Transit to eternal youth: Lifecycle and generational trends in Greater Montreal public transport mode share

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ABSTRACT

Young people appear to be using public transit more than their predecessors, reversing 20th century trends, but the importance of such findings depends on whether high transit use persists as these riders age. This paper examines whether transit mode share for commuting trips is increasing; socio-economic and geographic trends are also explored to attempt to determine whether these trends are likely to continue. The study uses repeated cross-sectional origin-destination surveys of Greater Montreal (1998, 2003 and 2008). Over 45,000 home-to-work and home-to-school trips are studied for each survey year. A general lifecycle pattern of decreasing transit share with age is apparent within cohorts until individuals reach their early 30s, followed by decades of stability. This pattern appears to hold in recent years, but with higher youth use rates, and it is argued that the higher use will continue as current younger cohorts mature. Suburbanization by those in their early 30s is evident and, along with household composition changes, appears to explain much of the final within-cohort mode share declines before equilibrium. Transit providers might see lasting ridership gains, as those currently in their early 30s and younger replace lower-use cohorts in the workforce, provided service provision keeps pace. Addressing the needs of young people, whose mode choices are comparatively unsettled, should be a priority for transit agencies to ensure higher transit usage in the future.

Keywords: Public transport – mode share – generation – cohort – lifecycle – Montreal

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1. INTRODUCTION

According to the National Household Travel Survey data, people in the US aged 16 to 34 are substantially reducing their automobile use and increasing use of public transit (Davis, Dutzik, & Baxandall, 2012). From 2001 to 2009, this age group decreased in size by 2%, but made 15% fewer driving trips, travelled 40% more passenger-miles using transit, and 23% fewer [private] vehicle-miles per capita (Davis et al., 2012). This is a wide group, both spatially (spanning diverse regions of the US), and demographically (notably including both teens on the cusp of driver's licensure and adults likely to have children of their own). Some of these reported changes in transportation outcomes might be attributable to (possibly temporary) demographic or spatial shifts. The apparent magnitude of change, however, begs further investigation.

Can a similar shift be seen under more controlled circumstances - in a single metropolitan region, at a scale where context can better be observed, and within smaller, more homogenous age groups? If such change is happening, will the transportation behavior of today's young commuters continue, or will they adopt the behaviors of their predecessors as they mature? Kuhnimhof, Buehler, Wirtz, and Kalinowska (2012) find a similar change for general trips (particularly for males), explained as stemming in part from urbanization, municipal livability policies, and transport-related prices, but note uncertainty about its permanence.

While cumulatively including both finer scales of analysis and discussion of stability, most existing literature on age-specific mode share changes over time, as well as literature exploring changes by individuals or groups as they age, are centered on automobile use or, more often, ownership. This can be (although not necessarily) highly negatively correlated with transit use. They often use household, rather than individual-level data, tied to age of the household head, which can misrepresent children's emergent driving as increased use by their middle-aged parents. Most importantly, few published studies on these topics use recent enough data to speak to the shift that Davis et al. (2012) and Kuhnimhof et al. (2012) describe, and, instead, capture the opposite 20th century trend of increasing automobile use.

Hoping to fill this gap in the transportation literature, this study examines recent age-specific, individual-level, mode share data at the regional scale (where service decisions are made), comparing 1998, 2003 and 2008 Greater Montreal work and school commutes, as recorded in respective cross-sectional origin-destination surveys provided by *Agence Metropolitaine de Transport* (AMT) (1998, 2003, 2008). Expecting similar findings to those of the aforementioned studies and aiming to address the issue of continuance of high transit use as commuters age, this study seeks to answer two key questions:

1) Has transit mode share for home-based work and school trips increased from 1998 to 2008 between successive groups of young people aged 20-24, 25-29, and 30-34?
2) Is transit mode share for home-based work and school trips stable within five-year birth cohort groups as they age through their 30s, 40s and 50s, between 1998 and 2008?

If both of the above research questions test positively, it is suggested that future transit demand of people in their 30s to 50s will be higher than the ridership seen today, perhaps increasing total ridership considerably.

This paper proceeds with the following structure: Section 2 reviews previous research. Sections 3, 4 and 5 briefly describe the study area, the data and the employed methodology. Section 6 presents results of the analyses for overall trends and tested significance, followed by household structure- and home location-controlled findings. The paper concludes with suggestions for future research directions and policy implications.

2. LITERATURE REVIEW

Several decades of study have produced a substantial body of literature on factors affecting mode choice, many of which can be grouped into socioeconomic characteristics, mode-specific travel costs, and origin-destination spatial characteristics (Cervero & Kockelman, 1997; Limtanakool & Dijst, 2006). Some authors add attitudes to the list (Handy, Cao, & Mokhtarian, 2005; Kitamura, Mokhtarian, & Laidet, 1997), some even try to explain and nullify apparent spatial influences (Bagley & Mokhtarian, 2002). Often overlooked is the importance of inertia

(Simma & Axhausen, 2003; Thogersen, 2006), an omission Thogersen (2006) attributes to typical cross-sectional study designs.

Mode choice through life

Employing panel, retrospective survey, or repeated cross-sectional designs, several studies conducted in recent years have explored variations through time, by individuals, households or larger groups, in mode choice or mobility tool ownership (Dargay & Hanly, 2003; Matas & Raymond, 2008; Nolan, 2010; Simma & Axhausen, 2003; Thakuriah, Menchu, & Tang, 2010). Mobility tool ownership studies are usually limited to automobiles (Garling & Axhausen, 2003), but it can be a reasonable behavior indicator (Beige, 2008; Thogersen, 2006), and appears to be more commonly studied than actual mode choice, perhaps owing to data availability.

Such studies tend to suggest a sizeable degree of mode choice consistency. This is not surprising, considering the large investment involved in ownership and use of mobility tools, especially automobiles. Mode share change is found to occur, however, with disaggregated data. Nolan (2010) notes that over a fifth of Irish households changed automobile availability at some point over a 7-year period. Dargay and Hanly (2007) found 4.2% of commuters annually leaving automobiles and 5.2% adopting them in England between 1991 and 2000. Beige (2008) calculates 3% individual annual mobility tool change in the Zurich region from 1985 to 2004.

Mode share changes are not evenly distributed. Dargay and Hanly (2003) find them at almost three times the average frequency when respondents also change both home and work locations. Beige (2008) notes that moves and mobility tool changes are both heavily concentrated between the ages of 20 and 35 years, and that age is negatively related to moves in the literature. Family or household structure changes are also related to mode shift (Nolan, 2010; Scheiner & Holz-Rau, 2012). Intuitively, having children impacts home location, feature preferences, and time availability, often resulting in increased preference for automobiles. Coupling and other household structure changes can also impact mode choice, affecting available income and home location choices. Thakuriah Tang, and Menchu (2009) situate much

of the changes in the US within the 18-24 age group, progressing in that time from 80%-30% living with parents, near 0% to almost 30% with children, and about 7% to 40% married.

