WEAKENING OBSTACLES TO TRANSIT USE:

Changes in Relationships with Child Rearing and Automobile Access from 2000-2010

Andrew Guthrie*
Humphrey School of Public Affairs,
University of Minnesota
149 Humphrey Center
301 19th Ave. S.
Minneapolis, MN 55455
Tel. (612) 625-4534
Fax (612) 625-3513
guth0064@umn.edu
*Corresponding author

Yingling Fan
Humphrey School of Public Affairs,
University of Minnesota
295 Humphrey Center
301 19th Ave. S.
Minneapolis, MN 55455
Tel. (612) 626-2930
Fax (612) 625-3513
yingling@umn.edu

Submitted for presentation at the 95th Annual Meeting of the Transportation Research Board and publication in *Transportation Research Record*
August 1, 2015

Word Count:
6,197 words (including references) + 5 tables = 7,447 total words.

ABSTRACT

Early indications of a significant generational change in travel behavior have raised hopes of robust growth in transit use in the immediate future, especially as the millennial generation comes of age. The eventual transition to family life and child rearing, however, has led to significant declines in the transit use rates of older age cohorts. For high transit use rates among millennials to be durable, the relationship between the presence of children and travel behavior must change. In addition, despite lower rates of automobile ownership among millennials than among previous cohorts, automobile ownership is still widespread: increased attraction of choice riders is important for future growth in transit use as well. The authors look for changes in the basic relationship between the presence of young children or automobile access on the one hand, and the probability of transit use on the other between 2000 and 2010 based on data from the Twin Cities Metropolitan Council's decennial Travel Behavior Inventory. Pooled logistic regression models at both the trip and person level find a weakening of access to an automobile as a negative predictor of transit use, as well as the disappearance of young children in the household as a negative predictor. Chow tests establish these observed changes represent significant changes in the relationships with mode choice in question. The results call for research on similar potential changes in other regions, and underscore the importance of family-oriented housing and community features in transit-served areas.

INTRODUCTION

Transit use is in the midst of an historic period of growth across the United States. Transit oriented neighborhoods—many of them long neglected—are desirable again. As the millennial generation plays an increasingly important role in shaping the culture and driving the economy, their travel behavior becomes more and more notable for how it differs from older generations'. The largest generation since the baby boom owns fewer cars *(1)*, drives fewer miles *(2)* and uses transit more, both for commute and personal trips than older generations *(3)*. While this generational shift in travel behavior is dramatic, questions remain about its durability: will millennials continue their high rates of transit use as they increasingly settle down and start families? Will the strictures of adulthood, combined with brighter economic times lead them to higher rates of automobile ownership and gradually reshape their travel behavior into something more like their parents'? For the answer to either or both of these questions to be no, the relationship between mode choice on the one hand and household composition and/or access to a personal vehicle on the other must fundamentally change.

Despite any differences between millennials' automobile ownership and that of older generations, overall automobile ownership rates in the United States are still quite high *(4)*. Traditionally, access to an automobile has a strong negative predictors of transit use. While recent transit improvements have proven able to attract increasing numbers of choice riders *(5)*, significant increases in transit use may also require a change in the relationship between automobile access and mode choice for at least some trips.

This paper looks for evidence of such changes in the specific case of the Twin Cities region of Minneapolis-Saint Paul, Minnesota. A moderately-sized metropolis with decades of automobile-dominated suburban sprawl and no legacy rail system, but a strong, knowledge-based economy, in-migration of millennials and a growing, modern transit system, the Twin Cities region mirrors many others working towards a more transit-oriented future. In addition, the Twin Cities Metropolitan Council conducts a detailed Travel Behavior Inventory every ten years, offering a wealth of highly-detailed, longitudinal travel behavior and demographic data with the geographic precision required for effective analysis of transit usage. Specifically, this paper explores whether the relationship between the presence of children in one's household or one's access to an automobile and one's likelihood of using transit either for a particular trip or at least once on a given day changed between 2000 and 2010.

The period in question is opportune in a general sense as it marks the coming of age of the leading edge of the millennial generation. It is also opportune in the specific case of the Twin Cities, as it saw the opening of the region's first modern light rail line as well as numerous bus system improvements, including a network of high-frequency local routes promising quarter-hourly service at minimum throughout the day. As such, the case in question is one with substantially lower baseline transit demand than found in coastal megaregions, but one in which there is also a significant effort underway to catch up. This situation makes the research relevant to regions across the nation seeking to entice more of their residents onto buses and trains.

