



CETRA²⁰¹²

2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



Organizer
University of Zagreb
Faculty of Civil Engineering
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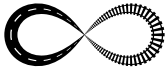
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DEMOGRAPHIC MODEL 'AGE-COHORT' FOR MODELLING OF URBAN MOBILITY IN LONG TERM

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Abstract

The forecast of urban mobility in the long term is one of the great challenges of planning of the urban transport. The classical model for traffic demand forecast is represented by one algorithm based of following four steps: trip generation, trip distribution, mode choice and route assignment. The contestation of traditional method, based of statistical data collected on one period, shall be improved by usage of demographic model. The demographic model is pertinent for estimation of trip generation. The use of the demographic approach with data from repetitive surveys makes it possible to get insight in the behaviour dynamics of individuals belonging to the several generations at various stages of their life cycle. The decomposition of temporal effects into an effect of age and an effect of generation (cohort) makes it possible to draw the sample profile during the life cycle and to estimate its temporal deformations. It is the fundamental concept of the 'age-cohort' model which has been developed in INRETS-DEST (France – from January 2011, the INREST-DEST is a part of The Institute of Science and Technology for Transport, Development and Networks – IFSTTAR: www.ifsttar.fr), basically for projection of car household ownerships, and after it is adapted for forecast of mobility on long term. The comparison of forecasts between the 'age-cohort' model and the growth factors method shows the relevance of the demographic model. Sensitivity tests of the model, as well as the capacity of the model to carry out simulations are also justified. The application of the model relates to the agglomeration of Lille (France), where we have three data surveys at approximately 10 years intervals.

Keywords: urban mobility, age, cohort, transport planning, mobility forecast model.

1 Introduction

The demographic model in its basic form describes the change in number and structure of a human population in a particular territory. Demographic changes are characterized by great inertia of change and this is a reason why the projections are generally based on extrapolation of past trends. To apply the model in the projections of daily mobility, it should separate projections of the population on the one hand, and projections of mobility on the other. Thus, the general structure of a population model contains two main parts (Gallez, 1994):

- the first part includes projections of population based on purely demographic phenomena like fertility, mortality and migration of the population. Thus, we obtain estimations containing the number of individuals (or households) according to age, sex and area of residence;
- the second part is principal for modeling of mobility and includes estimates of a standard profile-type during the life cycle. The basic idea is to trace the evolution curve of the endogenous variable of mobility (for example, the number of trips per day, distances ...) according to age of individuals and to quantify the deformation of this standard profile-type

caused by the effects of generation and time. The modeling is done through a model Age–Period–Cohort (APC), or a model Age–Cohort (AC). The first part of this model is the subject of demographic study and the second part is the subject of our interests with the objective of achieving the projection of mobility on long–term.

2 Data used in the analysis

2.1 Cross–sectional standardized surveys

The main sources of mobility analysis are cross–sectional surveys designed to identify the principal determinants of mobility at a given date. The indicator normally used to measure daily mobility is the number of trips a person makes each day.

These surveys are standardized, but they contain large heterogeneities on the age of individuals and generations to which these individuals are associated. In this paper we show how cross–sectional surveys repeated at regular intervals can be used to construct a longitudinal data essential for analysis and projections of daily mobility.

Using personal mobility surveys conducted in Lille (French urban agglomeration), we can reconstitute the mobility of several generations (cohorts) of Lille residents, and project daily mobility up to 2030 with a model distinguishing age and cohort effects.

Mobility data shall be collected using specific techniques to ensure optimum reliability. These techniques can be classed in two broad families (Orfeuil, 2000):

- Counts made in public transport facilities or road traffic counts to record the number of travellers or vehicles at one point in the network
- Household surveys to estimate the main mobility indicators with reference to several factors (CERTU – Centre for studies on urban planning, transportation and public facilities, France – standard).

The data used in this paper come from CERTU standard household travel surveys conducted in 1976, 1987 and 1998 in Lille. Sample size is large enough to distinguish three zones of residence and to disaggregate the population for analysis by age groups and gender.

Table 1 Samples used for the analyses – Lille agglomeration

Questionnaire type	Number of responses by survey		
	1976	1987	1998
Households	9804	3465	3744
Individuals (age>5years)	27005	8345	8454
Internal trips	76383	29967	33907
Total trips	79948	31969	35804

*Internal trips are those whose origin and destination are inside the 1976 survey limits Sources: INRETS, Household travel surveys 1976, 1987 and 1998

2.2 Creation of a longitudinal data

The analysis and long–term projections of urban mobility, based on temporary effects of age, cohort and period, need use of longitudinal data. The ideal basis for longitudinal data analysis is a panel of individuals observed over a long period. However, the main statistical sources on daily mobility are cross–sectional surveys designed to identify its determinants on a given date. These surveys are not panels, but they can be used to construct a 'pseudo panel'.

