Life-Cycle, Money, Space, and the Allocation of Time

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ABSTRACT

The allocation of time to various activities is known to be a function of various demographic, socio-economic, seasonal, and scheduling factors. This paper examines those variables through exploration of the 1990 Nationwide Personal Transportation Survey, which has been inverted to track activity durations. The data are examined in single and multi-variate contexts. Two key issues are considered. First, to what extent does activity duration influence travel duration after controlling for activity frequency. This is tested with a set of models explaining travel duration which show activity duration does have positive and significant effects on travel duration, supporting recent arguments in favor of activity based models. Second, which is a more important effect in explaining the large changes in travel and activity patterns over the past thirty years accompanied by the increase in female labor force participation, the loss of discretionary time due to work, the change in metropolitan location, or the rise in per capita income. To examine this second question more rigorously, a choice model is constructed which examines both the decision to undertake an activity and the share of time within a 24 hour budget allocated to several primary activities: home, work, shop, and other activities. The utility functions for the activities are comprised of demographic, socio-economic, temporal, and spatial factors. The data also suggest that income and location have modest effects on time allocation compared with the loss of discretionary time due to working.

INTRODUCTION

An interest in when and where trips are made leads remorselessly to the realization that travel cannot be understood in isolation from the activities which induce it. Travel and activity are two sides of the same coin, activities must be pursued in space and over time, and space must be traversed in time to engage in activities. Furthermore, how time is spent depends on how money is earned - the decision to work profoundly alters daily schedules for two main reasons: less available time and more available money. To account for the interaction of travel and activity, transportation analysts have begun studying activity duration, frequency, sequencing, chaining, and scheduling (Clarke et al. 1981; Allaman et al 1982, Damm 1983, Golob and Golob 1983, Kitamura and Kermanshah 1983; Pas 1984 Kitamura 1985; Pas and Koppelman 1986; Recker, McNally, and Root 1989; Hamed and Mannering 1992; Hatcher and Mahmassani 1992; Kalfs, 1995; Levinson and Kumar 1995a,b; Ma and Goulias 1996a,b, 1997; Golob and McNally 1997; Pas and Harvey 1997; Beek, Kalfs and Blom 1997; Kalfs and Saris 1997; Niemeier and Morita 1996; Hsu and Hsieh 1997). This is in contrast to early research which attempted to analyze trips independent of the activities which caused them, an approach now embedded in current practice.

The study of human activity patterns has engaged researchers across disciplines. Sorokin and Berger (1939), Szalai (1972) , Robinson (1977), and Michelson (1985) have pioneered the analysis of the use of time. Meanwhile, sociologists have examined the impact of rising female participation in the labor force on the quality of life and changing roles of time at work and leisure (de Grazia 1962, Schor 1991, Cross 1993); planners and geographers have studied the allocation of time by activity and by location, for demographic and socioeconomic classes (Meier 1959, Chapin and Hightower 1965, Chapin 1968, 1974, Hanson and Hanson 1981, Garling 1992) and developed space-time metrics (Hagerstrand 1970); and economists have developed a theory of the allocation of time proposing that individuals or households combine time and market goods to produce “commodities” (Becker 1965). Despite these recent research efforts, little transition has been made from theory to practice, and these ideas are only slowly entering the domain of transportation planning.

This paper has two main purposes. One purpose is to demonstrate the significance of activity duration on travel duration after controlling for activity frequency. This paper does not concern itself with causality, which is a chicken-and-egg argument, it suffices that travel to a specific activity and that activity are economic complements, one cannot be undertaken without the other, and thus the cost and benefit of each effects the other. However, since all activities (including travel) are undertaken within the confines of a 24 hour day, to some degree they also substitute for each other. While the first part is interested in predicting travel duration as a function of activity patterns (since the author's primary interest is in transportation), one could just as easily consider the effect of travel or location on activity durations, depending on one's interest.

