TRIP CHAINING AND ITS IMPACT ON TRAVEL BEHAVIOUR

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INTRODUCTION

Historically, trips were at the basis of main transportation models. With the increasing complexity of travel and the increasing capacities of technological and mathematical tools, models are being updated to more efficiently represent the underlying logics of travel behaviours. Activity-based models and the study of entire trip chains have now become the focus of model development. This paper builds on large-scale travel survey data collected during the 2003 Montreal OD survey and proposes various contributions to the body of knowledge regarding trip chaining behaviours.

The paper proposes a typology of trip chains based on the spatial-temporal structure of trips and activity type at the destination. Anchor points, loops and dominant activities are defined and used for classification purposes. A hierarchical classification of simple and complex trip chains is derived and used to measure the occurrence of typical trip chaining behaviours among an active population segment, the 25-44 years old.

The paper is organised as follows. First, some background notions regarding the study of travel behaviours and trip chaining are provided. Then, the methodology is defined. An entire section is devoted to the presentation of a trip chain typology along with summary analysis of the occurrence of these various types of chains for the population under study. Relations between trip chaining and socio-demographic variables are then examined and discussed. A conclusion follows.

BACKGROUND

Activity models

Typical transportation models rely on the notion of single trips. The widely used four-step model predicts the number of trips that will occur in a study area and relies on this simple concept through the four steps in order to estimate the level of usage of various transportation infrastructures. The four-step model is simple and economical. However, it can hardly tackle behavioural analyses and many limitations emerge when analysts want to perform more complex analyses or look at the impacts of innovative strategies. Many have discussed these difficulties, often due to the fact that four-step models are not representative of individual travel behaviours. Indeed, such models allow examining trips from one point to another without considering the socio-demographic characteristics of the individuals performing these movements. Moreover, according to a study conducted by the Virginia Department of Transportation (2009), the four-step model presents some difficulties in estimating impacts of certain policies, such as road pricing, scenarios of transit fares, land use control, non-motorized modes, traffic volumes and speeds at specific times or movement of freight vehicles.

Faced with these limitations, the increasing complexity of travel behaviours and the increasing capacities of technology, new modelling approaches are being developed to enhance the relevance of models and outputted results. Activity-based models are one of the directions taken by the research community in order to enhance modelling capacities. These models rely on the notion that trips are a derived demand for the necessity, or desire, of individuals to perform out-of-home activities in various locations. One of the strong point of this model is its disaggregate nature since it performs the analysis at the individual level (set of trips made by an individual). Davidson et al. (2007) identify three important and positive features of this new generation of models:

- they are tour-based i.e. the tour instead of the single trip is the base unit for modelling travel.
- they rely on an activity-based platform that implies that travel is derived within the general framework of the daily activities undertaken by households and persons
- micro-simulation techniques are applied at the disaggregate level of persons and households.

Behaviours of individuals and households are examined simultaneously to account for combined trips and the negotiation between individuals to gain access to mobility tools. With this underlying framework, it is easier to address more complex behaviours. It is also easier to make comparisons between each household and not just between sectors. Figure 1 presents the typical structure of an activity-based framework.

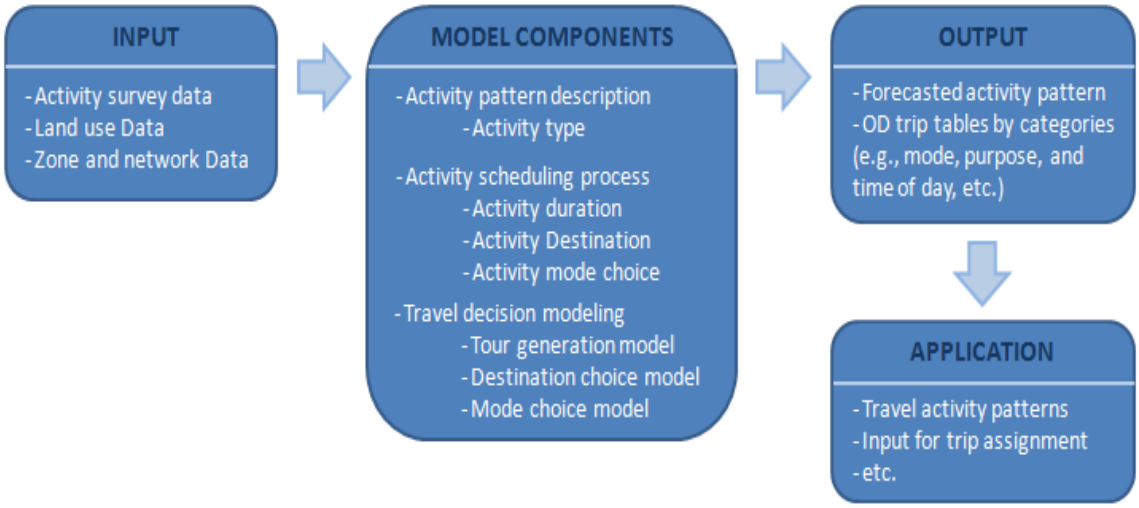

Figure 1. Input, model components, output and application of activity-based approaches

Tour or trip chain

Activity-based models support analysis at the tour or trip chain level. Several authors have conducted studies on daily behaviours for typical days and propose various definitions of a trip chain. For instance, McGuckin and Murakami (1999), suggest that a trip chain is a series of trips between two anchor points, home and work. Others suggest that a trip chain includes all trips between leaving home and returning to it. It is the case for Primerano et al. (2007) and Srinivasan (1998). Holzapfel (1986) is mostly in agreement with this previous definition but adds that a trip chain is not necessarily only "home – activity – home", but can also be "home - activity 1 - activity 2 - activity N – home".

In addition, several authors have examined statistical relations between trip chains and variables such as gender, age, presence of children in the household, mode of travel, residence location and others. First, gender greatly influences trip chains. According to Kumar and Levinson (1995), women have a higher likelihood of performing multiple activities during their trip chains than men. In addition, women do more trip chains per day than men. Primerano et al. (2007) focus their analysis on the trip purposes of men and women. The results show that women perform a greater number of simple trip chains for shopping, drop-off and pick-up than men. Household composition also greatly influences trip chains. According to McGuckin and Murakami (1999), the presence of children increases the number of activities involved in single trip chains. Also, the younger are the children, the more this phenomenon is amplified. In addition, single-parent households tend to make more stops in their chains (increased complexity). In terms of transportation modes, Kumar and Levinson (1995) mention that a good accessibility to activity locations has an effect on the number of trip chains: people will be less likely to combine activities and will do simpler trips chains. Moreover, cars being more flexible, the complexity of trip chains generally becomes greater when they are used.

METHODOLOGY

Information system and study area

In the Greater Montreal Area (GMA), in Canada, large scale travel surveys are conducted approximately every five years since 1970. These surveys provide rich data on the travel behaviours of around 5% of the residing population. In 2003, some 70,000 households were surveyed, providing socio-demographic details for these and for the people they gather as well as spatial-temporal information on every trip made by them during a particular weekday (people aged 5 years and older). Home location as well as trip ends are geocoded with x-y coordinates and allow for precise estimation of distance travelled. These data have the potential to reveal how people schedule their daily out-of-home activities and how this schedule translates into trip sequences.

For this research, only people residing on Montreal Island and aged between 25 and 44 years old are observed. The island of Montreal includes a total of 16 cities, including the largest city in the province of Quebec; Montreal. Its population reaches almost 1.8 million inhabitants spread over an area of nearly 500 km^2. Alone, the island of Montreal accounts for nearly a quarter of the population of the province of Quebec. Behaviours of the people aged between 25 to 44 years old are examined; this population segment is interesting since it is one of the most active population segments. In addition, this age group is the most likely to be part of households with children, a feature that affects the spatial-temporal structure of travel behaviours. In total, this sample (unweighted) includes 17,982 people generating 23,593 trips.

Methodology

The OD survey dataset was processed to extract only the trips made by people aged between 25 and 44 years old and residing on Montreal Island. Once extracted, travel behaviours are sequentially examined to identify trip chains (enumeration process) and to characterize them based on the number of trips, trip purpose (activity type) and spatial-temporal structure. The sequence of steps required to identify and classify trip chains is illustrated in Figure 2.

