Mobility patterns in Switzerland: past, present and future

Francesco CIARI
Institute for Transport Planning and Systems (IVT)
ETH Zurich, HIL F 33.2
CH-8093 Zurich
Phone: +41-44-633 71 65
Fax: +41-44-633 10 57
Email: ciari@ivt.baug.ethz.ch (Corresponding author)

Alejandro MARMOLEJO
Institute for Transport Planning and Systems (IVT)
ETH Zurich, HIL F 51.3
CH-8093 Zurich
Phone: +41-44-633 71 65
Fax: +41-44-633 10 57
Email: Alejandro.marmolejo@ivt.baug.ethz.ch

Alexander STAHEL
Institute for Transport Planning and Systems (IVT)
ETH Zurich, HIL F 51.2
CH-8093 Zurich
Phone: +41-44-633 30 89
Fax: +41-44-633 10 57
Email: alexander.stahel@ivt.baug.ethz.ch

Kay W. AXHAUSEN
Institute for Transport Planning and Systems (IVT)
ETH Zurich, HIL F 31.3
CH-8093 Zurich
Phone: +41-44-633 39 43
Fax: +41-44-633 10 57
Email: ciari@ivt.baug.ethz.ch

ABSTRACT

This paper reports on an ongoing project which main goal is the setup of a scenario for the microsimulation model MATSim for the year 2030. Running the model on such scenario is expected to deliver a plausible prediction of transportation demand in Switzerland in that year. The work involves various challenges and can be broadly divided in two tasks. The first is the generation of a suitable synthetic population mimicking the real Swiss population in 2030. The second, which is the part described in this paper, is evaluating past mobility patterns, find out how they evolved until the present and figure out how they are expected to further evolve in the future. This has been done looking at Swiss travel diaries surveys from 1994 to 2010. The main finding of the research is that travel behavior did not change substantially in Switzerland in that span of time. In particular the number of out-of-home activities and home-to-home journeys for the same age groups across cohorts is fairly stable, although the time spent at activities is slightly decreasing. Some change has been observed also in license ownership and car ownership. Future mobility patterns have been delineated projecting the actual trend toward 2030. Additionally, two aspects which are supposed to play a major role in future mobility patterns – teleworking and teleshopping – were investigated.

INTRODUCTION

Various changes are expected to reshape our mobility forms in the future. The electrification of vehicles is one of the most important one. It is commonly assumed that a large diffusion of electric vehicles would guarantee reduced direct emissions in the atmosphere but, because of their limited range, would also need a careful planning of the necessary infrastructure. The possibility to use a vehicle-to-grid approach – vehicles' batteries could deliver electricity into the power grid, if needed – is another attractive feature. Despite all that, the electrification process is rather at a very early stage. The electric revolution in transportation was repeatedly announced but for the moment seems more like a very slow evolution with an uncertain end. From a research perspective, one of the most urgent questions to be answered is to understand how large the demand for this kind of mobility will be. This is part of the more general question on how transportation demand will look like in the future. This paper reports on an ongoing project which main goal is to deliver a plausible mid-term prediction of the use of electric vehicles in Switzerland. The mentioned issues related to electric vehicles' use – the necessary infrastructure, the range, and the vehicle-to-grid approach – suggest that the predicted demand should be completely disaggregated – i.e. at the vehicle, or the person, level – and the spatial and temporal dimensions of the demand are highly important. The agent-based simulation MATSim is a suitable framework – because it has the necessary spatial and temporal resolution and persons are modeled at the individual level – but its application is challenging. The work can be broadly divided in two tasks. The first is the generation of a suitable synthetic population mimicking the real Swiss population in 2030. The main challenge there is gathering all the relevant data and merging them in a coherent way. The second, which is the part described in this paper, is the imputation of the future mobility behavior of the people. This was done evaluating past mobility patterns, finding out if any trend is there, and use this information to figure how they are expected to further evolve in the future. The work was done looking at Swiss travel diaries surveys from 1994 to 2010. To complement this, two aspects which are supposed to play a major role in future mobility patterns – teleworking and teleshopping – were also investigated.

DATA

In Switzerland a statistical survey of the population's travel behavior (Micro-Census on Travel Behavior) has been conducted about every five years since 1974 by the Federal Office for Statistics (Bundesamt für Statistik) together with the Federal Office for Spatial Development (Bundesamt für Raumentwicklung). In 2010, 62'868 individuals belonging to 59'971 households were contacted by telephone to answer questions about the following

topics: vehicle ownership, possession of driver's licenses and/or public transport travel cards; daily travel patterns (number of trips, duration of trips, distances travelled); purpose of trips and means of transport used; one-day excursions and excursions with overnight stays; views regarding Swiss transport policies. This is the most complete data set available describing travel habits of the Swiss population and the sample is representative at both the household and the individual level (ARE and BfS, 2012). The Micro-Census consists of various datasets, and one of them contains information about the set of mobility tools that a particular person owns, including carsharing membership. Important to note here is that Mobility, the only Swiss carsharing operator, offers various types of membership. In particular, Mobility is one of the abovementioned operators offering membership for both private customers and business customers. The formulation of the question about carsharing in the survey seems clear enough to suppose that a positive answer actually corresponds to that person being private member. Nevertheless, since the distinction is not explicitly made in the question, it should be kept in mind that some persons having access to carsharing through their employer might have declared themselves as carsharing members. Another point is that it is unknown if a particular member is active, that is whether they use car sharing at least sporadically, or not.

COHORT ANALYSIS

Ten year cohorts, analysis by gender

This analysis aimed to look at the mobility tools ownership and usage by gender in the Swiss micro-censuses, such as driving license ownership, private car availability, daily distance travelled and daily travel time. The analysis was done for six micro-censuses, years 1989, 1994, 2000, 2005 and 2010, considered only the population over 18 years, and used person weights.

Driving License

Figure 1.a shows the percentage of people who own a driving license for the respective cohorts. The six points within each cohort represent the development in the course of the six evaluated Micro-censuses. It is seen that for the older cohorts, the proportion of the driving license holder is overall significantly lower than in the younger cohorts. The share of men who own a driving license is much higher than women of the same age. The trend among younger people go to a maximum share of driving license ownership of approximately 90-95 for men and about 80-85% for women, where a plateau is reached that starts decreasing

again only after 30 years. Younger generations reach the plateau (saturation) much faster than older generations.

Car availability

Figure 1.b shows the percentage of people that have car availability. In the microcensus, a person can respond to whether they have a car available with three possible answers: "always", "by arrangement", or "never". Here it is considered that a person has a car available, only if it is always available. Similar trends as the ones for driving license can be seen for car availability. The curve, however, is less pronounced, and saturation occurs at later ages (after age 30). The plateau occurs at 82% for men, and head towards 67% for women.

