is determined by the work duration and then choice of residential location or mode choice are determined too. Estimating a structural equations model for the activities duration, Van Wissen and Golob (1991), Golob and McNally (1997), Lu and Pas (1999) analyse relationships between travel time and activity duration. Some estimators can be interpreted in terms of travel time intensities for different activity types. For example, Golob and McNally (1997, p. 185) obtain a travel time intensity for maintenance that indicates that one hour of out-of-home maintenance activity requires on the average 7.8 minutes of travel time. However, Joly (2006) has shown that the propensity to accept supplementary travel time is dependent on the travel time already performed. Similarly, we can expect travel time intensity to depend on the activity duration.

This paper tests the proportional assignment paradigm, the travel time ratio and estimates non-linear travel time intensity based on the duration model framework. Timmermans *et al*. (2002) have shown significant effects of urban context on mobility and travel time. Consequently, we compare Swiss and French households mobility surveys and search for distinct or transferable relationships between activities duration and the corresponding travel time. Our samples are constituted of household mobility surveys of seven cities (Bern, Geneva, Grenoble, Lyon, Rennes, Strasbourg and Zurich) each observed at two different dates.

The following section presents the hypothesised representations and the models used to test each of them. We test first, the proportional assignment paradigm, second, the proportionality of daily travel times for each purpose type with the daily activity times, and third, the constant travel time ratio hypothesis extended to shopping and leisure activities. Finally, non-linear relationship is proposed in the duration model framework. The third section presents the data and discusses comparability of the 14 samples. Estimation results are presented and discussed in the fourth section. Log-linear models and duration models are estimated for the travel time associated with each type of activity: work, leisure and shopping. Results support a discussion on transferability of regularities in the travel time with respect to socio-demographic variables between the seven cities. The proportionality hypotheses are rejected and non-linear relationships are proposed.

2 Representation of the travel time and activity duration relationships

The individual activity times and travel times measures considered in the paper are the following;
a. the *activity/travel time*: the duration of the activity episode of type *j*, calculated as the difference between stopping and beginning times of an activity or a trip, as revealed in the travel surveys used in this study;
b. the *activity/travel time budget*: the daily duration of an activity of type *j* calculated as the sum of the duration of all the activity episodes of type *j* performed during the day; Travel time budgets are calculated as the daily sum of the travel time on all the trips during the day, regardless of the purposes and the transport mode.
c. the *travel time budget for the activity type j*: the daily travel time associated with an activity type *j*, calculated as the sum of the travel times associated with a given purpose *j*, during the day.

Following Goodwin (1981), the term “budget” is used to introduce the rationality, which is supposed in the process of allocation of time to travel. The travel time budget can be viewed as the solution of the competition for the scarce resource of time between activities. The study of travel time appears to be more complicated, because it is related to the decision of activity participation or of activity renunciation. The aggregate measure of time at the daily level permits us to reduce the complexity of the activity behaviour.
Literature distinguishes the following hypothesised representations of the travel time to activity relation.

2.1 Independence of the Travel Time Budgets

Depending on data, previous studies of travel time budgets have used numerous definitions and calculations. The early studies in the 1970’s only calculate daily travel time on car trips or motorised trips for work (Szalai, 1972; Zahavi, 1973, 1979; van der Hoorn, 1979; Hupkes, 1981). With higher quality of mobility data collection, travel times and travel time budgets are now calculated for all modes and all purposes (Metz, 2003; Armoogum *et al*., 2003).

The analysis of travel time budgets within the past decades leads to the distinction of two hypotheses. The first suggests stability in time and space of the travel time budget. A travel time budget of one hour per day is supposed to be a relatively good approximation of the mean travel time budget observed in cities from different countries and different time frames. Considering the heterogeneity of the observed urban situations, this “strong hypothesis of stability” of travel time budget gains sense. Regardless of the economic development, the level of transport infrastructure, the urban context, etc., the travel time budget remains approximately the same, whether in African villages or European, American, and Japanese cities (Schafer and Victor, 2000).

Nevertheless, this assumption is irrelevant at a disaggregated level. Analyses of travel time budget at an individual level reveal numerous relationships between travel time budget and other variables, such as socio-demographic attributes, mobility characteristics, or urban contexts (for a review of these effects, refer to Mokhtarian and Chen, 2005; Joly, 2005). The question of the regularity of these relationships constitutes the “weak hypothesis of regularity” of travel time budget. Depending on the data and methodologies, variables affect travel time budget on different ways. However, some relationships appears relatively stable between studies, as for example, the negative effect of the presence of children under 5 years, the weekly cycle of travel time budget lower on Monday and higher on Friday, effect of the residential location, etc. (see for example: Levinson, 1999; Schönfelder and Axhausen, 2000; Schwanen, 2002; Giuliano and Narayan, 2003; Kitamura *et al*., 2003; Levinson and Wu, 2005; Kim, 2008).

The search for regularities in travel time budget is limited by the dimensions that can be introduced at the daily level. For example, the modes of transport or the urban contexts of activity locations are difficult to describe at the daily level. Furthermore, some dimensions exceed the daily level, as the planning of activity participation over weeks or months.

Here, we pay special attention to the relationships of travel time budget with activity time budgets. The consideration of the daily process of travel time allocation appears to be an interesting approach to adapt and to test proposition of the microeconomics theory of the allocation of time, which principally considers the competition between activities for the daily available time (Jara-Diaz, 2003).

2.2. Proportional assignment hypothesis

The *proportional assignment* of available time to travel has been proposed by Beckmann and Golob (1972). It has been revisited and empirically studied by Kitamura *et al.* (1992), based on Dutch and Californian time use surveys. The daily travel time budget, as any other daily time budget of activities, is supposed to represent a certain proportion of total daily available time. The activity time budgets are calculated excluding associated travel time and the total available time is 24h less work duration.

Noting the activity time budget of type *j*, ATB_j, and *T,* the daily total available time, the proportional assignment hypothesis assumes that the following ratio is constant for an individual:

$$\frac{ATB_j}{T} = f\left(X,\beta\right) \tag{1}$$

This proportion is supposed to depend only on variables (X), and parameters (β). It leads to the first hypothesised representation:

Hypothesis 1: the daily travel time budget represents a fixed proportion of total daily available time.

Following Kitamura *et al.* (1992), the *test of proportionality* of activity/travel time budgets with respect to the total available time T consists of the test of the θ coefficient in the following form:

$$ATB_j = T^{\theta} \cdot f\left(X,\beta\right) = T^{\theta} X_1^{\beta 1} X_2^{\beta 2} \ldots \tag{2}$$

If $\theta = 1$, then the ratio of activity time budget, ATB_j, on available time, T, is a fixed proportion. This proportion is dependent only on the individual attributes, X. The test is performed using the OLS estimates of the log-linear model:

$$\ln ATB_j = \theta \ln T + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \ldots + \varepsilon \tag{3}$$

Kitamura *et al.* (1992) performed this test using the national time use surveys of Netherlands 1985 and California 1988. Results do not support proportionality for non-travel activities times. Proportionality is tested for daily travel time budgets, commute times and travel time for non-work activities. The tests conclude to a proportional assignment of travel time to available time. Work time is introduced in the regressors set. It leads to a positive correlation between commute and work time. Finally, it suggests that travel time budgets are not stable, because of the variations of the travel time for non-work activity. The stability of proportionality seems to be preserved by an adjustment mechanism between the travel times for the non-work activities and the commute times.