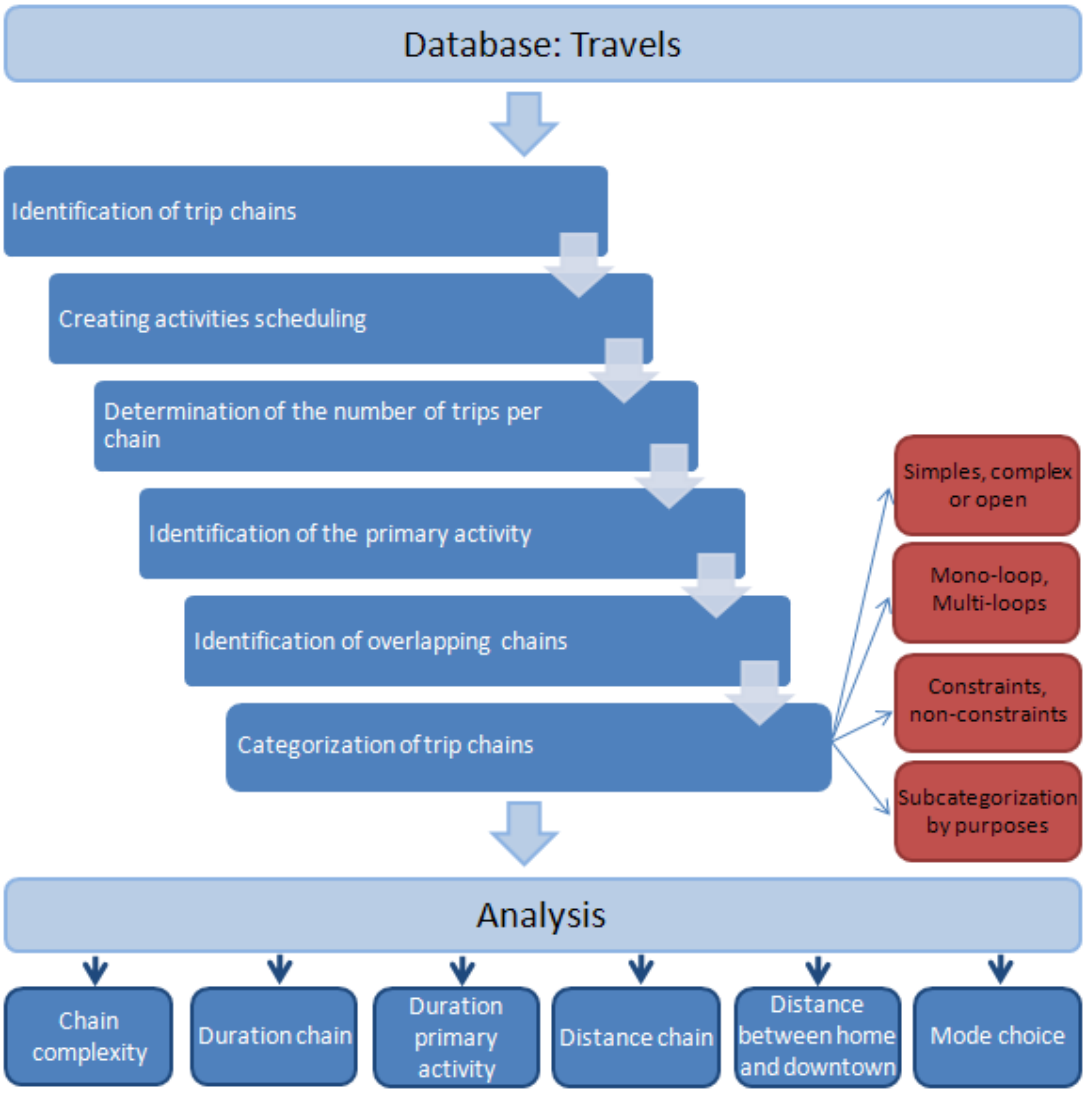

Figure 2. Various steps involved in the enumeration and classification of individual trip chains

KEY DEFINITIONS AND TRIP CHAIN TYPOLOGY

This section provides the key definitions required to develop a typology of trip chains.

Concepts

First, trip chains are based on anchor points. These anchor points are important and fixed spatial locations. For the purpose of this study, three locations can be set as anchor points: home location, workplace and study place. The home location is set as the anchor point at the beginning and end of every trip chain. Work and study activities are often considered mandatory; we will refer to those as constraint activities. Many of the people in the examined population segments will, during a typical weekday, travel for at least one of these purposes if not for both. Work place and study place are therefore important locations in the daily travel

behaviours of individuals; thus, the proposed typology will need to take these anchor points into consideration. Moreover, intermediate trips will often be linked to primary trips leading to these anchor points.

This leads to the definition of other important concepts: primary and secondary activities. The primary activity of a trip chain is the one with the longest duration. But if work or study is in the trip chain, it becomes the primary activity even if it is not the longest activity. Typically, primary activities are located at anchor points. However, other trip purposes may result in primary activities, especially when there are no work or study trips in the chain. In these cases, the activity with the longest duration will be set as the primary activity. The secondary activities are all the other activities conducted between home location and the primary activity of a trip chain. Thus, trip chain will include a single primary activity, and one or many secondary activities. Let's look at an example. A person leaves home for work but first, stops at the corner store to buy a newspaper. At the end of the day, he makes a stop at the grocery store on his way back home. Thus, this person makes one trip chain with two anchor points (home location and work place), whose primary activity is work and that has two secondary activities.

Another important concept is the loop. A loop includes all trips between the departure and arrival at a specific anchor point. For instance, in the example above, the person travels from his home location to the corner store and then proceeds to work. In the afternoon she stops at the supermarket on its way back home. This trip chain contains only one loop since it started and ended at the home location, no other anchor point is accessed twice during the chain. However, if that person leaves the office at lunch time to go to a restaurant and then comes back to its workplace, then another loop is created from that second anchor point (workplace). These two loops form a single trip chain.

Classification

Relying on these various concepts, classes of trip chains are proposed. These classes are determined by the number of trips per chain, the number of loops and the primary purpose of the chain. Bath and Singh (2000) applied a similar approach to the identification of tours and episodes.

Simple, complex and open trip chains

Using the previous concepts, a typology of trip chains is proposed and key figures for the population segment under examination are estimated. For the purpose of this research, the typology is inspired by the one proposed by Primerano et al. (2007) and Strathman (1994). According to data taken from the 2003 Origin-Destination (OD) Survey, three main classes of trip chains are discerned:

- Simple chains: it is the simplest form of trip chain and contains two trips and one activity in-between. These trip chains are very common and represent a little more than three quarters of all daily trip chains. Figure 3 exemplifies such trip chain.

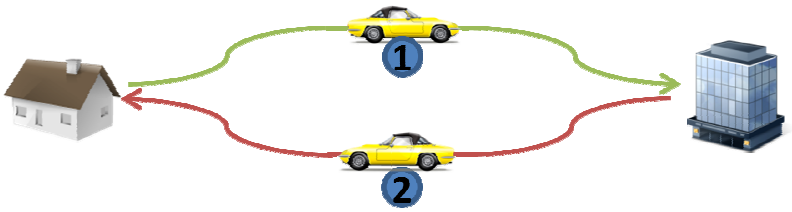

Figure 3. Illustration of a simple trip chain

- Complex trip chains. This category includes all trip chains with at least two activities. In other words, the complex chains are those which include a primary activity and one or more secondary activities. Of all observed trip chains, almost 19% of them are considered complex. Figure 4 exemplifies the concept of complex trip chains.

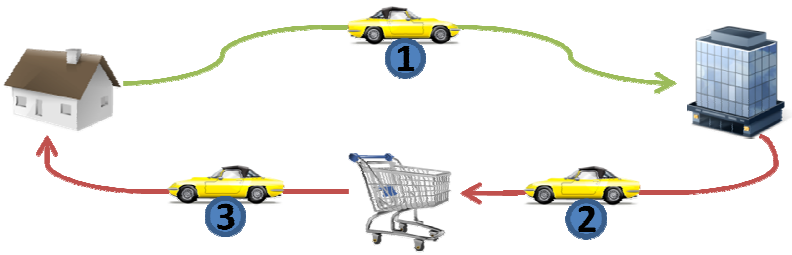

Figure 4. Illustration of a complex trip chain

- Open chains. These are chains that typically lack a starting or closing trip (unbuckled loops for example). Their existence can either be the result of an incomplete trip diary or due to the truncation of observations (only one day of observation). This type of trip chain is still very uncommon. Indeed, some 4% of the trip chains are open.

According to the 2003 OD survey, people aged 25-44 years old did 23,595 trip chains during a typical weekday. The following figure summarizes the prevalence of the three previous types of trip chains for the population under study (Figure 5).