Public transport subscription

In the diverse microcensus, different classifications of types of subscriptions have been used, so that the relevant details are not comparable. For this reason, Figure 1.c shows the percentage of people that have one or more public transport season tickets, regardless of the type of subscription. Trends in public transport subscription ownership are contrary to the driver's license and car availability. Women have a higher percentage than men across all ages, and people between 30 and 50 years have the lowest shares. A considerable increase of the public transport subscriptions holders share can be seen across generations. This is particularly clear for the youngest age group, between 18 and 25 years, where the proportion of public transport subscription holders increased from 26- and 38% in 1984 up to 75- and 82% in 2010 for men and women respectively.

Trips per day

Figure 1.d shows the average daily number of trips for the different cohorts. For this analysis, only trips inside Switzerland were considered (inland trips). It can be seen, that men are slightly more mobile than women at all ages, having approximately 0.5 trips more per day. Up to age 50, the total amount of trips per day varies between 3.5 and 4.5, and afterwards has a decreasing trend reaching two trips per day for the elder people. The differences within each cohort, i.e. over the course of the six evaluated Micro-censuses, probably arise in part due to methodological changes in the surveys.

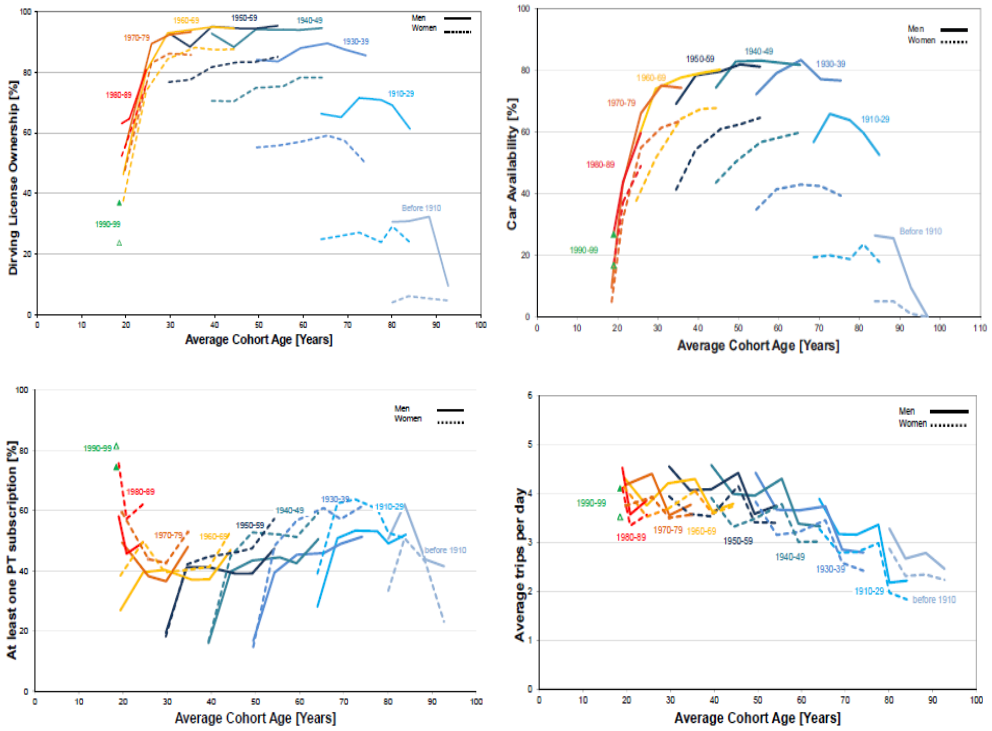

Figure 1: averages of driving license ownership, car availability, season tickets and trips per day by gender.

Daily distance travelled

Figure 2.a shows the average daily distance travelled for the different cohorts. Again, for this analysis only trips inside Switzerland were considered. There is a strongly pronounced difference (much more than for the daily trips) between men and women, with cases in which men travel on average over 20km more per day. For men, the curve is fairly stable between ages 20 and 50, with a daily travelled distance that fluctuates between 50-55 kilometers. After age 50, the curve has a clear decreasing trend, going down to less than 10km for the elder men. For women, however, there is a clear decreasing trend for all the age range. No substantial differences can be identified across cohorts.

Daily travel duration

Figure 2.b shows the average daily travel time for the different cohorts. Once more, for this analysis only trips inside Switzerland were considered. As for the daily distance travelled, a big difference can be noted between men and women, difference of around 25 min per day. Similar trends as the ones for daily travelled distance can be seen, since they are strongly correlated. The decreasing trend, however, is less pronounced. Roughly, the elderly travel half of the time as young people.

Out-of-home activities / trips ratio

Figure 2.c shows the ratio between the total out-of-home activities per day and the total trips, as an indicator of people's daily activity chain organization. This ratio can have a maximum value of 1 (plans with incomplete tours) and can be 0 if a person's plan have only home-to-home trips (walking the dog, riding the bike for leisure, etc.). For this particular analysis, only the mobile population was considered. As can be seen, the curve has a clear decreasing trend, which means that at higher ages, people do fewer activities per tour, i.e. they do shorter tours. Women have slightly a smaller ratio than men, although this is reversed for people older than 70 years.

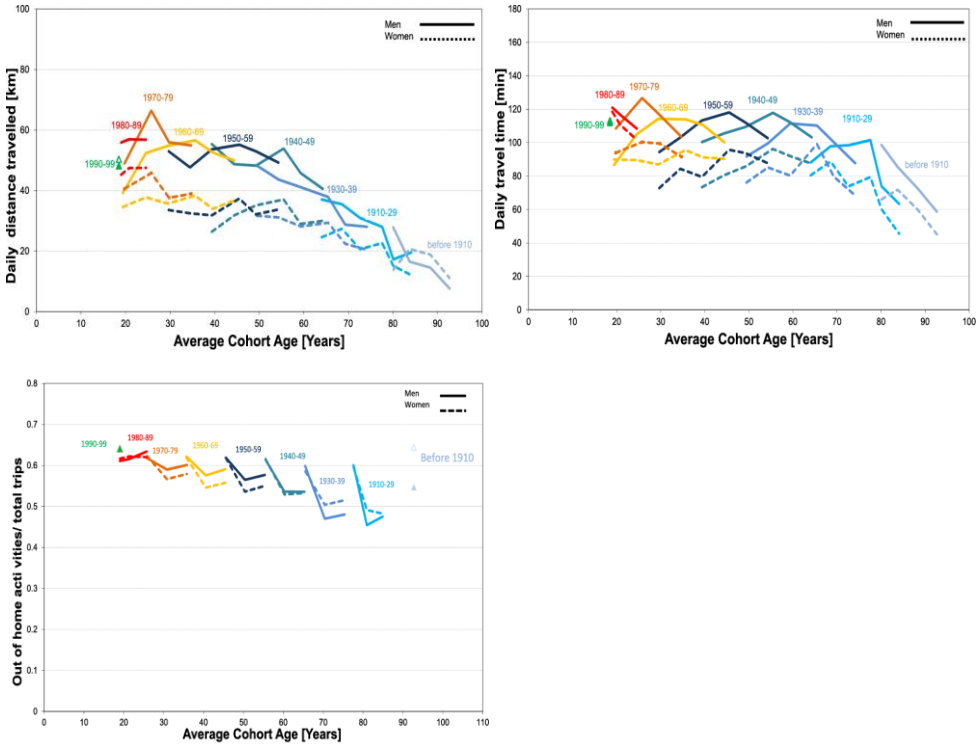

FIGURE 2: Averages of daily distance, daily travel time and ration home activities/ total trips by gender

Ten year cohorts, analysis by income terciles

Similarly to the ten-year cohort analysis by gender, this analysis aimed to look at the mobility tools ownership and usage in the Swiss micro-censuses separating the population by income terciles. This analysis was, however, done only for the last three micro-censuses, years 2000, 2005 and 2010, since no household income data was available for the previous years. Again, only the population over 18 years was considered, and used person weights.