2.3. Travel time ratio hypothesis

The *travel time ratio* is proposed by Dijst and Vidakovic (2000). They suggest that the activity participation at a given location is the result of the trade-off between travel and activity time. Individuals participate to activities that satisfy an acceptable ratio. The travel time ratio is supposed to reflect this trade-off and is expected to exhibit regularities. The travel time ratio is computed for activity participation, as the ratio of the associated travel time (round trip) to the sum of the travel time and activity duration at the destination:

$$\tau_j = \frac{TT}{TT + AT_j} \tag{4}$$

Where the travel time ratio for activity j is noted τ_j, TT indicates the travel time and AT_j denotes the activity duration.

Schwanen and Dijst (2002) calculate *travel time ratio* for commute trips by doubling the home-to-work travel time. For the 1998 Dutch National Travel Survey, the mean travel time ratio for a visit to the work place is 0.105 and the median is 0.085. It corresponds to a commuting time of 3.5 minutes an hour spent working (or 28 minutes for an 8 hours workday). A majority of individuals then possess a travel time ratio lower than 10% for work activity. This ratio is relatively stable with respect to the socio-demographics attributes. The travel time ratios are higher for the peri-urban residents.

The test of the travel time ratio principle is invalid at the daily level. This concept is valid at the episode activity level. It focuses on the travel time associated with an activity participation and duration. It raises the question of the definition and measurement of the travel time for an activity in a non-unique purpose chain of trips. Keeping the daily level of the time allocation process, we propose adaptation of the travel time ratio. We calculate the ratio on the basis of the time budgets of an activity and the part of the daily travel time budget associated with this purpose. It is only an approximation of the travel time ratio at the daily level that underestimates or overestimates the daily travel time budget for a given purpose. Underestimation will appear if the chain of trips is composed of only one purpose, because our calculation then excludes the trip back home. Overestimation can appear if the travel time associated with an activity in a chain is mostly explained by the other activities in the chain.

The travel time ratio is transformed by logarithm. Test of proportionality between travel time and activity time is based on OLS estimates of the log-linear model. Hence, to test for an activity type, *j* the proportionality hypothesis, two types of model are estimated, for each of the following hypotheses.

Hypothesis 2: the travel time budget associated with the purpose j represents a fixed proportion of the activity time budget of type j.

First, proportionality is tested between the travel time budget associated with the purpose j, TTB_j, and the activity time budget, ATB_j, in the following model:

$$\ln TTB_j = \theta_j \ln ATB_j + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ... + \varepsilon \tag{5}$$

where, θ_j is the coefficient to be tested for the activity type j.

Hypothesis 3: the travel time associated with the purpose j represents a fixed proportion of the activity duration at destination of type j.

Second, proportionality at the episode level is tested between the travel time associated with the purpose j, TT_j, and the activity duration, AT_j in the model:

$$\ln TT_j = \theta_j \ln AT_j + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ... + \varepsilon \tag{6}$$

2.4. Travel time intensity and non-linear assignment

The *travel time intensity* of an activity represents the supplementary travel time implied by an increase in activity duration of a given type. It can be found in Golob and McNally (1997), Lu and Pas (1999), or in other microeconomics models. To our knowledge, Chen and

Mokhtarian (2006) are the first to propose a “price time of activity” in a microeconomic time allocation model.
A general formulation can be:

$$TTI_j = \frac{\Delta TT_j}{\Delta AT_j} \cong \frac{\partial TT_j}{\partial AT_j} \tag{7}$$

Where the travel time intensity of the activity type j (TTI_j) is the relative variation (or the derivative) of the travel time associated with an activity type j (TT_j) with respect of the duration AT_j of the activity of type j. Most of the models that estimate the travel time on activity duration lead to interpret estimators in terms of travel time intensities.

The log-linear model is one of the forms allowing non-linear relationship. Test of the θ parameter in the model above will indicate the particular case of proportional assignment.

Nevertheless, adjustment quality can be gained by taking into account the non-normal distribution of duration data. The robustness properties of the linear estimators are lost without the normal distribution (Lawless, 2003). In this section, we propose to estimate travel time budget and travel time intensity in the duration model framework. First, this technique is suitable to deal with duration data that are non-negative and non-normally distributed. Second, this model estimates a flexible functional form of interaction between modelled time and covariates, producing non-linear travel time intensity associated with activity duration. Complete presentation of the duration model estimation theory can be found in Kalbfleich and Prentice (1980), Allison (1995), Hosmer and Lemeshow (1999), Lawless (2003).

The duration model framework assumes a log-linear model form. The logarithm of the duration, T, is estimated by:

$$\ln T = g(X,\beta) + \sigma\varepsilon \tag{8}$$

where X is the covariables matrix, β is the column vector of parameters associated with covariables and ε denotes the error term which distribution is supposed to be known (for example, usual distributions are normal, logistic or extreme value distribution). The error distribution choice will imply a particular time distribution.
Usual specification of the covariables transformation function $g(.)$ is:

$$g(X, \mu\ \beta) = \mu + X\beta \tag{9}$$

It leads to an easy interpretation of coefficients in terms of variation of the conditional expected value: $E[\ln T \mid X]$.
Assuming the error distribution, we can deduce the time density and distribution functions, $f(t)$ and $F(t)$:

$$f(t) = \lim_{\Delta \to 0^+} \frac{P(t \le T < t + \Delta)}{\Delta} \tag{10}$$

and

$$F(t) = P(T \le t) = \int_0^t f(u)du \tag{11}$$

Interpretation of the duration model estimations is particularly interesting in terms of survival time or survival probability and hazard rate. The survival function is given by the following probability:

$$S(t) = \Pr[T > t] = 1 - F(t) \tag{12}$$

$S(t)$ corresponds to the probability of an activity duration to exceed a given time t, and depends on the assumed distribution function of the error term. The hazard rate is given by the following conditional probability:

$$h(t) = \lim_{\Delta \to 0^+} \frac{P(t \le T < t + \Delta \mid T > t)}{\Delta} \tag{13}$$

h(t) corresponds to the conditional probability of interruption of the temporal process at date $t+\Delta$, given that it has lasted to time *t*. The hazard can be interpreted as the rate of variation of the survival curve.

The model estimations reveal an interesting interpretation in the median survival time variations with respect to covariables and especially here with the activity duration covariables. Median survival time and its derivative with respect of covariables depend on the assumed distribution of error term.

The duration model is applied to the travel time budget. Estimates of the impact of covariables (including activity daily time budgets) on travel time budget are produced and permit to derive estimated travel time intensity for each activity type.

3 Data

3.1 Enquête-Ménage Déplacements and Microrecensement National Suisse

The mobility surveys exploited in our study concern three Swiss cities (Bern, Geneva and Zurich) and four French cities (Grenoble, Lyon, Rennes and Strasbourg) each observed at two time periods. The Swiss data are from the Swiss national travel surveys (*Microrecencement National Suisse*) conducted in 1994 and 2000. The French data originate from the local mobility surveys of each city (*Enquête-Ménage Déplacements*).

