Tools to evaluate future actions on the traffic in Lausanne

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Abstract

Lausanne-Morges agglomeration will experiment strong increases in the number of inhabitants and jobs until 2020. The additional trips generated by these increases will have to be carried out in a larger proportion by soft mobility and transit.

There are many projects aiming at facilitating this orientation, in particular projects of important transit lines.

As these projects are very expensive, it is important to evaluate their impact before making a choice. This must not be delayed, in order to get Federal funds.

However the existing data concerning the demand are limited. For the past, one has data of the federal census of 2000 on commuters' trips, as well as cars and transit passengers counts for 2005.

For the future, there are estimates of the forecasted increases for population and employment by zone.

A modal shift model was established and calibrated for 2005, in order to have a better idea of transit and cars trips in 2020.

The main feature of the approach is related to the lack of behavioural data, and the mere availability of a restricted number of data. For example, the parking data, very important to explain the modal split, are not available. Nevertheless it was possible to identify a model exploiting the few data available. We will discuss its limitations and present some hints in order to improve it.

Keywords

Transportation planning – demand matrix – modal split

1. Introduction

For some decades already, Lausanne area is using transportation models as an aid to evaluate the impact of its transportation projects and compare different variants.

Until 2005, road and transit projects were mostly treated separately. For example one study examined some variants for the road network in the south of city (what roads to put one-way and which way, what turns to allow at the intersections). Another study consisted in comparing variants of the bus network in order to choose the most appropriate in the presence of a new rail line.

The transportation model was assigning car trips (respectively transit trips) on each network variant and, as a result of this assignment, was giving some useful values for the comparison (traffic loads, O-D time, etc.). As conditions change from an hour to another, typically the assignment was run on a peak hour, generally 7 to 8 a.m. In fact the problems due to traffic are more serious at peak hour. Moreover the demand is more regular day after day and better known, as the most part consists of commuters. Neither the demand knowledge nor the assignment algorithm accuracy needed to be perfect and to exactly produce the trips which would be made. The potential bias has just to be neutral regarding the variants to compare.

The transportation model used for over 15 years was Emme[1]. Emme is aggregated (about 500 zones in Lausanne-Morges agglomeration): all the trips from the same origin zone to the same destination zone with the same mode are assigned under the same conditions, independently of the exact locations of origin and destination inside of their zone[2].

The main difficulty was to get reasonable O-D demand matrices to assign. Generally, matrices representing the present situation or a recent past situation were used. They were built from a reference matrix and from counts following a method proposed by Spiess (1990). For example the transit matrix for morning peak hour (MPH) 2005 was built from the transit commuters' matrix of Federal census of 2000; this commuters' matrix was adjusted according to MPH 2005 counts on transit line segments. A similar work was done for car users' matrix[3].

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[1] Product of INRO, Montreal (www.inro.ca)

[2] Car assignment uses the user-equilibrium principle of Wardrop and transit assignment a specific method of Spiess (1989) (searching a strategy minimizing O-D generalized time expectance, the random elements being the waiting times).

[3] In this paper, if not specified otherwise, the considered demand will always be the one of MPH.

After various tests and improvements, these matrices were validated by a working party including the local authorities and transit company.

Road projects (or transit projects) were studied for themselves and not for their ability to induce modal shifts. For example, transit variants were compared for their ability to accomodate a predefined transit demand independently of the variant. The authors of the study were conscious that a good transit variant could attract more customers, but this effect was not quantified in the study.

Now the needs are different. People and decision-makers are more aware of climate and pollution problems. Those who would not be sensitive to these problems are at least aware of increasing congestion problems with the development of the agglomeration. Therefore an important objective is to diminish the car traffic and to foster transit and active modes (bicycle, walking). This effort is sustained by Swiss Confederation which is ready to subsidize projects aimed to long-lasting development, provided that their impact is proved. Therefore the ability to diminish car traffic and to increase transit becomes a central criterion for comparing variants. Thus one cannot work longer with predefined car or transit matrix; one must model possibilities of modal shifts.

Moreover, projects aimed to change modal choices are important and need a long preparation time (including the time to conceive them, to get a political decision, to receive all the authorizations). Therefore a present or recent past all-modes demand was not adapted. An estimation of future demand was needed.

