

## **Trip Chaining Trends in The U.S. – Understanding Travel Behavior for Policy Making**

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**ABSTRACT**

This paper uses data from the 1995 Nationwide Personal Transportation Survey (NPTS) and the 2001 National Household Travel Survey (NHTS) to examine trip-chaining trends in U.S. The research focuses on trip chaining related to the work trip, and contrasts the travel characteristics of workers who trip chain with those who do not, including their distance from work, current levels of trip making, and the purposes of the stops made within chains. Trends examined include changes in the purpose of stops and in trip chaining behavior by gender and lifecycle.

A robust growth in trip chaining occurred between 1995 and 2001, nearly all in the direction of home-to-work. Men increased their trip chaining more than women, and a large amount of the increase was to stop for coffee (we call this the Starbucks effect). We found that workers who trip chain live farther from their workplaces than workers who do not. We found that in two-parent, two-worker households who drop children at school, women are far more likely to incorporate that trip into their commute, and those trips are highly constrained within the 8:00 – 9:00 am time period. We analyzed workers who stopped to shop and those who did not but made a separate shopping trip from home and found a large potential to increase trip-chaining behavior in shopping trips.

The results of these analyses have important policy implications and also have implications for travel demand forecast model development. Finally, this paper uses these analyses to develop conclusions about the utility of transportation policies and programs that use the promotion of trip chaining as a primary TDM strategy.

## INTRODUCTION

*"Drop off the kids. Run by the bank. Pick up dinner. Save the air. It's amazing what a mom can accomplish in an afternoon! It's called trip chaining, or combining errands into one trip. It saves time and reduces traffic congestion and pollution, making \_\_\_\_\_ a better place to live."*

The preceding was a radio script developed by the U.S. DOT, U.S. EPA, and FTA as part of the *It All Adds Up to Cleaner Air*, an initiative to help raise public awareness about the connections between transportation choices, traffic congestion and air pollution. It was a national initiative that, through partnerships with local communities and a national coalition called the Alliance for Clean Air and Transportation (ACAT), distributed messages and materials that encouraged individuals to take action to improve air quality and reduce congestion. The messages were: maintain your vehicle; chain (or consolidate) your trips; and make more trips by transit, carpools, bicycling and walking. The initiative was funded under the Congestion Mitigation and Air Quality Improvement Program (CMAQ). The TEA-21 CMAQ program provided over \$8.1 billion dollars in funds to State DOTs, MPOs, and transit agencies to invest in projects that reduce criteria air pollutants regulated from transportation-related sources over a period of six years (1998-2003).

A high priority goal of projects funded under CMAQ is to reduce the number of trips made in single occupancy vehicles. Such reduction in vehicle miles of travel (VMT) is a pressing policy goal due to evidence of vast growth. Polzin (1) reported that since 1977, total daily person VMT has grown by 151 percent versus population growth of approximately 30 percent. Nearly 70 percent of VMT growth can be attributed to socio-culture, lifestyle, or socio-economic factors, and therefore, represents a type of behavioral effect that could be affected by policy strategies. This paper addresses a specific type of trip reduction strategy, namely trip chaining, and examines the trends in the incidence and type of trip chaining during the time when the "It All Adds Up to Cleaner Air" campaign was operative (1995 to 2001).

Research indicates that trip chaining has increased over the last decade, and is becoming a significant part of some worker's daily travel. Levinson and Kumar (2) reported an increase in trip chaining. They related the increase to higher family incomes and less time as women have entered the workforce and as dual career households buy services (such as day care) that were formally conducted in the home. Related to this latter point, McGuckin and Murakami (3) determined that trip chaining was the domain of females, rather than males, in the household, even as women have entered the workforce. Bianco and Lawson (4) found specifically that the work trip was becoming more complex as workers incorporate personal, household, and child-care activities into their commutes. Likewise, Nishii, Kondo, and Kitamura (5) discovered that an important secondary role for the work trip was to provide an opportunity to link non-work travel.

This begs the question: If an increase in trip chaining is a "naturally" occurring response to changing social, cultural, and economic conditions, why should Travel Demand Management (TDM) programs be funded to promote it? Are people trip-chaining to consolidate trips (as urged by policy makers), or are they adding trips into their existing commutes? What are the components of current trip chains, and where is the potential for encouraging this behavior?