The daily activity budget, which is a simple constraining fact, should not be confused with the idea of a travel budget, which is subject to significant debate (Zahavi 1974, Zahavi and Ryan 1980, Zahavi and Talvittie 1980, Chumak and Braaksma 1981, Prendergast and Williams 1981, Tanner 1981, Purvis 1995). One of the questions asked in this research is which activity pairs are complements and which are substitutes. Clearly, travel to a non-home activity is complementary to the activity itself, but are there are other relationships. Daily travel duration for an activity is in part a function of the duration of that activity and the number of times that activity is pursued. Simply put, the more times an individual undertakes an activity in a day, the more travel there will be. But what about time spent at the activity after considering frequency. It is posited that individuals will travel farther for non-home activities that they spend more time at. Two reasons suggest themselves: first individuals may wish to minimize total costs by spending more time at an activity in a single visit rather than requiring multiple visits; second, not all activities of the same kind are equal, the expenditure of additional time in travel implies greater benefits accrue at the farther activity because the farther destination of is of a higher quality or value.

While, the choice of time of day, destination, mode, vehicle occupancy, path, and sequence of trips are all significant research questions, this study focuses on the amount of travel (in minutes) undertaken for various activities. Determining the amount of travel is a precursor to many other questions, and though there is surely a feedback between components (for instance, the preferred amount of time undertaken for travel determines the choice of time of day, which in the aggregate influences congestion, manifesting itself in travel speeds and thus travel times), this paper confines itself to behavioral factors influencing the duration of activities as one of the major factors affecting the amount of travel.

The second purpose of this study is to isolate factors which have occurred simultaneously over the past few decades which have been suggested culprits in the rise in travel. These longitudinal trends are dissected by examining cross-sectional variations. To the extent that the movement of the population to different average values of a particular variable (for instance higher income, or lower density) is responsible for the change in patterns, differences within the range of that variable at a single point in time ought to manifest themselves. Of course, not all longitudinal factors can be captured in a single cross-section, there remain implicit assumptions that the effect of the various independent variables on the dependent variable (e.g. minutes per activity) have remained largely stable over time, and that the other important factors which are missing from the analysis don't change much either. While this analysis cannot validate the temporal stability of these effects (for if we could, we would not need to rely on the cross-section), future research should be aimed in that direction.

First, the past decades have seen a marked increase in the suburbanization of houses followed by jobs. While the suburbanization of housing in the absence of the concomitant suburbanization of jobs would surely have led to an increase in work travel durations, jobs did follow housing away from downtown, so little change in commuting times among workers has been seen. (Gordon, Richardson, and Jun 1991, Levinson and Kumar 1994). Still nonwork travel has risen (Gordon, Kumar, and Richardson 1988, Levinson and Kumar 1995a). Suburbanization has been accompanied by differential growth rates between the so-called rust-belt and the sun-belt. Are there variations in travel and activity patterns associated with location? This paper argues that spatial location is a weak explanatory variable for time allocation.

Next, per capita income has risen sharply over the past decades, though per family and per worker income has been largely stable, due mainly to the rise in the number of workers and declining household size. Income creates the opportunity to purchase from outside the home services formerly produced at home, such as food preparation, child care, and entertainment. Are there travel and activity variations associated with income? It is put forward that income is also a weak variable. Though time in travel rises slightly with income above a certain threshold income (where mode usage shifts from transit to auto dominance), this does not explain the large shifts.

It is argued that change in work status (entry into the labor force) is the driving factor. The reduction in time at home associated with working outside the house creates constraints that outweigh the opportunities associated with income and changes in accessibility associated with location. These hypotheses are approached several ways: through an exploratory data analysis, with an analysis of variance approach, employing a multivariate choice model. The key explanatory factors of household income, spatial location (local and national), and demographics are considered. Hypotheses about the effects of explanatory variables on time use are tested using standard t-tests, ANOVA, and in the context of a choice model.

This paper begins with a description of the data used in the analysis. The linkage between activity and travel is presented showing a regression analysis of time spent in travel for the key activities as a function of activity duration and frequency. Next is an examination of inter-activity complementarity. This section is followed by the results of an exploratory data analysis. The data exploration includes an examination of the key variables hypothesized to influence the amount of time spent at each activity.. This section is followed by a presentation of a choice model relating key explanatory variables and the amount of time spent at each activity. The last section concludes with a summary of study results and suggestions for future research.