To explore the allocation of time behaviour and to test the transferability of proportionality hypotheses between different urban contexts, we choose cities that are heterogeneous in terms of the following criteria:

- The form and spread of the peri-urbanisation process;
- The level of equipment in heavy network of public transport;
- The transport and urban policy managing the car accessibility.

Swiss cities are clearly more transit and pedestrian oriented in terms of infrastructure, transport networks and transport policy. In French cities, transport policies, such as restriction of automobile access to the centre and limitation of parking facilities, appeared relatively recently in comparison to Swiss cities. Joly *et al.* (2007) distinguish three urban contexts:

- Strasbourg, Zurich and Bern are characterised by efficient urban and regional public transport systems, optimised infrastructures and services, and regulated car accessibility to city centre.
- Lyon, Grenoble and Geneva present efficient urban public transport systems, but weak regional systems, develop simultaneously urban public transport infrastructures and car infrastructures, and apply no regulation policy of car accessibility to city centre.
- Rennes exhibits car oriented transport system, with weak urban and regional public transport system and promote individual transport modes.

Moreover, Swiss chosen cities were subject to a local oversampling in the Swiss national survey. The French cities were chosen for their survey periods, which resemble those of Switzerland. Socio-demographic characteristics of individuals and households and mobility indicators on a given weekday are collected. Using, starting and stopping times and the types of activities at the origin and destination of each trip, the one-day out-of-home activities diary can be reconstructed from the first to the last trip of the day.

The question of comparability of the different surveys arises regarding survey methodologies and the definition and measure of indicators. Table 1 presents the objectives and the convergence of the methodologies through a series of questions (who is surveyed, where, when, etc).

Table 1: Comparison of French and the Swiss survey methodologies

	Enquêtes-Ménages Déplacement	Microrecencement National
Survey	Local Mobility (agglomeration)	National Mobility (oversampling of 10 cantons)
Methodology	Unified CERTU methodology At-home interview	CATI
Objects	Household equipment, mobility behaviour, and opinions on transport policy and local themes	Household equipment, mobility behaviour, and trip with a night out-of-home, and air trip, opinions on Swiss transport policy
Sample size	Minimum of 1,500 households	(1994) : 16,570 households, 18,020 reference persons (2000) : 27,918 households, 29,407 reference persons
Who?	All household members older than five	Persons of reference older than six (2 persons in households with four or more members)
Which trips?	All trips realised the day before the survey (workdays)	All trips realised the day before the survey (workdays or weekend)
When?	A workday of reference chosen in several months (October to May)	A day of reference chosen in the whole year
Where?	The survey perimeter represents the agglomeration (defined by the entrepreneur)	The Swiss national country

The French data are constituted of the 8 local mobility surveys, that all follow the unified CERTU methodology. At least 1,500 households are questioned by at-home interview on their composition, motorisation level, mobility and certain local themes. Swiss information is from the NTS. 16,570 households in 1994 and 27,918 in 2000 were questioned using CATI methodology, on their composition, motorisation level, mobility and several local themes.

Divergences appear in the person interviewed. Swiss surveys concentrate only on a reference person older than six years old (2 persons of reference for households with 4 or more members). Conversely, in French surveys, mobility of all members is recorded. Swiss interviews are realised during the entire year, while French interviews are only performed between October and May. Swiss surveys include weekends and long distance trips realised at the national level, while French surveys exclusively consider trips on workdays and exclude trips that exit the perimeter of study. A number of operations were then executed to extract information on the same type of mobility. The same list of modes of transport is considered in each sample: walk, cycle, urban and interurban public transport (tramway, subways, buses, train, etc.), car.

3.2 Data handling and variable descriptions

In order to ensure comparability, the handling of the data consists in reproducing in Swiss data the conditions of the French CERTU methodology on the following directions.

Zone adaptation

First, Swiss perimeters have been constructed to correspond to the French perimeters. Second, each perimeter is divided into 3 zone types: centre, suburban and peri-urban, based on the definition given by Jemelin and Kaufmann (2002). For the French cities, centre zones are composed of communes[1] with more than 5,000 inhabitants per square kilometre and with more than 100,000 inhabitants. Suburban communes possess at least 50% of the residential capacity in collective buildings and are in continuity with a centre commune. The other communes of the perimeter are peri-urban. For Swiss cities, the classification is an adaptation of the one of the Federal Office of Statistics (Office Fédéral de la Statistique, 2000), which defined centre as an attraction point of the commute trips. The suburban type is defined on the type of buildings and is continuous with centre. The peri-urban zone is composed of the remaining communes.

[1] French municipalities.

Purposes adaptation
Swiss and French surveys focus on distinct purposes classifications. Around twenty trip purposes are described in the French surveys against nine in the Swiss surveys. To be comparable the purposes are grouped into a simple distinction: work, shopping/services and leisure activities.
Trips selection
Certain trips were systematically excluded from the data sample. Hence, we only preserve mobile persons on workdays that do not exit the perimeter, nor perform trips for professional purposes. Special attention was given to correct or to exclude errors on the timing of trips in order to keep only full time diaries.

Appendix 1 presents the samples sizes before and after data handling. Table 2 presents the samples sizes after correction and the mean travel time budget, the mean travel time and the mean daily number of trips. Mobility increase is observed in each city between the two dates. Travel times are higher in biggest cities (Lyon and Zurich). Swiss cities show higher travel times and lower daily number of trips than French cities. Transit oriented and car constraining transport policies can explain these observations.

Table 2: Sample sizes, mean travel time budget (TTB), mean daily number of trips and mean travel time (tt).

	Samples sizes		**Means**		
French cities	**# of Individuals**	**# of Trips**	**TTB**	**N of trips**	**tt**
Grenoble 1992	3,257	13,924	67.20	4.26	15.75
Grenoble 2001	5,288	24,978	78.92	4.72	16.72
Lyon 1985	7,240	29,235	67.79	4.04	16.77
Lyon 1995	11,063	47,152	78.44	4.26	18.40
Rennes 1991	6,127	24,757	57.44	4.04	14.21
Rennes 2000	7,476	31,743	70.91	4.25	16.70
Strasbourg 1988	3,668	17,103	69.94	4.67	14.99
Strasbourg 1997	4,661	23,126	78.90	4.96	15.90
Swiss cities					
Bern 1994	1,335	5,048	74.13	3.78	19.60
Bern 2000	1,348	5,457	85.41	4.05	21.10
Geneva 1994	353	1,397	83.41	3.96	21.08
Geneva 2000	1,919	8,100	84.06	4.22	19.92
Zurich 1994	1,574	5,903	82.11	3.75	21.89
Zurich 2000	2,010	7,954	87.35	3.96	22.07

4 Results

Estimations have been realised for each of the 14 samples, but to gain space, only synthetic results are presented. Table 3, 4, 5 and 6 present estimations based on the two Swiss and French samples. Appendix 2, 3 and 4 present synthetic results of each regression by city sample.