Therefore two challenges had to be overcome in modelling: firstly estimating the future demand and secondly estimating the modal shift in accordance to the quality of the supply. This job ought to be done with few existing data for calibrating the model and with no resource to search for other data. The possibility of using models developed in other cities was discarded because the differences in the mentalities, in the political choices, in the structure of the city or in the definitions of the variables to be used.

In spite of some theoretical and practical problems and limitations, the present research produced a model which is able to give realistic shifts between car and transit in accordance to supply modifications, and so to evaluate variants for their ability to induce such shifts.

This paper describes the study with a specific emphasis on problems and limitations, as they are a challenge for further research and improvement.

2. Estimation of the future motorized demand

Normally the all-modes demand for the future would depend on the quality of the transportation network. Therefore, if various supply scenarios are considered, one would expect a different all-modes demand for each scenario.

Due to the lack of time and data, we have not considered elastic demand. We have even assumed that the future motorized demand (i.e car demand + transit demand) would be the same for all the scenarios to be compared. Again, the spirit of this approach is to enhance the methodology to take the best out of the available data, not to address all limitations.

An estimation of the motorized demand for 2020 was needed. The existing data were: the O-D motorized matrix for 2005, the population and the number of jobs per zone in 2005, plus estimations of the population and the number of jobs for 2020, also per zone, obtained from the Canton of Vaud.

The 2020 motorized demand was generated based on the assumption that, for each zone, the ratio of generated trips generation per inhabitants will be the same in 2020 as in 2005. The same assumption was done for the ratios of attracted trips per jobs[4]. This rule allowed calculation of the 2020 generated and attracted trips. Minor corrections were made so that the total of generated trips exactly match the total of attracted trips.

Then the 2005 motorized matrix was adjusted using the Fratar or Furness method (roughly an iterative method which aims alternately to generations fitting and to attractions fitting) in order to fit 2020 generated and attracted trips and the result was assumed to be the 2020 motorized matrix.

Our approach considers implicitly the future as a mere extrapolation of the present. The evolution of motorized demand in the future is considered depending only on the evolution of population and number of jobs. No changes in mentality, in socio-economical conditions, in global political context are taken into account. Neither the structuring effect of the network modifications, nor induced demand, nor shifting between motorized and active modes nor shifting between MPH and other times of the day are considered. This limitation must be reminded for a sound understanding of model's results.

[4] If for a given zone, 2005 population or jobs number was too little, for 2020 one used the 2005 global ratio calculated on the whole agglomeration.

3. Building of a modal car / transit shift function

As explained before, we will consider 2020 MPH motorized demand as a constant-sized “pie”, independently from the variants to be compared. The quality of the compared supply variants will only influence the respective size of transit share and car share. We will thus not consider a modal *split*, but just modal *shifts* (between car and transit).

An improvement of transit conditions and/or retrogression of car driving conditions is expected to induce an increase of the share of transit, but to what extent? In order to answer this question, we must find a relationship between the modal choice for an O-D pair on the one hand, and some attributes (explanatory variables) of the origin, the destination or the O-D pair on the other hand.

There were two categories of available attributes: trip dependent, and trip independent.

The first category contains different times (O-D time by car except for initial and final operations, O-D time by transit decomposed into walking time, waiting time and in-vehicle time), as well as the length of the trip by either mode or also the number of transfers to be done by a transit user. It should be noted that some of these data are blurred by the aggregation. For example two transit users travelling from the same origin zone to the same destination zone can have a significantly different walking time because the exact location of their origin or destination inside of their origin or destination zone is not the same.

In the second category we had, amongst others, the location in Lausanne or in suburb of the origin or destination zone, the population density of origin zone and the jobs density of the destination zone. Unfortunately, two very important attributes were lacking: the ratio of cars to inhabitants per and the parking availability per zone.

It is important to emphasize that the information on the modal choice for MPH 2005, used for calibrating the modal shift function, are not directly observed data, but results of demand matrix adjustments starting from Federal census and traffic counts.

The calibration of modal shift function has been done on data 2005: modal choices are compared amongst the different O-D pairs in order to obtain a relationship between attributes on the O-D pair and the corresponding shares for both motorized modes. Then we have used this function to model the modal choice differences between different variants in 2020. So we implicitly assume that the differences in modal choice before/after a modification of the transportation network obey to the same rules that the differences in modal choice between the various O-D pair (and that even 15 years later !).