Driving license

Figure 3.a shows the percentage of people who own a driving license by cohorts, from which a strongly pronounced difference between the income terciles can be seen. The share of people who own a driving license is much higher when the average household income is higher. For the third tercile there is a clear plateau of 95% between ages 20 and 50, similar to the one previously seen for men, while the first and second terciles have a maximum share of driving license ownership of only 76- and 85% respectively, and do not have a clear plateau, but a decreasing trend with age after the initial increase. The overall significantly lower share of older cohorts compared to the one of younger cohorts is again clearly shown.

Car availability

Figure 3.b shows the percentage of people that have car availability for the income terciles groups. Similar trends as the ones for car availability for gender can be seen. Pronounced difference between the income terciles can be seen. The share of people who has car availability is much higher when the average household income is higher. The plateau are reached at 57, 68 and 78% for the first, second and third terciles respectively. Since here only the last three microcensuses were considered, the lower share of older cohorts compared to the one of younger cohorts cannot be distinguished.

Public transport subscription

Figure 3.c shows the percentage of people that have one or more public transport season tickets regardless of the type of subscription, for the different income terciles. An increase of the public transport subscriptions holders share across generations can be seen. The share of people who owns a public transport subscription is higher when the average household income is higher, which is a little surprising since with higher income people have higher car availability too. Especially interesting is the high share of public transport of the younger people of the new generations.

Trips per day

Figure 3.d shows the average daily number of trips for the income terciles. For this analysis, only trips inside Switzerland were considered (inland trips). It can be seen that people with higher income are more mobile than people with less income. The curves have similar trends as the ones Figure 2.5: up to age 50, the total amount of trips per day is fairly constant, followed by a decreasing trend with age.

Daily distance travelled

Figure 3.e shows the average daily distance travelled for the different cohorts and income terciles. Only trips inside Switzerland were considered. There is a strongly pronounced difference (much more than for the daily trips) between the other income groups. People

with higher income tend to travel longer distances. The highest income group travels considerably longer daily distances than the other two, roughly 10 and 15km more per day than the second and first income terciles respectively. No substantial differences can be identified across cohorts. The curve has a clear decreasing trend with age.

Daily travel duration

Figure 3.f shows the average daily travel time for the different cohorts and income terciles. Once more, for this analysis only trips inside Switzerland were considered. As for the daily distance travelled, people with higher income tend to travel longer time. Similar trends as the ones for daily travelled distance can be seen, since they are strongly correlated. The decreasing trend, however, is less pronounced. Roughly, the elderly travel half of the time as young people.

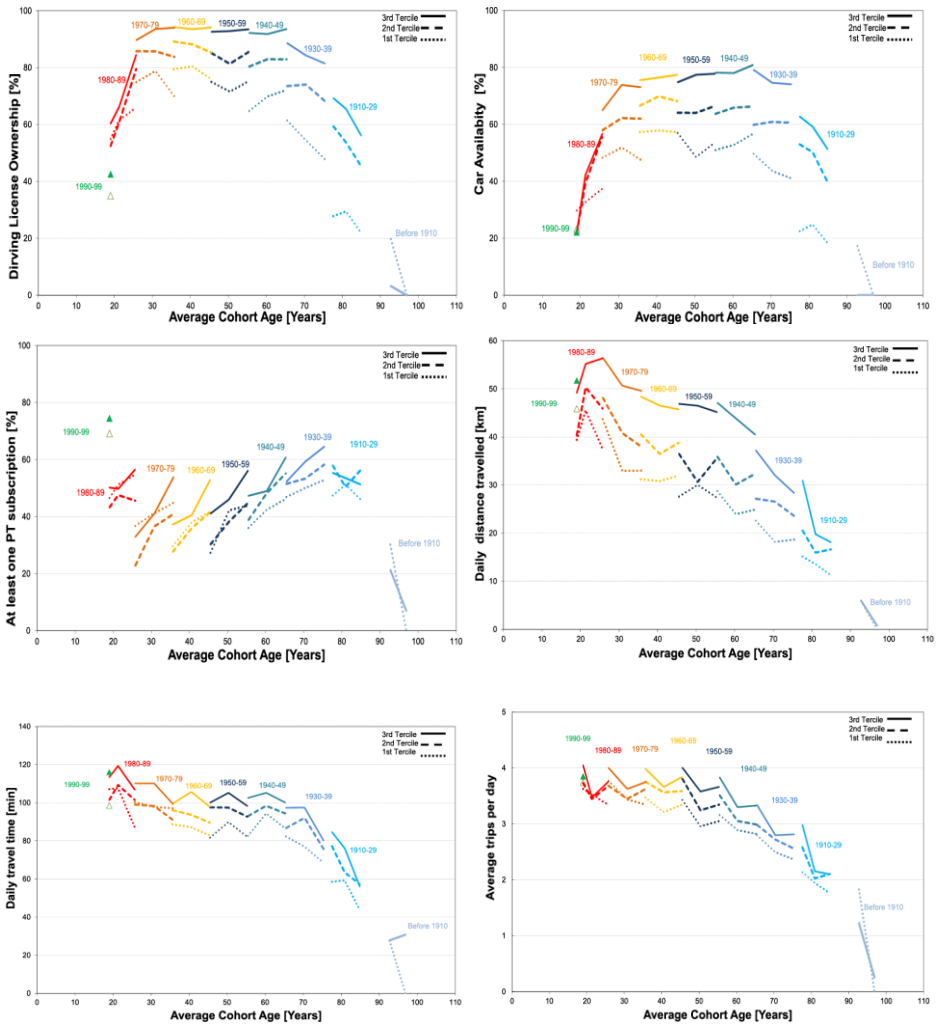

FIGURE 3: averages of driving license ownership, car availability, season tickets and trips per day, daily distance, daily travel time and trips per day by income terciles.

