WILL PEAK TRAVEL OBSERVED IN NORTHERN CITIES OCCUR IN THE SOUTH? CASE STUDIES IN FRANCE AND MEXICO

Irving TAPIA VILLAREAL [1]

Yves D. BUSSIÈRE [2]

Jean-Loup MADRE[1]

Jimmy ARMOOGUM[1]

[1] *University Paris-Est (UPE) - French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) – Department for Planning Mobility and Environment (AME) Lab. Economic and Social Dynamics of Transport (DEST), Marne La Vallée, France, F-77447.*

[2] *Benemérita Universidad Autónoma de Puebla (BUAP), Fac. of Economics, Cd. Universitaria, Puebla, Pue., Mexico 72240.*

ABSTRACT

In most developed countries urban mobility and car traffic have stagnated since the early 2000s. In France, various data sources show that the trend can be attributed primarily to people living in large urban areas: trips have become less frequent (with unbroken workdays) and less exclusively taken by car (as more young adults adopt multimodal behaviours), and car ownership is decreasing in denser areas, and to a lesser extent, in suburbs. Does this levelling-off of traffic suggest that the saturation point is near? Is this a structural phenomenon (population ageing, etc.) or a cyclical one linked to rising and volatile fuel prices and the recession? We shall explore these issues in the light of data collected in the Urban Areas of Montreal and Lille, and then move on to a comparison with two Mexican cities, Ciudad Juarez on the northern border of Mexico where the level of motorization is high compared to Puebla, our second Mexican case study, where motorization is still low. To each city we apply demographic based projections models in order to consider the extent to which, and in what timeframe, the trends observed in developed cities could spread southward to the emerging economies.
Keywords**:** Mobility, car ownership, peak travel, North, South, France, Mexico.

This paper is a largely revised version of Madre et al. (2012).

1. SITUATION OBSERVED IN DEVELOPED COUNTRIES

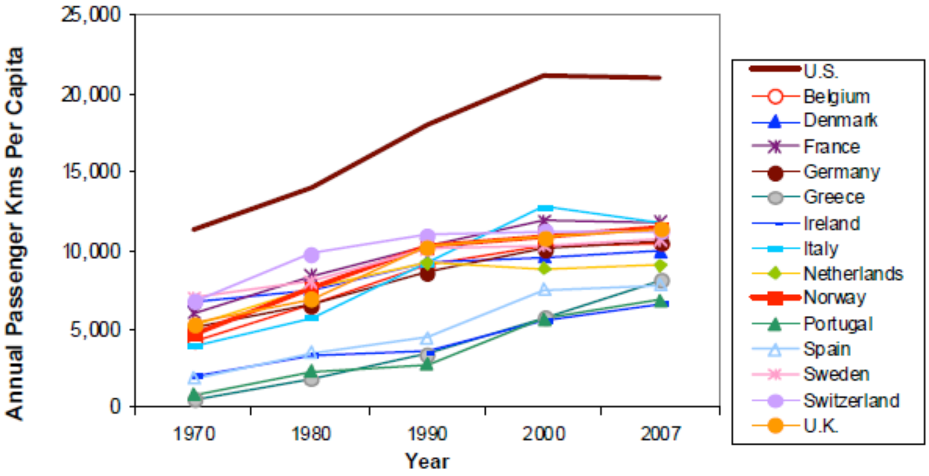
After expanding rapidly in the 1960s and 1970s, growth in road traffic of persons (as a per capita average) slowed in the early 2000s and seemed to approach the saturation point in a number of industrialised countries [Litman, 2009; Millard-Ball and Schipper, 2010; Newman & Kenworthy, 2011, Madre *et al*., 2012] (Figure 1). The Australian Bureau of Infrastructure, Transport and Regional Economics, which has compiled a long series for 25 countries, explains this trend as a reflection of fuel prices and economic activity, as well as a time-related saturation effect [BITRE, 2012]. A comprehensive analysis of global transport demand trends over the next 40 years was presented by the JTRC/ITF in May 2011 in Leipzig [OECD/ITF, 2011]. Having noted an apparent saturation in the developed countries, this working group nonetheless took a critical view of extrapolating demand on the basis of this assumption alone, stressing the need to take account of such other factors as rising fuel prices and the distribution of wealth, as well as the scope of future transport demand trends in the emerging economies. A round table on Peak Travel of the International Transport Forum in November 2012 concluded that while some explanatory factors are fairly well understood, others are more uncertain.

In most developed countries, the proportion of people holding driving licences at any given age had always been on the rise as compared with previous generations, and the increase had been greater for women than for men, thus indicating that their respective behaviour patterns were becoming more similar. It has now been found that the licence-holding percentage among young people has started to decline in some 10 countries [Sivak and Schoettle, 2012], in parallel with the development of the Internet, and that this is especially perceptible in the case of young males; these countries are located in North America (Canada and the USA), where the spread of the automobile began in the 1930s, in the Nordic regions (Norway and Sweden, but not Finland), in western Europe (United Kingdom, France and Germany, but neither Switzerland nor the Netherlands), and in the most densely populated areas of the Far East (Japan and South Korea); the flourishing of car ownership is too recent in central Europe (Poland, Latvia), and to a lesser extent the Mediterranean countries (Spain, Israel), for such a phenomenon to be observable yet. In France, the decline in the number of licence-holders could be attributed to the abolition in 1997 of compulsory military service, which had enabled young men to start driving at virtually no cost to themselves [Avrillier *et al*., 2010].

According to a comparative study of young adults (aged 20 to 29) in six industrialised countries (Germany, United Kingdom, France, Japan, Norway and the United States), between 1975 and 2010, in most countries, the average distance travelled peaked around the end of the 1990s, or at the beginning of the 2000s in the United States, and subsequently declined (Figure 2). Thus, young people are less likely to have a driving licence and to travel exclusively by car than youth in the previous generation [Kuhnimohf et al., 2012]. There are a number of possible explanations for this phenomenon: the fact that a growing proportion of young people pursue higher education, which defers their entry into the labour market; the tendency to start a family at a later age; rising fuel prices; the introduction of demand-management measures to reduce car traffic in cities; and lastly, a change in mentalities.

Figure 1

Figure 1 **International Vehicle Travel Trends** (Litman 2006)



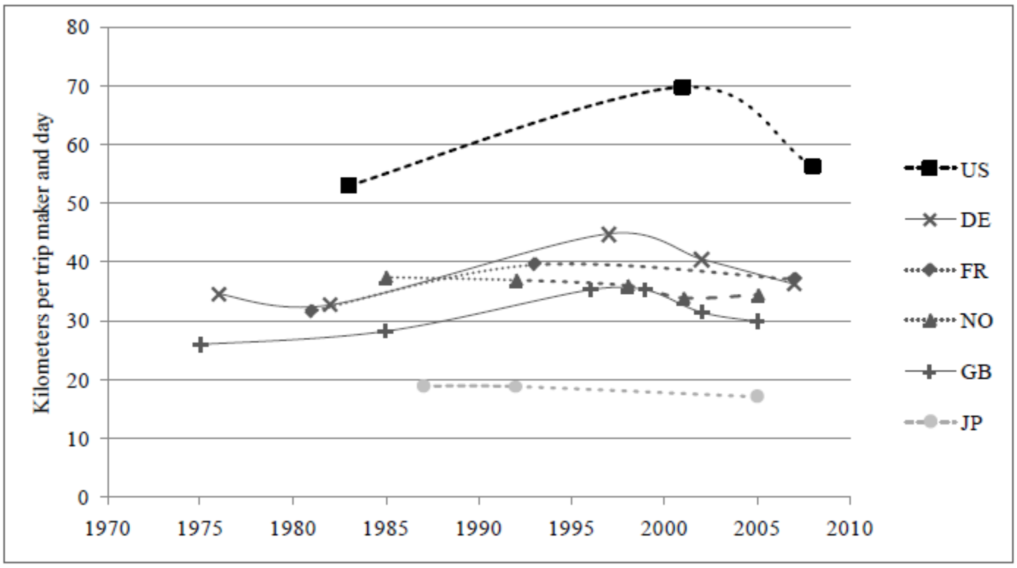
Per capita vehicle travel grew rapidly between 1970 and 1990, but has since leveled off in most OECD countries, and is much lower in European countries than in the U.S.