Switch frequency has also been found to not be even across modes. Automobile use is more consistent than the use of other modes (Beige, 2008; Dargay & Hanly, 2003, 2007; Simma & Axhausen, 2003), perhaps due to much higher initial costs, as well as the age or lifecycle point where automobiles are acquired and persistence of habits. Dargay (2007) finds automobile use declining with income less rapidly among older individuals than its increase among youth. Nolan (2010) and Matas and Raymond (2008) show similar patterns. Simma and Axhausen (2003) conclude that automobile ownership is a condition not easily reversed, even through major life changes. In a Montreal context, Morency and Chapleau (2008) show a high degree of consistency of access to automobiles within older adult cohorts over a 15-year period. Summarizing interdisciplinary literature, Bush (2005) adds that preferences and habits formed during late adolescence and early adulthood tend to persist through later life.

Automobile commute mode share rises and then plateaus before trailing off late in life due to timing of major changes, directionality of mode shift through life (transit to automobile), relative impressionability at different ages and habit. The trend is presumably opposite for transit use. Beige (2008) shows individual car ownership roughly stable between the ages of 35 and 55, earlier onset than household-level studies suggest (Dargay, 2007), and more consistent with the above explanations.

Generation

Several studies discuss mode share or tool ownership within like age groups in a given place at different points in time (Beige, 2008; Bush, 2005; Dargay, 2007; Matas & Raymond, 2008; Thakuriah et al., 2010), generally showing or suggesting recent increases in automobile use among young adults. As with differences between age groups, Dargay and Hanly (2007) explain this general trend toward car ownership and use across subsequent survey periods in terms of rising income and falling automobile purchase prices outweighing rising gasoline prices.

Thakuriah et al. (2010), comparing US 18-24 year-olds in 2006 to those in two previous generations, agree and add suburbanization as another explanatory factor. Many regions have seen outward expansion during the last several decades, and whether or not this independently influences mode choice, impacts on population density would affect potential transit efficiency.

Beige (2008), using stratified Zurich region longitudinal data from 1985 to 2004, shows that the youngest group (born 1980-89) owns much fewer vehicles than did those born 1970-79. Beige (2008) does not elaborate on this plotted information, and ownership rates for recent women aged 15-25 are not clearly lower than previously. She also found that only 45% of commensurate men own vehicles, compared to 60% for the previous birth group at the same grouped age. As with Davis et al. (2012), Beige's chosen age groups might be problematic in including people with a wide variety of life course situations and automobile ownership opportunity, but Beige's data do at least suggest a possible recent reversal of the previous trend toward increasing automobile use between generations.

3. STUDY CONTEXT

This study examines mode share changes, specifically those for transit, in Greater Montreal (**Fig. 1**). Montreal is the largest city in Quebec, with a metropolitan area population of 3,635,571 in the 2006 census, up modestly from 3,349,742 in 1996 (Statistics Canada, 2010a). It has several employment hubs other than the CBD, but they are all fairly central in the region (Coffey & Shearmur, 2001). Recent growth, however, has been more pronounced in more peripheral areas (Collin, Dagenais, & Poitras, 2003). Based on locational variables alone, one might expect transit mode share to have held steady or decreased over time.

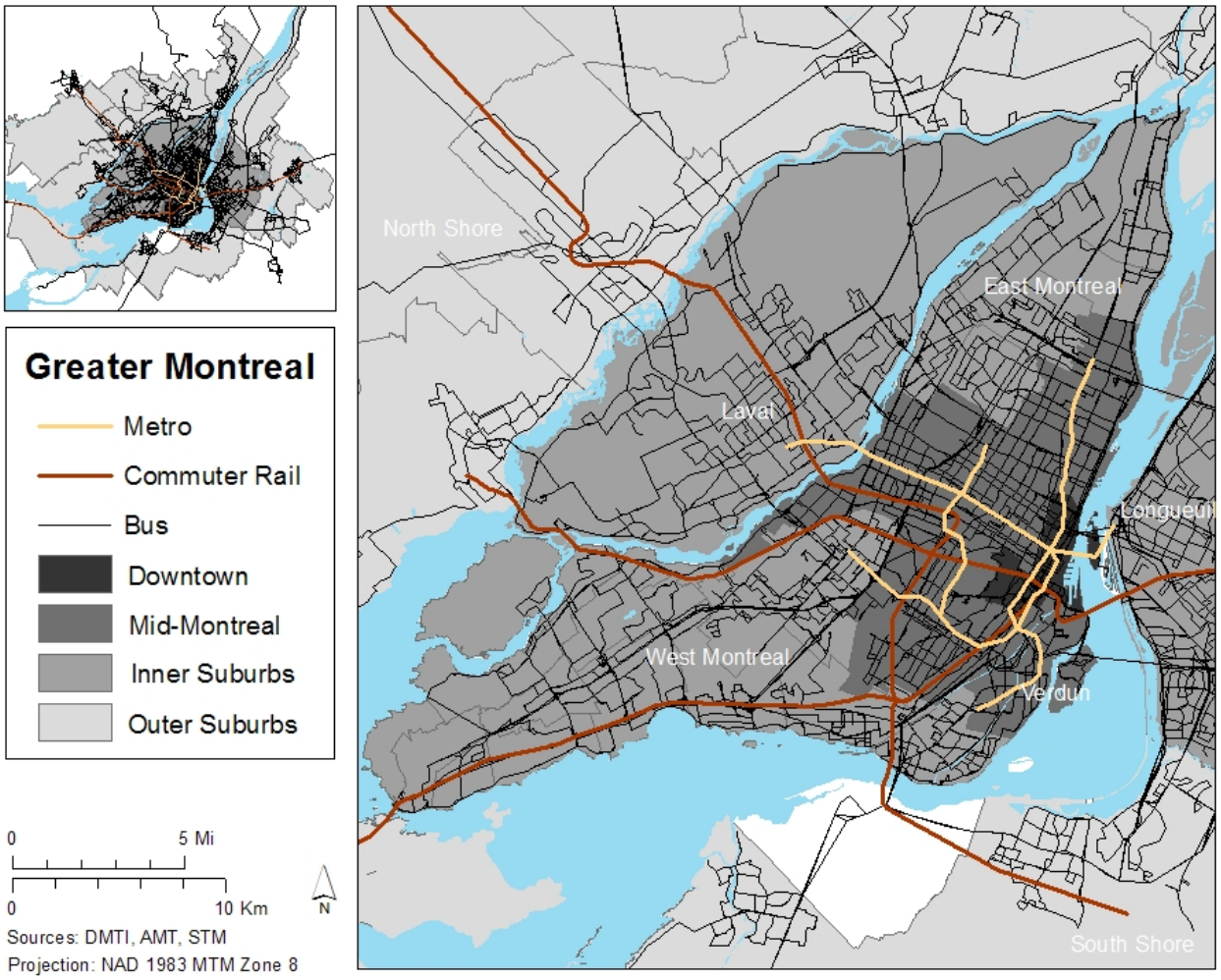


Figure 1: Context and home location zones

Since 1970, Montreal has experienced extensive telephone Origin-Destination (O-D) surveys roughly every five years covering the entire Metropolitan region (Agence Metropolitaine de Transport (AMT), 2012). Individuals are not tracked survey-to-survey. It is possible that the respondents sampled for one year differ in relevant ways from those taken in this study to represent the same people in another year. However, the high count of trips studied for each year (over 45,000) serves to minimize sampling error.