Practically, the calibration of modal shift function has been done with Biogeme (Bierlaire 2003, 2005). The functions are logit type. It means that for an O-D pair (i, j) the respective probabilities of both modal choices are:

$$\Pr ob[i \ to \ j \ by \ transit] = \frac{e^{U_{Transit,i,j}}}{e^{U_{Transit,i,j}} + e^{U_{Car,i,j}}} \text{ and } \Pr ob[i \ to \ j \ by \ car] = \frac{e^{U_{Car,i,j}}}{e^{U_{Transit,i,j}} + e^{U_{Car,i,j}}}$$

where $U_{Transit,i,j}$ and $U_{Car,i,j}$ are utility functions of transit and car mode. These utilities are functions of explanatory variables, involving unknown coefficients to be estimated. The modal choice probabilities are assumed to be independent from an user to another. The problem is to identify the significant explanatory variables amongst the available attributes and to propose an adequate functional form. The calibration is done using the maximum likelihood principle: searching the set of coefficients which maximizes the probability of getting the choices which are contained in the 2005 transit and car matrices.

As the modal shift function is built empirically, starting from 2005 data, it could hardly be used in completely different conditions. The more fundamental are the changes in the supply, the less credible is the function.

The quality of calibration was limited by the quality of available data. A first trial of calibration was done, implying various explanatory variables, depending or not depending on the conditions of the trip. The resulting function, applied to the 2005 motorized matrix, reproduced well the modal shares; however it was not able to react enough to modifications in supply. Therefore a second function was retained, using only trip times. It fitted not so well to 2005 modal shares, but had a better reaction to supply changes.

The utility functions describing this modal shift function for an O-D pair are the following.

$$U_{Transit} = 4.9347 - 0.4353 \ln(5.603 + t_{Wai1}) - 1.5693 \ln(5.603 + t_{WaiOth}) - 0.9305 \ln(5.603 + t_{WalkIF})$$
$$- 0.5751 \ln(5.603 + t_{WalkOth}) - 0.0105 t_{Veh}$$

$$U_{Car} = -0.7797 \ln(5.603 + t_{Car})$$

The attributes concerning the O-D trip of a transit user are:

t_{Wai1} = first transit waiting time

t_{WaiOth} = other transit waiting times

t_{WalkIF} = initial and final walking times

$t_{WalkOth}$ = intermediary walking times (at transfers)

t_{Veh} = in-vehicle times.

The last attribute concerns the trip of a motorist:

t_{Car} = car time without initial and final operations

All these times are expressed in minutes. It was reasonable to separate the first waiting time from the others, as it can be avoided arriving just in time at the stop. It is also reasonable to separate initial and final walking times, as they are blurred by aggregation. The initial and final operations for car trips are not taken into account because they are linked to the car initial and final positions, which depend on the parking availability (not considered).

The above function was used for trips inside the agglomeration. Other functions were built for in-going and out-going trips.

Some sensitivity tests were run by modifying the values of some attributes for O-D pairs. The function response looked reasonable.

4. Results and reactions

The function was first applied to the 2005 motorized matrix. The transit and car O-D matrices obtained with this function were compared with the initial ones, which had served as starting point for the function calibration. Of course the resulting global modal shares were exactly the same than the initial ones, which is expected due to the presence of an alternative specific constant in the model.

However, for some destination zones containing important schools, the differences were significant. For EPFL, University of Lausanne and Gymnasium of Bugnon, the respective transit shares, in the initial matrices were 50 %, 51 % and 55 %, but the shares given by the function were 34 %, 33 %, 35%. One explanation is that the modal shift function does not take into account the behaviour differences between students and workers, the former travelling more by transit and less by car than the latter. Another reason of the difference could be the lack, in the function, of a difference between travel by rail or by bus. It is known that, under equal trip time conditions, the rail is more attractive and in fact EPFL and University of Lausanne are accessible by rail.

In practice the students/workers bias is not too serious as it affects in the same way each variant, as long as the important schools are in the same place in all compared variants. The rail bias could have been easily corrected if more time had been available for the study.

Nevertheless the function was used as it was. It was applied to variants' comparison at the year 2020. All the compared variants had the same road network; the modifications respect to 2005 were mostly new highway junctions, new lanes and lower speed limits on some highway segments. Regarding transit, all the variants had a new important south-north subway line (the m2 line) starting from 2008. The differences concerned transit lines riding through SDOL[5] area, west of Lausanne. As this former industrial wasteland is destined for an important development, it needs a good network with density and frequencies near to those in Lausanne city itself. These variants of SDOL network were compared together and also compared to the 2008 network with just the new m2 line and no improvement in SDOL area.