LITERATURE REVIEW

Whatever their travel behavior in their younger years, previous generations have shown a strong trend of increased driving and decreased (or simply ceased) transit use as they move into their child-rearing years *(6, 7)*. Employing a mobility biography approach to evaluate changes in specific individuals' travel behavior over time, Scheiner and Holz-Rau find a significant decrease in trips by public transit (and a corresponding increase in automobile trips) following the birth of a child *(8)*. Specifically studying new mothers' travel behavior, Lazendorf finds a similar, though not universal, effect *(9)*. The pattern is international: as a case in point, Dieleman, et al find families with children make half as many (or fewer) transit trips per day as childless couples or other households even in the alternative transportation-friendly Netherlands *(7)*.

Lazendorf's specific focus on mothers speaks to the fact that women commonly shoulder a disproportionate share of household responsibilities, including those related to child rearing, to an extent that affects their travel behavior *(10)*. Crane finds that non-Black women showed considerably less growth in transit use rates than men between 1985 and 2005, and that mothers make more household- and child-related trips *(11)*. McGuckin and Murakami find that women with children are significantly more likely to trip-chain than either men or childless women—leading to travel patterns more difficult to accomplish without resort to an automobile *(12)*. If transit-oriented travel patterns can be sustained through the early years of child-rearing, however, they may prove durable long-term: Franke find a funnel effect, leading most people to become set in their ways, travel behavior-wise by roughly age 35 *(13)*.

It is well established that people with access to an automobile use transit less than those without *(14)*. Despite this fact, transit improvements such as light rail implementation have proven capable of attracting significant numbers of choice riders who previously drove for similar trips *(5)*. Transit service quality can be measured in simple terms of number of runs, route coverage, etc. or in terms of the accessibility transit provides. This approach considers what can be achieved through a certain amount of transit travel rather than simply how much transit travel can be achieved in a certain amount of time *(15)*. It is important to note that this approach considers both the speed of travel and the density of destinations. As a result, increasing one key determinant of accessibility tends to decrease another. However, a recent analysis of 52 metropolitan regions throughout the United States found that proximity to destinations advances the cause of accessibility in practice more so than high travel speeds *(16)*. Accessibility via various modes strongly predicts mode choice—even in the absence of traditionally included social and demographic variables *(17)*. In fact, in a region with significant variation of transit accessibility levels, strong, automobile-dominated suburban employment centers and a growing suburbanization of poverty, social and demographic factors may be insufficient to predict transit use: however poor one may be, one cannot commute by transit if there is no service connecting one's home and workplace *(18, 19)*. Inconsistent transit job accessibility by residential location and socioeconomic status is a particular problem in American metropolises *(20)*, which tends to constrain non-automotive travel options and employment opportunities for those without access to a car *(21)*. The use of accessibility as a measure of service also fits with transit improvements implemented in the Twin Cities region between the 2000 and 2010 TBI's. Research specifically focused on the Metro Blue Line found significant regional accessibility improvements associated with light rail implementation and associated bus service changes—improvements shared across income groups. Accessibility improvement also accrued primarily from the changes in transit service, not from any shift in regional employment patterns *(22)*. Research on the accessibility and social equity implications of improvements to the Toronto transit system reaches broadly similar findings of improving regional accessibility, with particular gains for disadvantaged areas *(23)*. Although accessibility does not exclusively measure transit service *quantity*, it offers a measure of transit service *quality* that more closely corresponds with the utility of transit travel, and can be expected to reflect service improvements.

METHODS

At its most basic level, transit use can be broken down into a pattern of individual trips, or, more precisely, individual trips involving a transit leg. The first model considered predicts the probability of transit use at the trip level; the response variable is binary, with a value of 1 if transit is the mode of at least one leg of a trip, and a value of 0 otherwise. This model provides the finest scale possible, with the impacts of individual trip purposes and origins/destinations included. It also implicitly assumes that an individual's mode choices throughout the day are independent of each other.

In addition, the authors also considered a person-level model, which estimates the probability of an individual using transit at some point in their travel day. This model considers the travel behavior implications of transit service improvements in terms of the total number of residents whose daily lives they touch, rather than in terms of their implications for individual trips. This is a valuable perspective from which to explore transit use, as even "transit-dependent" people generally make a significant portion of their trips by modes other than transit. The response variable is binary, with a value of 1 if the person in question used transit for at least one leg of one trip during the travel day. To provide a finer focus on transit use which may be most negatively affected by access to an automobile or the presence of young children, the model focuses specifically on walk-and-ride trips, with the response variable counting only transit trips with non-motorized access *and* egress modes.