The populations that the samples represent can also change due to migration. According to Statistics Canada (2010a), between 1996 and 2001 around 56.7% of people in Montreal's Census Metropolitan Area (CMA – a slightly larger territory encompassing the study region) did

not move house, and 58.8% the following 5 years, leaving sizeable minorities that did. Only 1.0% and 1.1% respectively, however, moved from a different province or territory, and 3.6% and 4.8% from out of country. No readily available data capture moves from points in the province outside the CMA, but based on the international and interprovincial numbers, the study population should be broadly similar between surveys.

The increase in recent immigration is nonetheless notable as a possible modifier of age groups as indicators of life stages. Schneider (2006) notes immigrants as being more likely than others to live in dense urban areas and Turcotte (2008) observes immigrants in Canada as being less likely to own their homes (curiously opposite to observed trends from 30 years prior). Beige (2008) finds that renters are much more likely to move than owners, which can have mode shift implications. Perhaps more significantly, the average age of Canadian mothers at first birth rose from 28.6 in 1998 to 29.3 in 2008, and the 2008 Quebec figure is identical (1998 unavailable) (Human Resources and Skills Development Canada, 2012). Average ages for new fathers, from 1995 to 2006, increased from 27.8 to 29.1 nationwide (Beaupre, Dryburgh, & Wendt, 2010). These trends suggest that an age group surveyed in 2008 might be less advanced in terms of life stage markers than the same age group surveyed in 1998.

Home ownership, however, increased in Greater Montreal from 48.6% to 53.4% from 1996 to 2006 (Statistics Canada, 2010a). The unemployment rates also decreased. Estimates for the entire potential workforce for each survey year, with the 18-25-year-old demographic in brackets, are given as: 1998 - 9.7 (16.6); 2003 – 9.5 (14); 2008 – 7.4 (12.8) (Statistics Canada, 2012a). Without the appropriate age-specific rates, these figures are less useful than they otherwise might be for informing discussion of age groups as life stage proxies, but if anything they indicate earlier life stage transition, counter to the immigration and childbirth trends above.

Other potentially noteworthy changes or events that have occurred in the region include the introduction of graduated drivers' licensing in 1997 (Simpson, 2003), reduced transit fare for students 18 to 25 in 2002, the 2007 extension of the metro system (subway) into Laval (the

largest neighbouring municipality to Montreal proper), and improved transit integration through the introduction of smart cards in early 2008 (STM, 2012). Other changes to bus, metro system, and commuter rail routes and frequencies might also have impacted ridership appreciably in specific sub-regions. Substantial transit investments took place between 2004 and 2008, which contradicts with budget cuts in the public transit financing that took place in the 1990s (Urban Transportation Task Force, 2009).

Gasoline prices also rose, averaging CAD $0.563 per litre in 1998, $0.767 in 2003 and $1.188 in 2008 (Statistics Canada, 2010b). The increase in 2008 was sharp and in 2009 the price declined to $0.977 per litre, before slowly returning to recent near-peak heights. Dargay (2007) and Goodwin et al. find fuel price changes to be much less influential to automobile ownership than vehicle purchase price and income, and concludes that increases in fuel prices would have to be quite large to produce a significant effect on automobile use. Sperling et al. (2009) agree, adding that to spur significant change, high fuel prices would also have to be sustained for several years to overcome effects of consumer scepticism, existing housing locations and vehicle investments. This is evidenced in annual US gasoline sales declining for the first time in 3 decades in 2008 after steady increase and doubling of real prices 2003-2008 (Sperling et al., 2009). The increase in 2008 was sharp and in 2009 the price declined to $0.977 in Montreal, before slowly returning upward (Statistics Canada, 2010b). Bi-weekly measures show that the 2008 price peaked much higher, near $1.50 per liter in Montreal, which might have affected commuting habits, although it declined beginning in July to near the annual average at the time of the O-D survey months later (Regie de l'energie Quebec, 2009). Overall transit ridership, without even accounting for population growth, decreased in the US and Canada by 3% from 2008 to 2009 with cheaper gasoline. By 2011, even as fuel prices rose again, it was still 2% lower than in 2008, (Dickens, 2012a), perhaps indicating that consumers suspect it will again decline. Montreal, however, appears to have experienced slight ridership, and possibly mode share, growth since 2008. Total transit ridership levels in Montreal in 2008

are not available to compare to subsequent totals, but in October 2009 ridership was only 2% lower than that in 2008 and October 2011 was 3% higher than October 2008. Annual AMT ridership (mostly commuter trains) is recorded and increased 7% between 2008 and 2011 (Dickens, 2010, 2012b). Apparently there was a gasoline price effect on ridership, but in Montreal its magnitude is unclear.

While gasoline prices rose between study periods, so too did transit prices. Transit in the Montreal region has multiple providers and multiple prices. Appropriately detailed consumer price indices are not available at the regional level, but the region constitutes nearly half the population of the province of Quebec, in which public transportation costs rose slightly faster than private transportation costs between study periods (Statistics Canada, 2012b). However, absolute private automobile costs are often much higher for commuters than are corresponding transit fares so comparable relative growth figures might hide unaffordable private vehicle cost increases.

4. DATA

Data were obtained from O-D surveys from 1998, 2003, and 2008, conducted in the fall of each year and containing 417,950, 329,353 and 354,914 total trips respectively, reported each year by samples of approximately 5% of region residents (Agence Metropolitaine de Transport (AMT), 1998, 2003, 2008). The territory that is sampled, by a group local of transportation authorities, has evolved between survey years and generally exceeds the reaches of the metropolitan area. For consistency, observations with trip origins or destinations located outside of Greater Montreal were removed using ArcGIS software.

This study focuses exclusively on work and school commute trips because, at least for regular commuters, they are more consistent, more diurnally concentrated and important for peak service provision (Levinson & Krizek, 2008) and are more likely to influence other trips than vice-versa (Shearmur, 2006). For this reason, observations for purposes other than work and school trips were removed from this analysis.