The application of modal shift function led to small differences. The modal share of transit was 27 % on the 2005 network (with 2005 demand) and 28 % on the 2008 network (either with 2005 demand or with 2020 demand). This was not really a surprise, as the simultaneous

[5] SDOL = Schéma Directeur de l'Ouest Lausannois

creation of new highway lanes and junctions compensate the potential increase of modal share expected from the m2 line. In Centre 2 variant (the selected SDOL variant), the modal share just increased to 29 %: 26,050 transit trips against 25,050 for 2008 network, i.e. an increase of 4 %.

The amount of shifts between car and transit differs from the total amount of changes in transit demand, which would be useful information for the transit companies. Some attempts to quantify this difference are described below.

Between 2004 and 2005, the local transit company has changed the connection between the suburb commune Crissier and Lausanne city, replacing a feeder line with a direct one; transit passenger counts have been done before and after. This change has been modelled with the 2005 motorized demand and the modal shift function; the results have been compared at a specific counting section. The increase rate of passengers in the real counts during MPH was 4 times larger than in the model. This suggests that a large part of the new transit trips consisted of trips which were not made beforehand or which were carried out by walking or cycling. The increase may also include trips which were made by car out of MPH (in order to have less congestion) and now use transit during MPH. The respective shares of all these components of the change cannot be quantified because the lack of corresponding cars, bicycles and pedestrians counts.

Considering the aggregate level of new transit demand in case of supply modification, two transit company professionals have suggested a rule of thumb consistent with their experiences: 100 % increase in transit vehicle-km. would induce 50% to 100 % increase in the number of passengers. From this rule, we could derive 2 coefficients of elasticity, applied to the changes between 2008 network and Centre 2 variant. The rule gave differences 2.5 to 4.4 times higher than modal shift function[6].

Thus one can reasonably accept the idea that changes predicted by modal shift function are roughly 3 or 4 times smaller than real changes in number of transit customers. However one could not consider for each individual O-D pair the change given by the modal shift function and simply multiply it by 3 or 4 for getting customers variations. The function allows working at the level of each O-D pair, but the customers cannot be calculated at this level.

[6] In fact the rule concerned the whole day, but we were constrained to apply it to MPH.

Once admitted that the modal shift function merely divides a constant-sized “pie” and does not claim to estimate the total number of transit passengers, can we consider that this function makes properly its job (i.e. variants’ comparison for their ability to convert ex-motorists)?

The calibration of the modal shift function has been affected by the lack of important data (e.g. parking) and by the aggregation of data. Therefore, the response of function to supply modifications may be too weak, but not as much as it seems at first sight. After all, in the real world too, the response is weak when transit times, though diminishing, still remain above the car times and when no serious penalty is brought to car traffic.

Whether the modal shift function response is proportionate or too weak, the crucial question is: does it properly sort the variants according to their ability to convert motorists? A priori we have no reason to think that a variant, better ranked according to the function, would convert fewer motorists. The ranking of SDOL variants with this function was the same as with the first trial function and also the same as with the rule of the professionals, which looks rather reassuring.

5. Conclusion

In Lausanne the variants' comparisons of transit network projects were previously based on a fixed O-D transit matrix. In the same way, studies of road network projects were too based on a fixed O-D car matrix. Considering the necessity of diminishing the share of trips made by car, a new model has been developed, working no longer with fixed transit or car matrices, but just with a fixed transit + car matrix and with a function to divide this demand into both modes.

We have described how to deal with frustratingly few data in order to derive a model that can be used for the comparison of variants. We have discussed at length the many limitations of the approach. Obviously, further efforts should be done to induce better responses. These efforts will depend on the resources and on the next studies to be done. The next efforts could turn on the introduction of a rail/bus variable and a parking availability variable among the attributes of the function. Another improvement (not in the function, but nevertheless in the realism) would be to describe better the impact of transit improvement on the road capacity available for cars (more capacity for buses resulting in less capacity for cars).

But, clearly, the need for disaggregate data to better understand, describe and predict the modal share in Lausanne appears to be critical.

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