Study Area and Trips Considered

Transit differs from other modes in that it is only available in part of the region. It would not be appropriate to include trips which could not reasonably be made using transit in a model predicting mode choice—in such cases, whether to use transit is not a choice. Park-and-ride lots can extend the effective transit-served area, but represent an option unavailable to travelers without a motor vehicle. In addition, according to the Twin Cities' Metropolitan Council's 2030 Park-and-Ride Plan, "Over 70% of park-and-ride users reside within the transit taxing district (TTD)." *(24)*, indicating that relatively few park-and-ride trips originate at extreme distances from transit stops. Also, of all trips including a transit leg, a relatively small proportion have non-motorized access and egress modes in both years (96 of 734 in 2000 and 312 of 2,378 in 2010). The trip model does not exclude park-and-ride trips, but focuses primarily on trips that *could* be made with non-motorized access and egress modes. For these reasons, the model focuses on trips with origin *and* destination points within 800M (0.5mi) network distance of a transit stop.

Spatial analysis for the person model focuses on participants' home locations. This allows the model to consider the impacts of residential location and neighborhood characteristics on travel behavior; the model also implicitly considers dependency between individuals' mode choices throughout the day. The walk-and-ride-focused person model includes participants who live within 800 m (one half-mile) network distance of a transit stop and who made at least one trip *either* an origin *or* a destination within 800 m (one half-mile) network distance of a transit stop. The individuals included thus have the spatial capability to access transit, and made one or more trips that conceivably could be made using transit.

Table 1 shows the total number of trips in the dataset, with origins and destinations in the seven-county metro area, with O/D points in the study area, along with the portion of the trips which included a transit leg for 2000 and 2010. It also includes the total number of observations and transit trips participating in our model. In both years, a majority of metro trips fall within the study area. In both years, a small share of transit trips have origin and destination points outside the defined service area.

Table 1 also shows the numbers of people included in the TBI, the seven-county metro area, within the walk-and-ride and park-and-ride, who made trips with transit-served origin or destination points and who actually made transit trips in 2000 and 2010. In both years, the percentage of *people* in the walk-and-ride population who made transit trips is more than double the percentage of *trips* in the trip model population that include a transit leg. This pattern reflects the fact that even habitual transit users generally make some trips by other modes.

TABLE 1 Trips and people

Trips	**2000**	**2010**
Total	56,811	115,821
In metro area	34,593	94,645
O & D within 800M (0.5mi) of transit stop	23,435	55,203
Used Transit, All	734	2,378
Used Transit, Outside Service Area	240	569
In trip model	20,321	45,940
In trip model, used transit	438 (2.16%)	1,541 (3.35%)
People		
Total	14,671	30,286
In metro area	11,771	28,137
Made trip with O or D within 800M (0.5mi) of transit stop	8,399	18,114
Used walk & ride transit—Total	355	1,109
Used walk & ride transit— > 800M (0.5mi) from stop	124	317
In person model	4,915	12,690
In person model, Used transit	231 (4.72%)	792 (6.85%)

The authors then produced cross-tabulations of transit use rates by trip and traveler characteristics and estimated two pooled logistic regression models (as described above) to explain the probability of transit use as a function of transit accessibility, trip characteristics and traveler characteristics. The pooled regression approach allows for the use of Chow tests to identify structural breaks in the data—statistically significant changes in the relationship between the probability of transit use and various explanatory variables between 2000 and 2010. Table 2 shows the explanatory variables included in each model.

TABLE 2 Variables used in regression analysis

Variable	Definition	Expected Sign	Trip Model	Person Model
Origin stop distance, Destination stop distance	The shortest path network distance, in meters, from the trip origin/destination to the nearest transit stop.	-	✓	
Home stop distance	The shortest path network distance, in meters, from the respondent's home to the nearest transit stop.	-		✓
Origin/Destination within 800M (0.5mi) of express route/limited stop route/light rail/ commuter rail	Binary variables identifying trips with origins and/or destinations within one half mile (800m) network distance of the type of premium transit service in question.	+	✓	
Express route, limited stop route, light rail and commuter rail within 800M (0.5mi) of home	Binary variables describing whether the participant's home is within 800M (0.5mi) network distance of each type of premium transit service operating in the Twin Cities during the study period.	+		✓
Population density at origin, Population density at destination	The density of population, in people per square kilometer in census blocks within 800M (0.5mi) of the trip origin and destination.	+	✓	
% Retail area at origin, % Retail area at destination, % Office/Institutional area at origin, % Office/Institutional area at destination	The percentage of the area of the block group containing each origin/destination occupied by retail and office or institutional land uses.	+	✓	
% Retail area and % Office/Institutional area at home	The percentage of the area within one half mile (800m) network distance of the participant's home occupied by retail and office or institutional land uses.	+		✓
One-person household	Binary variable identifying one-person households.	+	✓	✓
Children under 6 in household, Children 6-17 in household	Binary variables identifying households with children.	-	✓	✓
Household income	Ordinal variable for traveler's household income *(25)*, p. 30).	-	✓	✓
Licensed driver	Binary variable identifying travelers with a driver's license.	-	✓	✓
Household vehicles/household drivers	The ratio of motor vehicles to drivers in the traveler's household.	-	✓	
Household vehicles<household drivers	Binary variable identifying participants living in households where drivers outnumber cars.	+		✓
Worker, Student	Binary variables identifying workers and students.	+	✓	✓
Female	Binary variable identifying a female traveler.	+	✓	✓
<18 years old, 40-64 years old, 65+ years old	Binary variables identifying travelers' ages. (Note: 18-39 is omitted as the reference; the preceding variables compare a member of their age group to an 18-39 year old.)	-	✓	✓
Average temperature on travel day	The average temperature on the day of travel, in degrees Fahrenheit.	+	✓	✓
Precipitation	Binary variable identifying travel days with precipitation.	-	✓	✓
School destination activity, Utilitarian personal destination activity, Non-utilitarian personal destination activity, Home destination activity	Binary variables identifying the travelers' reported activity at the trip destination. Work is omitted as the reference.	-	✓	