Source: Litman, Todd (2009).

For the United Kingdom [Metz, 2010] observes that over the past 30 years the average travel time has remained stable at about 1 hour per day (375 hours per person per year), as has the average number of trips (1 000 trips per person per year). Car ownership has more than doubled, as have speeds, which in combination with rising income prompted a substantial increase in distances travelled, until a certain levelling-off as from the mid-1990s (Figure 3). Metz puts forward a number of explanations for the levelling-off of traffic: fewer local trips due to longer absences from home [Madre and Armoogum, 1997], worsening congestion, fewer trips as a result of strides in telecommunications, and structural saturation of the demand for travel.

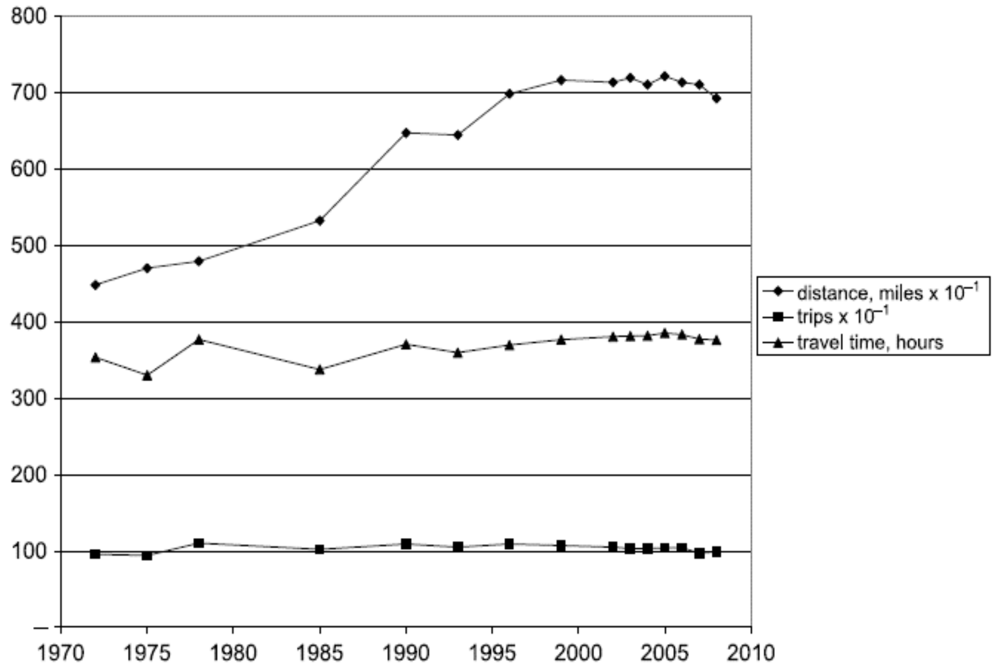
Do the trends being observed reflect the approach of the saturation point via a decoupling of the growth rates for traffic and income? [Millard-Ball and Schipper, 2010]. Is this decoupling manifesting itself first in the most densely populated regions and/or over a certain standard of living? Or does the levelling-off of traffic result rather from a cancelling out of opposite trends (continued growth in rural and suburban areas and decline amongst residents of the most densely populated areas) [Goodwin, 2010-2011] ? Some authors even make the assumption of a reduction in travel in the developed countries in the short and medium terms, attributable to a variety of socio-economic factors [Litman, 2011]. One could well ask whether this is a socio-demographic phenomenon (population ageing, re-densification of large centre-city areas, fewer but more-intensive workdays, with without returning home for lunch, etc.) or an economic one linked to rising and volatile fuel prices and the recession [Gardes *et al*., 1996; Collet, 2012]. The Mobility Research Task Force (ERA-MOB) of IFSTTAR's DEST laboratory has undertaken an analysis of the behavioural changes [Quételard, 2011] that are observed, for example, when people move house [Meissonier, 2011]. Among other things, these changes are obviously a key consideration with regard to the outlook for energy and the environment.

Figure 2. Vehicle-km trends (car driver and car passengers) per traveller, per day for young adults aged 20-29 (6 countries)



Source: Kuhnimohf *et al*. (2012).

Figure 3. Travel time (hours per person per year), distance (miles per person per year) in the UK



Source: NTS 2008, Table 2.1 in [Metz, 2010], p. 661.

2. CASE STUDIES PRESENTED

We will present 4 case studies representing various levels of motorization : 3 in North America (Montreal in Canada which resembles USA, and in Mexico, Cd. Juarez and Puebla representing two levels of motorization in an emergent economy). The fourth case study is Lille, in France which can be compared to Cd. Juarez, two international cities with a population in a range of 1 to 2 million inhabitants. These cities were chosen for their interest but also because of the availability of comparable Household Origin-Destination Surveys.

Montreal was founded in 1642 by French explorers and conquered by the English in 1760. It keeps its French influence with a majority of French speaking persons. After Toronto, it is the second city of Canada in size with a population of of 3.3 million with low density like most North American cities with a high level of motorization but with a good public transportation at least in the central city with the presence of a metro.

Ciudad Juarez, which was founded in 1635 by Spanish explorers, is located in the north of Mexico bordered to the north by the city of El Paso Texas in the United States. Juarez and El Paso are one the largest bi-national metropolitan areas in the world with a combined population of 2.4 million people. Juarez is still considered one of the most important hubs of the manufacturing industry in the United States-Mexico border despite the effects of the world economic crisis, violence and social problems in the city that began in 2008. Juarez is one of the premier manufacturing locations in Mexico alongside Tijuana and Monterrey. Overall, by 1996 Juarez had a population of 1.1 million and an estimated population of 1.2 million in 2006. Its strategic location (4 international crossings between US-Mexico), cheap labour and qualified employees were not the only reasons causing the manufacturing industry to chose Juarez as the location for their facilities, the Mexican government also contributed to this economic and employment boom by designing incentive programs that usually included low taxes and cheap land costs in order make Juarez even more attractive to investors. Juarez has subsequently grown substantially in recent decades, not only in terms of population with the large influx of people rapidly moving into the city in search for job opportunities but in terms of urban sprawl as well due to the preference of industries for sites located in the suburbs for logistic purposes, new housing developments trying to be closer to jobs and in general a lack of urban planning. In addition to this, the transportation infrastructure projects implemented in the last decades in Juarez were only highway and road construction and no public transport projects which made Juarez a car-dependent city over time.

Puebla, founded by the Spaniards in 1531, designed world heritage by UNESCO in 1987, is an urban area of 2 million, located in the centre of Mexico and much less motorized, representative of a more traditional life-style. Two Origin-Destination surveys are available: 1994 and 2011. In Mexico, population growth is still very rapid (averaging 1.58% per year between 1990 and 2010) but can be expected to slow down. According to CONAPO national projections of the annual growth rate should average roughly 0.67% between 2010 and 2030, with rapid and substantial ageing (the proportion of people aged 65 or over was 3.4% in 1950, 4.2% in 1990, 6.4% in 2010 and is forecast to be 12.5% in 2030 and 22.0% in 2050). In the cities, growth should be slightly more rapid because of a continuing rural exodus.