This paper uses data from the 1995 Nationwide Personal Transportation Survey (NPTS) and the 2001 National Household Travel Survey (NHTS) to examine trip-chaining trends in U.S. The research focuses on trip chaining related to the work trip, and contrasts the travel characteristics of workers who trip chain with those who do not, including their distance from work, current levels of trip making, and the purposes of the stops made within chains. Trends examined include changes in the purpose of stops and in trip chaining behavior by gender and lifecycle.

A robust growth in trip chaining occurred between 1995 and 2001, nearly all in the direction of home-to-work. Men increased their trip chaining more than women, and a large amount of the increase was to stop for coffee (we call this the Starbucks effect). We found that workers who trip chain live farther from their workplaces than workers who do not. We found that in two-parent, two-worker households who drop children at school, women are far more likely to incorporate that trip into their commute, and those trips are highly constrained within the 8:00 – 9:00 am time period. We analyzed workers who stopped to shop and those who did not but made a separate shopping trip from home and found a large potential to increase trip-chaining behavior in shopping trips.

Finally, the paper seeks to draw policy implications from this detailed study of trip chaining behavior. There is often a gap between assumptions on which policies are based and the actual behaviors that occur in the marketplace - which greatly affects perceptions of the success or utility of the policies or strategies.

For example, the compressed workweek is often promoted as a trip reduction policy initiative. It is assumed that employees who work fewer days per week will make fewer trips per week, thus reducing demand on transportation infrastructure. However, a before and after case study by Commuter Transportation Services, Inc. (CTS) examined the effects of this strategy on travel behavior and found that employees actually made more trips on their compressed work day-off than they did on any other day. In actuality, employees took advantage of the additional time off from work to accomplish personal and household business. The 2001 NHTS data also showed that to be true: workers who took a work trip made an average of 3.9 total person trips on the travel day versus workers who did not take a work trip and averaged 4.8 person trips. Thus, an over-arching purpose for this paper is to examine trip-chaining behavior with an eye to developing better policy and market-place understanding.

### **ABOUT THE DATA USED IN THIS RESEARCH**

A National Household Travel Survey (NHTS) has been conducted by the U.S. Department of Transportation periodically since 1969 to obtain an inventory of daily travel for the nation. The survey includes demographic characteristics of households and people, detailed information on trips for all purposes, the use of household vehicles, and additional information on travel to work. Our research was conducted on the public use files of the 1995 and 2001 surveys. The 1995 NPTS included *all trips* by people over the age of five, and the 2001 NHTS included *all trips* by all people regardless of age. Both surveys provided travel-day coverage for all 365 days of the year, including holidays and weekends. The households and people are weighted to represent the nation as a whole. Detail about the survey methods, questions, and weighting can be found at <http://nhts.ornl.gov>.

Most importantly, similarities in survey design and question wording for the 2001 and 1995 data permit trend analyses. The 2001 NHTS and the 1995 NPTS have been processed simultaneously using the same rules and logic streams to develop the trip chains analyzed in this research. Both 2001 and 1995 files are available for research from the FHWA for analysis by academics, policy makers, and other interested parties. Changes in trip chaining behavior found during comparison of the 1995 NPTS and the 2001 NHTS, when statistically significant, are not artifacts of differences in scope, methodology, or question wording.

### **DEFINITION OF TRIP CHAINING**

The NHTS, like most household travel surveys, collects travel information about trips—movement from one address to another. In this way, every movement by any mode for any distance is reported for all respondents. For example, a person can make a total of 4 separate trips but two chained trips—stopping at a coffee shop on the way to work and at a daycare center on the way home. This common behavior complicates our understanding of the commute trip, and is an important element to include in the measure of commute times and distances.

Trip chaining is a relatively new way to look at the series of trips made by people every day, and there is no formal agreement on the definition of a chained trip. Although transportation planners have been aware of the behavior for nearly a quarter of a century, little empirical research on the incidence of trip-chaining behavior within comparable travel markets has been published. Different terms and expectations exist as to what types of trips should be considered part of a chain, whether only trips for certain purposes (dropping a passenger) or only trips with certain dwell-times (15 minutes or less). Some of the earlier national research used no time or purpose constraints at all (6), so comparison with that previous work is difficult.