TABLE 2 (cont'd)

Variable	Definition	Expected Sign	Trip Model	Person Model
Mid-day departure, PM peak departure, Evening departure	Binary variables included to identify the time of day at which the trip was made. AM peak is excluded as the reference.	-	✓	
Network distance <= 800M (0.5mi), Network distance > 800M (0.5mi), <= 3.2kM (2mi)	Binary variables identifying short trips for which non-motorized modes may compete with transit. Trips longer than 2 miles (3.2 km) are excluded as the reference.	-	✓	
Home-based trip	Binary variable identifying trips with a home origin activity.	+	✓	

RESULTS

Table 3 shows transit use rates by traveler and trip characteristics in both study years. In addition to the overall trend of transit use rates increasing in general, trips and travelers with certain specific characteristics show particular increases in their probability of using transit between 2000 and 2010. Travelers ages 18-39 use transit for 6% of their trips, and 14% of trips with origins or destinations in either central business district include a transit leg in 2010, compared with 3% and 7%, respectively in 2000. Travelers in lower and moderate-income household categories also show significant gains in transit use, though high-income travelers and licensed drivers show increased transit use as well. Longer (in terms of shortest-path network distance) trips are also more likely to use transit in 2010.

Trip Model

Logistic regression results are most easily interpreted through the use of odds ratios. Odds ratios measure the difference in the probability of the response variable having a value of 1 associated with one unit of change in each explanatory variable. For example: Student in the 2000 model has an odds ratio of roughly 1.5—meaning that, all else equal, a student is 1.5 times as likely to use transit as a non-student. Odds ratios are always positive; values less than one indicate a negative coefficient. For example—Children under 6 in household in the 2000 model has an odds ratio of roughly 0.33, meaning that, all else equal, a traveler with young children in their household is just over *one-third* as likely to use transit as a traveler from a household without young children.

Origin and destination accessibility are significant and positive in both years. With means ranging from 33,000 to 85,000 jobs and a unit of 10,000 jobs, the potential range of predicted transit use is large. Stop distance is significant and negative in all cases.
Licensed driver and household vehicles/household drivers are both significant and negative in both years, but less negative in 2010 than in 2000. For instance, a trip made by a member of a household with twice as many drivers as cars in 2000 would be roughly eight times as likely to use transit as a trip made by a member of a household with equal numbers of drivers and cars. In 2010, the trip from the former household would be roughly four times as likely to use transit as the trip from the latter household.

Children Under 6 in Household is significant and negative (as expected) in 2000. In 2010, however, it is insignificant. In other words, the model shows no statistically significant difference in the probability of transit use between travelers with young children in their households and those without.