The cross–sectional data have the potential to identify individuals from the same cohort, named the cohort of birth. Between the observation period (p), age of individual (a) and birth of cohort (c) exist the following relationship:

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

Using this technique, we can create longitudinal data (pseudo-panel), which enables to follow the dynamic of behaviour (Deaton, 1997; Godwin and Layzell, 1985). According to these three surveys we can make a following longitudinal data sample (table 2).

This longitudinal data is sufficient to create cohort by gender and precede the analysis and projections of mobility through demographic variables. Therefore, the pseudo-cohorts are formed using the date of birth and the individual characteristics which are not subject to variation during life cycle as a gender.

3 Analysis of mobility according to cross-sectional surveys and pseudo-panel data

The mobility in the study area is measured along three specific variables:

- The average number of trips per person aged 5 or over made by city-dwellers in a normal weekday for any purpose and using any form of transport.
- The average distance travelled daily (named 'distance budget') calculated over 26 zones in urban agglomeration,
- The average time spent on daily trips, called the 'time budget'.

The mobility in the Lille agglomeration grew rapidly over the period 1976–1998, particularly among women population.

Table 2 Longitudinal data sample sizes – Lille agglomeration

Birth year (cohort)	1976 survey		1987 survey		1998 survey	
	Age of cohort in 1976	Cohort size	Age of cohort in 1987	Cohort size	Age of cohort in 1998	Cohort size
Pre 1895	82 &+	444				
1895–1905	71–81	1807	82 &+	159		
1906–1916	60–70	2603	71–81	519	82 &+	150
1917–1927	49–59	3485	60–70	832	71–81	526
1928–1938	38–48	3842	49–59	1039	60–70	793
1939–1949	27–37	4032	38–48	1111	49–59	958
1950–1960	16–26	5403	27–37	1520	38–48	1418
1961–1971	5–15	5389	16–26	1661	27–37	1350
1972–1982			5–15	1504	16–26	1835
1983–1993					5–15	1424
Total		27005		8345		8454

Sources: Calculation based on household travel surveys in Lille

Table 3 Evolution of mobility in the Lille agglomeration – internal trips*

Year	Number of trips/per.			Distance budget (km/per./day)			Time budget (min./per./day)		
	Men	Wom.	Total	Men	Wom.	Total	Men	Wom.	Total
1976	3,02	2,66	2,94	7,1	4,2	5,6	49,1	40,2	44,4
1987	3,74	3,47	3,54	8,5	6,3	7,4	52,9	46,1	49,4
1998	4,05	3,97	4,07	9,9	7,8	8,8	56,9	53,5	55,1

*Internal trips are those whose origin and destination are inside the 1976 survey limits Sources: INRETS, Household travel surveys 1976, 1987 and 1998

The greater use of private car affects growth of the daily mobility. The existence of urban infrastructure and access to modes of transport also affect mobility behavior. The trips realized by walking and by public transport are more frequent in centre than in the suburbs where the car is dominant mode of transport.

The age dependent variations in mobility obtained by each cohort according to the longitudinal data are different from those obtained through cross-sectional observation (figure 1).

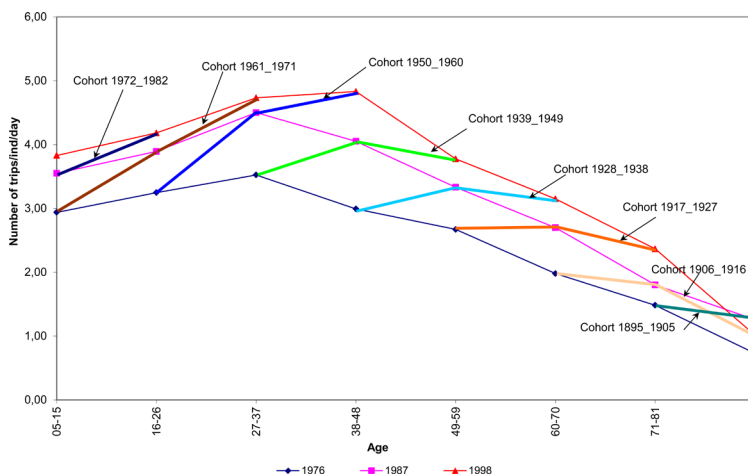


Figure 1 Cross-sectional and longitudinal view of mobility by age and cohorts – number of trips/individual/day

The figure 1 clearly illustrate the difference between a cross-sectional view of mobility by age (a curve for each of the three survey dates) and a curve showing the variation in mobility by age (the curves for each cohort). The divergences between the curves of the different cohorts at any given age can be interpreted as the cohort effects.

4 Notion of the model 'age-cohort' (AC)

The effects of time in the analysis can be introduced along the three dimensions of age, cohort and period. Nevertheless, the pure effects of each component are impossible identify separately. We assume here that there are no period effects, since these can be ignored when dealing with short-term instabilities. Besides, the number of surveys used in this study is too small to correctly identify period effects. This is the raison to use the model AC specification that captures the influence on behaviour of the 'age' and 'cohort' factors only.

The standard profile-type of mobility during the life cycle can be reconstructed for a reference cohort (figure 2).