DATA

The database used in this analysis comes from the 1990/91 Nationwide Personal Transportation Survey (NPTS). The NPTS was conducted as a telephone interview survey by the Research Triangle Institute, sponsored by the United States Department of Transportation (USDOT 1991). The survey collected data on household demographics, income, vehicle availability, location and all trips made on the survey day. The survey was conducted between March 1990 and March 1991 and consisted of almost 22,000 household interviews and over 47,000 persons making almost 150,000 trips. Stricly speaking, the NPTS was not a simple random sample, there were known biases in favor of the number of phone lines per household as well as others which are unknown. However, for the level of analysis conducted here, those biases are not expected to alter the results in an important way, so for the statistical tests, random sampling is assumed.

This study employs a one-day cross-sectional survey, though different individuals were interviewed on different days over the course of 18 months. Other activity studies have used multi-day surveys, which is certainly to be preferred, all else being equal. Multi-day surveys allow inter-day scheduling trade-offs for single individuals to be captured directly rather than being inferred from overall averages, for instance while shopping may or may not be undertaken on a given day, it is much more likely to be undertaken for a given week, month, etc. Unfortunately, all-else is not equal, there are not (yet?) any national, large, multi-day samples which can provide the same information as the NPTS for the United States. For the same budget, there is always a trade-off between depth and breadth, and while this study (and the survey) leans towards breadth, both are important to fully understand the nature of travel and activity behavior. Research into both the behavior, and the best ways to measure that behavior (that is, the appropriate tools) are still important in this relatively new area of enquiry.

First, it may be useful to define travel, activities, and their inter-relationship. Activities are of two classes: location-specific activities and travel. Location-specific activities are defined based on the reported destination activity (purpose) from the travel survey. Travel is the activity which links other spatially separated location-specific activities. The 1990 NPTS provided respondents with a choice of answering where they went next (trip purpose), how they got there (mode), and how long it took (trip duration). In some places in this paper, activity and travel categories are consolidated for analysis.

Only two pieces of time information were provided: the time of departure for a trip, and the travel time for that trip. To create activity data, this study takes the NPTS "Travel Day" database, and by looking ahead to the departure time of the next trip, determines the duration of the stop at the destination. A number of individuals did not report the time of arrival or departure for one trip during the day. These individuals were excluded as their daily time did not add to 1440 minutes. Only individuals who ended the day at home were considered in this study, and time at home was computed based on final arrival time at home and initial departure at the beginning of the day. This is added to any stops at home in the middle of the day. For the graphs and tables presented in this paper, only adults aged 18 to 65 were considered. The elderly and children clearly have different travel and activity patterns, and these may be evaluated in further research.

TRAVEL DURATION

Why should a practitioner of travel analysis care about understanding activity duration? While the analyst may recognize that the total amount of time spent in travel depends on the number of trips (or activities), that analyst may point out that activity frequency is well ensconced in the standard urban transportation modeling procedures as trip generation. Table 1 demonstrates the dependence of travel time on both activity frequency and activity duration using a simple linear model, as described below.

(1) $$TD_i = \beta_0 + \beta_1 AD_i + \beta_2 AF_i$$

where: TD_i = daily travel duration for activity i (in minutes)

AD_i = daily activity duration for activity i (in minutes)

AF_i = daily activity frequency for activity i

(number of times activity i appears as destination)

$\beta_0, \beta_1, \beta_2$ = coefficients

The underlying assumption of this form is that travel time will be composed of a fixed cost, linearly proportional to the number times that activity is undertaken per day, plus a variable cost reflecting the importance of that activity, measured by the minutes spent at the activity. The more time spent at an activity, the more willing will the traveler be to travel farther to get there. Since given two locations to perform an activity, the individual will choose the closer one, ceteris paribus, then the choice of the farther one implies a benefit sufficiently greater to outweigh the travel cost. Also increased activity duration at a far away activity at one point in time may be a means to conserve travel in toto, by consolidating time at an activity and eliminating additional trips. An activity (i) will be undertaken when the net benefit (benefit - cost) exceeds the net benefit for any other activity (at that same time, location, given previous choices etc.) (j) (j•i). If both

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benefit and cost are positively associated with time, we expect an individual to be willing to expend more time in travel to get more benefit from time at an activity.

The inverse hypothesis also may be true, suggesting a desire to have a low average cost for travel, the longer an individual has to travel, the longer that individual will spend at the activity to spread the cost of travel over the largest time possible. In other words, the association between an activity and its complementary travel is due both to the number of activities and to the duration of activities.