Commuters under the age of 20 were excluded from this analysis because their travel outcomes are difficult to attribute and their inclusion would be problematic for studying the other commuters (explained below). The earliest age at which individuals can legally drive automobiles in Quebec is 16, but with graduated licensing and the purchase costs, many people who would choose automobile commuting cannot do so at age 16. Also, very young adults, as Thakurriah et al. point out (2009), mostly live with parents so their mode choices might be heavily influenced by location and mobility tool decisions made by others. Moreover, changes among adults in their 20s to 50s, particularly those approaching or attaining possible mode share stability, are of interest in this study. Five-year age groups were used to match the five-year intervals between subsequent O-D surveys. Age brackets must all be equal if they are to be staggered through surveys to represent birth cohorts, and 34 is the terminal age in the group Davis et al. (2012) claim to be changing travel behavior. It is possible that choosing to start groups at 20, rather than 18 or 16, might have appreciable effects on results beyond the youngest groups, but it ensures consistency with other research and ease of communication (early 20s, late 20s etc.).

Likewise, commuters aged 60 and over were excluded from this analysis, due to the need for five-year groupings, and also because retirement often begins somewhere between 60 and 65. Furthermore, commuting might not be as important for home location and general trip outcomes for this age group as for other groups, and those who do commute might disproportionately have certain job types or health status that is unrepresentative of the population. Finally, commute trip counts for people over this age were low and reduced opportunities for sub-regionally disaggregated investigation.

Lastly, and after a round of initial investigation, commutes originating at a location other than the respondent's place of residence were excluded to minimize the effect on mode choice that factors such as having to drop children off at school, for example, might generate. Therefore, only home-based trips were examined. This had little effect on means and excluded

only about 15% of trips. The final count for the total number of trips included for analysis was 144,610, including 53,739 trips from 1998, 45,822 trips from 2003, and 45,049 trips from 2008. The notable drop in 2003 might be attributable to an increasing proportion of the population living outside the standardized boundaries for this study. Importantly, 2003 trip counts averaged 2.3 trips per person per day, the same as in all survey years since 1987 (Morency & Chapleau, 2008).

The O-D survey is designed to account for multiple modes for each trip, using any combination of 17 possible modes. These 17 mode categories were grouped into transit, automobile (including driver and passenger), park-and-ride, walk or bike, and other. 'Other' includes interregional transport, motorcycles, and taxicabs, and was by far the smallest group in all years. Park-and-ride, a combination of transit and automobile, was kept separate, being of similar apparent magnitude to walk/bike, and having infrastructure and other implications distinct from each constituent category. Singular categories were assigned using an algorithm assigning 'other', 'park-and-ride', 'automobile', 'transit, and 'walk/bike', in that order, where, should criteria be met to satisfy one it would be assigned. If not, the next, leaving walk/bike–assigned trips as only those including no other mode. This method allows for distinct groups and eliminates potential bias in determining how to classify trips that include both public and private transport. Trip counts and percentage by mode for each year are listed in **Table 1**.

Table 1: Trip Counts by Mode

Age Group	Year	Modal Split Percentage (Count)						Age Group %
		Transit	Automobile	Walk/Bike	Park & Ride	Other	Total	Of Year Total
20-24	1998	36.2% (2731)	49.6% (3742)	9.4% (709)	3.8% (290)	0.9% (71)	100.0% (7543)	14.0%
	2003	41.7% (2671)	42.8% (2744)	10.9% (700)	3.8% (243)	0.8% (52)	100.0% (6410)	14.0%
	2008	43.4% (2173)	40.8% (2042)	8.4% (419)	6.5% (323)	1.0% (49)	100.0% (5006)	11.1%
25-29	1998	22.5% (1460)	68.0% (4418)	6.3% (409)	2.4% (157)	0.8% (50)	100.0% (6494)	12.1%
	2003	28.3% (1661)	60.0% (3527)	7.8% (461)	3.2% (188)	0.6% (38)	100.0% (5875)	12.8%
	2008	36.4% (1607)	50.2% (2217)	8.9% (394)	3.5% (154)	1.1% (48)	100.0% (4420)	9.8%
30-34	1998	17.8% (1275)	74.0% (5311)	4.7% (340)	2.5% (180)	0.9% (68)	100.0% (7174)	13.3%
	2003	21.4% (1115)	69.2% (3612)	5.4% (281)	3.4% (179)	0.7% (35)	100.0% (5222)	11.4%
	2008	27.0% (1369)	60.4% (3063)	7.9% (398)	4.0% (205)	0.7% (34)	100.0% (5069)	11.3%
35-39	1998	15.4% (1303)	76.2% (6464)	4.6% (394)	3.2% (274)	0.5% (46)	100.0% (8481)	15.8%
	2003	17.3% (1024)	74.1% (4373)	4.8% (282)	3.2% (187)	0.7% (39)	100.0% (5905)	12.9%
	2008	22.7% (1183)	66.2% (3446)	6.3% (330)	4.1% (215)	0.6% (30)	100.0% (5204)	11.6%
40-44	1998	15.6% (1338)	76.2% (6526)	4.7% (403)	2.8% (238)	0.6% (55)	100.0% (8560)	15.9%
	2003	15.5% (1086)	76.0% (5330)	4.9% (346)	3.1% (217)	0.5% (34)	100.0% (7013)	15.3%
	2008	17.8% (1184)	71.2% (4744)	6.1% (406)	4.2% (279)	0.7% (46)	100.0% (6659)	14.8%
45-49	1998	15.6% (1071)	76.5% (5268)	5.0% (343)	2.4% (163)	0.6% (39)	100.0% (6884)	12.8%
	2003	15.5% (1019)	76.2% (5004)	4.8% (318)	2.9% (192)	0.5% (34)	100.0% (6567)	14.3%
	2008	18.3% (1334)	71.5% (5214)	6.0% (435)	3.8% (276)	0.5% (36)	100.0% (7295)	16.2%
50-54	1998	15.1% (863)	77.0% (4414)	5.2% (297)	2.3% (132)	0.5% (26)	100.0% (5732)	10.7%
	2003	16.3% (910)	74.9% (4173)	4.9% (275)	3.3% (183)	0.6% (31)	100.0% (5572)	12.2%
	2008	19.7% (1399)	69.7% (4960)	6.3% (445)	3.9% (274)	0.5% (34)	100.0% (7112)	15.8%
55-59	1998	13.1% (376)	79.8% (2291)	4.8% (138)	1.8% (53)	0.5% (13)	100.0% (2871)	5.3%
	2003	14.8% (482)	77.0% (2508)	5.6% (181)	2.1% (67)	0.6% (20)	100.0% (3258)	7.1%
	2008	19.9% (852)	69.8% (2991)	6.6% (281)	3.2% (136)	0.6% (25)	100.0% (4285)	9.5%
Total	1998	19.4% (10417)	71.5% (38434)	5.6% (3033)	2.8% (1487)	0.7% (368)	100.0% (53739)	100.0%
	2003	21.8% (9968)	68.2% (31271)	6.2% (2844)	3.2% (1456)	0.6% (283)	100.0% (45822)	100.0%
	2008	24.6% (11101)	63.7% (28677)	6.9% (3108)	4.1% (1862)	0.7% (302)	100.0% (45050)	100.0%
Total		21.8% (31486)	68.0% (98382)	6.2% (8985)	3.3% (4805)	0.7% (953)	100.0% (144611)	100.0%

Noticeably, percentages of total annual trips decline for young groups and increase for older groups between survey periods. This in part reflects demographic trends (Statistics Canada, 2012c), and effects of cell phone only households (Trepanier, Chapleau, & Morency, 2008).