Ten year cohorts, activity chains analysis

This analysis aimed to look at the structure of the activity chains obtained from the Swiss micro-censuses regarding the time spent performing activities, total number of activities and home-to-home journeys. The analysis was done for five micro-censuses, years 1994, 2000, 2005 and 2010, and by activity type. All the population was considered. Table 2.1 shows the classification of the activities for the different micro-censuses. The latest ones, MZ2005 and MZ2010, define more purposes/activities than the previous ones. This difference has an evident impact in the analysis, and has to be carefully taken in mind when interpreting the results.

	WORK	LEISURE	SHOPPING	EDUCATION	BUSINESS	OTHER
MZ 1994	Work	Leisure	Shopping	Education	Business Dienstfahrt	No answer
MZ 1994	Work	Leisure	Shopping	Education	Business Dienstfahrt	Accompanying, errands, use of services, no answer
MZ 1994	Work	Leisure	Shopping	Education	Business Dienstfahrt	Overnight, foreign property, pseudo-stage, change of mode, accompanying children, accompanying other persons, errands, use of services, other
MZ 1994	Work	Leisure	Shopping	Education	Business Dienstfahrt	Overnight, foreign property, pseudo-stage, change of mode, accompanying children, accompanying other persons, errands, use of services, other

TABLE 1: Classification of activities for the different micro-censuses.

Home

Figure 4 shows the development of the time spent at home and at out-of home activities by cohort for the five micro-censuses. Between ages 20 and 50, people spend a fairly stable amount of time at home, of between 15 and 16 hours. After 50, the time spent at home has a pronounced increasing trend that reaches up to 22.5 hours for the elder people. It is seen that younger cohorts slightly increase their time spent at home, and consequently, decreases the time spent at activities compared to the older cohorts.

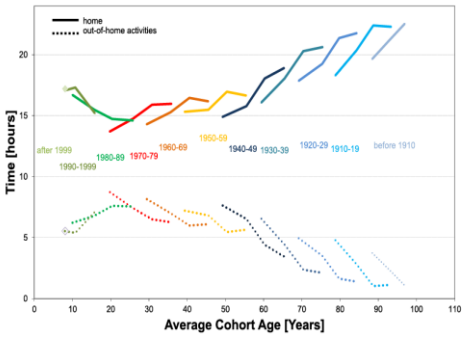

FIGURE 4: Time spent in home/out-of-home activities.

Other activities

For the other activities considered time spent at the activity, number of activities, and number of home-to-home journeys that involve such activity were analyzed. In general, for one activity type, all three curves are similarly shaped. Also, all three curves are fairly stable across all micro-censuses, evidencing no clear cohort effect The particular form, compared to the curves of the other activities, strongly hints the fact that some activities are peculiar of a given life period. In the case of work activity (Figure 5), for example, there is a big increase around age 18, remaining fairly constant until age 50, and then abruptly decreasing reaching almost zero by age 80.

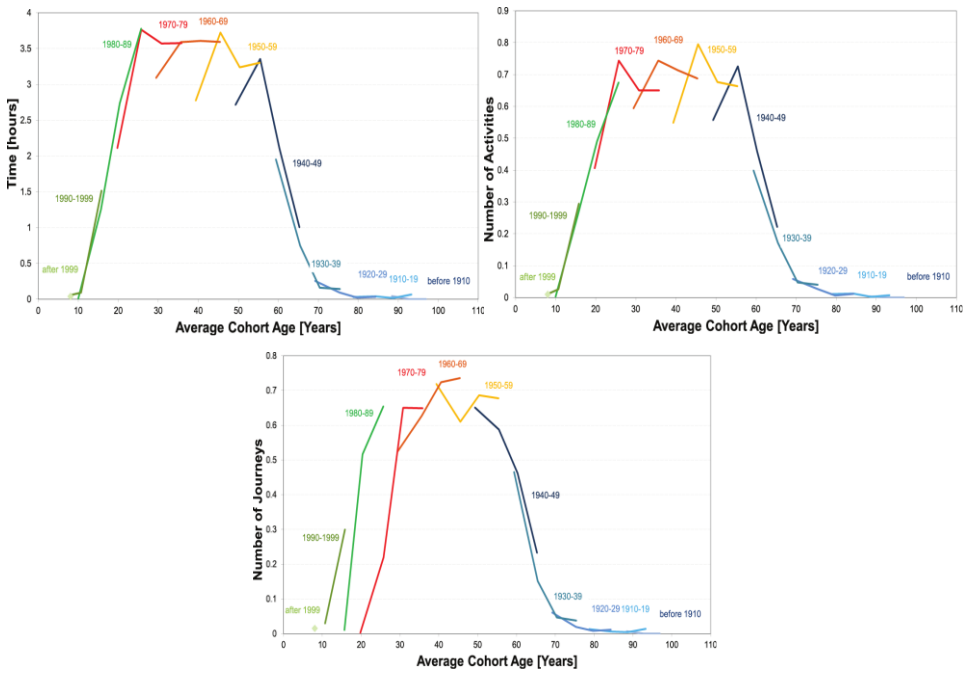

FIGURE 5: Temporal length and number of work activities, number of journeys related to work.

PEAK SPREADING ANALYSIS

The peak spreading analysis aimed to look at the peaking patterns in departures of trips going-to and returning-from different activity purposes in the Swiss micro-censuses. For this analysis, only the departure times of the trips were considered.

Returning home

Figure 6.a shows the peak spreading analysis for trips returning home. The y-axis shows the percentage from the total amount of trips returning home at a given time. Time intervals of 1-hour were considered. The development in the course of the six evaluated Micro-censuses shows no change in the peak hours at which people return home. Through the years, nevertheless, the curve shows a tendency to flatten. Two peak hours can be distinguished, centered at 11 and 17 hours.

Leaving for work

Figure 6.b shows the peak spreading analysis for trips leaving for work. The development in the course of the evaluated Micro-censuses shows the same tendencies as for trips returning home. Two peak hours can be distinguished, centered at 7 and 13 hours. The peak values have decreased from 12 and 16%, down to 8.5 and 12.2% for the two peak hours respectively.

Going/returning to/from leisure

Figure 6.c shows the peak spreading analysis for trips going to or returning from a leisure activity. In this case, no tendency to flatten can be distinguished; on the contrary, the curve is fairly stable across all micro-censuses. For trips going to leisure, no clear peaks can be seen, with relatively equal shares distributed from 12 to 20 hours. For trips returning from leisure, there are two clear peaks centered at 13 and 17 hours.

Going/returning to/from shopping

Figure 6.d shows the peak spreading analysis for trips going to or returning from a shopping activity. Also, in this case, no tendency to flatten can be distinguished; on the contrary, the curve is fairly stable across all micro-censuses. For trips going to shopping, two clear peaks can be seen, at 10 and 14 hours, while for trips returning from shopping, two peaks centered at 10 and 16 can be distinguished. Again, these peaks show a tendency to flatten through the years.

