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LONGITUDINAL DATA FOR MODELING URBAN MOBILITY ON LONG TERM[1]

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Abstract

The usage of longitudinal data for modelling urban mobility is crucial when the analysis and forecast model would consider temporal modifications of behaviour of population in studied urban area. This paper treats the modelling and forecast of urban mobility on long term based on pseudo-longitudinal data. The analysis and investigated data are related to the urban area Lille in France. The examined data are carried out in 1976, 1987 and 1998, according to the standard methodology for mobility survey of households in France. The longitudinal data are made from repetitive surveys which makes possible to get insight in the behaviour dynamics. The decomposition of temporal effects into an effect of age and an effect of generation (cohort) makes possible to draw the sample profile during the life cycle and to estimate its temporal deformations. This is the origin of the "age-cohort" model for forecasting of urban mobility on long term.

Keywords – urban mobility; forecast; longitudinal data; model

INTRODUCTION

The forecast of urban mobility on long term is great challenge of urban transport planning. The traditional aggregated model in 4 steps (generation, distribution, modal split, route assignment) is used frequently to estimate transport demand [1]. However, this approach is contestable when the transport demand would be projected on long term. The conventional

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approach needs a data from one survey in particular date, therefore the forecasting of mobility on long term is based on static methodological approach.

The most frequently used variables in the first step of traditional aggregate model are the demographic variables. Basically, the demographic approach exploits data from repetitive surveys from different dates, which makes possible to get insight in the behaviour dynamics. The notion of longitudinal data includes usage of several surveys from different periods which enables the analysis of evolutions of studied event [2].

The mobility analysis and forecast is possible according to the longitudinal data if the temporal effects are divided into an effect of age and an effect of generation [3]. The effects of period, or the impact of the factors affecting all individuals on the particular date, could be neglected if the stability of these effects is delicate. The decomposition of temporal effects makes possible to trace the sample profile during the life cycle and to estimate its temporal deformations. The specification of the “age-cohort” model exploits the longitudinal data coming from different mobility surveys and the demographic data of population. This model is pertinent to forecast trip generation on long term.

TRANSVERSAL AND LONGITUDINAL DATA

The analysis of demographic phenomena can be carried out according to:

• Transversal analysis - It is possible to analyse the individuals from different generations given to on date. These analyses, based on transversal data, mask the fact that the individuals belong to different generations.

• Longitudinal analysis –It is possible to analyse the individuals who belonging to a certain generation. The longitudinal data make possible to enter into the dynamic comportment and into history of the generations. This type of analysis requires observations deployed in time which is a difficult characteristic to be fulfilled for certain studies.

The longitudinal analysis in demography has been used since long time. The German statistician Lexis offers already in 1875, an original graph to display simultaneously on the same diagram the relationships between three dimensions: time (or period), age of individuals (position in the life cycle) and generation (or cohort) of birth [2]. The year of birth is on abscissa, the age is on ordinate and in this case the observation period appears on the main diagonal (Fig. 1).This representation permits seeing the difference between transversal and longitudinal data. In the case of a transversal analysis, the time is presented only by the age of individuals. The usage of longitudinal data enables the measurement of time by age (in line) and also a historical measurement of time (in column).The observations corresponding to same generation appear on the diagonal crossing the age of individuals and year of observation. It is possible to observe how each generation affects the life cycle of the studied phenomena, and the impact by replacement of generations.

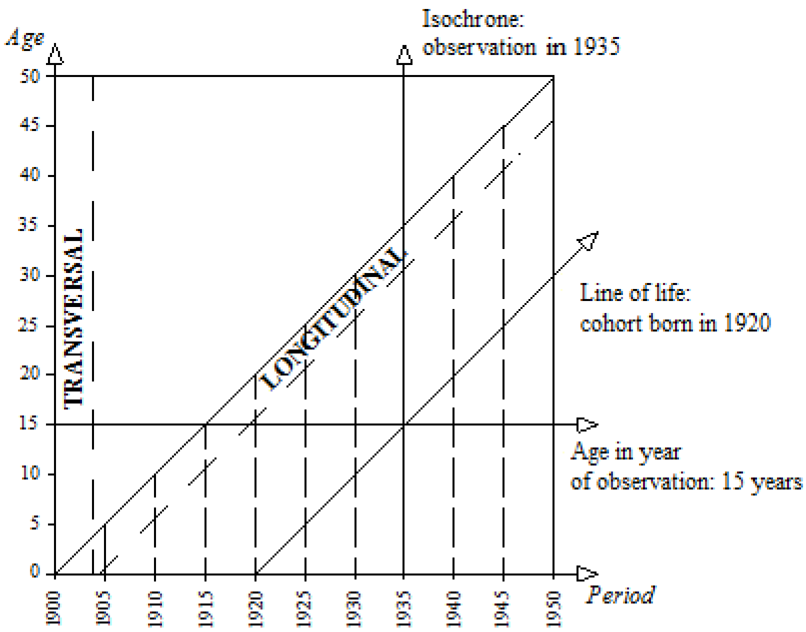

Fig.1. Diagram of Lexis-Becker-Pressat [2]