5. METHODOLOGY

Initial analysis consisted of plotting transit shares of age groups at each year and by birth year group, and testing for difference between years for age groups and for birth year groups with Pearson's chi-square test using statistical software. Transit mode shares were also plotted separately for four household structure groups (single and multiple 20+ years old with and without children under age 16), and four residence sub-regions (refer to Fig. 1). Gender was also examined, with transit mode share consistently about 5% higher for women than men, but the trends were similar across genders through these time periods, so males and females were not analyzed separately in depth.

The geographical zones chosen are intended to differentiate between areas based on urban/suburban character and transit accessibility, while following political boundaries and AMT groupings for communication and data assimilation purposes. The four residence sub-regions are: (1) downtown (Montreal's *Ville Marie* borough, roughly commensurate with the AMT's *Montréal Centre-ville* TAZ composite zone); (2) mid-Montreal, including AMT's *Montréal centre* zone plus the highly accessible Verdun borough near downtown; (3) inner suburbs, including West Montreal (excluding Verdun), East Montreal, Laval and some of the South Shore (Longueuil and surroundings), each of which contains its own notable employment center (Coffey & Shearmur, 2001); and (4) outer suburbs, consisting of the North Shore and the remaining South Shore municipalities.

The birth cohorts represented in the various household structures and sub-regional graphs cannot be viewed the same as those in the aggregated analysis. Couples aged 20-24 with no children in 1998 might not remain in the same situation as 25-29-year-olds in 2003. Likewise, 40-44-year-old downtown residents in one survey year might be largely different people than 45-49-year-olds there in the next, making the term 'cohort' more loosely applied in this analysis than with the more aggregate data. Because sample populations in each situation change membership, statistical significance of cohort trends within household structures and home locations might be misleading and therefor was not tested. That said, household structure and spatial factors might account for much of the variation observed, so mode share changes or consistency within these groups merit attention, and population shifts between groups can potentially be inferred by comparison to overall patterns.

6. RESULTS

6.1 General Trends

Figure 2 shows 1998, 2003 and 2008 transit mode share for home-based work and school commuting trips by age (five-year group center), period and birth cohort. Solid lines follow birth cohorts between years and dotted lines connect data points for age groups in a single year. As

expected, the general pattern is a decline in transit share with age until the 30s or 40s, at which point transit share becomes relatively stable. Transit share increases overall from 1998 to 2003 and from 2003 to 2008. The patterns of change between these two periods are very different, however, with the more recent transition applying somewhat universally, and the previous transition largely limited to the youngest groups. Conditions in 2008, such as the gasoline price spike, might somewhat exaggerate lasting population change. It is interesting that the youngest age group in 2008, unlike the others, is not appreciably different than that in 2003. Perhaps there is a point after which further increase in ridership is difficult.

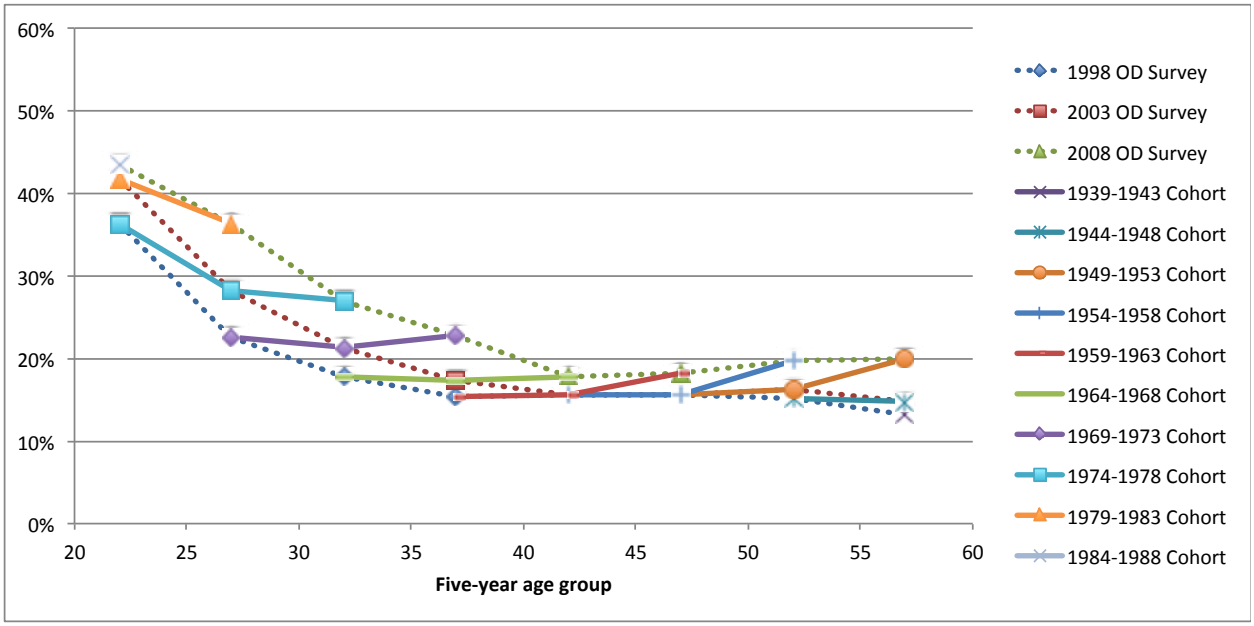


Figure 2: Transit commute mode share

While there is decline across both inter-survey time periods until cohorts reach their early 30s, thereafter cohorts' transit shares appear not to change – or even to increase if 2008 data is taken at face value. Transit use for those born in 1963 and earlier appears to be remarkably consistent from 1998-2003 at about 15%, before 2008 increases that curiously appear stronger with age after the early 40s. Setting aside 2008 increases, it appears that these cohorts share a similar stable long-term transit share. Stable transit shares appear to be emerging for younger cohorts too, although at a higher use level. Transit use for those individuals born between 1964

and 1968 seems to be holding at about 17%. Those born between 1969 and 1973 reach their early 30s (which appears to be the age of stability onset) in 2003, with about 21% transit use, and people born five years later at the same age use transit for 27% of commutes. Those born 1983 and earlier appear to be changing their mode share with a very similar pattern to those born five years prior, but from a higher starting rate, as was the case for several preceding birth cohorts. At this time, however, data are not available for this cohort past their late 20s, which is a volatile age, so forecasting its long-term transit use at rates beyond those of people recently in their early 30s might be imprudent. The graph in Figure 2 does suggest that future home-based commuter transit use by those born since 1969 is likely to remain above 21%, much higher than the 15% share for preceding commuting groups. Chi-square analyses confirm the variation within age groups, especially young age groups, between survey years. These analyses also confirm stability in transit mode share over time within specific cohorts.