4.1 Test of the proportional assignment of daily available time

The test of proportional assignment of available time is performed through Stepwise OLS estimations, constrained to include the total daily available time as an explanatory variable. The logarithm of daily time budgets for work, shopping, leisure and transport are regressed on the logarithm of daily total time available and dummy variables for sex, class of age, professional status, residential location, household structure, day of trip, driver licence, motorization, and dummies for cities crossed with periods. Separate regressions for each city sample result in the same conclusions as in tables 3 and 4.

Table 3: Tests of the proportional assignment of total available time (French cities)

French sample	Work TB / T	Shopping TB / T	Leisure TB / T	Travel TB / T
R²	0.73	0.076	0.09	0.1063
# of significant variables	21	15	17	29
θ (*se(θ)*)	-2,81 (0,01)	1,76 (0,10)	1,02 (0,09)	0,96 (0,03)
Test statistics	92284.7	54.53	0.05	1.69
(P-Value)	(<0.0001)	(<0.0001)	(0.81)	(0.193)

TB: Time budget T: Total time available

Table 4: Tests of the proportional assignment of total available time (Swiss cities)

Swiss sample	Work TB / T	Shopping TB / T	Leisure TB / T	Travel TB / T
R²	0.70	0.23	0.23	0.06
# of significant variables	13	16	20	20
θ (*se(θ)*)	-2,31 (0,03)	2,36 (0,21)	1,78 (0,11)	0,51 (0,06)
Test statistics	15622.9	21.44	6.28	51.52
(P-Value)	(<0.0001)	(<0.0001)	(0.0123)	(<0.0001)

TB: Time budget T: Total time available

Proportional assignment hypothesis is rejected for work, with high level of significance, in all cities and for shopping activities in almost cities. However, time budgets for leisure and travel seems to be fixed proportions of available time in French cities. Only the sample of Grenoble 1992 does not support the proportional assignment hypothesis for leisure. The first surveys of Lyon, Grenoble and Strasbourg reject proportional assignment for transport. Tests realised on each city samples indicate that the proportional assignment hypothesis is accepted for the shopping activity for the samples of Bern 1994, Geneva 1994, and Zurich 1994 and 2000. The proportional assignment of time to leisure activity is only valid for Bern 2000 and Zurich 2000. Globally proportional assignment seems to be supported for leisure and travel by the most recent surveys and / or largest surveys for each city.

Finally, the qualities of adjustment are weak, as it is usually the case for linear model of activity duration. By construction of the total time available, *T*, the R^2 is relatively high for the work time budget regression.

4.2 Test of proportionality between travel and activity times

Results indicate that the *daily* travel times associated with a purpose is not a fixed proportion of the daily time of the associated activity type (Tables 5 and 6, Appendix 3). Hypothesis 2 is rejected.

Table 5: Tests of the proportionality of the daily travel times for a purpose with respect to the activity time budget (French cities)

French sample	TTB for Work / Work TB	TTB for Shopping / Shopping TB	TTB for Leisure / Leisure TB
R²	0.062	0.253	0.142
# of significant variables	26	25	26
θ (*se(θ)*)	0,08 (0,01)	0,36 (0,00)	0,25 (0,01)
Test statistics	6069.09	18021.5	13151.2
(P-Value)	(<0.0001)	(<0.0001)	(<0.0001)

TT: Travel time TB: Time budget

Table 6: Tests of the proportionality of the daily travel times for a purpose with respect to the activity time budget (Swiss cities)

Swiss sample	TTB for Work/ Work TB	TTB for Shopping / Shopping TB	TTB for Leisure / Leisure TB
	TTB / Work	TTB / Shopping	TTB / Leisure
R^2	0.038	0.147	0.144
# of significant variables	19	12	11
θ ($se(\theta)$)	0,13 (0,02)	0,21 (0,01)	0,26 (0,02)
Test statistics	1553.28	3989.09	2156.69
(P-Value)	(<0.0001)	(<0.0001)	(<0.0001)

TT: Travel time TB: Time budget

The last step in the search for proportionality and regularities is at the travel time ratio level. The travel times for the work, shopping and leisure activities are analysed. Estimations of the logarithm of the travel time preceding activity participation are realised on the logarithm of the activity duration and the other socio-demographic variables. Stepwise OLS are performed for each activity type on each city sample (Appendix 4) and on the two national samples, results of which are presented in tables 7 and 8.

For national samples, R^2 are comparable with other studies, about 0.20. For national and cities samples: the tests reject proportionality for the three trip purposes; and the activity duration effects on travel time are positive for work, shopping and leisure. For example, in French sample, a 1% increase of shopping time implies a 0.18% increase of expected travel time. The values of estimates associated with duration of each activity type are similar between the French cities samples (around 0.10 for work; 0.23 for shopping; 0.12 for leisure). Values are close between Swiss cities, but lower than the French values (around 0.05 for work; 0.08 for shopping; 0.05 for leisure). Few Swiss estimates are significant. Difference between Swiss and French values may result form the quality of the trip purpose definition and precision between the Swiss and French surveys. Log-linear model estimations reject proportionality hypothesis 3 but seem to indicate non-linear regularities in the relation between travel time and activity duration.

Stepwise selection of independent variables identifies individuals, household and trip significant characteristics. We find common results with the literature and regular results between estimations based on the two national samples. Signs of the estimates are similar between Swiss and French cases. Despite different variables are selected, they illustrate similar global effects. For example, results illustrate weekly cycles, with higher travel time for work on Friday and lower travel times for shopping on Monday. Presence of children reduces travel time for work, and absence of child leads to higher travel times for each activity type. Worker and young spent less time travelling to shopping and leisure activities. Public transport users experience higher travel time for all activities. Non-motorised persons have higher travel time than motorised persons or driver licence holder. Finally the cities dummies capture city size effect, but are imprecise to estimate transport policy or urban context effects.

Table 7: Regression of the travel time for work, leisure and shopping purposes (Swiss sample)

Variable	TT for Work		TT for Shopping		TT for Leisure	
Intercept	2.236	***	2.013	***	2.506	***
Log Work time	0.035	***				
Log Shopping time			0.041	***		
Log Leisure time					0.022	**
Male					-0.047	**
Worker			-0.102	***	-0.298	***
Suburban					0.047	**
Monday			-0.052	**		
Tuesday	0.072	***				
Friday	0.115	***			0.124	***
Couple with 3 children	-0.363	***				
Single without child	0.044	**				
Age < 19			-0.230	**	-0.134	*
18 < Age < 35					-0.059	**
49 < Age <65					0.057	*
Age > 66	0.104	*				
Driver Licence			-0.069	***		
2 cars	-0.031					
3 cars	0.150	**				
Walk	-0.665	***			-0.212	***
Bicycle	-0.340	***			-0.116	*
Motorcycle	-0.104					
Public transport	0.827	***	1.168	***	0.849	***
Car	0.106	*	0.395	***	0.129	***
Other mode			0.272	*	0.950	***
Bern 94			-0.221	***	-0.122	***
Bern 00			-0.057	*		
Geneva94					-0.092	
Geneva00	0.086	***	0.056	*		
Zurich 94			-0.157	***	-0.144	***
Zurich 00	0.047	**			0.083	***
R^2	*0.31*		*0.24*		*0.17*	
Proportionality F Test	15,927.4	***	11,967.9	***	7,953.70	***