LONGITUDINAL DATA FROM SURVEYS MADE IN DIFFERENT PERIODS

The main sources for studying and forecasting mobility are household surveys directed to identify the mobility determinants of population at a certain date. These surveys are standardized, but contain large heterogeneity regarding the age and generations of individuals [5]. Nevertheless, the transversal data offer the possibility to identify individuals belonging to the same cohort or generation of birth. Between the observation period (p), the individual's age (a) and the generation of birth (cohort c) there is the following relationship:

$$c = p - a \qquad (1)$$

Using this technique, it is possible to create longitudinal data (pseudo-panel), which enable to follow cohorts and enter in the dynamics of behaviour. During the different periods of data collection the economic, social and institutional modifications were certainly with a variable level. The three surveys "Household-Trips (EMD), standard CERTU[2]" made in Lille (North of France) in 1976, 1987 and 1998 (Table 1) are the main sources to examine the urban mobility and to create a longitudinal data (Table 2) [6].

Table 1. Samples size of the three surveys

Type of questionnaire	**Size of survey**		
	1976	1987	1998
Households	9 804	3 465	3 744
Individuals (age>5years)	27 005	8 345	8 454
Internal trips	76 383	29 967	33 907
Total trips	79 948	31 969	35 804

Source: EMD 1976, 1987 &1998 inLille

Table 2. Longitudinal data created according to the three surveys

Year of birth (cohort)	**Survey 1976**		**Survey 1987**		**Survey 1998**	
	Age	Size	Age	Size	Age	Size
Before 1895	82 &+	444				
1895-1905	71-81	1 807	82 &+	159		
1906-1916	60-70	2 603	71-81	519	82 &+	150
1917-1927	49-59	3 485	60-70	832	71-81	526
1928-1938	38-48	3 842	49-59	1 039	60-70	793
1939-1949	27-37	4 032	38-48	1 111	49-59	958
1950-1960	16-26	5 403	27-37	1 520	38-48	1 418
1961-1971	05-15	5 389	16-26	1 661	27-37	1 350
1972-1982			05-15	1 504	16-26	1 835
1983-1993					05-15	1 424

Source:EMD 1976, 1987 &1998 inLille

[2]CERTU – Centre d'études sur les réseaux, les transports, l'urbanisme et les constructions publiques

ANALYSIS OF MOBILITY THROUGH TRANSVERSAL AND LONGITUDINAL DATA

The analysis of mobility of inhabitants in Lille is made using a transversal and longitudinal data through the three variables: number of trips per day and per inhabitant, travel time budget[3](TTB) and travel distance budget[4](TDB). The analysis of transversal data show that the mobility of inhabitants in Lille increases permanently in the analysed period from 1976 to 1998.

Table 3. Mobility analysis according to the three surveys in Lille

Variable	**Year of survey**		
	1976	1987	1998
Number of trips/individual/day	2,83	3,60	4,01
Travel time budget (min./individual/day)	44,5	49,5	55,1
Travel distance budget (km/individual/day)	5,6	7,4	8,8

Source: EMD 1976, 1987 & 1998 in Lille

The longitudinal data reveals the impact of different generations for mobility changing(Fig.2).

[3] TTB is a sum of time for all trips which one person made during an ordinar day.
[4]TDB is a sum of distance for all trips which one person made during an ordinar day.

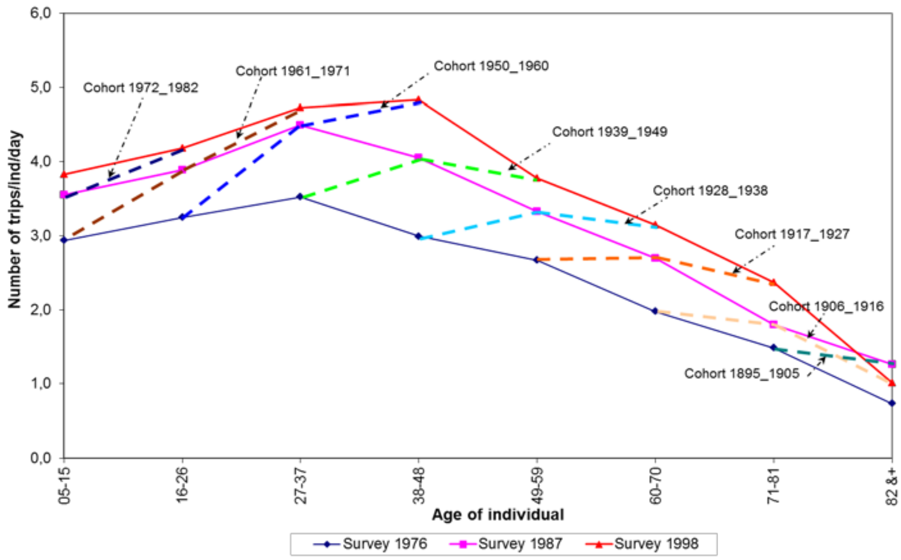

Fig.2.Number of trips/person/day by age group and cohort in the three surveys

The difference between the curves of different cohorts at any given age can be interpreted as the cohort effect. This approach allowscreating“age-cohort”model which is pertinent to forecast mobility on long term [5].