The 2008 O-D survey observations increase variation in older groups along both age and birth year axes, but no significant difference is detected between 1998, 2003 and 2008 transit mode shares in 1969-1973 or 1964-1968 birth cohorts, nor in those born 1944-1948, who do not appear in the 2008 survey as commuters under 60. Even within the younger groups, there is more variation within age groups than within cohorts, as reflected in the higher commensurate Chi-square scores. The early 40s age group has been remarkably stable over the course of the three O-D surveys examined in this analysis (owing to diminutive 2008 increase) but like all other age groups it has seen change. The resulting p-value (which indicates the likelihood of observed differences between years being due to sampling error) of 0.000 for this age group, is much smaller than the 0.190, 0.764, and 0.738 p-values of the aforementioned (1964-1973 and 1948-1948) birth cohorts. Birth cohort groups entering their early 40s do so having experienced less change than that seen within this age group. The most recently surveyed cohort to have arrived in their early 40s (i.e., those born 1964-1968), after members have shown stable transit use for a decade, uses transit at this age more than did

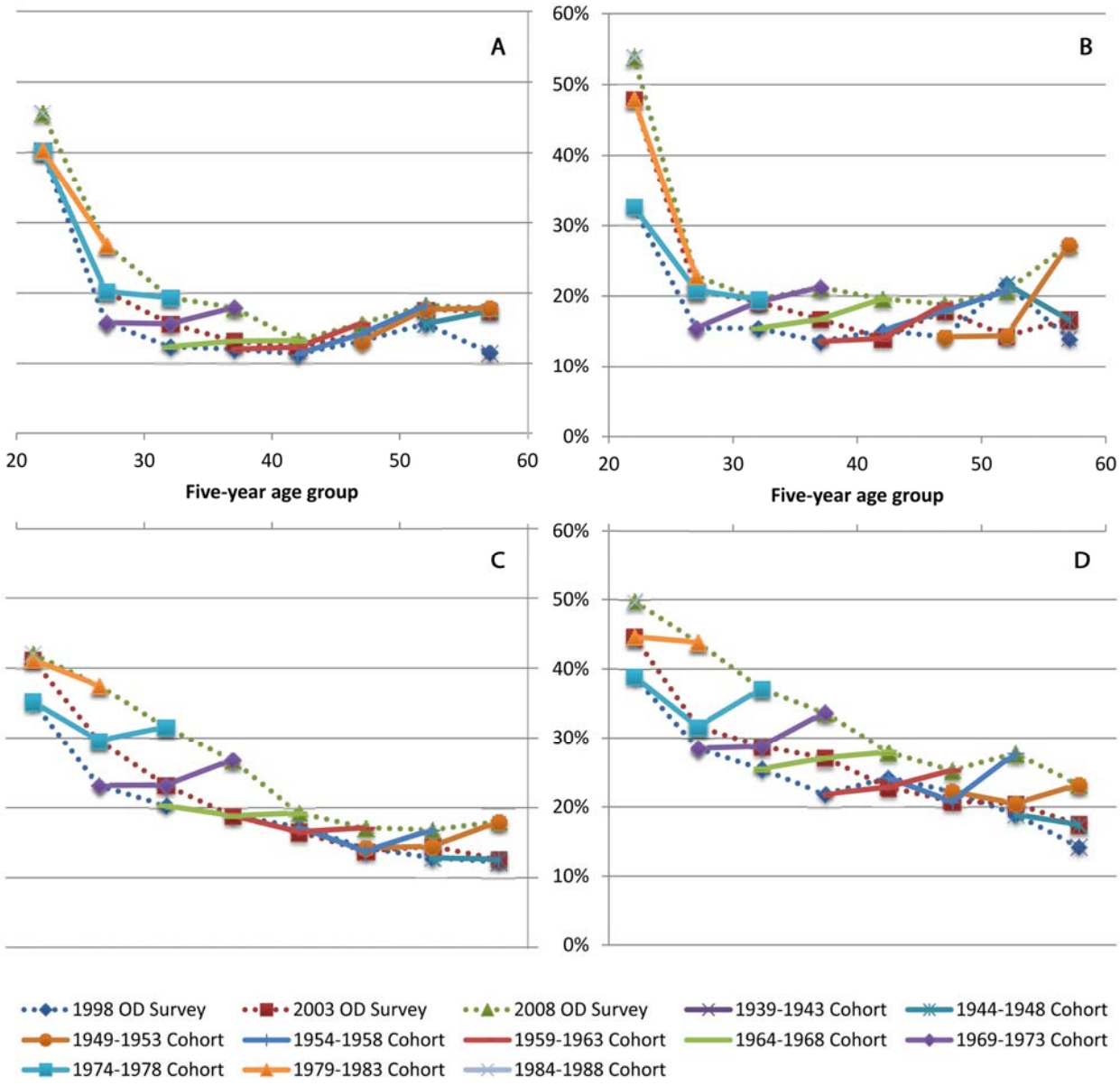
preceding cohorts. The cohort due to reach its early 40s next, born 1969-1973, has shown a much lower likelihood of change in the past ten years than has the age group they will represent in 2013. While prediction is difficult, there appears to be a higher likelihood that the 1969-1973 cohort will continue near its current use levels than that it will adopt that of its predecessors.

6.2 Household Type

Figure 3 shows transit mode share for commuters of four household types: multiple and single commuter, with and without children. Certainly many individuals move between these groups in time. This movement is reflected in the relative weights of each on the aggregated (**Fig. 2**) pattern. Overall transit use for those in their late 20s for each year closely resembles the same in multiple-commuter households without children but in the late 30s, groups with children more closely resemble the average as a growing share of people have had children.

Transit mode shares are generally much lower for those individuals with children than for those without. Similarly, transit mode shares are generally much lower for those individuals who live with other commuters than for those who do not, especially when no children are present. Individuals without children also show a more linear pattern of decrease than those with children, declining gradually with age before stabilizing, similar to the general pattern shown in **Figure 2**. The continued decline into and beyond the 30s for childless groups, approaching levels comparable to those with children, is more pronounced for individuals in multiple-commuter households. This trend for childless groups might indicate the inclusion of expecting parents and those whose children have recently left (but whose location and transit habits remain). Therefore, it might not be the case that individuals living in multiple-commuter childless households tend to continue to decrease transit use later in life, but rather that those with children, as they age, maintain their habits even after their children leave home. Individuals from childless, single-commuter households might be less likely to have recently had children move out than their multiple-commuter counterparts, providing an explanation for this group's comparative intra-cohort mid-life stability. Interestingly, older age groups with children appear to

increase transit use, possibly reflecting reduced time demands of older children. On the whole, after considering movement between household situations represented by the graphs in **Figure 3**, they do not refute the post-30s mode stability thesis explained in the previous section of this paper despite patterns shown in each specific case in **Figure 3**.