To aid researchers and to set the stage for a common definition of a trip chain, the Federal Highway Administration recently developed an operational definition of a “trip chain” as a sequence of trips bounded by stops of 30 minutes or less.<sup>1</sup> A stop of 31 minutes or more defines the terminus of a trip. Using this definition, the 1995 NPTS and the 2001 NHTS trip data have been parsed into trip chains, but previous years have not. Therefore, the comparisons in trip chaining behavior presented in this paper describe trends over this relatively short timeframe.

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<sup>1</sup> This definition was adopted by the Federal Highway Administration (FHWA) in 2003, after extensive research into the effect of time constraints for dwell times on purpose.

## **POPULATION OF ANALYSIS: WEEKDAY WORKERS**

For at least the past 25 years transportation planners have focused on the commute as one of the major organizing elements of household travel. In this paper, we concentrated on the subset of workers who make a work trip on a weekday. We included all the trips those individuals made by all modes of travel (although the vast majority of work travel is in private vehicles), and occasionally looked at non-work travel as related to the stops made to and from work. The focus on the home-work and work-home travel behavior of people who made a work trip on a weekday helps us visualize the commute, especially as part of travel-demand forecasting enhancements or TDM measures—both of which also focus primarily on the weekday work trip. Weekday work trips account for 90 percent of all work trips, 20 percent of all vehicle trips, and nearly 25 percent of VMT by people aged 16 and older.

## **INCIDENCE OF TRIP CHAINING AMONG WEEKDAY WORKERS**

In 2001, nearly 18.8 million weekday workers (27 percent of all weekday workers) chained trips as part of their commute compared to 17.3 million in 1995 (25 percent of weekday workers), which represents a nine percent increase (see Table 1). In number, over one and one-half million more weekday workers chained their trips in 2001 than in 1995. Almost all of them added chains in the home-to-work direction of the trip--which had a 21 percent increase. The workers who trip-chained in both directions increased by over 12 percent, while the number of workers chaining trips on the way home from work stayed about the same. The remaining workers stopped for 31 minutes or more during their commute.

[Insert Table 1 here.]

TDM programs often rely on social marketing campaigns to educate the public about transportation and cleaner air and to change travel behavior, while trying to ensure that there are significant upgrade benefits for the costs of the initiative. It is obvious from the above tables that trip chaining has not reach market saturation. Slightly more than one quarter of weekday workers practice any type of trip chaining, showing opportunities to induce more trip-chaining behavior in commuters.

But, will inducing trip chaining necessarily correlate with a reduction in VMT? This analysis found that people who trip chain have higher reported annual miles of travel than those who travel directly between home and work (see Table 2). These data alone do not provide cause to state that trip chaining is related to higher VMT but they do provide the opportunity for conjecture. Perhaps, like those workers with a compressed week, commuters who trip chain take advantage of the efficiencies to make more trips, accomplishing more personal and household business. To better understand the relationship between VMT and trip chaining, we took a closer look at the travel behaviors and trip characteristics that were associated with chaining.

## **TRAVEL BEHAVIOR AND TRIP CHARACTERISTICS ASSOCIATED WITH TRIP CHAINS**

While commute trips are often thought to be highly repetitious, and therefore highly predictable, commute times and distances are highly variable by day of week and direction. Trip chaining significantly impacts commuters' in-vehicle travel time and route choice (distance), which is comparable to findings of Li, et al (7)

Workers who trip chain have longer commutes, or do the workers with longer commutes trip chain? We found that workers who chain trips into the commute live farther from work, and travel significantly more miles than their reported distance to work (the NHTS asks workers the 'usual' distance to work and obtains the distance from reported home and work locations as a great circle distance). These workers also travel more miles and minutes than those who do not trip chain. Comparison of workers miles and minutes to work measured by the sum of miles traveled to work on a weekday, the reported distance to work, and the geocoded great circle distance is shown in Table 2.