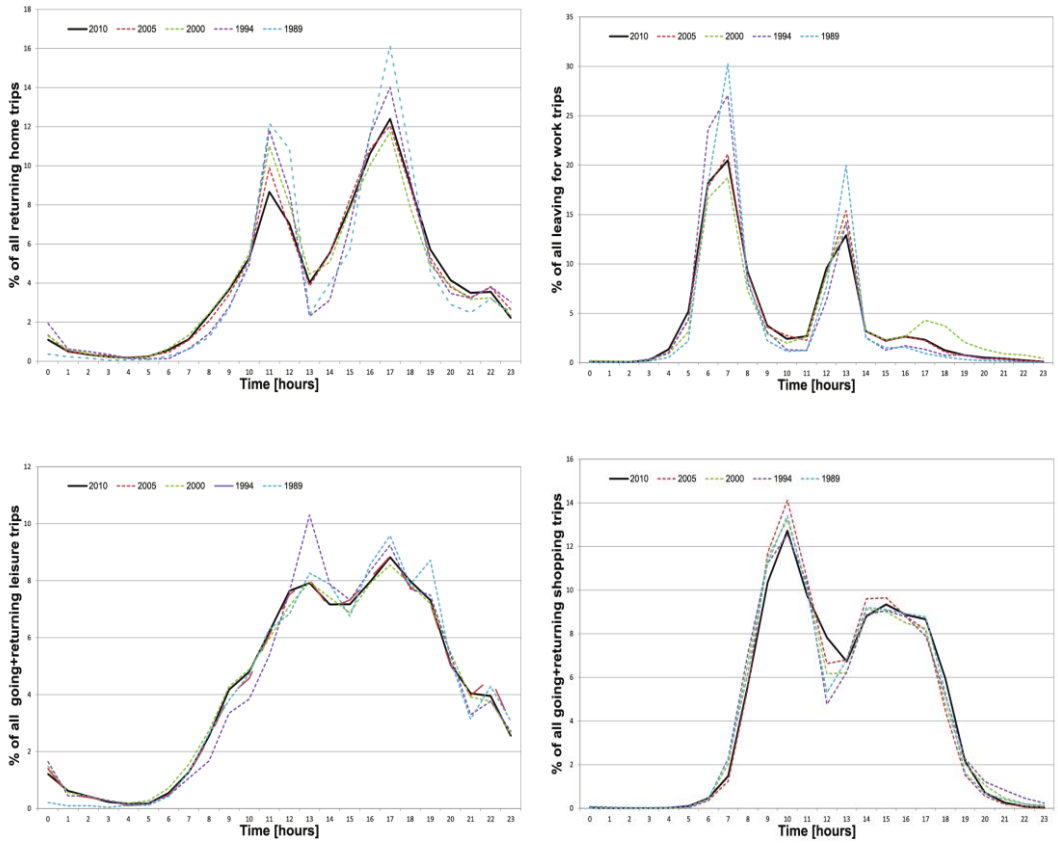

FIGURE 6: Peak spreading for home, work, leisure and shopping activities

Going all purposes

Figure 7 shows the peak spreading analysis for all trips, showing the combined effect of all curves shown above (the previous analysis are not exclusive, since some of the trips returning home are trips also, for example, returning from shopping). The development of the peak patterns is fairly stable across the different micro-censuses. Three peaks can be distinguished. The first one, also the lowest one, centered at 7 hours driven by the people leaving for work. The second peak/plateau occurs between 11 and 13 hours, and the last peak, the highest, occurs at 17 hours.

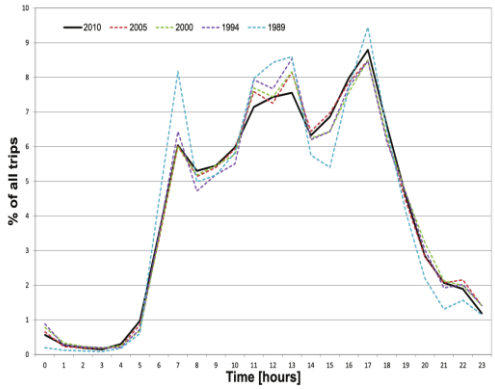

FIGURE 7: Peak spreading for all activities together

TELEACTIVITIES IN SWITZERLAND

Teleworking and e-commerce are two phenomena that are part of the information technology revolution. Some expect them to reshape human behavioral patterns in the years to come, substantially reducing the amount of travel. This section focuses on the potential effects of these phenomena on the Swiss transportation system in the future.

Teleworking

There have been many attempts to define teleworking in the past. Of course, the estimates on how many people telework depend widely on how far you stretch your definition. Teleworking is defined by Nilles (2000) as "Any form of substitution of information technologies (such as telecommunications and computers) for work-related travel; moving the work to the workers instead of moving the workers to work". The European Union funded research project ECaTT, which ended in 1999, aimed to benchmark and generate representative information on the prevalence and spread of electronic commerce and new forms of work in Europe. They defined the following types of teleworking:

1. Home-based teleworking: Work from home (instead of commuting to a central workplace) for at least one full working day per week, using a personal computer and telecommunication links.
2. Supplementary teleworking: Same as home-based teleworking, but less than one full day per week.
3. Centre-based teleworking: The extent of telework in telework-centers.
4. Mobile teleworking: Work at least 10 hours per week away from home and from main place of work (e.g business trips, on field, etc.).
5. Telework by self-employed in SOHOs: Self-employed with home as their main place of work.

The most recent estimate of actual teleworking adoption in Switzerland is the one of the SIBIS project, "Statistical Indicators Benchmarking the Information Society", which took up the challenge of developing innovative information society indicators to take account of the rapidly changing nature of modern societies and to enable the benchmarking of progress in EU Member States, and ran from January 2001 to September 2003. Figure 8 shows the results obtained on this project regarding total practitioners of home-based teleworking in several European countries. 11.3% of the Swiss population practiced one form of home-based teleworking in 2002, being above the European average (7.4%). 4.2% was a regular teleworker, while 7.1% practiced supplementary teleworking. It is important to consider, that these values are referring only to home-base teleworking as opposed to regular teleworkers

as on the EcaTT project. SIBIS estimates the total amount of teleworkers to be 16.8% (rather than 11.3%), figure that includes mobile and self-employed teleworkers. The latter two concepts overlap with home-based teleworkers, e.g a mobile teleworker can also be categorized as a home-based teleworker. Therefore, to avoid confusion and allow comparison with the EcaTT results, only the estimates for home-based teleworkers shall be considered. As said before, in the EcaTT project no self-employed teleworkers were determined in the surveyed sample, while the mobile teleworkers were estimated to be only 0.4%. Therefore, we can safely compare these two quantities.