(A) Households with multiple commuters and one or more children;
(B) Households with single commuter and one or more children;
(C) Households with multiple commuters and no children;
(D) Households with single commuter and no children

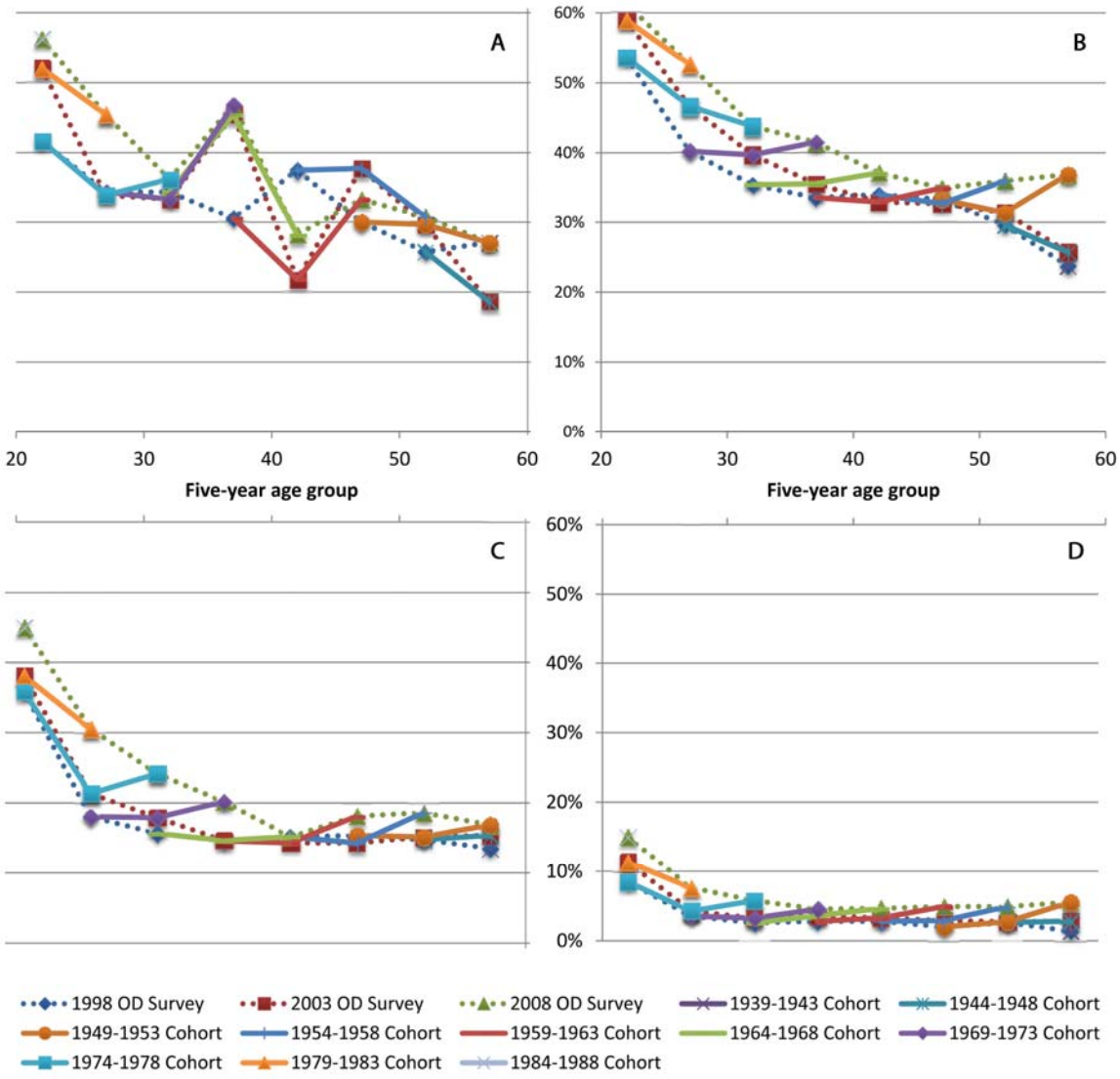
Figure 3: Transit commute mode share by household characteristics

The youngest cohorts decrease their transit use as they age in each case, especially individuals living with children; however, there is no clear increase or decrease in transit use during the transition from late 20s to early 30s age ranges, unlike in the fully aggregated data presented in **Figure 2**, suggesting that family situation plays a major role in mode choice at this stage in life and a sizeable number of people are moving between household types. For the late 20s and early 30s age groups, within-age group transit shares increase in all four cases (although young single-commuters with children show mixed results depending on survey years), but there is much more variation for those without children. Factors causing the general increase in transit use among youth between successive cohorts do not have a uniform effect; young lone commuters of similar age in households with children each year show less change than do individuals from commensurate multiple-commuter households, and still less than individuals without children. The reasons for this outcome is not clear – perhaps young single-commuter households with children tend to have single incomes and locate disproportionately in places with poor transit access to maximize space and security at minimum cost. Also conspicuous is the divide between young individuals from single- and multiple-commuter households without children. Transit use rates for single commuters at most young ages and years are about 5% higher than their counterparts. This might, as mentioned above, in part reflect location and lifestyle preferences of persons expecting children in the future, or increased ability to buy homes (while still only relatively affordable peripheral ones) with multiple incomes. What is clear is that household situation is related to commute mode choice, including that of young adults, and the degree to which recent changes can be seen varies greatly between household types.

6.3 Home Location

Figure 4 shows transit mode share for commuters of four home location areas: downtown, mid-Montreal, inner suburbs and outer suburbs, mapped in **Figure 1**. Like with household structure, sub-regional variation in transit use is apparent, as are population shifts between these groupings that can be seen by comparing area-specific values to their aggregated analogues.

Transit use patterns and shares in inner suburbs resemble those of the region as a whole (**Fig. 2**), although young people's use of transit is lower. Outer suburbs show a remarkably region-like pattern, but with much smaller values (1-15% depending on age and period, compared to 13-44%). Downtown and mid-Montreal transit use is much higher. Mid-Montreal use is 23-61% and downtown 19-56%, owing to frequent walking and biking. The pattern for downtown is rather erratic, as walking and biking reach over 40% for some groups. Mid-Montreal's pattern generally resembles the region's, although with higher rates.