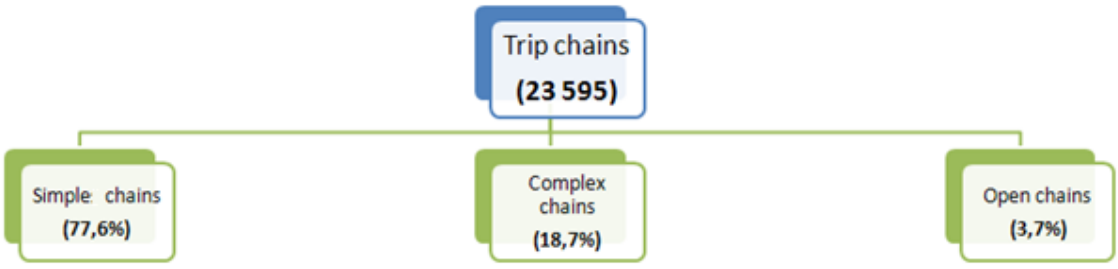

Figure 5. Key facts regarding the distribution of trip chains: simple, complex and open chains

Mono-loop and multi-loops trip chains

Complex trip chains can then be exploded in more precise classes based on their spatial-temporal structure. Complex chains can either be mono-loop or multi-loops.

- The mono-loop trip chains are composed of several trips but each location is visited only once. Also, it is anchored at the home location. More than 90% of all complex trip chains are mono-loop chains. Figure 6 exemplifies this concept.

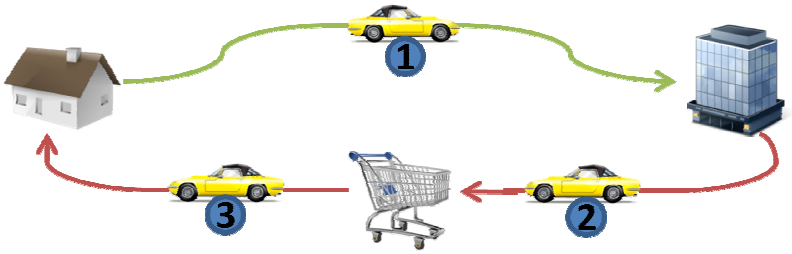

Figure 6. Illustration of a mono-loop trip chain

The remaining 10% of complex trip chains are multi-loops trip chains. These complex trip chains are composed of two or more loops, one of the loops being anchored at the home location. For example, an individual goes to work. At lunch time, he travels to a restaurant and then comes back to its workplace. He then returns home at the end of the day, closing both the loop anchored at the home location and the trip chain. Figure 7 exemplifies the concept of multi-loops trip chains.

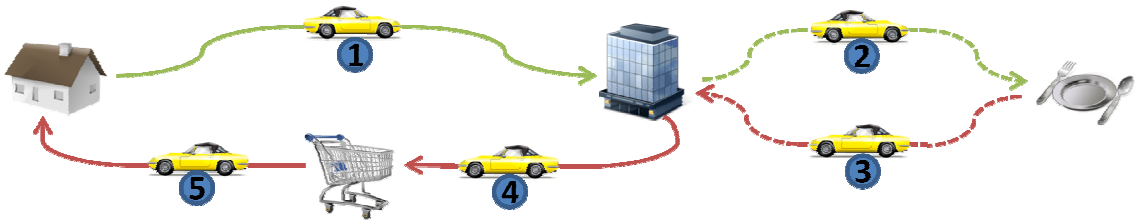

Figure 7. Illustration of a multi-loop trip chain

The segmentation of complex chains into mono-loop and multi-loops chains is summarised in Figure 8.

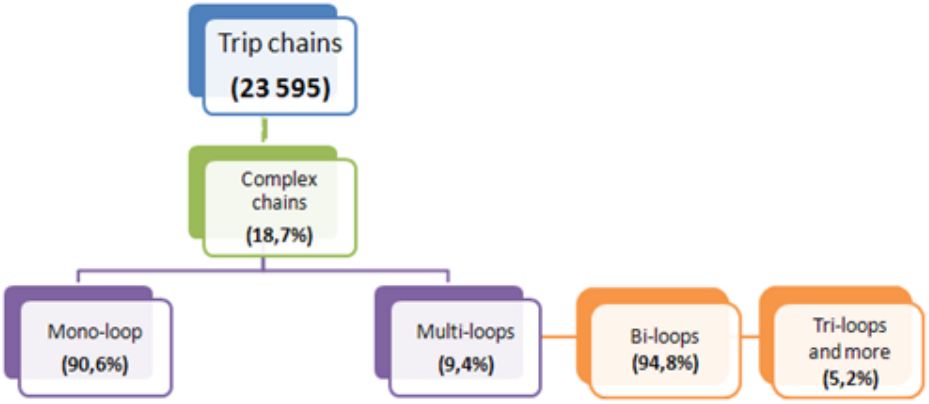

Figure 8. Key facts regarding complex trip chains

Constraint and non constraint trip chains

Trip chains can also be classified according to the purpose of the trip leading to the spatial location (activity type). We often relate to activity type in terms of constraint and non-contraint

activities. To be considered constraint, a trip chain must have at least one trip whose purpose is work or study. These two purposes are typically linked to mandatory activities and hence have precedence over other activities. Trip purposes such as “go get someone” or “drop someone”, when considered primary in the trip chain, are also classified as constraint trip chains. It is true that driving someone somewhere is often an obligation if not a burden since the passenger often depends on the driver to go from one place to another. It is the case, for instance, for parents that drive their children to school or for couples needing to organise all their travel needs with only one car.

Inversely, non-constraint trip chains combine trips related to leisure, shopping or other non-mandatory purposes.

Constraint trip chains are very frequent with around 72% of all trip chains. Also, the prevalence of constraints chains is higher within the complex chains group. Almost 94% of the observed multi-loops complex chains are constraint and more than 76% of mono-loop complex chains are constraint. It is also high for simple trip chain where more than 71% of the chains are constraint (see Figure 9).

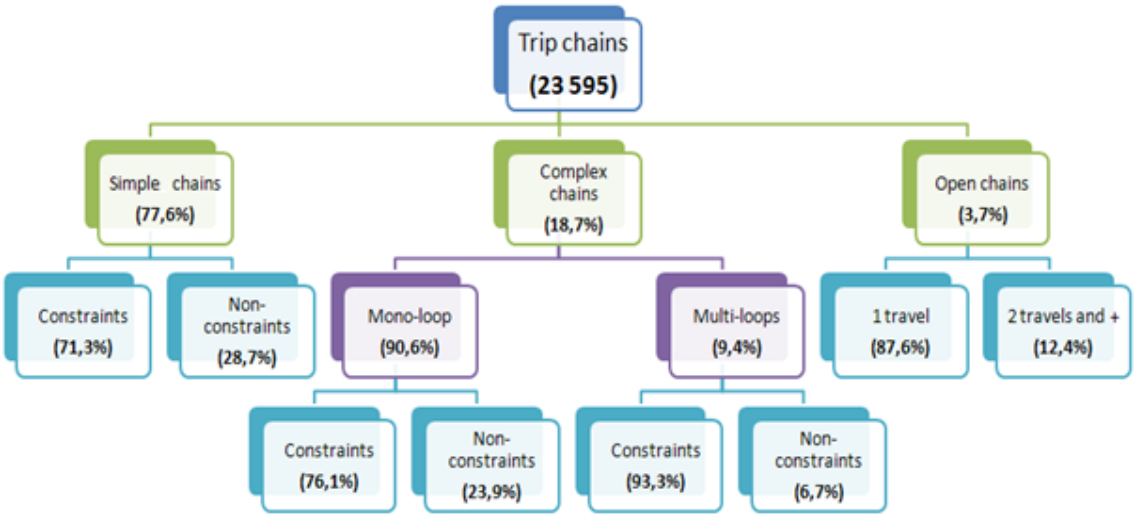

Figure 9. Key facts regarding trip chains in terms of being constraint or not

Classification according to trip purpose

A refinement of the previous classification is performed using trip purposes. As mentioned previously, work and study are basically associated with constraint chains and the other purposes are related to non-constraint chains. Hence, for simple constraint chains, three sub-classes are added: work, study and dropping-off / picking-up someone. As detailed in Figure 10, the majority of simple constraint trip chains are linked to work purposes (almost 75% of the chains). Driving someone to a destination accounts for 16% of these chains and almost 10% are due to study purposes. Simple non-constraint trip chains are also exploded in more classes, for the other typical purposes. The most frequent type is for shopping and almost equally Social and Recreation purposes. Both classes account for more than 80% of all simple non constraint trip chains.