* 0.1, ** 0.05, ***0.01 level of significance

Table 8: Regression of the travel time for work, leisure and shopping purposes (French sample)

Variable	TT for Work		TT for Shopping		TT for Leisure	
Intercept	2.218	***	1.785	***	1.997	***
Log Work time	0.088	***				
Log Shopping time			0.187	***		
Log Leisure time					0.091	***
Male	0.119	***	0.073	***		
Worker			-0.026	***	-0.096	***
Centre	0.058	***	0.070	***	0.055	***
Peri-urban			-0.020	*	-0.078	***
Monday			-0.026	***	-0.049	***
Tuesday					-0.035	***
Thursday	0.027	***				
Friday	0.023	**	-0.021	**		
Couple with 1 child			-0.040	***	0.028	**
Couple with 2 children	-0.029	***	-0.055	***		
Single without child					0.076	**
Single 1 child					0.078	**
Age < 19	-0.176	***	-0.129	***	-0.189	***
18 < Age < 35			-0.016			
34 < Age < 50	-0.022	***	-0.027	**	0.020	
49 < Age <65					0.097	***
Age > 66					0.165	***
Driver Licence	-0.078	***	-0.048	***	-0.036	**
High income					0.041	***
0 car	0.101	***	0.042	***	0.024	*
1 car	-0.017	**	0.023	**	0.023	**
Walk	-0.650	***	-0.301	***	-0.263	***
Bicycle	-0.282	***	-0.218	***		
Motorcycle	-0.168	***	-0.163	***		
Public transport	0.562	***	0.477	***	0.664	***
Car			-0.078	***	0.122	***
Other mode	0.374	***			0.608	***
Grenoble 01			0.019		-0.090	***
Grenoble 92	-0.106	***				
Lyon 85	0.045	***	0.036	***		
Lyon 95	0.108	***	0.123	***	0.080	***
Rennes 00	0.109	***			-0.032	**
Rennes 91	-0.120	***	-0.075	***	-0.049	***
Strasbourg 88	-0.138	***	-0.167	***		
Strasbourg 97						
R^2	*0.21*		*0.21*		*0.19*	
Proportionality F Test	51,165.0	***	49,285.7	***	46,138.7	***

* 0.1, ** 0.05, ***0.01 level of significance

4.3 Non-linear travel time intensity – Duration model

Tests of the relationship between travel time and activity time reject proportionality at trip level and daily level, but indicate concave functional form ($0 < \theta < 1$). Second remark is the fact that OLS estimation techniques may be unsuitable for duration data that are known to be non-normally distributed. Appendix 5 present tests rejecting normality of the travel time budgets in the two national samples. To overcome this limit, the duration model framework is used to model the travel time budgets. The form of the derivative of the predicted median value of travel time budget, and then the estimated travel time intensities, depends on the distribution adopted.

Hence, the first step is to determine the suitable distribution for the samples. Likelihood ratio test (LR) and Akaike Information Criterion (AIC) are used to select the distribution of the duration. Only nested distributions can be tested with the LR test. Then, table 9 shows the LR tests for Weibull, log-normal and generalised gamma distributions, for the two national samples. Because the log-logistic distribution is not nested in the generalised gamma, the LR test can not be performed to test this distribution. The gamma distribution gives the best adjustment, with estimates of distribution parameters indicating non-monotonic hazard. Finally, the loglikelihood and the Akaike Information Criterion (AIC) indicate that the non-monotonic loglogistic model fit best the data than the other models. Furthermore, the log-logistic distribution permits to calculate closed-form expression of the predicted median duration and its derivative, by opposition with the lognormal or gamma functions.

Table 9: Loglikelihoods, AIC and LR tests

Models	Loglikelihood		AIC	
	Swiss Sample	*French Sample*	*Swiss Sample*	*French Sample*
Weibull	-9,590.00	-54,830.76	19,258.00	109,739.52
Log Normal	-9,311.96	-52,008.80	18,701.92	104,095.60
Generalised Gamma	-9,270.99	-51,867.16	18,621.98	103,814.32
LogLogistic	-9,167.02	-51,658.06	18,412.04	103,394.12

Model 1 vs model 2	LR	
	Swiss Sample	*French Sample*
Weibull vs GG	638.02 ***	5,927.20 ***
Log N vs GG	81.94 ***	283.28 ***

The covariables set is derived from the set of socio-demographic variables resulting from the Stepwise selection process performed in semi-parametric methodology of the Cox model. This methodology is known to be a suitable way to estimate the covariables impacts on hazard (Oakes, 1977). Loglogistic estimation results for the two national samples, with dummies for cities and dates are presented in table 10.

Despite few coefficients are simultaneously significant in both sample, some regularities in covariables effects appear as for example the activity duration effect, the gender and age effects and day of the week effect. Male have higher travel time budget. Older persons have lower travel time budget. Travel time budget on Friday is higher. Conversely, the effects of the presence of children and motorisation are unclear, because of insignificant coefficient for the Swiss sample. Singles with children are characterised by higher travel time budget, maybe suggesting more constrained mobility and activity patterns. Residential location appears to have opposite effects between the two samples: central location reduces travel time budget in Swiss cities, but increases travel time budget in French cities. These results echoes those obtained by Joly *et al.*, (2007) analysing mobility and urban context in each of the seven cities. They show that Swiss cities present specific urban contexts, transport systems and transport policy that are particularly efficient in the city centre. These urban organisations lead to increasing travel times and travel time budgets from the centre to the peri-urban zones. Conversely, French cities exhibit lower travel times in sub-urban and peri-urban zones than in central zone, because of car oriented mobility and with good accessibility to centre.

The driver licence dummy seems to have a positive effect. Motorization has no significant effect. The dummies for cities indicate that travel time budget of Lyon 1995 and Strasbourg 1997 are the highest in the French sample. In the Swiss sample, Zurich and Bern 2000 have the highest travel time budget. These cities seem to cumulate two effects. First, a size effect: Lyon and Zurich are millionaire cities. Second, these four cities promote public transport against car accessibility, increasing then travel time by car and mean travel time budget.

Finally based on the significant coefficients associated with activity duration, we deduce travel time intensities for each activity type. Figures 3 to 5 illustrate the predicted median travel time budget and the travel time intensities calculated at the mean of the French sample as function of each activity time budget. For the loglogistic distribution, the expected median survival duration is given by: $t_{50}=1/\exp(-X\beta)$. The travel time intensity is increasing and convex with the shopping and leisure daily time budgets. Hence, travel time budget increase more than proportionally with the time spend in leisure and shopping activity. Leisure appears more intensive in terms of travel time than shopping. Conversely, the travel time intensity for work is constant. Travel time for work increases linearly with work duration.