The mean sum of miles traveled for weekday workers who chain on the home-to-work trip was 18.4 person miles of travel, compared to 12.0 miles of travel those who did not chain, and it was similar in the opposite direction. The vehicle miles of travel for those who trip chain was much higher than the reported usual distance to work, whereas

for workers who made a direct trip the actual and reported miles are virtually the same. Workers who chained during their commutes spent 15-20 minutes longer in travel than workers who did not.

[Insert Table 2 here.]

In the last decade there has been a growing interest in developing activity centers around transit stations to accommodate some of the purposes that are served by trip chaining, such as services and shopping. Our findings indicate that workers who usually use transit are almost twice as likely to make a direct trip to and from work, while workers who trip chain are more likely to depend on a private vehicle as a mode. Table 3 shows the usual mode to work by whether the worker trip chains.

Persons who chain (particularly those who chain in both directions) were significantly more likely to travel in a personal vehicle (90.7%) than were persons who make a direct trip to work or from work (83.7%). Transit was selected as the usual mode to work by 6.3 percent of the workers who do not stop, whereas for those who stop, that number dropped to 3.6 percent. Since workers who trip-chain are more likely to use personal vehicles than workers who do not, they may accrue more annual miles of travel, which was noted earlier.

[Insert Table 3 here.]

By far the most common purpose for stops within trip chains was to shop—such trips include both discretionary and household-sustaining activities. Detail on trip purpose in the 2001 NHTS does include a separate coding for buying gasoline and meals/coffee. The latter trip purpose showed a surprisingly robust percent of trips within chains. Figure 1 shows the proportion of trips within chains for selected purposes (work-related and other miscellaneous purposes are not included here). For workers who made stops, the most common type of trip embedded in the home-to-work chain was a serve passenger trip (35%), followed by family or personal business (16%) and stop for a meal or coffee (14%). For the work-to-home chain, the most common type of embedded trip was a shopping trip (36%), followed by serve passenger (24%) and family or personal business (22%).

[Insert Figure 1 here.]

We examined shopping stops (the most common) to determine whether workers that included a stop for shopping were more or less likely to make a home-based trip for shopping. This is an important question for policies related to reducing criteria air pollutants.

In the national data, most workers who took a work trip did not stop to shop (58.9 %) as shown in Table 4. About one-fifth (20.3%) of weekday workers did not chain a shopping trip into the commute, but made a separate trip for shopping. Nearly the same proportion (18.8%) stopped to shop on the way home from work but did not make a separate shopping trip. Two percent chained a shop trip on the way home from work and separately made a home-based shopping trip.

These findings indicate that there is a potential to move some of the workers who make separate trips from home to shop into trip-chainers. However, the data also indicate that 41 percent of workers who trip chain are making shopping trips during their commute home. Such findings provide support for the proposition that it is the growth of non-work trips embedded in commute trips that add to traffic congestion during peak times.

[Insert Table 4 here.]

Dropping off and picking up a passenger was the second most common trip purpose within weekday work-trip chains. Many of the passengers are children being dropped at day-care or school or other activities by parents. This is compatible with finding by Lee and Hickman (8) that the presence of children in households positively affects the

duration of out-of-home activities. We examined serve passenger trips within chains to drop-off or pick-up children (less than 18 years old).

In families where both parents work on weekdays, over 7 million parents drop-off and/or pick up their children during a weekday commute--2.7 million men and 4.3 million women. Over 6 in ten trips to drop off a child were made by women (see Table 5).

[Insert Table 5 here.]

Figure 2 shows the percent of trips by time of day for drop-off and pick-up trips of children. Eighty percent of the drop-offs occur before 9:00 am on weekdays, but there is much more variability in the time of day for pick-up. The fact that women make these drop-offs may indicate they have much less discretion in their departure time for the home-to-work trip than do men, with implications for congestion management in the A.M. peak.

[Insert Figure 2 here.]

### **SOCIO-ECONOMIC CHARACTERISTICS ASSOCIATED WITH TRIP CHAINS**

Like previous studies, we found that socio-demographic variables (e.g., age, income, geography, etc.) did little to explain differences in trip chaining behavior (9, 7). Yet, differences in behavior by sex and life cycle (using the number of adults and age of children) were found.