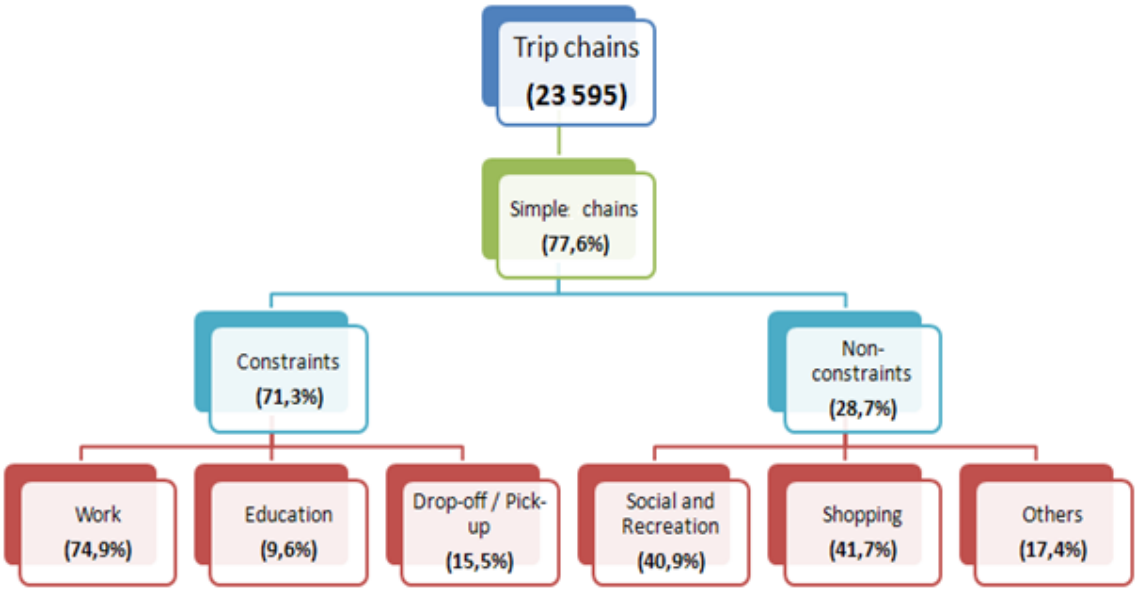

Figure 10. Key facts regarding trip chains with respect to trip purposes

A similar classification was applied to complex chains but with more classes since a complex chain can contain multiple activities (work and study for instance). Since it can sometimes be complicated to decide which constraint activity predominated, a class with both purposes was added. Key facts are summarised in Figure 11. Similarly to simple chains, work accounts for a majority of trip chains (more than 82%). For non-constraint complex mono-loop chains, shopping is the most frequent type of chains with almost 42%, followed by social and recreation (approx. 36%).

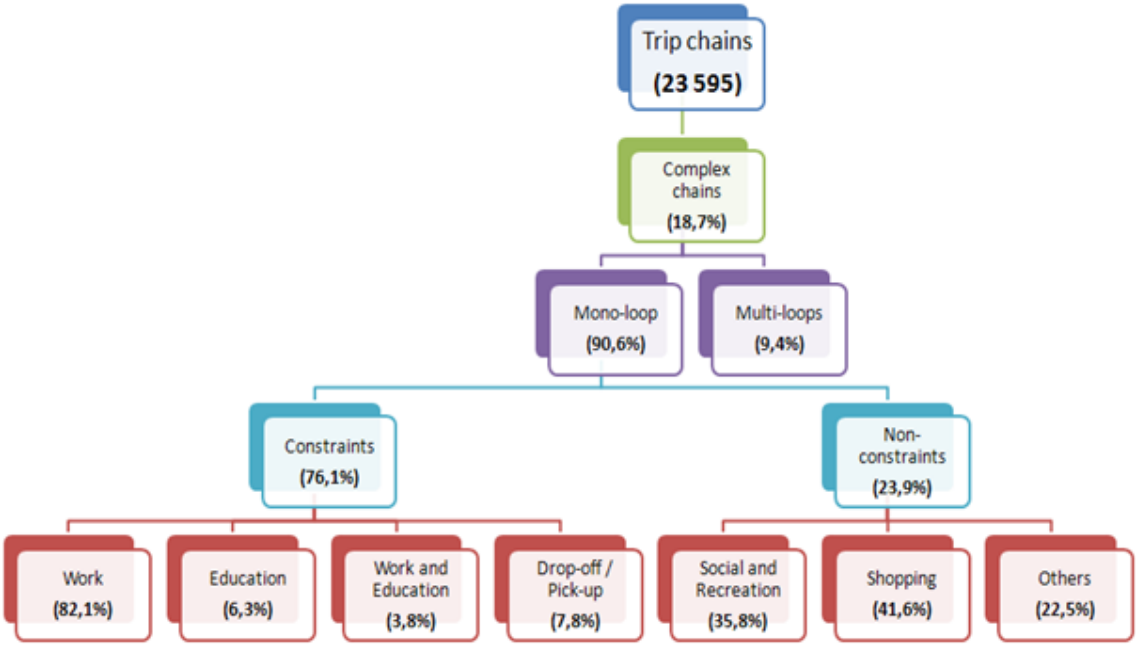

Figure 11. Key facts regarding mono-loop complex chains

For multi-loops, constraint chains are again predominantly linked with work (more than 94%) and non-constraint chains are more frequently related to social and recreation. The details of this classification are provided in Figure 12.

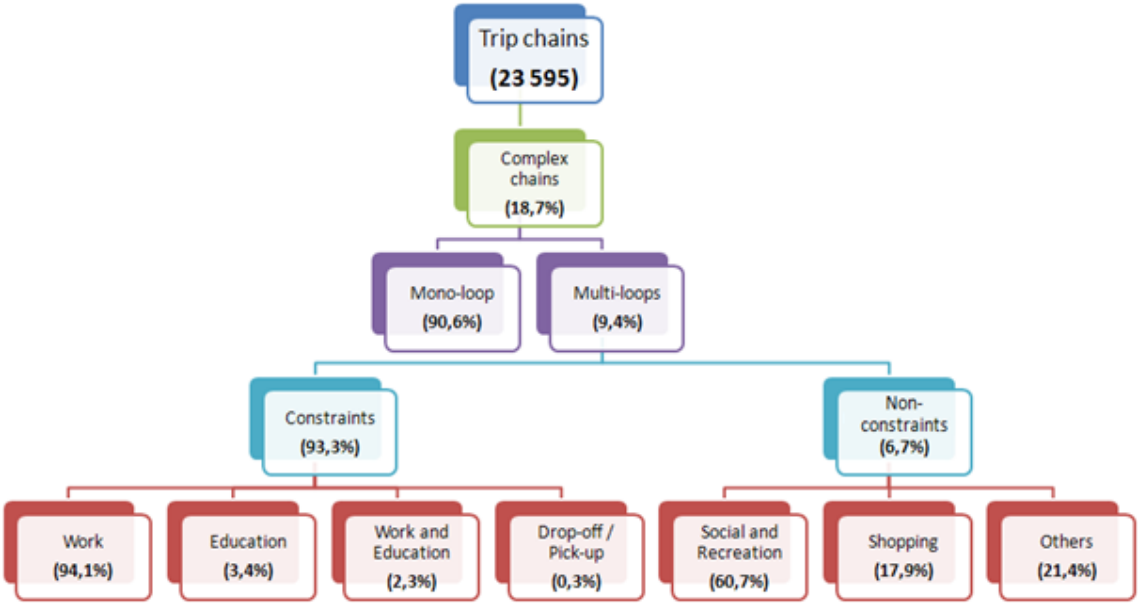

Figure 12. Key facts regarding multi-loops non-constraint trip chains

Using all these classes, it is possible to identify the most important trip chaining behaviours of the 25-44 years old residents of Montreal Island. Table 1 lists the ten most frequent trip chains. These ten types account for 95.3% of all trip chains performed by this population segment. Simple constraint chains for work purpose are the most frequent type of chains and gathers almost 42% of all chains. Also, six of the most frequent types of chains are simple and account for 78% of all trip chains.