Table 10: Loglogistic estimations on the two national samples

Parameter	*French Sample* Estimation		*Swiss Sample* Estimation	
Intercept	3.776	***	3.871	***
Work time budget	0.0001	***	0.0003	***
Shopping time budget	0.0019	***	0.0008	***
Leisure time budget	0.0014	***	0.0013	***
Male	0.081	***	0.051	***
Worker	0.115	***	-0.008	
Centre	0.045	***	-0.077	***
Suburban	0.009		-0.069	**
Peri-urban	-		-	
Monday	-0.092	***	-0.119	***
Tuesday	-0.039	***	-0.047	*
Wednesday	-0.060	***	-0.112	***
Thursday	-0.028	***	-0.109	***
Friday	-		-	
Couple 0 child	-0.028	***	0.040	
Couple 1 child	-0.062	*	0.075	
Couple 2 children	-0.073	**	0.082	
Couple 3+ children	-0.011		-0.005	
Single without child	-0.098	***	0.107	
Single 1 child	-0.028		0.083	
Age < 19	0.009		0.545	***
18 < Age < 35	0.249	***	0.169	***
34 < Age < 50	0.151	***	0.166	***
49 < Age < 65	0.101	***	0.151	***
Age > 64	-		-	
Driver licence	0.059	***	0.019	
High income	-0.015			
Low income	-0.022			
Medium income	-			
Non car	0.053		0.020	
1 car	0.043		-0.049	
2 cars	0.053		-0.039	
3 cars	0.064		0.032	
4 cars and more	-		-	
Bern 94			-0.232	***
Bern 00			-0.033	
Geneva 00			-0.048	*
Geneva 94			-0.172	***
Zurich 94			-0.153	***
Zurich 00				
Grenoble 01	-0.004			
Grenoble 92	-0.138	***		
Lyon 85	-0.079	***		
Lyon 95	0.051	***		
Rennes 00	-0.143	***		
Rennes 91	-0.227	***		
Strasbourg 88	-0.085	***		
Strasbourg 97	-			
Scale	0.394		0.457	
LogLikelihood	-51,658.06		-9,167.02	

* 0.1, ** 0.05, ***0.01 level of significance

Figure 3: Median expected daily travel time and travel time intensity given the Shopping daily time (French sample)

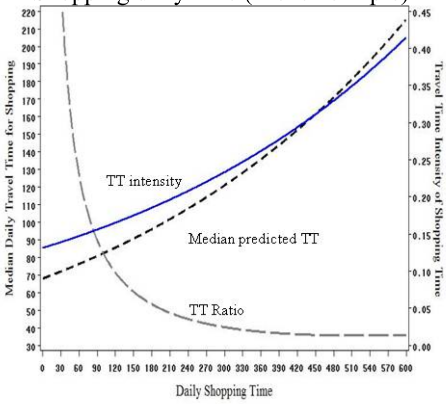


Figure 4: Median expected daily travel time and travel time intensity given the Leisure daily time (French sample)

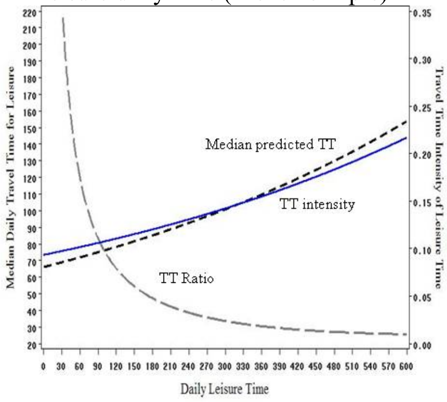
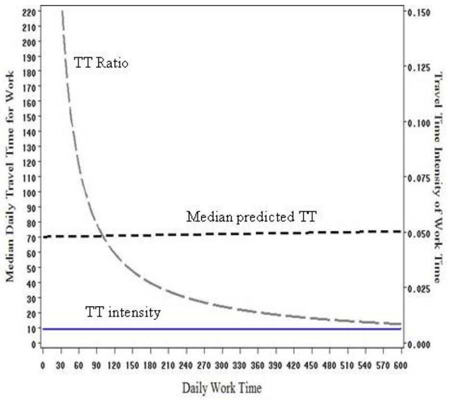


Figure 5: Median expected daily travel time and travel time intensity given the Work daily time (French sample)



5 Conclusions

Based on OLS estimation of log-linear models, we test the three paradigms: proportional assignment of daily total available time; proportionality between daily activity time and the daily travel time associated with; and proportionality between travel time and the activity duration at destination (constant travel time ratio). Estimations and tests were performed on 14 surveys (four French cities and three Swiss cities observed two dates).

The proportional assignment of daily available time is only valid for leisure and transport activities. The tests of the relationship between daily travel time associated with the purpose *j* and daily activity time budget of type *j* indicate that proportionality is not valid, regardless the type of activity. Finally, the travel time ratio hypothesis is rejected between travel time and activity time at the destination. The log-linear models estimated indicate a significant effect of activity duration on travel time, but in a non-linear form. The tests performed and the close estimated values of θ coefficients indicate regularities in travel time intensities (or elasticities) rather than constant travel time ratios.

To overcome OLS limitation and to gain in quality of adjustment we estimate travel time budget using the duration model framework . Duration model take into account the fact that travel time budgets are characterised by a non-normal distribution. Estimated travel time intensities indicate that travel time intensities for shopping and leisure are increasing with daily duration of activity. The propensity to accept supplementary travel time is increasing with the shopping and leisure duration. Conversely the travel time intensity associated with the daily work duration is nearly stable. This result echoes results of Dijst and Vidakovic (2000) of stable travel time ratio for work.

Furthermore, the proportionality hypotheses between travel time and activity duration fail to represent the allocation of time process. Non-linear form seems to fit best the relation between travel time and activity duration. The aggregated definition of the trip purposes used in the different studies may partially explain this problem. A shopping episode in a nearby small shop or in a distant shopping centre does not correspond with the same travel and activity relation, or with the same travel time acceptability. Introduction of non-linear relation take into account partially the lake of accuracy of the purposes definition.

The log-logistic distribution appears to give the best adjustment in the two national samples. This non-monotonic hazard form raises the question of the management of travel time budget and the eventuality of unobserved heterogeneity.

Finally, the definition of the travel time associated with the activity pursued is problematic. Future task will be to analyse the travel time of trips chain in relation with the duration of the activities performed.