The Urban Community of Lille has a population of 1.1 million. It is located in northern France close to the Belgium border. Trade oriented since its origins, industrial city textile

oriented, has made a reconversion since 1990 towards the service sector. Like most millionaire French cities it has a good public transit with a metro and trams.
In developed economies population is ageing but in emerging economies, with few exceptions, populations are still young, but the ageing phenomenon will arrive there as well. Emerging economies present very diverse situations. For example, in China ageing is important, due to the one child policy, but India has still very strong population growth rates.

3. THE DEMOGRAFIC PROJECTION MODELS USED

In an intent to project travel demand and isolate structural factors in the trends of an apparent saturation of urban mobility of persons, we used two models: (1) A simple straightforward demographic model which extrapolates a fixed behaviour with long term population series by 5 year age groups to future populations as well as past populations in the form of a retrofit. Thus we can reconstitute long series even though past data was absent and measure the effect of population growth and ageing through time. In these simulations all other factors are constant, namely behaviour and urban form. In these simulations we estimate total travel demand (Bussière, 2011). (2) The second model, is an econometric model, the Age-Cohort projection model developed by INRETS (now, IFSTTAR) which was used in three types of simulations: (2a) ageing: simulations similar to (1) but where population is constant but ageing, to measure the sole impact of ageing, behaviours and urban form are constant, and without retrofit, (2b) Measure of behaviour: A simulation with population fixed as well as urban form to which we apply changing behaviour and (2c) a more realistic simulation where recent population projections are used, and behaviour changes are taken into account documented by Household Origin-Destination Surveys. With the Age-Cohort Model mobility was defined as km/day/pers. We simulated All Modes (including walking, biking, etc..), Car Driver, Car Passenger and Public Transport.

3.1 Description of the Simple Demographic Model with an ageing fixed population

The meaning of ageing here is not so much the presence of elderly people, but the gradual change in the age pyramids, which leads, in the long term to more elderly people, but also, when the age pyramid is young, to more people in the age of driving. As explained above, an initial simple approach for measuring the impact on mobility of the shifting age pyramid is to apply constant transport behaviours to population projections with an age pyramid that is changing over the long term. The linkages between age or life cycle, mobility and modal choice are well established and relatively stable over time. As can be observed in the figures below, general mobility is bell-shaped. In Montreal, data of 1993 shows that it peaks at around age 35, and declines regularly thereafter until advanced ages. In Puebla, for the same year (1993-94), a virtually identical curve can be observed, but with a lower overall level of mobility. With regard to modal choice, car driver mobility is bell-shaped, peaking in Montreal at about age 40. The form of the curve in Puebla is similar, peaking somewhat later, at about age 45 albeit at a lower level. Public transport being in direct competition with cars, the observed curve is U-shaped in the case of Montreal and adopts a similar form in the case of

Puebla (Figures 11 to 13). The combined result of these trends will inevitably yield high individual car use in active age groups, translating into car/km such as can be noted in the United States for the period 1995-2001-2009, where a decrease in car/km can be seen in respect of the youngest drivers, but an increase for the over-65 age groups (Figure 14).

3.2 Description of the Age-Cohort Model

The projection of mobility (daily kilometres, number of trips per day…) for an individual of zone of residence (z), level of motorization (v) and gender (s) at the date (t) is given by:
Where:

t=a+k (a is the age of the individual reflecting the life-cycle and k his generation, defined by his date of birth);

a_a: measures the behavior of a generation of reference at the age a. This allows us to calculate a « Standard Profile » of the life cycle;

g_k: measures the gap between the cohort k and the generation of reference γ_{k^0} ;

Since the gaps between cohorts for recent generations tend to disappear we took the last observed cohorts gap for future generation [Madre & al., 1996].
The mobility for the population at the date t is estimated as follow:

$$M_t = \frac{\sum_{z=1}^{3}\sum_{v=0}^{2}\sum_{s=1}^{2}\left(P_{a,t}^{z,v,s} * \pi_{a,k=t-a}^{z,v,s}\right)}{\sum_{z=1}^{3}\sum_{v=0}^{2}\sum_{s=1}^{2} P_{a,t}^{z,v,s}}$$

Where:

$P_{a,t}^{z,v,s}$ is the population projection of zone of residence z, level of motorization v and gender s at the date t [Dejoux, et. al., 2009].

Using this model we made the 3 types of simulations mentioned above: (1) impact of population all other variables being constant, (2) simulations taking into account only ageing, only changes in behaviour, and (3) total impact. The mobility variables measured were total demand for the simulations with the simple model and for the simulations with the Age-Cohort model: km/day/person for all modes, car driver, car passenger and public transport.

4. RESULTS

The simulations with the simplified model where everything is constant except population are obviously not projections of past and future demand (in volume) because they do not take into account population growth and behavioural changes related to lifestyles and urban contours. The simulations with the Age-Cohort model take into account population growth and changes in behaviour with constant territory. The simplified model with the retrofit has the advantage of measuring the impact of population growth and ageing on a very long period but the Age-Cohort Model gives a more realistic projection taking into account behavioural characteristics of each generation.

4.1 North American Cities: Montreal and Puebla with the simple model with retrofit

We did this exercise 23 years ago on Montreal with constant behaviour observed in the 1982 O-D Survey applying this behaviour to future populations but also past populations in the form of a retrofit, but which at the time had left transport engineers sceptical. The projection was made over a 40-year time span (1971-2011) (Figure 15) [Bussière & Fortin, 1990]. More recently, for lack of detailed demographic data over a long series for the city of Puebla, we redid the same exercise using population data of Mexico, projecting Puebla's 1994 behaviour over a 100-year period (1950-2050) (Figure 16). To validate the methodology we did another simulation on 2000-2050 with Puebla demographic data, which yielded similar results since the ageing process of Puebla and the National level is similar. We obtained surprisingly very similar results to the case of Montreal.

In the case of Montreal, where the baby boom had been very substantial and followed by a sharp drop in birth rates, from the 1970s until the late 1990s there was an exponential increase in pressures towards individual car ownership and a decline in public transport, the period when freeways and urban freeways were built, then, individual car ownership reaches an inflection point in 2001, followed by a decline. This was a similar trend as was observed in the great majority of developed cities (Figure 1 above). Without prejudice to other factors (population growth, urban contours, access to cars, lifestyle), it can therefore be concluded that the demographic impact on trends in individual car ownership is substantial, and that we are currently witnessing a saturation effect in respect of that impact. The curves presented in Figure 1 above show a much higher increase than the Figure 15. Without the exact data we made a rough estimation for U.S., which could be comparable to Canada, of the growth between 1970 and 2000 which would be was around 83%. In the case of Montreal in the Figure 15, the index grows by around 29% between 1971 and 2001. Could this mean that ageing would explain 35% of the growth in Vehicle Travel Trends in Montreal the other factors (population growth, urban sprawl and changes in behaviour) explaining the rest? Not really, but the impact is certainly significant, probably more important in Montreal than in the U.S. due to a higher baby boom.