Table 1. Most frequent trips chains observed in the GMA for 25-44 years old residents

10 most frequent trip chains *25-44 years old and resident of the Montreal Island* *2003 OD survey*	
Trip chain	**%**
Simple constraint chain: Work	41.8%
Complex mono-loop constraint chain: Work	10.4%
Simple non-constraint chain Shopping	9.6%
Simple non-constraint chain Leisure	9.1%
Simple constraint chain: Traveling someone	8.5%
Simple constraint chain: Study	5.3%
Simple non-constraint chain: Other purposes	3.7%
Open chain	3.7%
Complex mono-loop non-constraint chain: Shopping	1.7%
Complex mono-loop non-constrain chain: Leisure	1.5%
Total (ten more frequent)	**95.3%**

Analysis and results

This section presents an analysis of the relation between various indicators describing trip chains and socio-demographic variables. The purpose is to validate whether people with different attributes have different spatial-temporal behaviours and to put the basis for upcoming modelling development. The variables examined are home location, gender and household size. On average, people aged 25-44 years old will do 1.31 chains per day. Overall, the difference between men and women is slight: 1.30 for men vs 1.32 for women. Also, the average number of trip chains per day increases with age, from 1.27 for the 25-29 years old to 1.34 for the 35-44 years old. Home location is first examined using maps and then using distance to CBD (Central business district).

The following sections look more deeply into the impacts of various attributes.

Indicators used to describe trip chains are:

- Average number of trip chains
- Complexity of trip chains: *ratio between the number of trips and the number of chains*
- Average duration of trip chains: *difference between the time of departure of the last trip of the chain and the time of departure of the first trip of the chain*
- Average length of trip chains: *sum of all trip straight line distances*

Key facts

Age and gender seem to influence the way people organise their daily activities, in space and time. At first, we observe that younger people will tend to have less complex daily patterns. The following figure summarises the distribution of daily behaviours according to various combinations of trip chains for population segments. At least 54% of all groups do only one simple trip chain per day. The share of people doing only one simple chain per day decreases with age and is always lower for women. Also, women are more numerous to do complex chains (Figure 13).

A simple mapping of various indicators describing typical chaining behaviours by home location shows that people residing in the western part of the Island will typically do more trip chains per day and these chains will be longer, in terms of kilometres travelled. They also have higher proportions of complex trip chains. These areas are known to be wealthier (higher average income per household) and are more dominantly English speaking (see Figure 14).

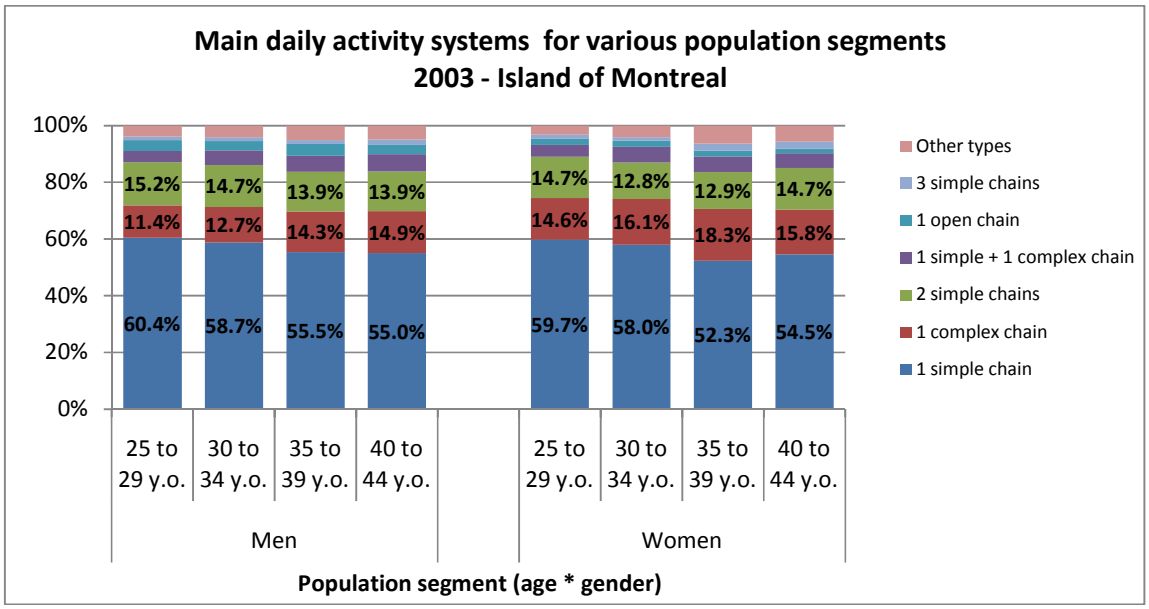

Figure 13. Main daily activity systems for various population segments (2003 - Island of Montreal)

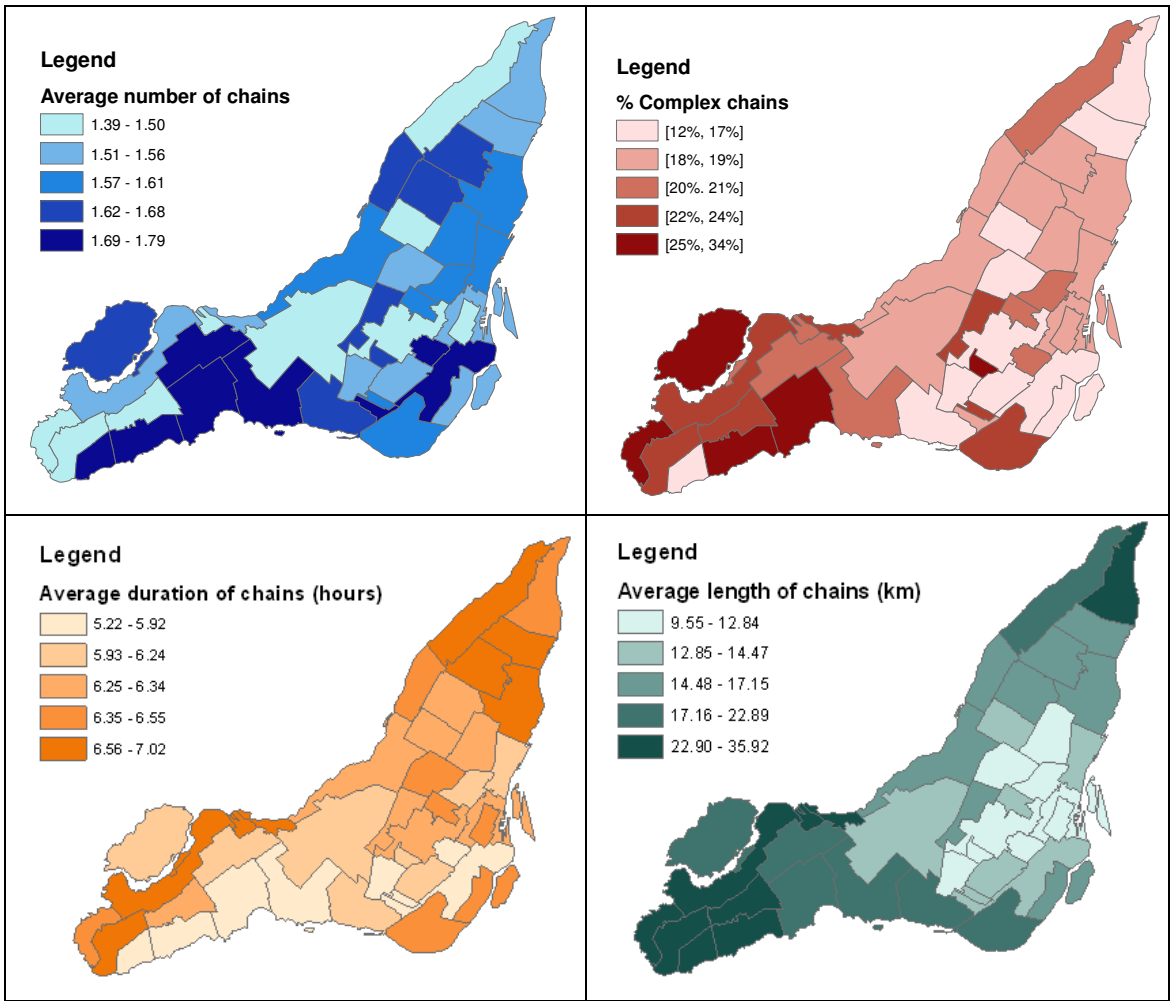

Figure 14. Average number of trip chains per day, average duration of chains, average length of chains and proportion of complex chains, for analysis zones

Average number of trip chains

When examining solely the average number of chains with respect to home location, expressed as the straight line distance from CBD, no significant differences appear. The values oscillate between 1.23 and 1.40, with no specific pattern. Actually, the previous map confirms no typical spatial patterns but reveals spots with distinctive values. It appears that areas with higher average income values show higher number of trip chains.