Both men and women have increased their trip chaining behavior, but overall men have added a trip in the home-to-work commute more often than women. The work-to-home trend is rather flat for both men and women. Figure 3 shows the trends in the mean number of stops for men and women by lifecycle for home-to-work trip chains. Men and women with adult children or no children in the household showed healthy increases in trip chaining behavior

[Insert Figure 3 here.]

As the research has shown, both men and women have increased their trip-chaining behavior. One area of increase has been in stops to get coffee/meals. Figure 4 shows the trends in the number of trips within weekday work chains (stops of 30 minutes or less) for meals/coffee for men and women for 1995 and 2001. We call the dramatic growth in these types of additive trips the “Starbucks” effect.

[Insert Figure 4 here.]

These findings point to a growing trend to add trips for what might have previously been in-home activities (breakfast and coffee) into the home-to-work commute, rather than consolidating trips that might have been made in a non-work tour at other times of the day. The fact that these trips seem to be additive may also be associated with higher reported annual miles of travel, and requires research into changes in route and time-of-day for morning commutes.

### **CONCLUSIONS AND POLICY IMPLICATIONS**

The operational definition put forward by FHWA facilitated a trend analysis of trip chaining behavior. We were able to derive a national incidence of trip chaining—in 2001 more than 18 million weekday workers (27 %) inserted a stop into their commute. Although this is an increase of one and one-half million weekday workers since 1995, one implication is that there are opportunities for TDM programs to increase trip-chaining behavior among weekday workers.

We found that workers who trip chain live farther from their workplaces than workers who do not, and accrue more annual vehicle miles of travel. We found that in two-parent, two-worker households who drop children at school, women are far more likely to incorporate that trip into their commute, and those trips are highly constrained within the 8:00 – 9:00 am time period. We found a large potential to increase trip-chaining behavior in shopping trips.

Surprisingly, nearly all of the growth in trip chaining was in the direction of home-to-work. Men increased their trip chaining more than women, and a robust amount of the increase was to stop for coffee (we call this the Starbucks effect). One conclusion from our analysis is that the growth in trip chaining between 1995 and 2001 has a large component of trips added into the home-to-work commute.

These findings can have particular relevance for travel demand forecast models that may need to address these additive types of trips. Our findings suggest that TDM programs need to consider that trip chaining may induce “new travel” into the commute as much as it consolidates trip making. Future research and policies should focus on within household dynamics so that a policy goal would be to reduce overall household trip making rather than personal trip making.

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TABLE 1 – Trends in the Number of Weekday Workers Who Trip Chain

	1995	2001	Change 1995- 2001	% Change 1995 - 2001
Workers who made a weekday work trip	68,760,000	68,990,000	230,000	0.33%
Made a Direct Trip	31,290,000	31,660,000	370,000	1.18%
Chained Work Trips:	17,276,045	18,842,670	1,566,625	9.07%
Chain Home-to-Work Trip	5,929,237	7,158,844	1,229,607	20.74%
Chain Work-to-Home Trip	7,762,956	7,659,436	-103,520	-1.33%
Chain Both	3,583,852	4,024,390	440,538	12.29%
Stopped Longer than 30 minutes	20,193,955	18,487,330	-1,706,625	-8.45%

TABLE 2 Mean Distance to Work for People who Chain and People Who Don't

	Workers who Chain	Workers who make a direct trip
Home-to-Work		
Person Miles of Travel	18.4	12.0
Vehicle Miles of Travel	16.0	10.6
Minutes	35.6	23.7
Reported Usual Distance to Work	13.6	10.6
Great Circle Distance Home-Work	8.4	7.0

TABLE 3 Percent of Workers By Usual Mode to Work for Trip Chains and Direct Trips

Usual Mode to Work:	POV	Transit	Walk/Bike	Other
Direct Trip	83.7	6.3	2.9	7.1
Home-Work Chain	88.1	3.4	1.1	7.5
Work-Home Chain	87.9	3.7	1.9	6.6
Chain Both Directions	90.7	3.5	0.6	5.2

TABLE 4 Workers Stopping to Shop or Shopping in Separate (Home-to-Home) Trips

Weekday Workers Who Made a Work Trip:	Percent
Did not stop on the way home from work to shop, but in a shopped in a separate trip	20.3%
Stopped after work to shop, and did not shop in a separate trip	18.8%
Stopped to shop on the way home from work, and also shopped in a separate trip	2.0%
Did not shop on the workday	58.9%