A simulation on Greater Puebla (1950-2050) made with the simple model with retrofit to measure the impact of demographic changes shows the beginnings of demographic pressures conducive to individual car ownership around the year 2000, at the same time that a slowdown was being observed in developed cities (Figure 16). In Puebla we should assist to two decades of heavy demographic pressure conducive to individual car ownership and a slowdown in Public Transit. The inflection point is to come at around 2035, after which there should be a slowdown in individual driving and a virtual levelling-off for Public Transport.
What conclusions can be drawn from this? This simulation represents a minimalist scenario because it assumes a continued low level of car ownership. If the growth in living standards and household car ownership factor is added in, the result would be explosive for at least another 20 years. A recent household origin destination transport survey in Puebla (2011) gives us interesting input with which to complete the picture. Between 1994 and 2011, per capita mobility remained stable (at 1.75 trip per day per person), as did individual car

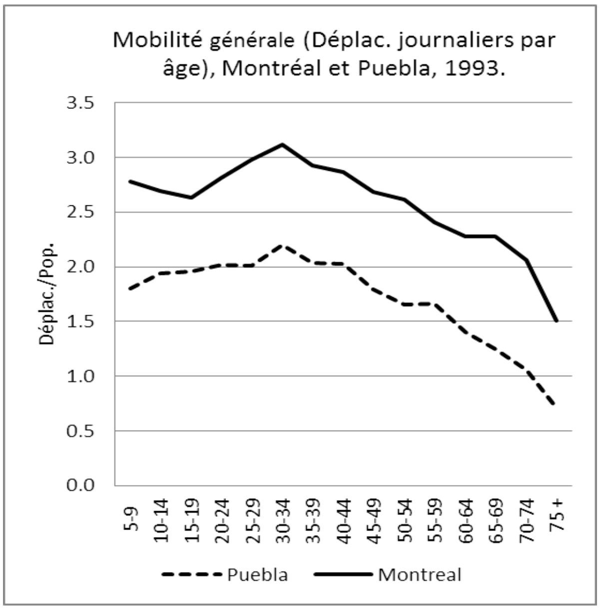
ownership, which followed population growth (+50%), but persistent poverty did not allow household car ownership to increase. On the contrary, the proportion of households with cars fell to 33% in 2011, as compared to 39% in 1994, and the proportion of households with more than one car was only 3.8% in 2011 versus 10.3% in 1994.

To a large extent, this trend reflects the persistence of poverty. While in 1994 19.0% of households suffered from food poverty, the rate did not change in 2008, with 19.5% (Figure 17) [Coneval, 2009]. In addition, over the same period, the average age of cars on the road increased from 9.4 to 13.0 years. A 2012 O-D survey in the city of Colima on the west coast of Mexico indicated also an average age of household cars of 13 years. In France, there has been an ageing of the cars on the road, the average age of which increased from 6.2 years in 1993 to 8.2 years in 2007 [Kolli, 2012], but for quite different reasons: the greater number of second cars, which are driven less and last for longer. In the next decades if poverty persists the answer to the demographic pressures towards more individual motorization may be further ageing of the vehicles

4.2 Lille

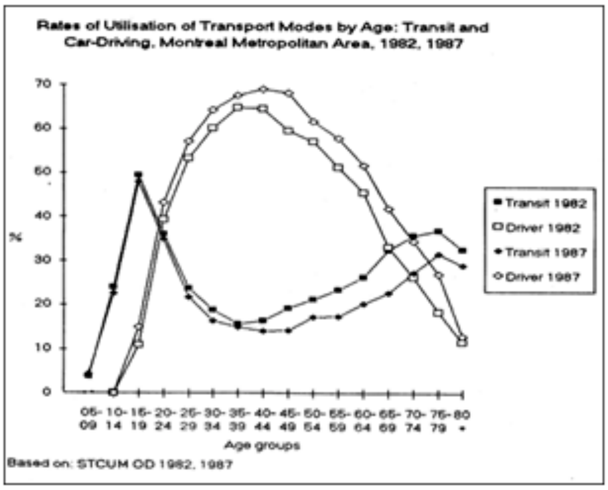
In the case of Lille, we used the Age-Cohort model with the three types of simulations mentioned above. The results presented here are based on a calibration of the model with the two most recent O-D surveys of 1998 and 2006 to capture the Peak travel effect (Figure 17). The simulation over the period 2000-2030 measuring the sole impact of ageing of the population with constant behaviour shows a monotonous tendency of diminishing mobility. If we kept the age structure of 2000 to measure the sole impact of changing behaviour, this diminution is postponed for Auto Driver and All Modes and stops the renewal of Public Transport use, which would stagnate starting in 2015. For Auto Passengers the projection at constant population of 2000 (behaviour only) would be lower than the projection of ageing only, a result opposite than for the other modes. This would mean that with ageing behaviour changes in favour of that mode. For Public Transit use, ageing indicates a diminution, due mainly to decrease of mobility, the behaviour model gives a diminution of use until 2020 then stabilization, and the complete Age Cohort model gives an increase in Public Transportation use which reflects all the factors, where population growth is important.

Figure 11. Overall mobility by age, Montreal and Puebla (1993) (Trips per day by age) Trips/Pop.



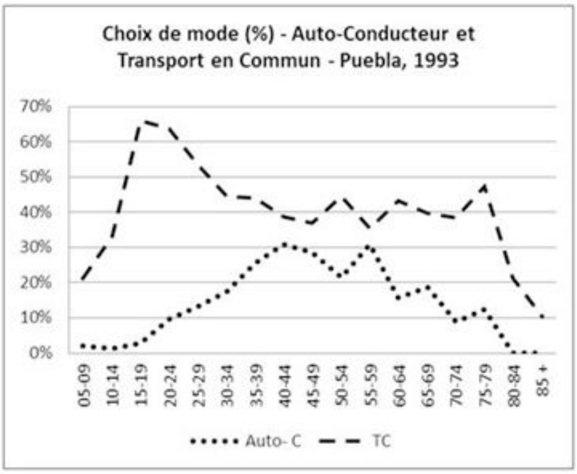
Source: Household Origin-Destination Surveys.

Figure 12. Modal choice by age Car – driver and Public transport (PT), Montreal (1982-1987)



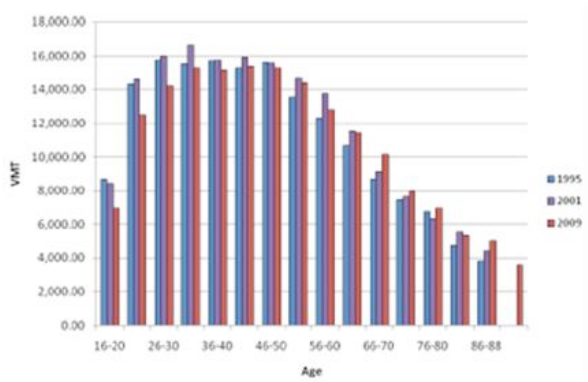
Source: Household Origin-Destination Surveys

Figure 13. Modal choice by age Car – driver and Public transport (PT) Puebla (1993)



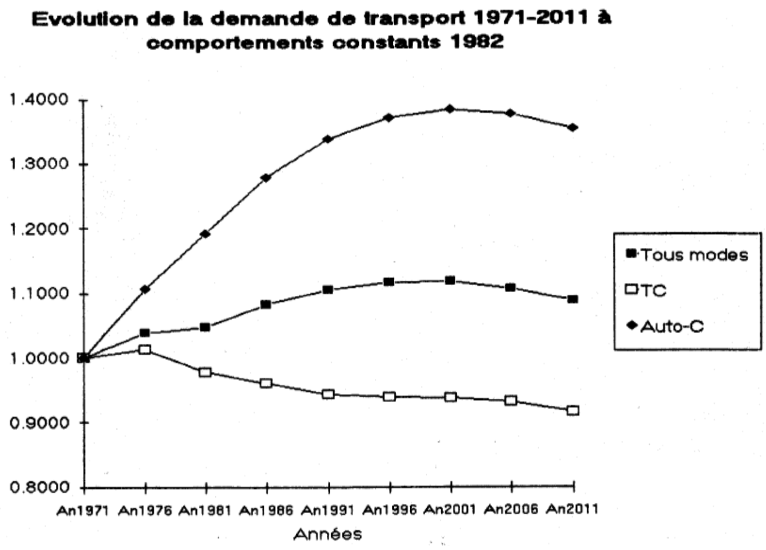
Source: Household Origin-Destination Surveys.