(A) Downtown; (B) Mid-Montreal; (C) Inner Suburbs; (D) Outer Suburbs

Figure 4: Transit commute mode share by home location

The differences between transit mode shares in these four zones are massive and understandably so; it is difficult to service sparse, outlying areas with efficient transit. Even where that is not the case, cheaper peripheral land makes for cheaper parking, as well as a higher likelihood of nearby jobs and services (however many there might be) that cater to automobiles. It is interesting to note that, other than downtown, the patterns of change, by period, age, or cohort, are quite similar in shape to each other and to those of the cumulative region. This suggests that factors influencing mode share changes, both from a lifecycle perspective and inter-'generationally', apply region-wide. Magnitudes of change within age groups vary from one zone to the next, being somewhat commensurate with its level of previous use, likely reflecting service provision challenges and mode choice inertia. One notable exception to this unexpected change pattern (not magnitude) regularity across zones is seen in late youth. Aside from mid-Montreal between 2003 and 2008, all zones differ from the regional pattern in that cohorts passing from their late 20s to early 30s either increase or maintain fairly consistent transit use. This indicates that a sizeable number of Montrealers move from relatively central to relatively peripheral areas at this time in life and this transition is reflected in, if not impacting, their transportation decisions. Complementary work by Morency and Chapleau, studying the same region 1987 – 2003, shows average home distances from the CBD increasing with age between these groups in every survey year (Morency & Chapleau, 2008).

Cohorts of individuals over 35 have recently, between 2003 and 2008, been increasing transit use after stable levels between 1998 and 2003. Mode shares for 1998 and 2003 are similar for all groups born before 1964, spanning their late 30s to late 50s. If the data were available, one would expect to see the same in their early 30s. This tight pattern and 2008 deviation are also noticeable in both disaggregated suburban zones (outer suburbs viewed at a different scale), and to a slightly lesser extent mid-Montreal, which might support a gasoline price spike explanation. The two intervals' patterns of change are curiously less distinct in

household composition groupings (**Fig. 3**), perhaps due to trends in household makeup, such as children moving out, happening concurrently.

7. DISCUSSIONS AND CONCLUSIONS

Even if viewing 2008 figures with caution, it can be seen that recent cohorts of young people are using transit more than those in past years, although they are decreasing use as they age, related in part (and by their late 20s very much) to residential location and household situation changes. By their early 30s, cohort transit use remains much higher than cohorts' at the same age in earlier surveys, and appears to hold, both generally and within sub-regions, as they age into their late 30s and beyond.

The literature, sparse as it may be, suggests a similar life course mode choice pattern, or a reciprocal pattern for automobiles, as well as explanations. Mode choice consistency, maintained by habit, vehicle availability, and attitudes and preferences formed to a large degree early in life, is tempered by key events. Home and work location changes, household composition changes, and automobile access changes are disproportionately frequent in late teens and early adulthood (ages16-35). Birth cohorts by their early 30s have established transportation preferences, opportunity to drive, and some degree of location and family stability; therefore, after reaching this age range, widespread mode shift is both unobserved and unexpected. High transit use rates observed among Greater Montrealers currently in their early 30s are expected to continue as they replace older, lower-use birth cohort commuters.

Transit agencies aiming to increase ridership should work on attracting the younger generations more. This study shows a drop in use by the younger generations as they age, yet they end up with higher transit mode share compared to the older generations at the same age who had lower transit mode share when they were younger. After cohorts reach ages in the early 30s, mode share changes as they age are minimal. Such changes are shown to not even be statistically significant for either birth cohort passing into their late 30s. Similarly, people aging from their early to late 50s between 1998 and 2003, who are not represented in the

transit-heavy 2008 data, show no significant change. Transit mode shares also appear stable for the remaining cohorts over 35, controversial 2008 growth aside. Accordingly transit agencies should adopt policies that can attract younger commuters and increase ridership through providing services that meets their taste in terms of reliability, speed and information. An increase in ridership levels among cohorts of younger riders is expected to be easier and will remain for longer periods compared to the older cohorts.

While increases in transit use, particularly among youth, are evident in the data, the causes of such changes are not clear. The introduction of graduated licensing mentioned previously, which increased the time and training needed to get a license and the restrictions on new drivers, would have had a more pronounce impact on surveys after 1998. Similarly, the 2002 introduction of reduced transit fares for students 18-25 likely had a pronounced impact on this price-sensitive population segment – and Montreal has a high student population. It is tempting to theorize that changes in attitudes or technological improvements also play key and lasting roles. In 2004 the Quebec provincial government added sustainable development focus to the public school curriculum (Ministère de l'education loisir et sport, 2004), and other government programs have aimed to increase awareness in the general public (Transports Canada, 2010a, 2010b). Ruud and Nordbakke (2005) have shown that young people increasingly use transit without preparation, possibly due to increasingly available real-time transit information and route-finding applications.

The precise influences of such developments, however, are difficult to quantify as pertinent data are not available and several potentially influential variables were not controlled for. Relevant socioeconomic data generally are not available for specific age groups (for instance income is recorded in the survey but at the household rather than individual level and is not available for all survey years). The period around 2008 was a turbulent economic time worldwide, but unemployment should not profoundly impact a study limited to commuters, and it seems to have declined slightly at any rate. Parking cost and availability have been found to be

extremely important to mode choice (Chung, 1997; Kuzmyak, Evans, & Pratt, 2010; Marsden, 2006), and parking fees, as well as traffic calming measures, are increasingly being used in the city (City of Montreal, 2003). Incorporating parking information for each period, and commensurate transit networks, might also explain some of the change. Unfortunately such data were not readily available for this paper. Nonetheless, transit demand in Montreal appears likely to grow, even if socioeconomic or infrastructural influences have had substantial effects *and* policy reversals in time undo such conditions. Many of today's youth will enter their mode-stable years with high transit use rates and presumably display some of the consistency in transit use seen in other generations.

In addition to incorporating variables mentioned above, future research might include additional survey years if and when they become available. The 2013 O-D survey results will support or refute suggested changes and consistencies herein. Data for 1993 could speak to the observed life stage mode choice patterns. Similar studies in other cities would be interesting; however, Montreal's high transit service level and density, by North American standards, might make comparison difficult. Where time and money permit, a panel or retrospective study, including attitudinal questions, might be more effective for explaining the apparent burgeoning demand for transit, being able to temporally link cause and effect in individuals. Repeated cross-sectional studies such as this one, that can use more readily available data, might be more efficient for detection.

Transit use requires provision to address demand. Study shortcomings temper the accuracy of the suggested magnitude of mature adult commute transit share gains, seemingly around 40% (not accounting for the city's aging demographic composition); metro, train or bus overcrowding and other service issues might also lead to more modest actual growth. Provision must keep up with demand, and cursory examination suggests that the latter will grow in all broadly defined zones outside downtown – and presumably downtown as a destination. Greater spatial precision – identifying specific routes, corridors or neighborhoods for targeted investment

– might be manageably and meaningfully attained by examining the travel and location patterns of 30-34 year-olds, those entering what appears to be a long period of steady mode choices.

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