To provide some interpretation for Table 1, using the Travel duration to Home column as an example, the number of stops is positive (7.89) while the activity duration is negative (-0.024), the constant is 41.22 minutes. This means that each stop at home adds 7.89 minutes to travel to home to the otherwise expected 41.22 minutes of travel, each minute at home reduces travel to home by 0.024 minutes.

Of nine activities for which this exercise was conducted, activity frequency was significant (and positive) in all nine, reflecting its primacy in existing travel forecasting procedures. Activity duration was significant in seven of the nine categories, positively so in six, while negatively so for time at home. The negative relationship for time at home makes sense when it is recalled that trips to home are coupled with trips to non-home activities, and home and non-home activities are generally substitutes (as described in the next section).

This model formulation can be extended with consideration of more complex functional forms and additional variables. However, it should be noted that prediction of time in travel for any given individual is notoriously hard, and a function of many factors which cannot be readily captured. This explains why so many trip duration models are analyzed at the aggregate level, as with most conventional trip distribution procedures, including gravity and logit models.

CORRELATIONS

This section examines the issue of inter-activity complementarity and substitutability. In economics, two activities are considered substitutes if they have a positive cross-price elasticity, that is: if the price of “A” goes up, then the demand for “B” increases. However they are complements when they have negative cross-price elasticity:

if the price of “A” goes up then demand for “B” declines. The Pearson correlation matrix tells us a similar thing. If the correlation between two activities are positive, that is the duration of the two activities are positively associated, they will be defined as complements. Similarly if the correlation is negative between the two numbers, the activities will be considered substitutes. The correlation matrix of course tells us nothing about causation - which in activity patterns runs two both ways as individuals adjust preferences to the confines of an activity budget. One difficulty in causality here in contrast to economics is that quantity and price are the same in this analysis - both are measured in units of time.

Because all activities (including travel) are undertaken within the confines of a 24 hour day, to some degree they necessarily substitute for each other. But are any non-travel activity pairs (where a non-travel activity pair is for instance time at home and time at work, or time at shop and time at other) complementary? At first glance work, which earns money, and activities such as shopping and eating out, which spend money, may be thought to be complementary, since money can be substituted for time spent performing chores at home. Activities (such as personal services) which in the absence of a job might be performed at home would instead be purchased from the outside when the job consumes time and produces income. But depending on how activities are classified this may or may not be the case. Broad activity categories, such as shopping, eating out, and personal business can be undertaken at almost any income level, so while the income from work may affect the quality of the activity, there is no guarantee that the quantity will increase as well. The economic concept of normal goods (whose consumption rises with income) cannot be directly applied in the case of time, which like money is subject to a budget.

Tables A1 to A3 show the correlations between non-travel activity durations, between non-travel activity durations and travel durations, and between travel activity durations respectively. The values on the diagonal on A2 are not 1 because the durations of activities and travel to those activities are not the same and not perfectly correlated. The values in the correlations matrices are summarized below (in Chart 1), where total cells is the number of cells in the correlation matrix, and the signficance is determined by whether the column and row are positively (or negatively) correlated using the Pearson correlation test.

Chart 1: Summary of Activity and Travel Duration Correlations Matrices

	Matrix	Total Cells	Positive and Significant	Negative and Significant
1	Activity-Activity	66	1	29
2	Activity-Travel	144	15	39
3	Travel-Travel	66	11	10

Note: Significance is significantly correlated using the Pearson correlation test

First, the results indicate that most non-travel activities (referred to, hereafter, as activities) are in fact substitutes for each other. Of the significant correlations, only time at home and time at shop were positively associated, indicating that shopping for goods which are consumed at home substitutes for consuming time and effort out of the home, perhaps at "other" activities. The suggestion that work and activities such as shopping and other might be associated was clearly refuted by the data, indicating that the time loss from having to work outweighs the advantages of additional money to spend on out-of-home activities. This neither demonstrates nor refutes though, for instance, that among workers, those with more money spend more time outside the home, which is examined in the next section.

Second, the correlations between activity and travel are somewhat more complicated. While in almost all cases, an activity was positively (and significantly) associated with travel to that activity, indicating as expected, that a trip and its activity are complements, travel was positively (and significantly) associated with different activities in four cases, perhaps representing trip chaining. Time at home was negatively associated with most types of travel, except travel to shop. Similarly time at work was also negatively associated with travel to all activities except work.