PRINCIPALS OF MODEL AGE-COHORT

The basic form of a demographic model describes the changes of the size global and structure of a human population in a given territory. The application of the model for mobility projections requires separating the projections of population and the projections of mobility behaviours. Thus, the general structure of a demographic model contains two main parts [4]:

- The first part includes the estimations of population and
- The second part concerns the mobility modelling and estimation of a standard profile during the life cycle.

The data from the three surveys enable assessing the mobility for a certain number of observed cohorts. The effects of age on urban mobility could be described by a curve called „life-cycle standard profile” for reference cohort (Fig.3). The “age-cohort” model estimates the life-cycle standard profile by age. The fundamental assumption is that all deformations of this standard profile are caused by the effects of cohorts.

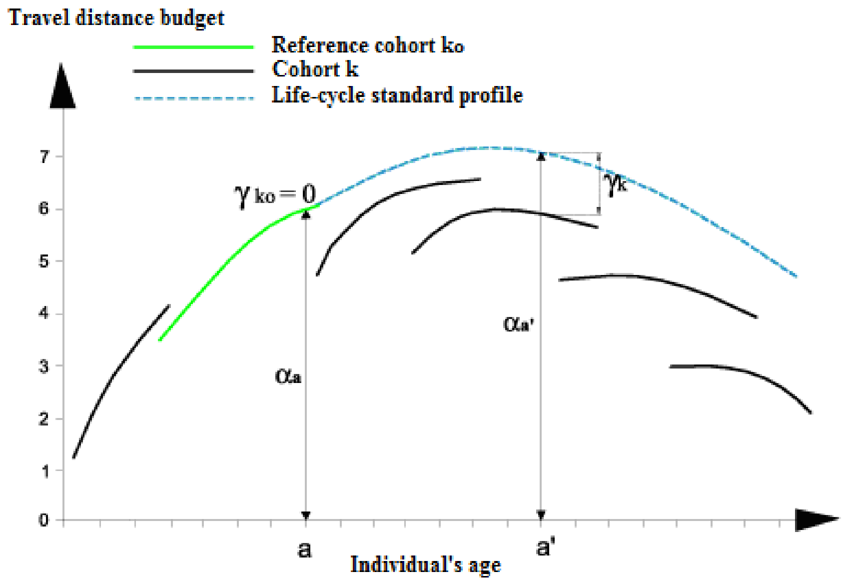

Fig.3.Principle for specification of “age-cohort” model

The mathematical expression of the “age-cohort”model is as follows:

$$M_{a,k} = \alpha_{a(ko)}A_a + \gamma_k C_k + \varepsilon_{a,k} \qquad (2)$$

where:

- $M_{a,k}$ is a measure of mobility observed at age “a”, for individuals of cohort “k”,
- $\alpha_{a(ko)}$ is a measure of mobility at age “a” for individual of the reference cohort “ko”,
- $\gamma_k$is a difference in the trajectory of each cohort “k” relative to the curve for the reference cohort “ko” (γ_{ko}=0 for the reference cohort “ko”),
- A and C are dummy variables for “age” and “cohort”
- $\varepsilon_{a,k}$ is an error term in the model.

CONCLUSION

The “age-cohort”model can be specified using a pseudo-panel created from several surveys made in different periods. The usage of this model is pertinent to enter into the behaviour of different cohorts at specific life time cycle.The demographic variables as a number of individuals by gender residing in particular urban area are very suitable for long term projection because they have a very big inertia concerning important changes in long period.

The projections of mobility in Lille are made until 2030. The analysis and projections of mobility indicate that the usage of cars increases the daily distances by preventing at the same time the progression of budget-time. This trend gives the impression that the gain of car travel time is converted into extra daily distances.

The projections of mobility by the “age-cohort” model are significantly lower than the projections made using a growth factors derived from transversal data. The insertions of cohort effects influence long-term projections decreasing purely trend growth.

The “age-cohort” model is appropriate for long-term mobility projections according to different demographic scenarios. It is important to note that the projections of population are exogenous.

The verification of projection results is carried out using two methods:

- the confidence interval concerning the data in the three surveys and the forecast results.

- the linear regression between estimations and observations of mobility.

The validation of model projections is satisfactory for the two audit criteria which mean that the “age-cohort” model resumes correctly the observed behaviour in the past.

The main weakness of the “age-cohort” model is that this model recommends a long-term evolution scenario that seems be unique and unavoidable. The absence of economic factors in the modelling such as income of the individual or the prices of transport modes avoids their respective roles in the projections. However, the projections of economic factors on long term also present many difficulties and risks [10].

The introduction of a new dimension in the model (i.e. the speed of trips) helps to overcome the difficulties of the “age-cohort” model related to the incapacity to simulate different scenarios of transport supply [5].

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