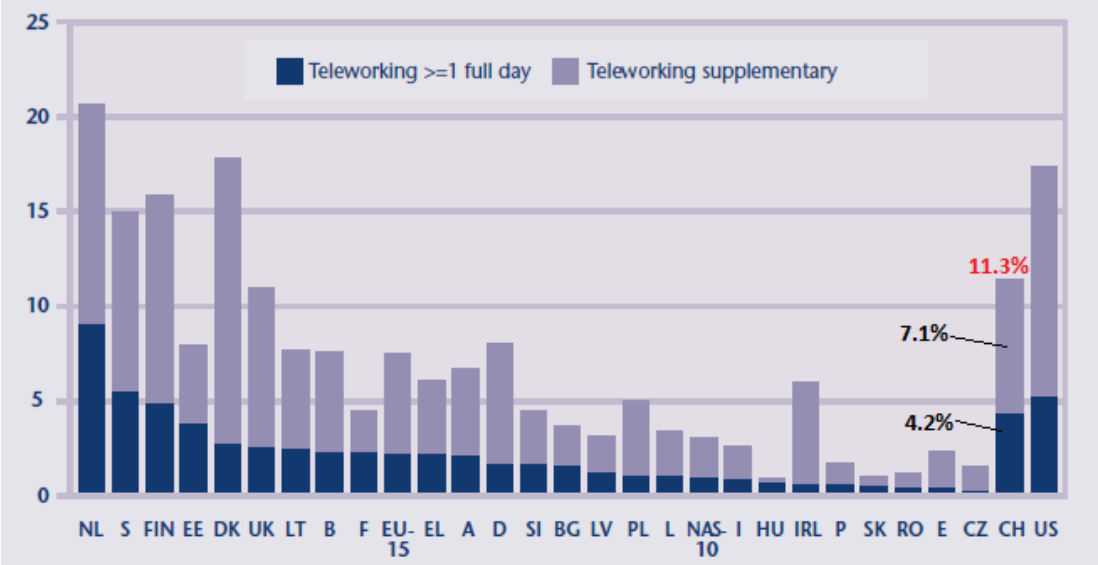

FIGURE 8: Teleworking diffusion in the EU countries (source: SIBIS project).

A forecast for the future growth of teleworking in Switzerland was made by Nilles (2008). This forecast is based solely on the analysis of the general demographic data for Switzerland since no survey data on the actual number of teleworkers in the country was available. The forecast describes the likely number of people who have jobs suitable for relatively frequent telework, including both home – and telework-center – based telework. Under these assumptions the potential teleworkers in Switzerland in 2030 would be 1.4 Million. To get a better estimate, including the distribution between teleworker types, a much better description of the distribution of job types and numbers in Switzerland would be needed. As to mobile workers, they are not included as a class because many mobile workers still use transportation as much as non-teleworkers and, again, their distribution was not known. In absence of government collects on number of teleworkers, the data was disaggregated under the assumption that the evolution of telework would be analogous to that in the US. Income per capita, the extent and competitiveness of the information infrastructure, technology import/export restrictions, government regulations, educational levels, and a variety of

demographic factors, all affect the acceptance -as well as the estimates- of telework. In particular, it was assumed that population growth rates worldwide will be roughly the same as they were in the early 1990s. In transportation, policy makers regarded promoting ICT to substitute commuting for telework as a viable instrument to solve (hyper) congestion problem. However, the empirical evidence indicates that the relation between using ICT for telework and travel is not as clear-cut as supposed. With the increase in teleworking, significant changes in travel behavior and demand are bound to happen. The question is to what extent and in what direction (de Graaf, 2004). Several studies have been made regarding the effects of teleworking on a person's travel behavior. Different opinions circulate on how working from home could affect the way people schedule their daily trips and affect the total travel demand. The increased flexibility that allows teleworking can have several positive impacts, such as a net travel decrease (vehicles miles traveled, VMT) and travel outside peak (uncongested) hours. However, teleworking could also induce/generate non-commuting travel and favor the substitution of multipurpose efficiently linked trips by several one-stop trips, thereby increasing the total VMT. Also, it could increase the use of the telecommuter's vehicle by household members, hence canceling the positive effects previously mentioned. Figure 9 summarizes the results of several studies on the substitution of teleworking (Andreev, 2010).

Nature of study		Character of the ICT impact for empirical study	Modeling approach		
Conceptual	Empirical		DCM	SEM	SEA
Salomon (1985)	Nilles et al. (1976)	Substitution			●
Salomon (1986)	Bennison (1988)	Teleconference-complementarity			●
Mokhtarian (1988)	Mokhtarian (1988)	Teleconference-complementarity			●
Mokhtarian (1988)	Krunt (1989)	Substitution			●
Krunt (1989)	Kitamura et al. (1990a)	Substitution			●
Mokhtarian (1990)	Kitamura et al. (1990b)	Substitution			●
Mokhtarian (1991a)	Goulias and Pendyala (1991)	Substitution			●
Mokhtarian (1991b)	Hamer et al. (1991)	Substitution			●
Salomon et al. (1991)	Pendyala et al. (1991)	Substitution			●
Nilles (1994)	Salomon et al. (1991)	Substitution			●
Mokhtarian et al. (1995)	Mokhtarian et al. (1995)	Substitution			●
Mokhtarian and Salomon (1996a)	Henderson and Mokhtarian (1996)	Substitution			●
Mokhtarian and Salomon (1996b)	Koenig et al. (1996)	Substitution, complementarity (number of non-work trips)			●
Mokhtarian and Salomon (1996c)	Golob (1997)	Substitution	●	●	
Golob (1997)	Balepur et al. (1998)	Substitution			●
Johnson (1997)	Mokhtarian and Varma (1998)	Substitution			●
Mokhtarian and Salomon (1997a)	Mokhtarian (1998)	Substitution			●
Mokhtarian and Salomon (1997b)	Choo et al. (2001)	Substitution			●
Mokhtarian (1998)	Hopkinson and James (2001)	Substitution			●
Salomon (1998)	Hopkinson et al. (2001)	Substitution			●
Golob (2000)	Hjorthol (2002)	Complementarity substitution (number of commuting trips), modification (timing)			●
Mokhtarian (2000)	Hopkinson et al. (2002)	Substitution			●
Salomon (2000)	Lim (2002)	Substitution			●
Golob and Regan (2001)	Vora and Mahmassani (2002)	Substitution			●
Mokhtarian and Chen (2002)	Collantes and Mokhtarian (2003)	Substitution			●
Lim et al. (2003)	De Graaff and Rietveld (2003)	Substitution modification	●		●
Mokhtarian (2003)	Hopkinson and James (2003)	Substitution complementarity	●		●
	Jensen et al. (2003)	Substitution	●		●
	Lim et al. (2003)	Substitution			●
	Senbil and Kitamura (2003)	Substitution		●	
	De Graaff and Rietveld (2004)	Substitution			●
	De Graaff (2004)	Substitution			●
	De Graaff (2004)	Substitution			●
	Ory and Mokhtarian (2004)	Substitution			●
	Choo et al. (2005)	Substitution			●

FIGURE 9: Summary of studies dealing with transportation and teleworking (Andreev, 2010).