Figure 14. Annual vehicle-miles per driver by age USA, 1995, 2001, 2009



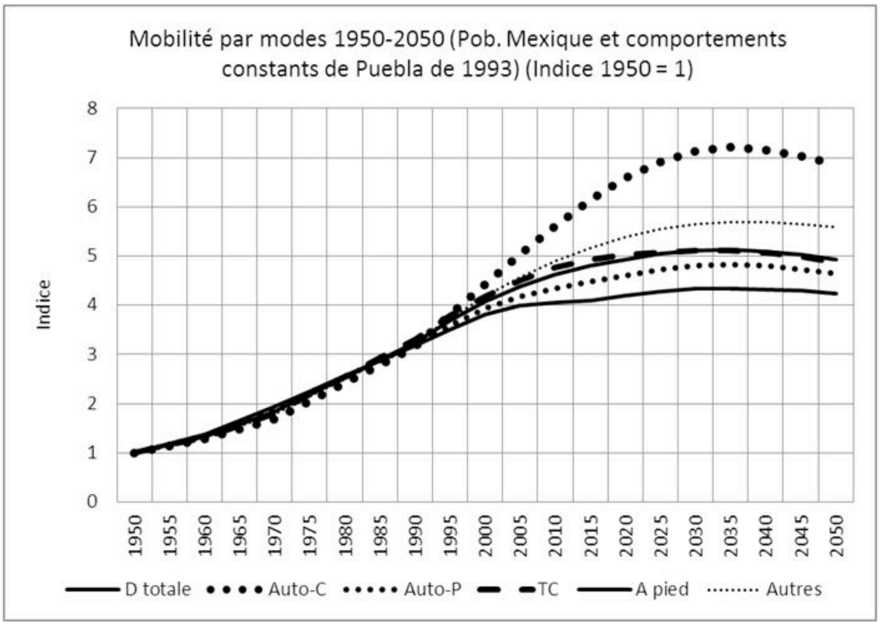
Source: OECD/ITF (2011), p. 29, pdf, www.

Figure 15. Transport demand trends measuring population impact (All modes, public transport, Car-Driver) Montreal 1971-2011 (1971 = 1) - At constant 1982 behaviour



Source: Bussière & Fortin, 1990.

Figure16: Transport demand trends in Puebla measuring the impact of population 1950-2050 by mode on mobility defined as total daily trips (All Modes, Auto Dr., Auto Pas., Publ. Tr., Walking, Others)



Source: Bussière (Oct. 2011).

4.3 Puebla and Ciudad Juarez simulation with the Age-Cohort Model

To complete the initial analysis we made on Montreal and Puebla with a more complex econometric model that incorporates a greater number of factors, we applied the Age-Cohort over the period 2000 to 2050 for Puebla, based on 1994 and 2011 surveys (Figure 18); and for a Northern Mexican City, Ciudad Juárez, 1995-2050 using 1996 and 2006 surveys (Figure 19). We made the three types of simulations mentioned above.

In Puebla, in order to put the results from the 1994-2011 calibration in perspective we made a simulation calibrated on 1994 only, in this case the Auto Driver simulation shows a strong increase until reaching a peak around 2030 and then diminishing matching the forecast made previously for this city (Figure 16). The behaviour model shows a downward trend, which reflects the results of the O-D Surveys of 1994 and 2011 showing a decrease in personal motorisation. A trend, which might not be structural since the O-D survey in 1994 was made in a peak economic activity and the 2011 O-D survey in a low economic context. Auto-Passenger still increases mainly for demographic growth since the ageing and behaviour factor have a negative impact. Public Transport sees a negative impact with ageing but strong impact with behaviour, which reflects the results of the O-D's, which may extrapolate a cyclical phenomenon. For All Modes, veh-km reaches a peak around 2035 and then stabilizes.

For Cd. Juarez we chose a slow demographic growth scenario given the current context of violence (projected average annual growth rates of 1.60% from 2006 to 2012 and 1.06% from 2015 to 2030). For All Modes in Cd. Juarez we would see a stable demand in veh-km, the positive impacts of behaviour being compensated by the negative impacts of ageing, in a context of slow demographic growth. For Car Driver, the ageing factor is very different from the one observed in Puebla. It has a negative effect for all the period of forecast, but the Behaviour Model gives a strong positive impact, reaching a peak around 2020. The Auto-Passenger reaches a peak in 2005 and then diminishes constantly. Public transit with the ageing model sees a downward trend for all the period. The Behaviour Model gives a peak in 2015 and then diminishes constantly. The inflection for car-driver use point appears in 2020, which could not be explained by population ageing, since only 5.4% will be aged 65 or over in 2015, but probably by a beginning of saturation of individual car ownership, with 72% of households having cars, as compared with 84% in France in 2007-08, and 36.4% of households having more than one car, as compared to 38% in France in 2008 [Kolli, 2012] and in contrast to other major non-border Mexican cities, where this percentage of households with at least one motorized vehicle hardly goes over 45%. In Mexico City for example, only 37% of the households have a vehicle available [INEGI, 1994]. Here, also, average vehicle age is increasing, rising from 11.7 years in 1996 to 13.8 in 2006, due possibly to multiple ownership, the persistence of relative poverty and the proximity of the US border, which facilitates lightly taxed imports of vehicles aged ten years or more. According to the latest Urban Observatory of Security and Safety, the total amount of private vehicles in Juarez was approximately 750,000, which, considering the 1,332,131 inhabitants reported in the population census of 2010, this result in a rate of 0.6 vehicles per capita [Hernández, 2012].

In spite of the disparities that two different economies might cause to urban commuting behaviour, the percentage of private vehicle use in the modal choice seems to be almost the same in Lille and Ciudad Juárez. In general we see slightly higher occupancy rates in Juarez than in Lille and almost the double number of daily trips per person in Lille in comparison with Juarez. The main difference between these contrasted urban areas could be in fact a result of the important gap in terms of income between developed and developing countries [Pison, 2011].

Nevertheless in Juarez both the occupancy rates (1.7 pas/veh) and the private car share (50%) appear to be stabilized between 1996 and 2006 showing a strong automobile dependency for a Mexican city (for example only 27% in the Guadalajara Metropolitan Area in 2007). In contrast to Lille, this is due mostly as mentioned before to poor public transportation infrastructure, sprawled urban form and the availability of cheap used cars imported from the U.S. On the other hand the public transport share decreased from 25% to 22% between 1996 and 2006 showing that in Juarez private auto users could be seen as captive users which are generally unable to change to other travelling alternative modes due to structural reasons. In 2011 in Puebla the occupancy rates were 1.7 pas/veh but the private car share was down to 14% from 21% in 1994 and public transit use rose from 46% to 53%, a surprising result according the 2011 O-D Survey, which may be explained by persistent poverty and a possible sub-estimation of motorization due to the difficulty to survey gated communities and cyclical phenomena mentioned above.

Table 1: Indicators de mobility in Lille and Cd. Juarez

	Lille 2006	Juarez 1996	Juarez 2006
Trips/pers/day	3.99	1.89	2.11
% by private vehicle (driver+pass)	53%	51%	50%
Occupancy rate private vehicle	1.35	1.70	1.70
Average distance/driver trip (km)	5.7	3.1	3.7

Source: O-D Household Surveys and calculations of IFSTTAR.