Third, travel to an activity is positively associated with the return trip, often to home, as shown by the positive association between travel to home and travel to other activities. In theory, travel to work could either increase or decrease travel to other activities. If one engages a long trip to work, there is less time for other activities and thus travel, but if the other trip is to be made anyway, it might be recorded as a long trip, if it is a stop on the chain between home and work for instance. In fact, travel to work is negatively and significantly associated with travel to seven other activities. In general, travel between other activities (neither home nor work) are uncorrelated.

ACTIVITY DURATION

Having shown travel duration depends on activity duration, the next logical question is “What does activity duration depend upon?” This section examines how activity duration varies with explanatory factors. The factors considered in this analysis are spatial, socioeconomic, and demographic. The spatial variables include land use density, metropolitan area and population, region of the nation. The socioeconomic variable examines household income for workers and non-workers, stratified by gender. Demographic variables considered are gender, age, and life cycle stage. The differentiation in the use of time across the range for values for each of these variables will indicate the extent to which they may explain the long term rise in travel and shift in activity patterns, as the means of the values have changed over time. These variables are addressed in turn.

Space

Density

Local residential density is the best available measure in the 1990 NPTS dataset of relative location of the household within the metropolitan region. Building off of previous research (Levinson and Kumar 1997) this paper adopts the position that, as a determinant of time use, the variable representing local residential density measures most importantly congestion and distance from the metropolitan center(s), rather than density itself. Some variation in activities associated with the density variable might be expected. First, there may be a different level of accessibility to activities associated with different densities, out-of-home activities may be more easily accessed in the city than the low density suburbs, and particularly exurban areas. Historically, the center city was the location of the accessibility peak. Over time this changed as the suburbs became increasingly accessible for more activities, particularly shopping. If the monocentric dominance remains, a higher out-of-home activity behavior in the high density areas would be expected. This may be further compounded by differences in socio-economic variables. Urban areas have a different, and self-selected, population mix than the suburbs and rural areas. Thus, those who enjoy the benefits of urban activity will take advantage of it, while those who prefer space and quiet sort themselves into the lower density suburbs.

Examining the effect of density on activity duration gives mixed results (Figure 1). While the very highest density classes, those over 10,000 persons per square miles (ppsm) show significant differences in most of the activity categories, there remains a high degree of variance. In the suburban densities for instance, one density will be associated with a significantly higher than average activity duration, while an adjacent class will be associated with a significantly lower than average duration. In fact, time at home, shopping, and in other activities declines at the highest densities, while time at work and in travel rises. Broadly speaking, the suburbs (densities of 100 - 10000 ppsm) are relatively homogenous, while the highest and lowest densities have noticeably different patterns. This suggests that shifts in metropolitan location to lower density suburbs cannot be the dominant cause of the rise in total travel. Examining this issue more formally, using analysis of variance (Table A4), shows that residential population density is a statistically significant factor in measuring activity durations of home, work, and travel, but not a particularly important factor, variation in density explains less than 1% of the variation in activity patterns for those three categories.

Metropolitan Area and Population

As with density, hypotheses surrounding activity duration and metropolitan area population rest principally with an accessibility argument. In brief, the larger the metropolitan area, the more choice for out-of-home activities that a resident has. The additional choices may provide the incentive for the marginal consumer of non-home activities to pursue a few more minutes per day outside the home.

An examination of the census defined CMSA's finds little metropolitan differentiation in the use of time (Table 2). While there is a slight trend toward more time at work and less at home as cities increase in size, the trend is not statistically significant. A comparison of the mean duration for each activity by city and nationally shows few cities deviate significantly from the average, only 8 of 95 cells in the table differ from the mean with more than 95% confidence on a two tail t-test. (and about five can be expected to differ at that confidence level without ascribing any meaning to the results). The lack of inter-metropolitan differentiation refutes suggestions that changes in travel patterns can be explained by the rise of certain fast-growing sunbelt cities at the expense of the rust-belt.

Use of ANOVA (Table A5) to examine the effect of metropolitan population shows that the population is a statistically significant factor for explaining variations in durations of home, work, and travel categories, though not an important factor, explaining less than 1% of the variation. Interactions between population and region of the country were generally not significant except for the travel duration category.