TABLE 3 Cross-tabulation of transit use and trip/person characteristics

		2000 Used Transit No	2000 Used Transit Yes	2000 Total	2010 Used Transit No	2010 Used Transit Yes	2010 Total
	<18 yrs old	99%	1%	4,445	99%	1%	6,114
	18-39 yrs old	97%	3%	7,043	94%	6%	10,840
	40-64 yrs old	98%	2%	9,725	97%	3%	27,325
	65+ years old	98%	2%	2,222	98%	2%	10,924
	Licensed driver	98%	2%	19,550	97%	3%	48,162
	Not licensed driver	96%	4%	3,287	94%	6%	7,103
	AM peak departure	96%	4%	4,057	94%	6%	9,816
	Mid-day departure	99%	1%	7,885	98%	2%	19,450
	PM peak departure	97%	3%	6,971	96%	4%	16,684
	Evening departure	100%	0%	4,165	99%	1%	8,635
	CBD origin	93%	7%	233	86%	14%	3,549
	Non CBD origin	98%	2%	23,202	97%	3%	51,654
	CBD destination	93%	7%	2,133	86%	14%	3,550
	Non CBD destination	98%	2%	21,302	97%	3%	51,653
	Network dist. <= 800M (0.5mi)	99%	1%	4,300	99%	1%	7,840
	Network dist. >800M (0.5mi), <=3.2kM (2mi)	98%	2%	5,454	98%	2%	14,707
	Network dist. >3.2kM (2mi), <=16.1kM	97%	3%	10,442	96%	4%	26,120
	Network dist. >16.1kM (10mi)	98%	2%	3,239	95%	5%	6,536
	Worker	97%	3%	15,815	96%	4%	30,540
	Non worker	99%	1%	7,125	98%	2%	24,663
	Student	98%	2%	4,289	97%	3%	9,435
	Non student	98%	2%	18,503	97%	3%	45,768
	Female	98%	2%	12,674	97%	3%	30,545
	Male	98%	2%	10,761	97%	3%	24,617
	Cars in household >= drivers	99%	1%	20,012	98%	2%	46,808
	Drivers in household > cars	93%	7%	3,423	90%	10%	8,395
Household Income	**< $5,000**	96%	4%	107	81%	19%	383
	$5,000 - $10,000	83%	17%	144	84%	16%	403
	$10,000 - $15,000	92%	8%	311	87%	13%	757
	$15,000 - $20,000	96%	4%	615	91%	9%	905
	$20,000 - $25,000	95%	5%	945	94%	6%	1,245
	$25,000 - $30,000	97%	3%	763	96%	4%	1,473
	$30,000 - $35,000	96%	4%	860	95%	5%	1,202
	$35,000 - $40,000	98%	2%	745	96%	4%	1,237
	$40,000 - $45,000	97%	3%	791	94%	6%	1,283
	$45,000 - $50,000	99%	1%	1,453	97%	3%	2,008
	$50,000 - $60,000	98%	2%	3,258	97%	3%	3,661
	$60,000 - $75,000	99%	1%	3,546	98%	2%	6,011
	$75,000 - $100,000	98%	2%	3,803	97%	3%	9,404
	$100,000 - $150,000	99%	1%	2,491	98%	2%	10,272
	>= $150,000	99%	1%	1,252	98%	2%	5,796

TABLE 4 Trip-level model

Response Variable:	**2000**		**2010**		**Chow Test**
Probability that a given trip uses transit	N	20,321	N	45,940	
	Pseudo R2	0.2961	Pseudo R2	0.37	
Explanatory Variables:	**β**	**Odds Ratio**	**β**	**Odds Ratio**	**Prob > chi2**
Origin Stop Dist.	-0.7247	0.4845	-2.0715 ***	0.1260	0.0401 **
Destination Stop Dist.	-1.3593 *	0.2568	-1.5282 ***	0.2169	0.7286
Origin Accessibility (x 10,000)	0.0650 ***	1.0672	0.0664 ***	1.0686	0.5383
Destination Accessibility (x 10,000)	0.0559 ***	1.0575	0.0527 ***	1.0542	0.5737
Kids Under 6 in Household	-1.0992 ***	0.3331	-0.1709	0.8429	0.0178 **
Kids 6-17 in Household	-0.2249	0.7986	0.0294	1.0298	n/a
One-Person Household	0.2299 *	1.2585	0.1801 **	1.1973	0.3968
Household Income	-0.0499 ***	0.9514	-0.0771 ***	0.9258	0.0000 ***
Licensed Driver	-1.6403 ***	0.1939	-1.4679 ***	0.2304	0.1834
Cars/Drivers	-1.9881 ***	0.1370	-1.2699 ***	0.2809	0.0000 ***
Student	0.0470	1.0481	0.4227 ***	1.5261	0.2168
Worker	0.5309 ***	1.7004	0.2072 ***	1.2303	0.2105
Female	0.1375	1.1474	-0.0237	0.9766	n/a
Age Under 18	-1.0724 ***	0.3422	-2.4126 ***	0.0896	0.0056 *
Age 40-64	-0.0903	0.9136	-0.0273	0.9731	n/a
Age 65 and Over	-0.1997	0.8190	-0.5169 ***	0.5964	0.2492
Average Temperature	0.0093 *	1.0093	-0.0043 ***	0.9957	0.0214 **
Precipitation	0.0421	1.0430	0.3757 ***	1.4560	0.1086
School Destination	-0.1189	0.8879	0.0381	1.0389	n/a
Utilitarian Personal Dest.	-0.2045	0.8150	-0.8145 ***	0.4429	0.0003 ***
Non-Utilitarian Pers. Dest.	-1.0676 ***	0.3438	-0.8856 ***	0.4124	0.9457
Home Destination	0.2661	1.3048	-0.1175	0.8892	n/a
Mid-Day Departure	-1.1362 ***	0.3211	-0.7099 ***	0.4917	0.0669 *
Pm-Peak Departure	-0.5172 ***	0.5962	-0.2664 ***	0.7661	0.1672
Evening Departure	-2.4795 ***	0.0838	-1.3345 ***	0.2633	0.0002 ***
Trip <= 800M (0.5mi)	-1.5052 ***	0.2220	-2.7652 ***	0.0630	0.0000 ***
Trip > 800M (0.5mi), <= 3.2kM (2mi)	-0.9889 ***	0.3720	-1.3132 ***	0.2689	0.0310 **
Home-based Trip	-0.0557	0.9458	0.0723	1.0750	n/a
Constant	-0.6052		0.0951		n/a