Three classes of car accessibility within the household are used to measure impacts on trip chaining:

- 0: no car available in the household;
- <1: less than one car available per potential driver in the household (shared access);
- >=1: at least one car available per potential driver. This means that everyone needing to travel can use the car without limitation due to unavailability.

Data show that having no access to a car reduces the number of trip chains per day but the difference is small. Also, women having a shared access to a car do, in average, more trip chains per day and those aged 40-44 years old have the highest average.

Table 2. Number of trip chains per day according to car accessibility

	Men				Women		
	0	**< 1**	**>= 1**		**0**	**< 1**	**>= 1**
25 to 29 y.o.	1.24	1.28	1.28		1.21	1.29	1.29
30 to 34 y.o.	1.24	1.31	1.29		1.23	1.32	1.27
35 to 39 y.o.	1.27	1.33	1.32		1.28	1.40	1.28
40 to 44 y.o.	1.28	1.34	1.30		1.26	1.42	1.28
Sample	**1790**	**5450**	**1870**		**1860**	**5500**	**1510**

The size of the household to whom the individual belongs do have an important impact on the number of trip chains per day, namely for women of all ages but more importantly for the 35-44 years old. For this population segment, the number of chains per day increases with the size of the household (from 1.24 to 1.48).

Complexity of trip chains

The complexity of trip chains is the average number of trips per chain. When examined solely according to distance from CBD, no systematic trend is observed. The map presented in Figure 14 already showed this. Again, the western part of the Island, with higher average income, is distinctive.

Household size (from 2 to 4 people and more) is positively correlated with complexity of trip chains for all population segments, and more importantly for women. An additional person in the household translates into 1.5 to 6.5% increase in chain complexity. Women aged 35-39 years old and living in 4 or more people households have the highest chain complexity (2.46 trips per chain, on average). Figure 16 presents this relation.

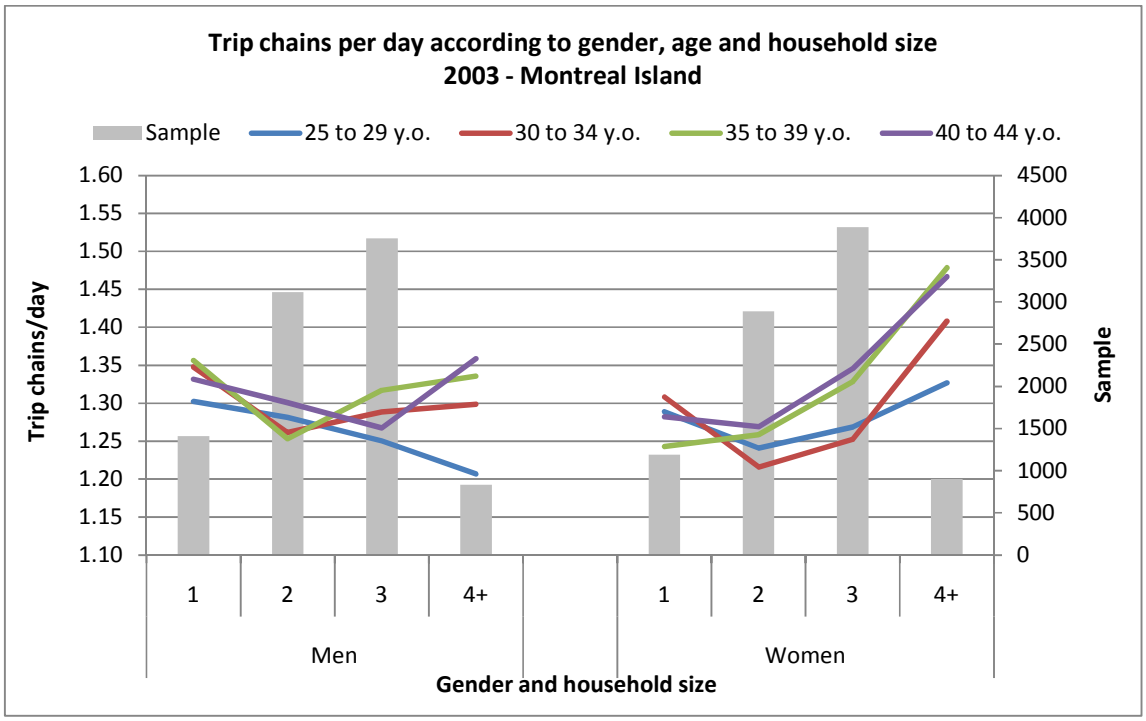

Figure 15.Trip chains per day according to gender, age and household size (2003 - Island of Montreal)

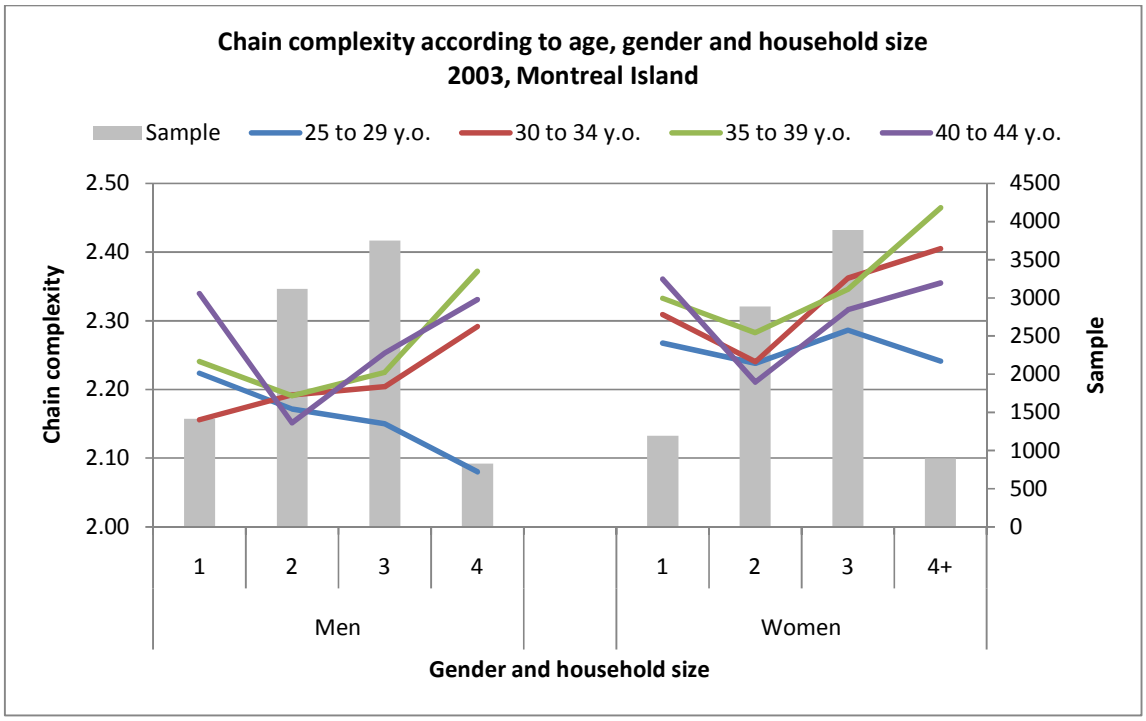

Figure 16.Chain complexity according to gender, age and household size (2003 - Island of Montreal)

Average duration of trip chains

Since travel times are not collected during the travel survey, the average duration of trip chains is estimated using the time of departure of first and last trip of the chain. The total out-of-home time is hence underestimated; still, values can be compared since estimated similarly. The overall average trip chain duration is 7.12 hours; however, this duration is directly linked to the primary purpose of the chain, as can be seen in Figure 17. As predicted, trip chains related to work activities are the longest, for men and women, followed by chains due to study activity. Women only have longer duration chains for shopping. A higher complexity of chains is also related to chains for constraint activities.