The importance to model a highly motorized city such as Juarez lies in the necessity to observe and predict the trends of the most pollutant mode, which is private car. In the year 2001 in the Parisian region 90% of the total CO_2 emissions from transport were caused by only 44% of the total modal share (private cars) [Tapia, 2011]. In the "Cd. Juarez Auto Driver Model" the impact of changes of population age pyramid and mobility behaviour seems to slow down the private vehicle trend observed in the past (increase only of 10% from the base index to 2050) showing some evidence of saturation or peak car in developing countries.

CONCLUSION

To summarise with respect to France, the main findings are as follows: the same trend towards a decline in mobility can be found here as in most other developed countries, starting in the early 2000s, whilst the average distance travelled by households was levelling off and dropped slightly thereafter, with cyclical variations probably linked to fuel price variations, a drop in the percentage of young people holding driving licences in the most densely populated urban areas (elsewhere, the opposite can be seen), the social distribution of car ownership, which is attaining its limits, with the decline in inequalities of automobile ownership and the widespread increase in second cars, an ageing of the cars on the road, a saturation of car ownership. In addition, there can be seen significant growth in the use of public transport.

In our case studies in Mexico, we can also make out a saturation phenomenon that could take place in roughly 20 years in the most traditional cities and slightly earlier in more developed cities, provided there is a slowdown in population growth. The car population is old, however, and is not tending to get any younger, for lack of purchasing power, but also due to policies that encourage ownership of old vehicles, such as the annual vehicle tax from which cars aged 10 years or older are exempt – a tax that was recently abolished at the national level (federal tax) and in certain states (Puebla and Tlaxcala in 2011).

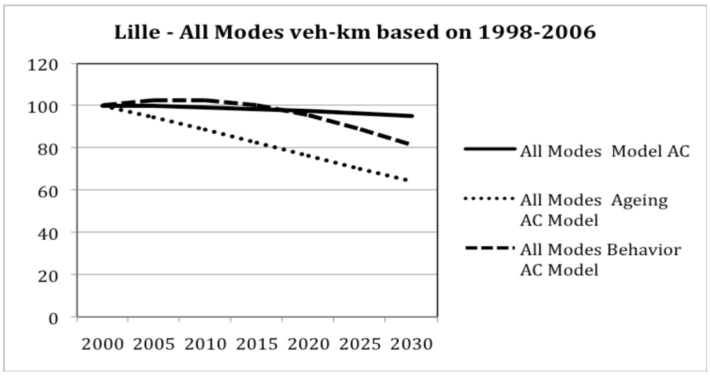
Given the finding that overall mobility as well as urban car mobility has reached a saturation point, or at the very least has been slowing in the developed countries, along with the probable appearance of a similar tendency in emerging economies, but only in about 20 years after intense pressure for individual car ownership, what can be concluded in policy terms? With respect to developed countries, in which the growth of cities is changing, there is an encouraging sign that it will be easier to shift the focus of urban transport planning: restrict car usage in the city, while promoting the use of public transport and soft modes; find ways to control urban extension by making suburbs denser; rethink the construction of toll roads at the periphery of metropolitan areas, which are perhaps no longer useful nor worthwhile economically; rethink our conception of quality-of-life in the city, with less emphasis on the fluidity of car travel; introduce various measures to manage demand in order to diminish the number of trips and car travel within cities. It would also be necessary to address the technology by imposing stricter standards on manufacturers; nevertheless, the impact on the production cycle and the renewal of cars on the road could take another two decades. The transition must therefore be accelerated [Schipper, 2011].

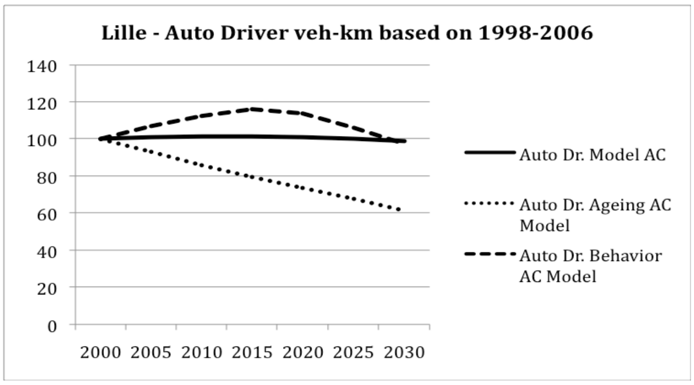
With respect to emerging economies, despite the great disparities from one country to another, and from one city to another, the example of Puebla and Ciudad Juárez can give us an idea of the magnitude of the challenge to be taken up in the years ahead: a determinant factor is population growth which will remain relatively strong for at least another one or two generations; it is likely that cities will expand in a way that is disordered and staggered; and socio-economic equality between households in terms of car ownership is only beginning, the great majority of transport policies favour the use of automobiles, along the lines of the US model from the 1970s, at least in Mexico and elsewhere in Latin America; most public transport is fairly rudimentary and not very competitive in relation to travel by car, and the absence of redistributive taxation makes it difficult, except in very large cities, to modernise it and introduce operating subsidies to make it more competitive; the public's lack of awareness of environmental issues; security problems are complicating the introduction of non-motorised modes, which cities in the north are adopting more and more. What, therefore, would be the most appropriate policies?

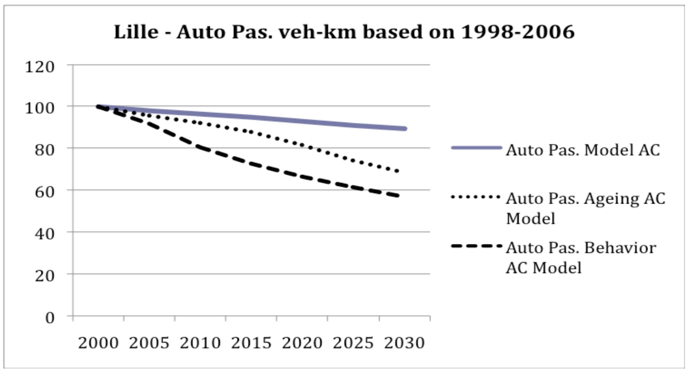
First, existing facilities must be strengthened. Many Mexican and Latin American cities built on the European model still have high population densities comparable to European cities. Policies should be crafted to maintain the density of city centres and avoid constructing ring roads without complementary measures to avoid population flight from the centre to the periphery; modernising public transport to make it more competitive relative to cars and to change its image from a mode of transport for poor people to a mode of transport for everyone; to foster the introduction of pedestrian areas in city centres and in suburbs; foster continued use of bicycles in many cities where it has not yet disappeared; promote expansion of bicycle use for utilitarian and recreational purposes; regulate the fleet of cars to make it younger, with cleaner vehicles; disseminate information and facilitate procedures to have access to carbon vouchers that could finance these measures.

Yes, the trend towards ever-greater urban mobility, which seems to be reversing in the developing countries, can be expected to spread to a number of emerging economies, but only in a couple of decades. The challenges for sustainable transport are as great as ever.