TABLE 5 Number and Percent of Weekday Workers who Drop-off and/or Pick-up Children as Part of Work Trip Chains

	Men		Women		Total
Drop-Off	1,166,325	43.4%	1,519,712	56.6%	2,686,037
Pick-up	996,470	47.8%	1,087,775	52.2%	2,084,245
Both	562,240	24.8%	1,705,113	75.2%	2,267,353
Total	2,725,035	38.7%	4,312,600	61.3%	7,037,635

FIGURE 1 - Percent of Stops During Commutes by Selected Purpose, 2001 NHTS

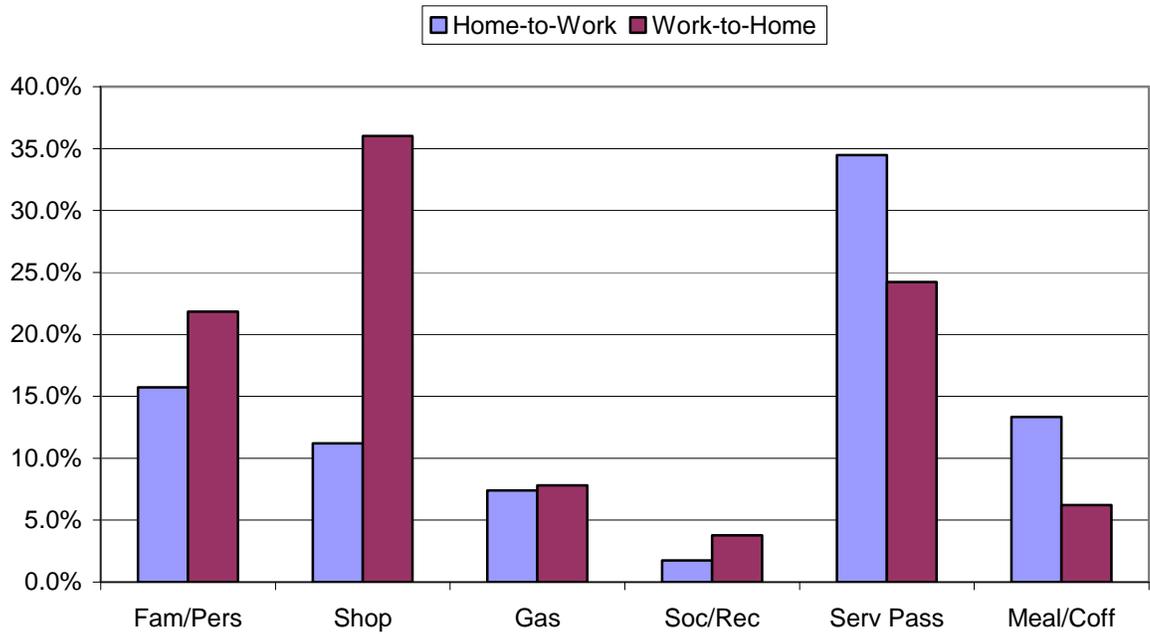


FIGURE 2 - Time of Day for Stops to Drop-Off and Pick-Up Children

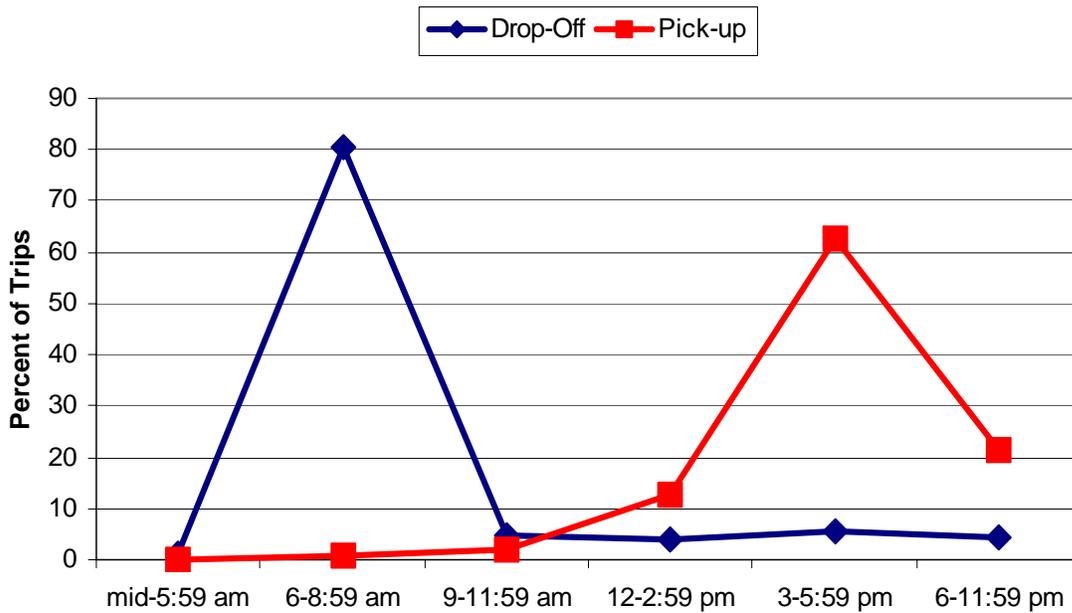


FIGURE 3 - Trends in Mean Number of Stops--Home-to-Work by Lifecycle.

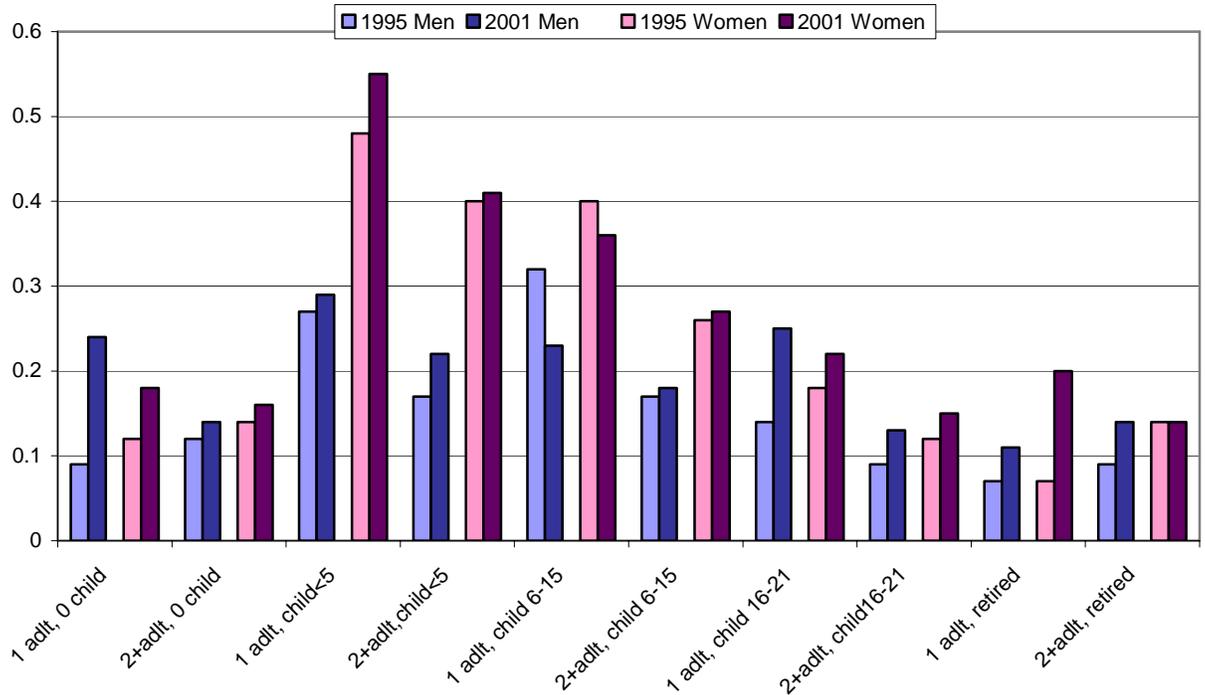


FIGURE 4 - Trends in the Number of Stops to Get Meals/Coffee