Legend: *p<0.1; **p<0.05; ***p<0.01

In addition, Student is significant and positive in 2010—showing a trip made by a current student is roughly 1.5 to 1.7 times as likely to involve transit as a trip made by a non-student. In 2010, all age variables except 40-64 are significant and negative, underscoring the propensity of 18-39 year-old travelers to use transit. The lack of significance for the Age 40-64 variable also indicates there is no statistically significant difference between this age group the 18-39 year-old reference group.

Chow Tests

Table 4 also shows the results of Chow tests for variables significant in at least one year. The Chow test tests the null hypothesis that the coefficients produced for a given variable significant in 2000 and/or 2010 are actually equal. If the test statistic is less than a critical value of 0.1, or preferably 0.05, we reject the null hypothesis and conclude that there is a structural break in the data—a genuine change in the relationship between explanatory variable and transit use between the two observations. The test statistics for both origin and destination accessibility variables fail to achieve significance. As a result, we fail to reject the null hypothesis, and cannot conclude there is a structural break in the data.

While the licensed driver variable fails to produce a significant test statistic, Household vehicles/household drivers—directly measuring access to an actual vehicle—is significant. According to our model, access to a motor vehicle (not surprisingly) is negatively related to the probably of using transit for any given trip in both 2000 and 2010, but that relationship significantly weakened between the two years.

Under 18 years old, Evening departure and Household income also show structural breaks. Trips shorter than 800M (0.5mi) are even less likely to use transit in 2010 than in 2000. Mid-day and evening departure show a similar pattern to Vehicles/drivers: negative in both years, but significantly less so in 2010. Household income becomes slightly more strongly negative in 2010.

The presence of children under 6 in the household is a significant negative predictor of transit use in 2000, but not in 2010. This result indicates that the disappearance of children under 6 as a negative predictor of transit use between the two observations is the result of a genuine change in the relationship between the presence of young children and the probability of transit use.

Person Model

Table 5 presents the results of the person-level model. As expected, employment accessibility is significant with a positive coefficient in both years of its model. Its odds ratios of 1.0949 and 1.0334 indicate a 9% and 3% (respectively) increase in the probability of transit use for every additional 10,000 jobs reachable within 30 minutes' transit travel from an individual's home, holding all else equal. The constant term of the model becomes significantly less negative in 2010, reflecting the overall increase in transit use rates. (This pattern may reflect less accessible areas "catching up" somewhat to more accessible area, as overall levels of both transit service and transit use rise.) Distance to the nearest transit stop is significant, with the expected negative coefficient in the 2010 model only.

Among the household characteristics variables, the presence of young children in the household is significant (with a strongly negative coefficient) in 2000, predicting a 77% decrease in the probability of transit use for both modeling approaches. For 2010, however, the variable is insignificant. The variable indicating one-person household is significant and positive in both years, though with a weaker coefficient in 2010 than in 2000. Household income is significant and negative in 2010 only, and a household in which drivers outnumber cars is significant and positive in both years. In both years, the model predicts a person from such a household is roughly 4.5 times as likely to use transit at some point in their travel day than a person from a household with at least as many cars as drivers.

Whether or not the participant is a licensed driver is significant and negative in both years, but the relationship is weaker in 2010. While the model predicts a 95% decrease in the probability of using transit from having a driver's license in 2000, it predicts an 89% decrease in 2010. Worker is significant and positive in both years, while student is significant and positive in 2010 only. Female is significant and positive in 2000. Participants under age 18 (in both years) and age 65 and over (in 2010) are significant, with the expected negative coefficients.