Figure 17. Age-Cohort model simulations, Lille 2000-2030.
Average distance travelled per day per person in veh-km by mode (base index 100 in 2000)







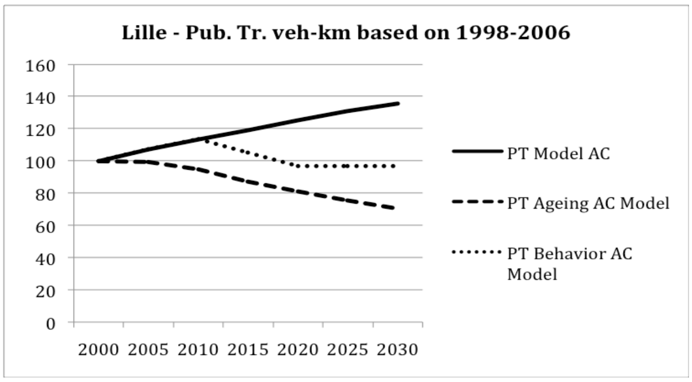
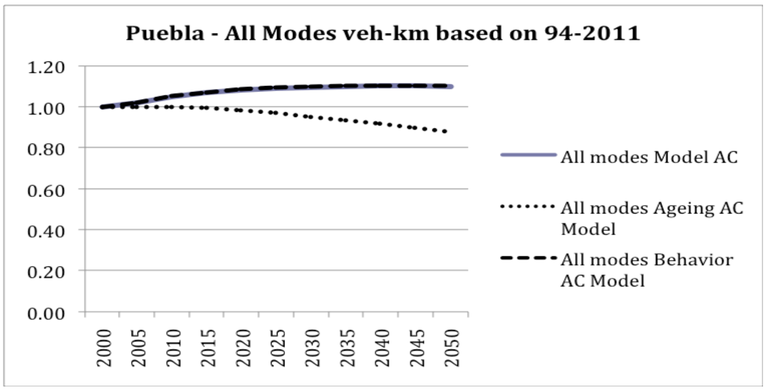
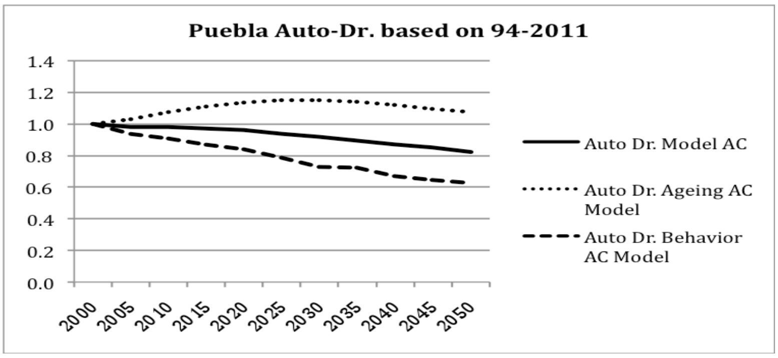
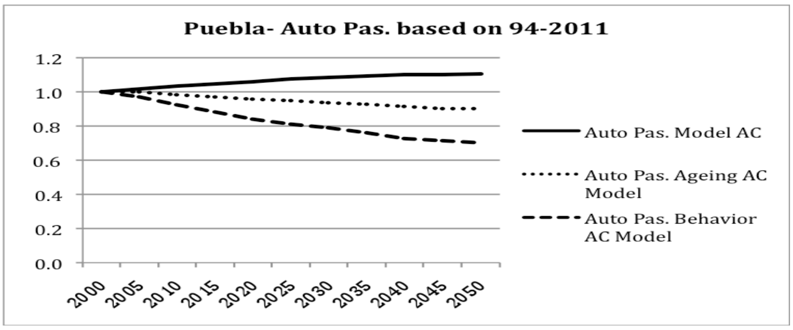


Figure 18. Age-Cohort model simulations, Puebla 2000-2050.
Average distance travelled per day per person in km by mode (base index 100 in 2000)







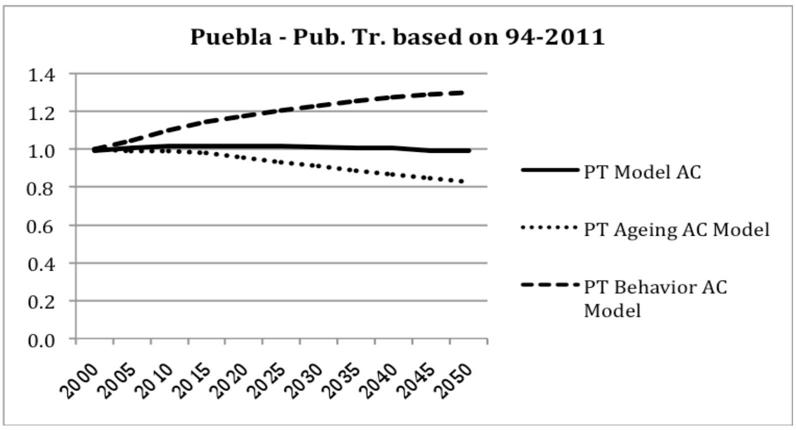
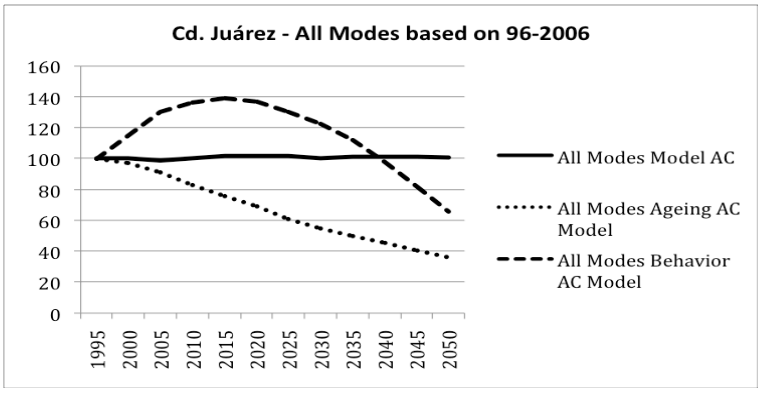
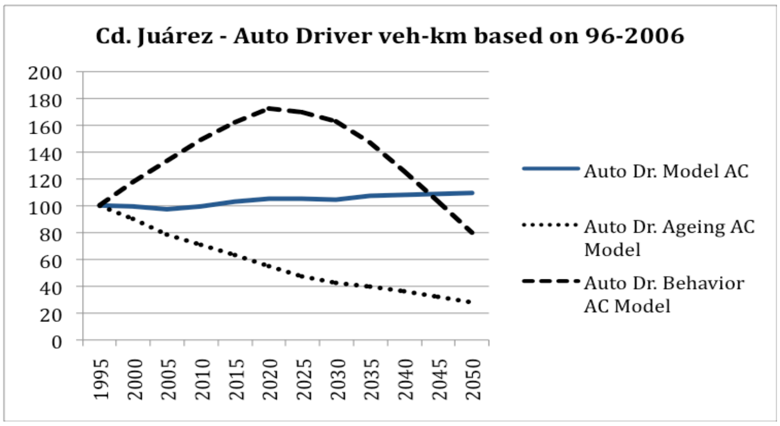
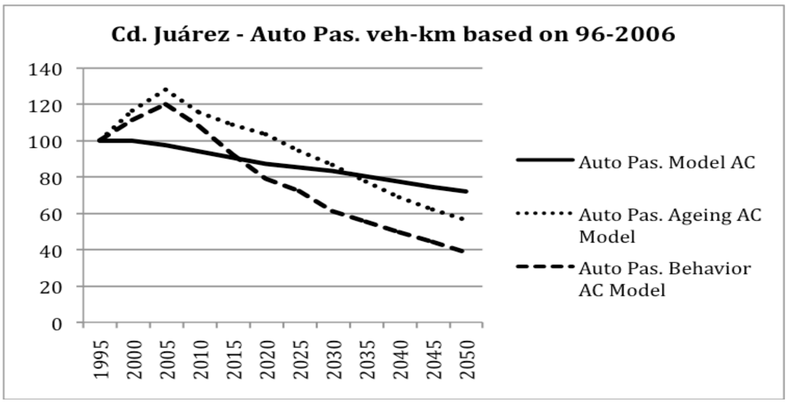
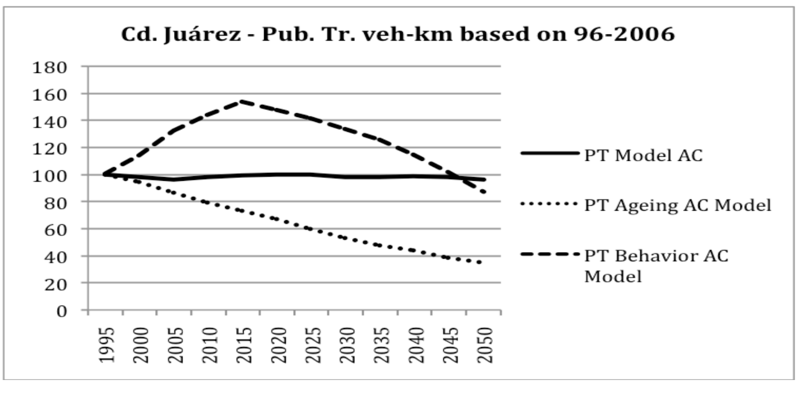