A short description of the results found in some of them:

- Niiles et al., 1976: substantial reduction in one-way commuters from 108 tele-centers.
- Balepur et al., 1998; Mokhatarian and Varma, 1998: lower substitution, if at all.
- California Pilot Telecommuting Project, several studies: 20% reduction in total travel for telecommuters, no increase in non-work travel, no substantial changes in travel of telecommuters' household members.
- Koenig et al., California Pilot Telecommuting Project: reduction of total travel by 27%, increase of non-work-related trips by 0.5 trips/person, but reduction on non-commuting VMT by 5.3 miles! More frequent but shorter non-commuting trips.
- Mokhtarian et al., 63% reduction on VMT in telecommuting days, trips per day slightly increase.
- De Graaf, 2004: telecommuting and actual commuting can be clearly considered as substitutes and that working at home substitutes around 20% of the total travel.

It is safe to say, in general, that in the short term telecommuting leads to reduction of the various travel characteristics (e.g., VMT, PMT, morning-peak hours, emission, and number of commuting trips). Commuting and working at home act as substitutes. Moreover, at home work and total travel seem to be substitutes too. The substitution effect between total travel and telecommuting is estimated to be rather substantial, namely around 20% (on working-from-home days). Teleworkers substitute their activities across the week (temporal substitution), which partly offsets the decrease of travel demand. This compensation is estimated to 40%.In the long term, however, telecommuting impacts are still blurred. Some studies suggested that in the long term the values of the telecommuting substitution for commuting would be much lower due to the induced travel demand and residential relocation.

Teleshopping

Teleshopping is a much better documented phenomenon than teleworking. This is probably because the elements characterizing teleshopping are relatively easy to measure statistically through surveys. For example, the Swiss Federal Statistical Office (BFS) carries out a detailed survey of internet usage, which gives good estimates on the number of online shoppers. Figure 10 reports the estimate of the number of persons in Switzerland making internet shopping and online-banking. This is based on an estimate of the group of "internet intensive users".

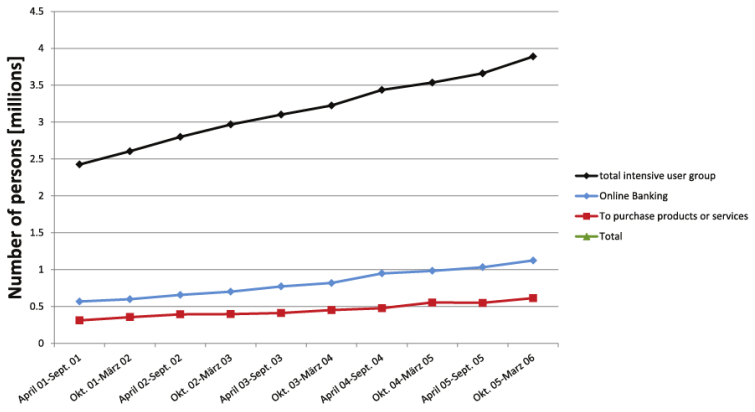

FIGURE 10: Number of internet intensive users, online banking users and online shoppers (2001-2006, BFS).

The BFS provides a forecast of future diffusion of this behavior too. This is made using a simple logistic model for the growth of the intensive internet users group and assuming that the proportion of online-banking users and online shoppers within this group does not change. The result can be seen in Figure 11.

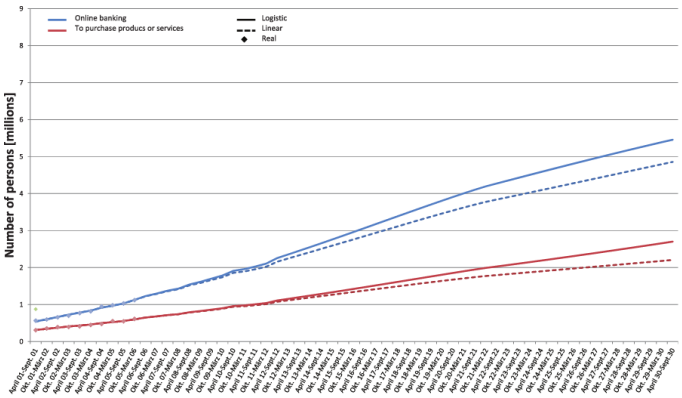

FIGURE 11: Number of online banking users and online shoppers (forecast, BFS).

The forecast shows that by 2030 almost the entire Swiss population over 14 years of age would use such services.

Teleshopping and travel behavior

Several studies have been made regarding the effects of teleshopping on a person's travel behavior. Although intuitively one would expect that online shopping would act at least partially as a shopping substitute, evidence does not support this, but on the contrary, results have encountered that teleshopping could even act as complement to traditional shopping activities. It all comes down to the motivations and reasons why people shop. Several researchers have found that particular characteristics of store-shopping such as enjoyment of the shopping experience and the social-recreational component are key variables to understand costumer behavior. There are several attributes inherent to store shopping that

cannot be attained by online shopping, such as sensual contact, ability to personally interact with sales representatives and store owners, socializing or simply escape from the routine (Mokhtarian, 2004). The empirical study of Parr and Lashua (2004), showed that more than 70% of Americans consider store shopping under some circumstances as pleasure. Figure 12 summarizes the results of several studies on the potential effects of teleshopping into traditional shopping activities (Andreev, 2010).

Nature of study		Character of the ICT impact for empirical study	Modeling approach		
Conceptual	Empirical		DCM	SEM	SEA
Tauber (1972)	Tacken (1990)	Substitution			●
Salomon and Koppelman (1988)	Koppelman et al. (1991)	Complementarity	●		
Salomon and Koppelman (1992)	Gould and Golob (1997)	Complementarity		●	
Gould and Golob (1997)	Handy and Yantis (1997)	No substitution	●		
Gould (1998)	Gould et al. (1998)	Complementarity		●	
Salomon (1998)	Sjögren et al. (1999)	Telemedicine-substitution			●
Underhill (1999)	Casas et al. (2001)	Complementarity			●
Mokhtarian (2000)	Zmud et al. (2001)	No substitution, complementarity			●
Gould and Golob (2002)	Gould and Golob (2002)	Complementarity			●
Koivumäki et al. (2002)	Hjorthol (2002)	Modification, neutrality			●
Koufaris (2002)	Luley et al. (2002)	Substitution			●
Chen and Dubinsky (2003)	Farag et al. (2003)	Complementarity	●		
Lee and Tan (2003)	Lenz (2003)	Substitution			●
Mokhtarian (2003)	Senbil and Kitamura (2003)	Neutrality		●	
Yoh et al. (2003)	Farag et al. (2004)	Complementarity	●		●
Dijst (2004)	Ferrell (2004)	complementarity			●
Mokhtarian (2004)	Kwan and Ren (2004)	Substitution (number of trips for frequent teleshoppers) Neutrality, complementarity	●		●
Rotem and Salomon (2004) Visser and Lanzendorf (2004) Cao and Mokhtarian (2005)	Krizek et al. (2005)	No substitution			●

FIGURE 12: Summary of studies dealing with transportation and teleshopping (Andreev, 2010)

A short summary of their conclusions:

- The majority of studies shows that teleshopping is no substitute for travel and might be a complement to traditional shopping activities.
- Mud et al. (2001) have concluded that shopping via the Internet does not eliminate travel and most likely even generates additional shopping trips
- Casas et al. (2001) showed that Internet shoppers do not travel less and in some cases travel even more than non-Internet shoppers.
- Tacken (1990) found that teleshoppers tend to save shopping time and traveled distance.
- Two studies from Germany did find a substitution effect as well: Luley et al. (2002) found reduction in the frequency of trips, while Lenz (2003) found 10% reduction of total shopping travel due to teleshopping.
- Farag et al. (2004) claimed that teleshopping complements store shopping.
- "E-shopping will substitute for store shopping at the margin, but both forms of shopping will probably continue to expand and co-exist. Thus, the dominant relationships between e-shopping and store shopping will not be replacement of the

latter by the former, but interactive augmentation and modification of both" (Mokhtarian, 2004).