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Appendix

Table A-1: City Sample

City	Trips			Individuals		
	Before correction	After correction	% of deletion	Before correction	After correction	% of deletion
Grenoble 2001	26004	24978	-3,95	5916	5288	-10,62
Grenoble 1992	15672	13924	-11,15	3992	3257	-18,41
Lyon 1985	32819	29235	-10,92	8959	7240	-19,19
Lyon 1995	50057	47152	-5,80	12902	11063	-14,25
Rennes 2000	33059	31743	-3,98	8392	7476	-10,92
Rennes 1991	27054	24757	-8,49	7151	6127	-14,32
Strasbourg 1988	18776	17103	-8,91	4442	3668	-17,42
Strasbourg 1997	25426	23126	-9,05	5531	4661	-15,73
Bern 1994	5718	5048	-11,72	1575	1335	-15,24
Bern 2000	6319	5457	-13,64	1628	1348	-17,20
Geneva 1994	1516	1397	-7,85	388	353	-9,02
Geneva 2000	9196	8100	-11,92	2236	1919	-14,18
Zurich 1994	6530	5903	-9,60	1793	1574	-12,21
Zurich 2000	8893	7954	-10,56	2317	2010	-13,25
Total Sample	267039	245877	-7,92	67222	57319	-14,73

Table A-2: Stepwise estimation results of *proportional assignment* model (hypothesis 1)

$$\ln ATB_j = \theta \ln T + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ... + \varepsilon$$

WORK	R²	# of variables	θ	se(θ)	T test	F test
French Sample	0.74	21	-2.81	0.01	-224.13	92284.70
Grenoble 2001	0.78	14	-2.74	0.03	-78.49	11475.00
Grenoble 1992	0.77	7	-2.87	0.04	-67.00	8154.74
Lyon 1995	0.74	13	-2.60	0.03	-103.85	20688.30
Lyon 1985	0.76	12	-2.85	0.03	-92.89	15751.40
Rennes 2000	0.76	16	-2.60	0.03	-91.00	15878.30
Rennes 1991	0.78	13	-2.85	0.03	-89.54	14625.90
Strasbourg 1997	0.72	10	-2.87	0.04	-66.65	8074.74
Strasbourg 1988	0.70	11	-3.46	0.06	-55.87	5186.97
Swiss Sample	0.70	10	-2.31	0.03	-88.66	16147.10
Bern 1994	0.85	5	-2.39	0.04	-53.71	5805.55
Bern 2000	0.60	7	-2.51	0.09	-27.07	1432.02
Geneva 1994	0.91	8	-2.33	0.07	-35.74	2610.31
Geneva 200	0.68	12	-2.52	0.07	-35.47	2457.01
Zurich 1994	0.83	9	-2.10	0.04	-57.92	7311.11
Zurich 2000	0.72	8	-2.04	0.05	-43.08	4124.22

LEISURE	R²	# of variables	θ	se(θ)	T test	F test
French Sample	0.09	17	1.02	0.09	11.21	0.82
Grenoble 2001	0.12	10	1.01	0.24	4.27	0.00
Grenoble 1992	0.22	14	1.98	0.39	5.13	6.46
Lyon 1995	0.05	9	0.81	0.19	4.23	0.98
Lyon 1985	0.09	12	1.04	0.23	4.48	0.02
Rennes 2000	0.09	7	1.29	0.24	5.31	1.45
Rennes 1991	0.06	8	0.60	0.26	2.31	2.28
Strasbourg 1997	0.10	11	1.10	0.25	4.35	0.16
Strasbourg 1988	0.11	8	0.76	0.32	2.38	0.58
Swiss Sample	0.16	18	1.78	0.11	15.79	47.53
Bern 1994	0.32	11	2.01	0.23	8.67	18.90
Bern 2000	0.11	4	0.95	0.29	3.28	0.03
Geneva 1994	0.43	7	2.51	0.50	4.98	8.97
Geneva 200	0.11	8	0.42	0.23	1.82	6.32
Zurich 1994	0.24	5	1.93	0.20	9.66	21.55
Zurich 2000	0.12	12	0.66	0.29	2.25	1.31

SHOPPING	R^2	# of variables	θ	se(θ)	T test	F test
French Sample	0.08	15	1.76	0.10	17.05	54.53
Grenoble 2001	0.08	9	1.47	0.30	4.83	2.40
Grenoble 1992	0.16	8	2.02	0.44	4.63	5.47
Lyon 1995	0.08	10	1.64	0.23	7.18	7.92
Lyon 1985	0.08	8	1.78	0.27	6.60	8.35
Rennes 2000	0.08	6	1.81	0.24	7.38	10.83
Rennes 1991	0.11	6	2.25	0.30	7.55	17.59
Strasbourg 1997	0.07	6	1.60	0.33	4.92	3.43
Strasbourg 1988	0.13	9	1.70	0.32	5.24	4.61
Swiss Sample	0.16	13	2.36	0.21	11.38	43.15
Bern 1994	0.28	8	1.81	0.64	2.82	1.60
Bern 2000	0.21	5	2.38	0.43	5.53	10.29
Geneva 1994	0.35	4	1.36	0.85	1.61	0.18
Geneva 200	0.26	8	2.21	0.41	5.35	8.58
Zurich 1994	0.16	5	1.32	0.53	2.48	0.37
Zurich 2000	0.18	7	1.55	0.37	4.20	2.20

TRAVEL	R^2	# of variables	θ	se(θ)	T test	F test
French Sample	0.11	29	0.96	0.03	30.17	1.69
Grenoble 2001	0.08	14	0.90	0.99	0.91	1.05
Grenoble 1992	0.24	17	1.58	0.12	13.00	22.56
Lyon 1995	0.08	14	0.99	0.67	1.46	0.03
Lyon 1985	0.06	15	0.73	0.08	8.74	10.23
Rennes 2000	0.10	17	0.96	0.08	11.77	0.24
Rennes 1991	0.11	14	1.09	0.09	12.07	0.94
Strasbourg 1997	0.08	9	0.85	0.10	8.49	2.27
Strasbourg 1988	0.09	16	0.80	0.10	7.64	3.77
Swiss Sample	0.05	17	0.51	0.06	8.86	70.48
Bern 1994	0.10	10	0.60	0.15	4.00	7.12
Bern 2000	0.12	12	0.68	0.14	4.78	5.23
Geneva 1994	0.15	4	0.71	0.26	2.70	1.24
Geneva 200	0.07	8	0.61	0.13	4.66	8.82
Zurich 1994	0.11	11	0.69	0.12	5.54	6.24
Zurich 2000	0.08	14	0.45	0.13	3.44	17.51

F test are for H0: θ=1.

Table A-3: Stepwise estimation results of travel time budget ratio model (hypothesis 2)

$$\ln TTB_j = \theta_j \ln ATB_j + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ... + \varepsilon$$

WORK	R^2	# of variables	θ	se(θ)	T test	F test
French Sample	0.06	26	0.08	0.01	6.96	6069.09
Grenoble 2001	0.06	14	0.17	0.04	4.32	427.79
Grenoble 1992	0.12	9	-0.03	0.04	-0.76	582.15
Lyon 1995	0.04	11	0.06	0.29	0.20	1094.15
Lyon 1985	0.05	11	0.11	0.03	3.59	871.01
Rennes 2000	0.05	19	0.05	0.03	1.60	833.72
Rennes 1991	0.06	14	0.06	0.03	1.68	817.28
Strasbourg 1997	0.06	10	0.12	0.04	3.16	587.25
Strasbourg 1988	0.07	12	0.13	0.03	4.30	837.17
Swiss Sample	0.03	15	0.13	0.02	5.80	1565.66
Bern 1994	0.08	10	0.04	0.06	0.59	234.63
Bern 2000	0.07	7	0.12	0.04	2.84	414.07
Geneva 1994	0.10	6	-0.10	0.12	-0.85	86.12
Geneva 200	0.07	8	0.23	0.04	5.77	379.93
Zurich 1994	0.04	7	-0.05	0.06	-0.91	323.16
Zurich 2000	0.08	11	0.17	0.06	2.90	215.12