Figure 19. Age-Cohort model simulations, Cd. Juarez 1995-2050.
Average distance travelled per day per person in km by mode (base index 100 in 1995)









ACKNOWLEDGEMENTS

We would like to thank: the *Cuerpo Académico de Economía Urbana y Regional* of the Faculty of Economics of the *Benemérita Universidad Autónoma de Puebla*, the Mexican National Council on Science and Technology (CONACYT) (subsidy CB-2011-01 No. 168388) for their support; Dr. Salvador González-Ayala (IMIP) for providing Ciudad Juárez's urban mobility surveys; First author thanks the Mexican National Council for Science and Technology (CONACYT) for its support during his Ph.D. studies.

REFERENCES

Avrillier, P., Hivert, L., Kramarz, F. (2010). "Driven Out of Employment? The Impact of the Abolition of National Service on Driving Schools and Aspiring Drivers", 24 p., first published online: 17 Aug. 2010, Online ISSN: 1467-8543, published in the *British Journal of Industrial Relations*, Volume 48, Issue 4, Dec. 2010, pp784-807, © Blackwell Publishing Ltd/London School of Economics.

BITRE (Bureau of Infrastructure, Transport and Regional Economics) (2012). "Traffic Growth: Modelling a Global Phenomenon", Report 128, Canberra ACT.

Bussière, Y. D. (0ct 2011). Paris (Marne-la-Vallée), Invited speaker, "Puebla: Évolution de la mobilité 1994-2011", IFSTARR, DEST. 27 Oct., Ppt, 54p.

Bussière, Y. and L. Fortin (1990). "Demande de transport et évolution démographique: rétroprojection et prospective", Communication, 14th Annual Meeting of the Canadian Regional Science Association, University of Victoria, Victoria, Canada, 2-4 June, 26p.

Bussière, Y., Madre, J.-L., Armoogum, J., (1996). "Vers la saturation? une approche démographique de l'équipement des ménages en automobile dans trois régions urbaines", *Population*, No. 4/5, pp. 955-977.

Collet, Roger. (2012). "Household car use in France: a demographic and economic analysis", *Economics Bulletin*, 2012, Vol. 32, Issue 1, pp. 475-485.

Coneval – Consejo Nacional de Evaluación de la Política de Desarrollo Social (2009). *Evolución de la pobreza en México*. 24p. pdf. www.

Gardes F., Langlois S. and Richaudeau D. (1996). "Cross-section versus time-series income elasticities", *Economics Letters*, 51, p. 169-175.

Goodwin, Ph., (2010-2011). "Peak Car", series of five articles in *Local Transport Today*, June 2010-June2011" *Local Transport Today*, London, 14p.

Hernández Hernández V. (2012). Análisis exploratorio espacial de los accidentes de tránsito en Ciudad Juárez, México. Rev Panam Salud Publica. 2012;31(5):396–402.)

INEGI (1994). OD Study for the Mexico City Metropolitan Area".

Instituto Municipal de Investigación y Planeación, www.imip.org.mx

Madre, J.-L., Y. D. Bussière, R. Collet, I.T. Villareal (2012). « Are We Heading Towards a Reversal of the Trend for Ever-Greater Mobility? ». OECD. International Transport Forum, Discussion Paper 2012-16.

Kolli, Zéhir, (2012). "Dynamique de renouvellement du parc automobile. Projection et impact environnemental", Doctoral thesis in economics, Université Paris 1. Panthéon-Sorbonne, 309p.

Kuhnimhohf, T., Armoogum, J., Buehler, R., Dargay, J., Denstadli, J.M., Yamamoto, T., (2012). "Trends in Young Adults' Behaviour: Evidence from Six Industrialized Countries", 90th TRB Annual Meeting, IFSTTAR, Working document.

Litman, T. (2011). "The Future Isn't What It Used To Be. Changing Trends and Their Implications For Transport Planning", Victoria Transport Policy Institute, 49p. www.vtpi.org/future.pdf .

Litman, Todd (2009). Evaluation Public Transit Benefits and Costs. Best Practices Guidebook. Victoria Transport Policy Institute. www.vtpi.org.

Madre, J.-L, Y. Bussière, R. Collet, I. Tapia-Villareal (2012). *Are We Heading Towards a Prepared for the Roundtable on Long-Run Trends in Travel Demand*, OECD, International Transport Forum, Discussion Paper 2012-1629-30 nov., 27p. (also available in French).

Madre, J.-L., Armoogum, J. (1997). "Interview et présence au domicile" 14th Annual International Symposium on Methodology Issues, Statistics Canada, Ottawa (publication of a condensed version in French and English).

Madre, J.-L., J. Armoogum (1996) "Motorisation et mobilité des franciliens aux horizons 2010-2020", Rapport INRETS n°209.

Meissonnier J., (2011). "Le déménagement: un déclencheur des changements dans les choix modaux? Le cas de trois agglomérations du nord de la France", Dixièmes rencontres francophones Est-Ouest de socio-économie des transports, DRI - Ecole polytechnique de Montréal, 1-5 June 2011, Montreal, Canada.

Metz. D. (2010). "Saturation of Demand for Daily Travel", *Transport Reviews*, 30: 5, 659-674.

Millard-Ball, A., Schipper, L. (2010). "Are We Reaching Peak Travel? Trends in Passenger Transport in Eight Industrialized Countries", *Transport Reviews*. http://www.tandfonline.com/doi/abs/10.1080/01441647.2010.518291.

Newman, P. and J. Kenworthy (2011). " 'Peak Car Use': Understanding the Demise of Automobile Dependence", *World Transport, Policy & Practice*, Vol. 17.2, June, Pdf 14p.

OECD/ITF, International Transport Forum, (2011). "Peak car travel in advanced economies?", Chapter 3, *Transport Outlook: Meeting the Needs of 9 Billion People*, Paris.

Pison G (2011). "Tous les pays du monde 2011", Population et sociétés, Numéro 480 Juillet 2011

Quételard (2011). "Une rupture dans l'évolution de la mobilité urbaine: Les enseignements des dernières EMD", Atelier thématique RST *Demande de Transport : méthodes de recueil, analyses et prospective*, Certu, 6 December.

Schipper Lee (2011). "Automobile use, fuel economy and CO_2 emissions in industrialized countries: Encouraging trends through 2008?", *Transport Policy* 18, pp. 358-372.

Sivak M, Schoettle B. (2012). "Recent changes in the age composition of drivers in 15 countries", *Traffic Injury Prevention,* 13:126-132.

Tapia Villarreal, Irving (2011) "Évolution de la mobilité quotidienne, énergie et émissions en Île-de-France. Diagnostic des évolutions entre 1991 et 2001", 48e Colloque de l'Association de Science Régionale de Langue Française (ASRDLF) juil., Schoelcher, Martinique.