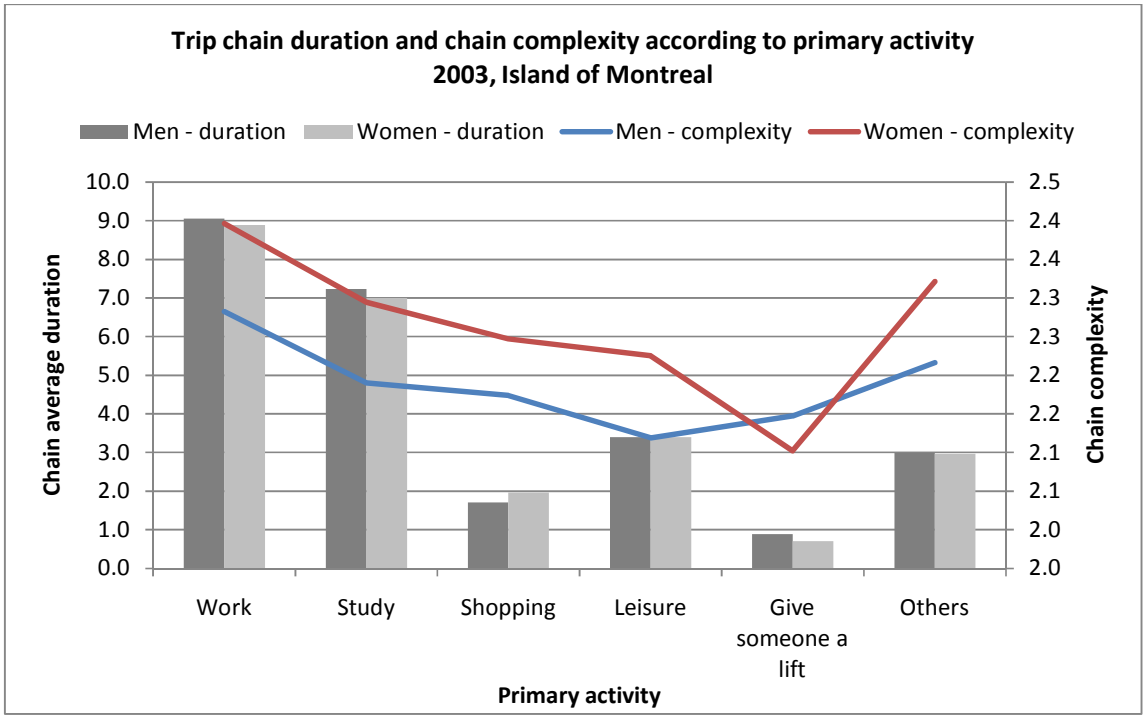

Figure 17. Average duration of trip chain according to primary purpose (2003 - Island of Montreal)

The cumulated frequency distribution of chains according to duration, for various population segments, allows observing the impacts of demographic features on duration. The following table illustrates this distribution using various cut-off points, for comparison purpose. We see that people living in households with young children have a more compact distribution with almost 10% of their trip chains lasting less than one hour; this is directly related to the fact that these people also have a higher number of trip chains per day (1.34 vs 1.29 for those living in households with no young children). People aged 25 to 29 years old, in counterpart, have the most dispersed distribution with just under 4% of chains with durations of less than one hour and just under 20% lasting less than 4 hours; it is no surprise that they have the higher mean trip chain duration. In fact, number of trip chains and duration of chains have a -0.50 correlation factor.

Table 3. Cumulated frequency distribution of trip chains for various segments

Proportion of trip chains of this duration for:	25 to 29 y.o.	30 to 44 y.o.	Household with children (0-4 y.o.)	No car	Women
less than 1 hour	3.81%	6.04%	9.79%	4.41%	6.90%
less than 2 hours	9.29%	13.17%	19.15%	11.08%	14.78%
less than 4 hours	19.90%	23.88%	31.20%	23.62%	26.69%
less than 8 hours	47.51%	48.88%	53.08%	52.54%	50.74%
less than 10 hours	75.97%	75.87%	77.69%	78.43%	79.78%
less than 12 hours	90.52%	91.90%	93.07%	91.99%	93.18%
Mean trip chain duration	7.34 h	7.05 h	6.49 h	6.92 h	6.77 h

Average length of trip chains

The last indicator examined is the total distance travelled during trip chains. This is one of the variables that clearly have a spatial trend: it increases with distance from CBD as a consequence of the increasing distance between home location and activity location. On average, every kilometre further from the CBD translates into an increase of the mean trip chain length of 0.68 km.

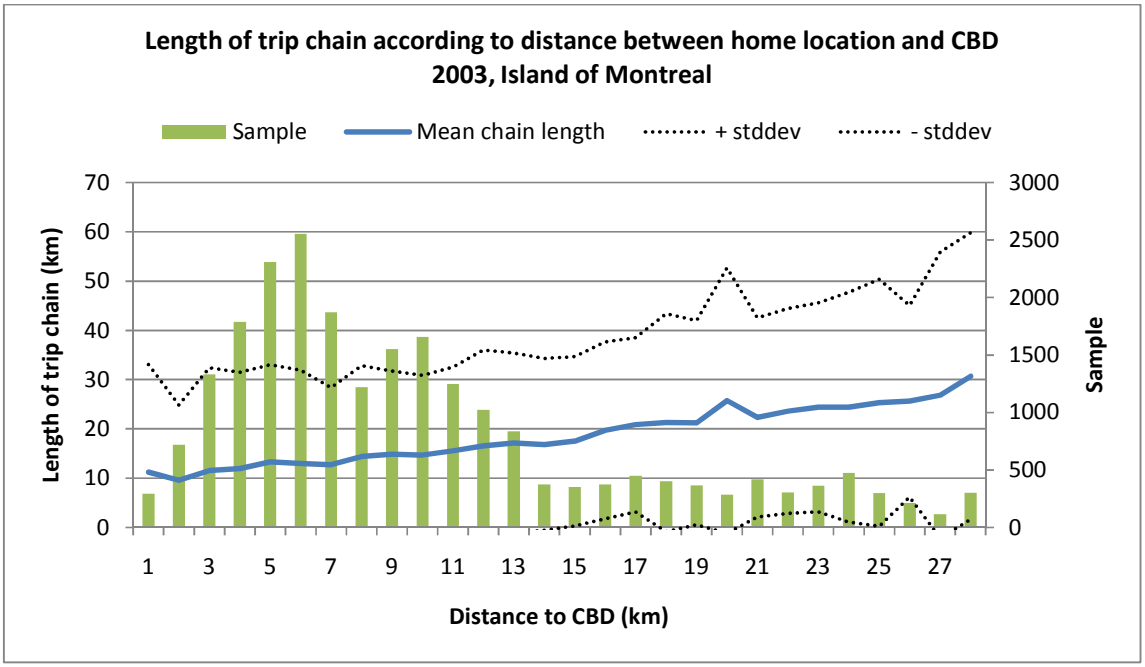

Figure 18. Average length of trip chain according to distance between home location and CBD (2003 - Island of Montreal)

Mean trip length is also related to socio-demographic features (see Figure 19) and seems to be inversely related to the average number of trip chains per day. On the one hand, we clearly see that the number of trip chains per day is lower for higher classes of trip chain lengths for both men and women and for all ages. On the other hand, we observe that an increase in the number of trip chains per day translate into a decrease of kilometres travelled

per trip chain. The relation could be in both directions: people who need to go far, will do one single trip chain with higher activity duration and gave less time left to do other activities. Also, people who do multiple chains could explode their needs to go to various places in multiple tours.

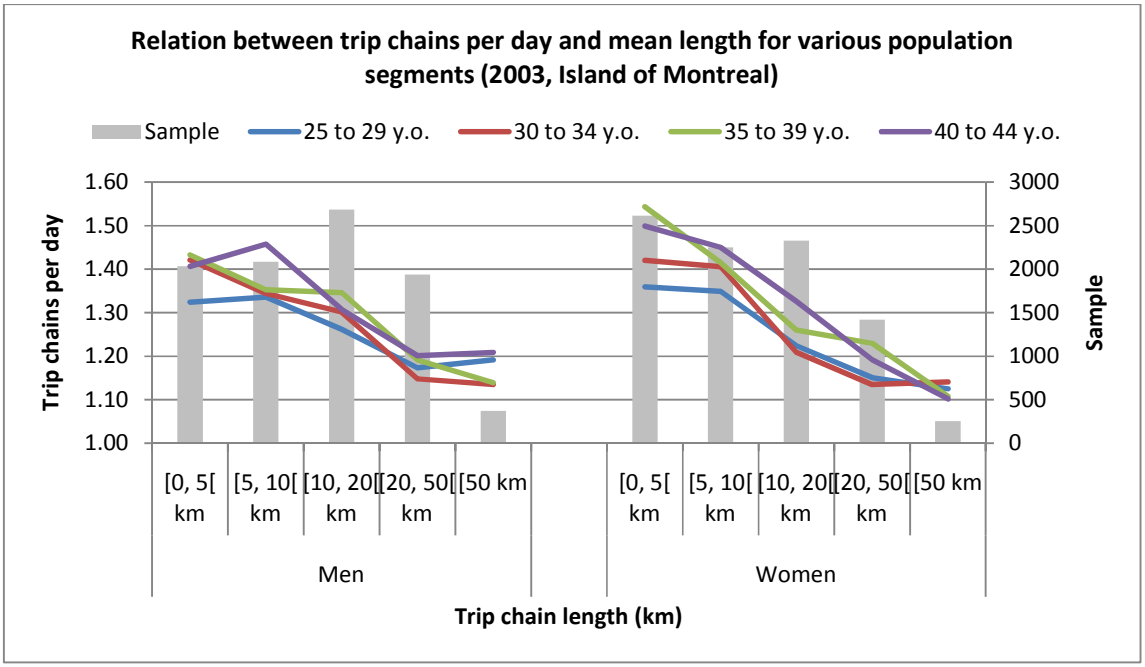

Figure 19. Average length of trip chain according to distance between home location and CBD (2003 - Island of Montreal)

Interactions

It is clear that the previous analysis does not consider the combinatory impacts of the socio-demographic features on the indicators describing trip chains. As a start point for more extended modelling experiments, some simple linear regression models, including a set of explanatory variables, were tested to see if they were somehow related to one of the trip chain indicators. These variables are: population density and mean / median household income (zonal attribute), gender, age group, presence of children, household size, car ownership, and distance to CBD.