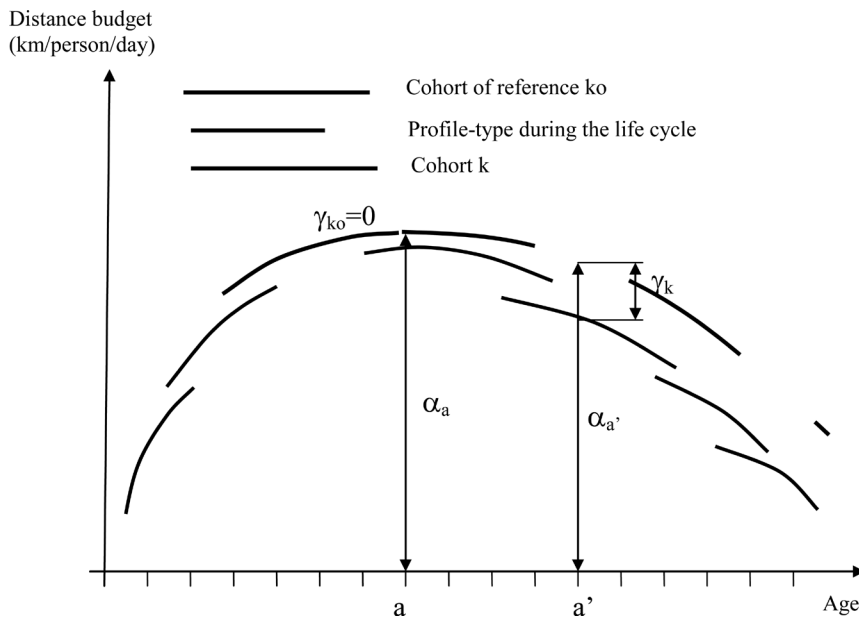


Figure 2 Theoretical basis for estimating 'age-cohort' model

The cohort effects are showed by the difference between each cohort's trajectory and the curve of the standard profile-type for the reference cohort ko. For an additive AC model we make the assumption of parallel trajectories for successive cohorts. The effects for a cohort k are thus given by the divergence between its life-cycle curve and the standard profile-type for the reference cohort ko which is equal in distance to the relative difference go. The mathematical expression of the model is follows:

$$M_{a,k} = \alpha_{a(k_a)} \cdot A_a + \gamma_k \cdot C_k \cdot \varepsilon_{a,k} \quad (2)$$

where:

- $M_{a,k}$ is the measure of observed mobility at age a, for the individuals of cohort k,
- $\alpha_{a(k_a)}$ is the measure of estimated mobility at age a for an individual of the reference cohort ko; this defines the 'standard profile-type' over the life cycle,
- γ_k is the difference in the trajectory of cohort k relative to the curve for the reference cohort ko (go=0 for the reference cohort ko),
- A_a and C_k are indicator variables for age and cohort,
- $\varepsilon_{a,k}$ is the error term for the model.

5 Projections of mobility on long-term

The application of the model AC needs to separate population projections from the mobility projections. The population projections are based on fertility, mortality and migration assumptions. They can be made according to age and sex of individual by zone of residence. The projections of mobility up to year 2030 in the Lille agglomeration are made using this AC model following the methodology presented earlier (Armoogum and Madre, 1997; Armoogum et al., 2002).

The model AC is use first to project the proportion of persons living in no-car households, single-car households, and multiple-car households, then we make mobility projections for each population category.

The projections for the number of trips per day per person within the study area yield a growth rate of 20% until 2030, which indicates a slowdown in the increase observed in the period 1976–1998 (about 42% increasing).

The projections of time budget indicate small growth of around 6,5% between 1998 and 2030, which is also slower relative to the period 1976–1998. The estimations show that the time budget will approach a value of 59 minutes.

The model also indicates a 24% growth in budget distance between 1998 and 2030, which is lower than the rate of growth observed in the past (57% between 1976 and 1998).

The projections based on the rates of growth are also made. The growth rates are calculated according to three surveys, and they can be compared with the projections produced by the AC model.

6 Conclusions

The results estimated with the AC model are not as high as those obtained with the growth rate method. Comparison of the projections shows large differences between the results from AC model and those obtained with the growth rates. The trend extrapolation approach does not take into consideration the behaviour specific to each cohort and the projected values are higher than the model estimates. The demographic models appear to be much better than classic modelling approaches based on growth rates, since they capture more fully the tendency to saturation observed in a part of population.

The age-cohort model reaches its limits when modelling is geared towards evaluation of transport policy scenarios. Because economic variables such as incomes and prices are not taken into account, their respective roles in the changes cannot be estimated. Nevertheless, the long-term projection of economic factors also presents some difficulties related to discontinuities. In reality, the age and cohort effects encompass several dimensions that are not explicitly defined by one variable, but are embedded in individual habits and behaviour. The introduction of individual speed into the model makes it possible to constitute several scenarios for evolution of total daily distance and to consider several actions in transport planning.

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