TABLE 5 Person-level model

Response Variable:	**2000**		**2010**		**Chow Test**
Probability of transit use at least once on travel day	N	4,915	N	12,690	
	Pseudo R2	0.2205	Pseudo R2	0.1984	
Explanatory Variables:	**β**	**Odds Ratio**	**β**	**Odds Ratio**	**Prob > chi2**
Meters to Nearest Stop	-0.0006	0.9994	-0.0011 ***	0.9989	0.1356
30 min Job Accessibility (x 10,000)	0.0907 ***	1.0949	0.0328 ***	1.0334	0.0000 ***
Children Under 6 in Household	-1.4784 ***	0.2280	0.1084	1.1145	0.0015 ***
Children 6-17 in Household	0.1090	1.1152	-0.1543	0.8570	n/a
One-Person Household	0.8431 ***	2.3235	0.7011 ***	2.0160	0.9849
Household Income	-0.0216	0.9786	-0.0654 ***	0.9367	0.1557
Fewer Cars than Drivers	1.5656 ***	4.7855	1.5648 ***	4.7819	0.6383
Licensed Driver	-2.9544 ***	0.0521	-2.2345 ***	0.1070	0.0166 **
Student	0.0391	1.0399	0.2400 *	1.2712	0.8566
Worker	0.7832 ***	2.1884	0.6553 ***	1.9258	0.6967
Female	0.3115 **	1.3655	-0.0529	0.9485	0.0139 **
Age Under 18	-2.7263 ***	0.0655	-2.6076 ***	0.0737	0.9161
Age 40-64	-0.1598	0.8524	-0.0935	0.9108	n/a
Age 65 and Over	-0.4321	0.6492	-0.9032 ***	0.4053	0.1291
Constant	-1.5677 ***		-0.5771 ***		0.0192 **

Legend: *p<0.1; **p<0.05; ***p<0.01

Chow Tests

The test statistics indicate a significant structural break between 2000 and 2010 for transit job accessibility, which is significant and positive in both years, but less so in 2010. In addition, significant structural breaks appear for the presence of children under 6 (which goes from significant and negative to insignificant) and being a licensed driver (which is negative in both years, but less strongly in 2010.)

CONCLUSIONS

The models provide strong evidence that the basic relationship between having young children in one's household or having access to an automobile on the one hand, and one's probability of transit use on the other has changed. Regardless of the specific measure or the modelling approach employed, these two traditional obstacles to the maintenance of young adults' transit use rates as they mature either weakened or disappeared entirely between 2000 and 2010 in the Twin Cities region. Further research is required to determine if similar changes have taken place elsewhere, but it is worth noting that a number of regions with broadly similar populations, densities and built forms to the Twin Cities have implemented similar programs of transit improvements in recent years; the rise of the millennial generation (albeit to varying degrees) is taking place everywhere. Regions with dramatically differing levels of transit service than the Twin Cities—both higher and lower—also offer an interesting topic for continued research. Conducting similar analysis on both small, bus-only systems and large, legacy rail systems could shed further light on the importance of transit service levels and types in driving mode choice change.

The structural break found for access to an automobile in both models (though by different measures), is compelling. True, easier access to a car makes one considerably less likely to use transit in both 2000 and 2010, however, the effect is moderated enough in the latter year to have significant practical implications in terms of attracting choice riders. It also indicates policies aimed at encouraging car shedding and car-lite lifestyles hold significant potential to encourage transit use. Given the trip model's finding of a significant structural break on the ratio of cars to drivers, that potential appears to exist even among members of households with at least one car. This finding may indicate some broadening of the appeal of transit between the two years studied—a conclusion supported by the disappearance of children under 6 in the household as a negative predictor of transit use.

This result, found again by both models, suggests the change in the relationship between the presence of children and transit use may be greatest in urban areas, where walk-and-ride trips are most common. It also points to a high level of importance for ensuring an adequate supply of family housing, as well as family-oriented community features such as high quality schools and playgrounds in transit served areas. The findings also suggest transit may be better able to hold onto its market share than before as current young cohorts mature.

REFERENCES

1. Cardenas, M. P. The Decline of the Car Enthusiasts: Implications for Undergraduate Engineering Education. , 2013.

2. Federal Highway Administration. *Traffic Volume Trends.* Office of Highway Policy Information, Washington, D. C., 2010.

3. American Public Transportation Association. *Millennials & Mobility: Understanding the Millennial Mindset.* APTA, Washington, D. C., 2014.