LEISURE	R^2	# of variables	θ	se(θ)	T test	F test
French Sample	0.14	26	0.25	0.01	38.20	13151.20
Grenoble 2001	0.16	14	0.31	0.02	15.37	1162.37
Grenoble 1992	0.12	13	0.16	0.02	8.86	2045.62
Lyon 1995	0.14	13	0.25	0.01	17.61	2678.87
Lyon 1985	0.17	14	0.29	0.02	15.99	1502.56
Rennes 2000	0.18	14	0.23	0.02	13.79	2128.70
Rennes 1991	0.17	16	0.28	0.02	14.52	1326.83
Strasbourg 1997	0.14	15	0.25	0.02	12.31	1388.76
Strasbourg 1988	0.14	9	0.23	0.02	10.29	1163.44
Swiss Sample	0.14	9	0.26	0.02	16.50	2304.82
Bern 1994	0.09	8	0.15	0.05	3.01	300.58
Bern 2000	0.22	8	0.28	0.03	8.08	432.50
Geneva 1994	0.22	9	0.04	0.08	0.53	144.58
Geneva 200	0.21	6	0.34	0.03	11.35	491.40
Zurich 1994	0.15	12	0.13	0.04	3.08	407.76
Zurich 2000	0.21	12	0.33	0.03	10.87	466.40

SHOPPING	R^2	# of variables	θ	se(θ)	T test	F test
French Sample	0.25	25	0.36	0.00	74.47	18021.50
Grenoble 2001	0.26	13	0.36	0.01	26.46	2141.41
Grenoble 1992	0.21	12	0.29	0.02	16.85	1640.25
Lyon 1995	0.28	13	0.37	0.01	36.79	3850.82
Lyon 1985	0.24	12	0.35	0.01	27.62	2678.30
Rennes 2000	0.26	10	0.38	0.01	30.34	2460.10
Rennes 1991	0.24	13	0.34	0.01	24.09	2145.55
Strasbourg 1997	0.27	14	0.38	0.01	26.04	1825.38
Strasbourg 1988	0.23	9	0.34	0.02	19.09	1327.53
Swiss Sample	0.15	10	0.23	0.01	19.48	4201.83
Bern 1994	0.14	6	0.21	0.03	6.68	645.52
Bern 2000	0.21	9	0.24	0.03	8.84	793.59
Geneva 1994	0.23	7	0.16	0.06	2.55	188.45
Geneva 200	0.16	8	0.25	0.03	9.12	789.85
Zurich 1994	0.16	5	0.24	0.03	7.98	634.48
Zurich 2000	0.18	11	0.25	0.02	10.39	963.03

Table A-4: Stepwise estimation results of travel time ratio model (hypothesis 3)

$$\ln TT_j = \theta_j \ln AT_j + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \ldots + \varepsilon$$

WORK	R²	# of variables	θ	se(□)	T test	F test
French Sample	0,05	18	0,11	0,00	24,31	41122,50
Grenoble 2001	0,04	10	0,11	0,01	7,72	4131,10
Grenoble 1992	0,13	9	0,06	0,01	4,35	4619,20
Lyon 1995	0,04	9	0,12	0,01	12,37	8505,68
Lyon 1985	0,04	11	0,12	0,01	9,72	5397,28
Rennes 2000	0,05	12	0,13	0,01	11,19	5632,34
Rennes 1991	0,04	10	0,11	0,01	7,57	3709,18
Strasbourg 1997	0,04	12	0,09	0,01	7,05	5180,86
Strasbourg 1988	0,06	10	0,10	0,01	7,18	4031,04
Swiss Sample	0,31	15	0,04	0,01	4,68	15873,80
Bern 1994	0,38	11	0,02	0,02	1,08	2877,40
Bern 2000	0,34	13	0,00	0,02	0,09	3333,49
Geneva 1994	0,31	7	0,01	0,04	0,18	669,09
Geneva 200	0,25	16	0,01	0,02	0,60	4160,38
Zurich 1994	0,42	11	0,05	0,02	2,58	2522,15
Zurich 2000	0,34	15	0,07	0,02	4,13	3369,76

LEISURE	R²	# of variables	θ	se(□)	T test	F test
French Sample	0,14	20	0,23	0,00	62,27	43355,30
Grenoble 2001	0,14	9	0,25	0,01	23,44	5117,00
Grenoble 1992	0,13	10	0,19	0,01	14,65	3883,30
Lyon 1995	0,14	9	0,25	0,01	30,36	8730,56
Lyon 1985	0,14	6	0,24	0,01	23,24	5657,75
Rennes 2000	0,14	10	0,24	0,01	24,36	6212,43
Rennes 1991	0,11	9	0,19	0,01	17,34	5268,89
Strasbourg 1997	0,14	9	0,24	0,01	22,51	5291,62
Strasbourg 1988	0,13	8	0,23	0,01	16,45	3112,05
Swiss Sample	0,24	13	0,04	0,01	4,76	11961,50
Bern 1994	0,40	10	0,06	0,02	2,85	2365,34
Bern 2000	0,23	8	0,01	0,02	0,57	2524,74
Geneva 1994	0,39	10	0,09	0,04	2,08	491,20
Geneva 200	0,19	11	0,01	0,02	0,64	2375,98
Zurich 1994	0,28	8	0,10	0,02	4,71	1851,55
Zurich 2000	0,21	9	0,03	0,02	1,66	2516,10

SHOPPING	R^2	# of variables	θ	se(□)	T test	F test
French Sample	0,08	22	0,12	0,00	26,47	38553,40
Grenoble 2001	0,07	9	0,15	0,01	10,08	3430,36
Grenoble 1992	0,14	12	0,12	0,01	12,58	7967,39
Lyon 1995	0,06	13	0,10	0,01	9,61	7300,67
Lyon 1985	0,10	13	0,12	0,01	9,01	4113,61
Rennes 2000	0,11	12	0,12	0,01	9,62	4982,61
Rennes 1991	0,09	12	0,16	0,02	10,32	2953,83
Strasbourg 1997	0,07	9	0,09	0,01	6,39	4677,33
Strasbourg 1988	0,06	9	0,10	0,01	7,02	3729,92
Swiss Sample	0,17	17	0,02	0,01	1,99	7958,31
Bern 1994	0,21	10	-0,01	0,03	-0,19	1076,10
Bern 2000	0,14	10	-0,02	0,03	-0,64	1565,03
Geneva 1994	0,22	9	0,01	0,06	0,11	307,72
Geneva 200	0,18	12	0,05	0,02	2,55	1968,36
Zurich 1994	0,26	12	0,06	0,03	1,95	1053,89
Zurich 2000	0,13	10	0,01	0,02	0,66	2111,29

Table A-5: Normality tests of the travel time budgets in the Swiss and French samples

Test	**Swiss sample**		**French sample**	
Kolmogorov-Smirnov	0.146825	***	0.139915	***
Cramer-von Mises	68.69115	***	340.4489	***
Anderson-Darling	412.0926	***	2042.172	***
Jarque-Bera	1145012.003	***	157588.3841	***

***: 0.01 level of significance