The basic modelling attempts conducted did not provide any good results and call for more in-depth modelling development. They nevertheless confirmed the influence of some explanatory variables, within the available ones:

- Number of trip chains:
  - higher if: presence of children in the household (5-9 years old have the highest impact, followed by 10-16 years old and 0-4 years old), single-person households, leaves near the CBD (< 5 km);
  - lower for people living in non-motorised households.
- Complexity of trip chains:
  - higher if: the presence of 0-9 years old children (more importantly for 5-9 years old), leaves near the CBD (< 5 km) and lives alone;

  - lower if: people living in dense and low-income areas (more important impact), men, non-motorised households, 25-29 years old.
- Average duration of chains (hours):
  - higher if: men, aged 25-29 years old, distance from CBD (increases with);
  - lower if: children of any age in the household (more important impacts for 0-4 years old, then 5-9 years and 10-16 years old), no car available in the household, decrease with increasing population density of lived-in area.
- Average length of chains (km):
  - higher if: increasing median income of home neighbourhood, men, lives alone, increasing with distance from CBD.
  - lower if: children of any age in the household (more important impacts for 10-16 years old, then 5-9 years and then 0-4 years old), no car in the household.

CONCLUSION

This paper has first proposed a typology of trip chains based on concepts such as loops, anchor points and activity type. It is an integration of various definitions found in the literature. It has also proposed four indicators describing the features of these trip chains.

Some analyses were then conducted using large-scale Origin-Destination household travel survey data gathered in the Montreal area in 2003. Many relations were observed between demographic attributes and number of trip chains per day, complexity of trip chains (trips per chain), duration and length of trip chains. The current analysis has demonstrated that the presence of children, the non-availability of cars and the fact of living alone have significant impacts on all features of trip chains. Other factors such as primary activity and transportation mode also influence the characteristics of trip chains but, since the aim is to explain these features without a priori knowledge on travel and activity patterns, they were not included in the modelling experiences.

To go further into the understanding of trip chaining behaviours of individuals, other variables need to be examined as well as other modelling techniques. Interesting perspectives are:

- Models with spatial expansion factors that allows to explicitly consider the individual's place of home location at the x-y coordinates or other comparable spatial techniques;
- Exploratory spatial data analysis techniques will also be used to identify whether activity chaining behaviours present spatial patterns, something that was suggested by the mapping of the trip chains indicators (see for instance Anselin et al., 2006)
- Other variables describing the neighbourhoods need to be examined and introduced in a modelling framework that allows considering various levels of attributes (person, household, neighbourhood);
- Extension of the analysis to all population segments and to the Greater Montreal Area;
- Application of the analysis to previous Origin-Destination to measure how things have changed over time for similar population segments and locations (1987 to 2008);
- Addition of variables describing accessibility to transportation networks and activity locations.

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REFERENCES

AMT (2003). Enquête Origine-Destination 2003, La mobilité des personnes dans la région de Montréal, Faits saillants. [On line], july 16, 2009, adresse URL : http://www.cimtu.qc.ca/EnqOD/2003/Faits_saillants/EnqOD03_FS.pdf

Anselin, L, Sridharan, S, Gholston, S. (2006), *Using exploratory spatial data analysis to leverage social indicator databases: the discovery of interesting patterns*. Social Indicators Research, 82, p. 287-309.

Ascher, F. (1998). Recherche bibliographique sur l'évolution des mobilités et des temporalités dans les villes américaines. INRETS, 127 pages.

Bath, C. R., Singh, S. K. (2000), *A comprehensive daily activity-travel generation model system for workers*. Transportation Research Part A, 34-1, p 1-22

Beauvais, J-M. (1999). Recherche sur les comportements des familles non motorisées. Beauvais Consultants, 53 pages.

Beckx, C, Arentze, T, Timmermans, H, Int Panis, L, Janssens, D, Wets, G, (2008). The application of an activity-based model to evaluate the dynamic population exposure to air pollution. Transportation Research Board, 17 pages.

Chapleau, R, Allard, B, Lavigueur, P, Grondines, J. (1995). Les nouvelles données de la mobilité des personnes sur la Communauté Urbaine de Montréal. AQTR, 25 pages.

Clarke, M. (2000). Modèles de déplacements en milieu urbain : l'expérience américaine. DRAST, 47 pages.

Davidson, W., Donnelly, R., Vovsha, P., Freedman, J., Ruegg, S., Hicks, J., Castiglione, J., Picado, R. (2007). Synthesis of first practices and operational research approaches in activity-based travel demand modelling, Transportation Research Part A, 41 (2007), 464-488.

Griesenbeck, B, Garry, G, Hossack, S, Porter, R, Penmetsa, R, (2008). Small is beautiful: why you should get rid of zones and start using parcels in your travel demand model. Transportation Research Board, 20 pages.

Kaufmann, V. (1999). Mobilité et vie quotidienne: synthèse et questions de recherche. 2001 Plus Synthèses et recherches, 42, 64 pages

Kumar, A, Levinson, D. M. (1995). Chained Trips in Montgomery County, Maryland. ITE Journal, 65 (5), 27-32.

Lichère, V, Foulon, G. (1999). Modélisation des déplacements intermodaux. Semaly, 85 pages.

McGuckin, N, Murakami, E. (1999). Examining trip-chaining behavior: a comparison of travel by men and women. Transportation Research Record, 16 pages.

Miller, E, J, Roorda, M, J, Carrasco, J, A. (2005). A tour-based model of travel mode choice. Transportation, 32 (2), 105-134.

Morency, C. (2004). Contributions à la modélisation totalement désagrégée des interactions entre mobilité urbaine et dynamiques spatiales. École Polytechnique de Montréal, 539 pages.

Primerano, F, Taylor, M. A. P., Pitaksringkarn, L, Tisato, P. (2007). Defining and understanding trip chaining behavior. Transportation, 35 (1), 55-72.

Rietveld, P. (2000). Non-motorised modes in transport systems: a multimodal chain perspective for The Netherlands. Transportation Research Part D, 5 (1), 31-36.

Roorda, M. J., Miller, E. J., Habib, K. M.N. (2008). Validation of TASHA: A 24-h activity scheduling microsimulation model. Transportation Research Part A, 42 (2), 360-375.

Rossi, T, Winkler, B, Ryan, T, Faussett, K, Li, Y, Wittl, D, Abou Zeid, M, (2008). Deciding on moving to activity-based models (or not). Transportation Research Board, 17 pages.

Steenberghen, T, Toint, P, Zuallaert, J. (2005). Déterminants des choix modaux dans les chaines de déplacements. Politique scientifique fédérale, 15 pages.

Trépanier, M. (1999). Modélisation totalement désagrégée et orientée-objet appliquée aux transports urbains. École Polytechnique de Montréal, 255 pages.

Vande Walle, S, Steenberghen, T. (2006). Space and time related determinants of public transport use in trip chains. Transportation research part A, 40 (2), 151-162.

Virginia Department of Transportation (2009). Implementing Activity-Based Models in Virginia. VTM Research Paper, 09-01, 29 pages.

Ye, X, Pendyala, R, M, Gottardi, G. (2007). An exploration of the relationship between mode choice and complexity of trip chaining patterns. Transportation Research Part B, 41 (1), 96-113.

ITE (2009). Transportation planning handbook. Institute of Transportation Engineers, 3e édition, 1043 pages.