4. Giuliano, G., and J. Dargay. Car Ownership, Travel and Land use: A Comparison of the US and Great Britain. *Transportation Research Part A: Policy and Practice*, Vol. 40, No. 2, 2006, pp. 106-124.

5. Cao, X., and R. Jordan. *Understanding Transportation Impacts of Transitways: Demographic and Behavioral Differences between Transitway Riders and Other Transit Riders.* Center for Transportation Studies, University of Minnesota, Minneapolis, 2009.

6. Zwerts, E., D. Janssens, and G. Wets. How the Presence of Children Affects Parents' Travel Behavior. In *86th Annual Meeting of the Transportation Research Board*, TRB, 2007.

7. Dieleman, F. M., M. Dijst, and G. Burghouwt. Urban Form and Travel Behaviour: Micro-Level Household Attributes and Residential Context. *Urban Studies*, Vol. 39, No. 3, 2002, pp. 507-527.

8. Schwanen, T. Gender Differences in Chauffeuring Children among Dual-Earner Families. *The Professional Geographer*, Vol. 59, No. 4, 2007, pp. 447-462.

9. Lanzendorf, M. Key Events and their Effect on Mobility Biographies: The Case of Childbirth. *International Journal of Sustainable Transportation*, Vol. 4, No. 5, 2010, pp. 272-292.

10. Turner, T., and D. Niemeier. Travel to Work and Household Responsibility: New Evidence. *Transportation*, Vol. 24, No. 4, 1997, pp. 397-419.

11. Crane, R. Is there a Quiet Revolution in Women's Travel? Revisiting the Gender Gap in Commuting. *Journal of the American Planning Association*, Vol. 73, No. 3, 2007, pp. 298-316.

12. McGuckin, N., and E. Murakami. Examining Trip-Chaining Behavior: Comparison of Travel by Men and Women. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1693, 1999, pp. 79-85.

13. Franke, S. „Eigentlich Ideal, so Ein CashCar!“Ergebnisse Eines Feldversuchs. *Die Mobilitätsmaschine.Versuche Zur Umdeutung Des Autos, Berlin*, 2004, pp. 68-80.

14. Paulley, N., R. Balcombe, R. Mackett, H. Titheridge, J. Preston, M. Wardman, J. Shires, and P. White. The Demand for Public Transport: The Effects of Fares, Quality of Service, Income and Car Ownership. *Transport Policy*, Vol. 13, No. 4, 2006, pp. 295-306.

15. Cervero, R. Paradigm Shift: From Automobility to Accessibility Planning. , 1997.

16. Levine, J., J. Grengs, Q. Shen, and Q. Shen. Does Accessibility Require Density Or Speed? A Comparison of Fast Versus Close in Getting Where You Want to Go in US Metropolitan Regions. *Journal of the American Planning Association*, Vol. 78, No. 2, 2012, pp. 157-172.

17. Owen, A., and D. Levinson. Modeling the Commute Mode Share of Transit using Continuous Accessibility to Jobs. In *Paper Submitted to the Transportation Research Board 93rd Annual Meeting, Washington, DC*, Citeseer, 2013.

18. Fan, Y. The Planners’ War Against Spatial Mismatch Lessons Learned and Ways Forward. *Journal of Planning Literature*, Vol. 27, No. 2, 2012, pp. 153-169.

19. Glaeser, E., M. Kahn, and J. Rappaport. Why do the Poor Live in Cities? the Role of Public Transportation. *Journal of Urban Economics*, Vol. 63, No. 1, 2008, pp. 1-24.

20. Shen, Q. Job Accessibility as an Indicator of Auto-Oriented Urban Structure: A Comparison of Boston and Los Angeles with Tokyo. *Environment and Planning B: Planning and Design*, Vol. 33, 2006, pp. 115-130.

21. Grengs, J. Job Accessibility and the Modal Mismatch in Detroit. *Journal of Transport Geography*, Vol. 18, No. 1, 2010, pp. 42-54.

22. Fan, Y., A. Guthrie, and D. Levinson. Impact of Light Rail Implementation on Labor Market Accessibility: A Transportation Equity Perspective. *Journal of Transport and Land use*, Vol. 5, No. 3, 2011.

23. Foth, N., K. Manaugh, and A. M. El-Geneidy. Towards Equitable Transit: Examining Transit Accessibility and Social Need in Toronto, Canada, 1996–2006. *Journal of Transport Geography*, Vol. 29, 2013, pp. 1-10.

24. 2030 Park-and-Ride Plan. , 2010.

25. Owen, A., J. Schoner, and D. Levinson. *Travel Behavior Over Time: Task 2: Data Collection and Preparation.* Minnesota Department of Transportation, Saint Paul, 2013.