Despite expectations that teleshopping could potentiality substitute for traditional shopping, the majority of studies have found that the teleshopping impact is more likely to be complementarity rather than substitution. On the other hand, studies on other maintenance teleactivities (e.g., telebanking, telemedicine) report about a substitution effect (Andreev, 2010).

CONCLUSIONS

The main finding of the research is that travel behavior did not change substantially in Switzerland in the span of time analyzed. The number of out-of-home activities and home-to-home journeys for the same age groups across cohorts is fairly stable, although the time spent at activities is slightly decreasing. Some change has been observed, however, in license ownership, car ownership, and public transport subscriptions. In all microcensuses is possible to observe saturation in the number of persons with driving license and car ownership. In the newest microcensus the level at which this saturation happens is slightly lower than before and it happens a bit slower too. This means that even if the percentage of people having a driving license is more or less the same as in the previous survey, some persons are getting the license later in their life course. This result can be interpreted in various ways. On the one hand it might reflect a reduced interest in driving and owning a car by newer generations, as already found by other researchers in previous studies (Goodwin, 2011). In support of this view there is also the impressive growth of the number of public transport subscriptions which more than doubled in the last 20 years. This trend is particularly strong among younger generations and more affluent people. Another possible interpretation is that the substantial increase in the number of immigrants in Switzerland – some of them coming without a driving license accepted by the Swiss authorities and therefore getting one at an older age – might have introduced a bias in this analysis. In the analyses presented, however, nothing supports this and further investigation in this direction would be needed. The peak analysis did not show substantial changes either. The only noticeable difference through the years is a tendency of the peaks to flatten out. The peaks are still there and at similar time of the day but are not as high as they used to be. A possible interpretation is that people have learned, at least in part, how to avoid congestion if they are not bounded to a particular time. Teleworking and teleshopping were also investigated. Our literature review shows that a much larger diffusion in the next 10 to 20 years is expected for both activities. We were not able, though, to answer the question to which extent this will influence individuals' mobility behavior in the future. It is still unclear if these activities will substitute some activities, therefore reducing travel – as many researchers and planners hope – or if they have a rather complementary role at best or they even generate additional travel as some studies on the topic assessed. Looking at the analyses made, the safest prediction for the future is probably a "business like usual" scenario. If the trends emerged in this study will go on in the next years, mobility patterns in 2030 will probably not depart substantially from current patterns. Nevertheless, there are some hints that the society is, slowly but steadily, moving on from a car centered mobility to a more varied and possibly complex

mobility style. This does not look yet like a revolution, but rather like an evolution which might anytime take a different pace.

REFERENCES

Andreev, P., I. Salomon and N. Pliskin (2010) Review: State of teleactivities, *Transportation Research Part C,* 18, 3–20.

ARE and BfS (2007) Mobilität in der Schweiz, Ergebnisse des Mikrozensus 2005 zum Verkehrsverhalten, Bundesamt für Raumentwicklung; BFS Statistik der Schweiz, Neuchâtel.

Balepur, P.N., K. V. Varma and P. L. Mokhtarian (1998) Transportation impacts of center-based telecommuting: interim findings from the neighborhood telecenters project. *Transportation*, **25**, 287–306.

Casas, J., J. Zmud and S. Bricka (2001) Impact of shopping via internet on travel for shopping purposes, paper Presented at *80th Annual Meeting of the Transportation Research Board*, January 2001,Washington, DC.

De Graaff, T. (2004) On the Substitution and Complementarity between Telework and Travel: A Review and Application,

ECaTT (2000) Benchmarking progress on new ways of working and new forms of business across Europe, *ECaTT Final Report*, Bonn.

Farag, S., K. J. Krizek and M. Dijst (2004) E-shopping and its relationship with in-store shopping empirical evidence from the Netherlands and the US, http://www.hhh.umn.edu/img/assets/3757/e_instore_shopping.pdf.

Goodwin, P. (2011) Three Visions on "Peak-car", World transport policy and Practice, **17**(4) 8-17.

Koenig, B. E., D. K. Henderson and P. L. Mokhtarian (1996), The travel and emissions impacts of telecommuting for the state of California telecommuting pilot project', *Transportation Research C,* 4, 13–32.

Lenz, B. (2003) Will electronic commerce help to reduce traffic in agglomeration areas? *Transportation Research Record: Journal of the Transportation Research Board*, 1858, 39–46.

Luley, T., W. Bitzer and B. Lenz (2002) Travel substitution by electronic Commerce? A simulation model for the Stuttgart region (in German), *Zeitschrift für Verkehrswissenschaft*, 73, 133–155.

Mokhtarian, P. L. (2004), Reducing road congestion: A reality check – a comment, *Transport Policy*, **11**, 183–184.

Mokhtarian, P. L., M. N. Bagley and I. Salomon (1998), The impact of gender, occupation, and presence of children on telecommuting motivations and constraints, *Journal of the American Society for Information Science,* **49**, 1115–

1134.

Mokhtarian, P.L. and K.V. Varma (1998) The trade-off between trips and distance traveled in analyzing the emissions impacts of center-based telecommuting, Institute of Transportation Studies, *UC Davis in Institute of Transportation Studies series*, Working Paper Series UCD-ITS-REP-98-16.

Nilles, J. M., F. R. Carlson, P. Gray, and G. J. Hanneman (1976), *The Telecommunications-Transportation Tradeoff*, New York.

Nilles, J. M. (2000) Telework in the US, telework America survey 2000, JALA International, *International Telework Association and Council*.

Parr, M.G. and B.D. Lashua (2004) What is leisure? The perceptions of recreation practitioners and others, *Leisure Sciences*, 26, 1–17.

SIBIS (2002) Measuring the Information Society in the EU, the EU Accession Countries, Switzerland and the US, *SIBIS Pocket Book 2002/03*, empirica Gmbh, Bonn.

Tacken, M. (1990) Effects of teleshopping on the use of time and space, *Transportation Research Record* **1285**, 89–91.