Region of Country

Variations in time use by region of the country can be due to several factors. The most obvious is climate associated with the seasons. Other explanations may relate to demographic differences which are associated with region. Florida and Arizona have a high proportion of retirees (though this study examines principally workers). Similarly family sizes are not uniform either. Ethnic groups are not evenly spread across the United States, for example, Hispanics comprise a relatively large share of the population in New York, Florida and states bordering Mexico, as do Asian-Americans in the West, Native Americans in the Rocky Mountain states, and African-Americans in the East, particularly the southeast. If behavior is associated with ethnicity (and it is a plausible assumption), then it may be reflected spatially.

An investigation of the data, illustrated in Figure 2, suggests that there are significant differences between some of the regions for some activities. Comparing each region with the national average shows that people in the South Atlantic spend less time at home and more time at work than the national average (at the 95% confidence level), while those in the two South Central divisions spend less time at work. All divisions were near the national average on time spent shopping. Other activities were found shorter duration than average in the Middle Atlantic, and longer duration in the West North Central states. Those in the Middle Atlantic are traveling more though, while the Mountain States residents travel significantly less than the national average. Future research should more carefully examine the causes and consequences of regional variation.

Use of ANOVA (Table A5) to examine the effect of region shows that the census region is a statistically significant factor (at the 10% level) for explaining variations in durations of home, work, and other categories, but again not a particularly important factor, explaining less than 1% of the variation.

Money

Individuals use time to earn money, and money to buy services in place of spending their own time producing them. Since there are diminishing marginal returns to most goods at some satiation point, there are diminishing marginal returns to earning money. Thus, when the income per hour rises above a certain level, an individual may choose to work less hours and consume more time in leisure. However whether this point is represented in the data is unclear, as all income categories above $75,000 per year were consolidated and it is quite possible that the point at which individuals choose leisure over income is significantly higher than that.

One may plausibly posit that low income is positively associated with time shopping. Suppose that a given quantity of goods needs to be purchased, but that prices vary by store. Individuals with a relatively low value of time relative to money need to make each dollar go further, and may spend more time shopping for discounts rather than accepting the first satisfactory good. Low income individuals may accept higher search costs to attain lower prices, which may require more time spent traveling and/or shopping.

The data, shown in Figures 3-7, are for all adults 18 to 65 stratified by gender into workers and non-workers. While little in the way of trends can be seen within categories, the differences between category are stark. As shown in Figure 3, women generally spend more time at home than men, and non-workers spend more time at home than workers. The difference between genders is much smaller than the difference between different individuals with different work/non-work status. The variance is highest in the category with the fewest observations (male non-workers). In some income categories, women actually spend less time at home than their male counter-parts, but this is only true in 8 of the 34 income/work status categories for which the comparison is made, and the differences are not statistically strong.

Figure 4 compares time at work for working men and women. It should be noted that time at work is averaged over all seven days of the week, and so includes individuals in the workforce surveyed about weekend travel patterns. Therefore, time at work would be lower than if the survey were confined to weekdays only. At all but one income level, men work more minutes per day than women. This is explained in part by part-time jobs, but those could not be distinguished from the data. In general time at work rises with income level, but it might be stated the other way: income level rises with time at work. Causality runs both ways here - high income workers are expected to put in more time, while those who put in more time can be expected to earn more money. Because we are looking at household income, the result is not as stark as it might be if we had data on personal income.

Figure 5 illustrates time spent shopping by income level. As expected females shop more than men, but female workers even shop more than male non-workers in all but three cases. Generally, shopping takes the most time among those in the middle income brackets, a pattern which appears weakly in all four curves. While in few cases are the differences between travel times and the average travel time for the work/gender category significant, the differences between categories are. For instance, the difference between working women and non-working women on shop time is nine minutes, but this is out of an additional 300 or so minutes per day available because of the absence of work.

Figure 6 graphs time at other activities. Among workers, time at other for men and women is about the same across all income categories, averaging 98 minutes for all men and 97 minutes for all women. Non-workers spend more time than workers at other activities (due to the extra 300 minutes), though men and women again spend about similar amounts of time, after controlling for income (non-working males, a small sample, again show very high variance), the average time for men is still larger: 183 minutes compared with 158 minutes for women.

Travel, shown in Figure 7, shows the sharpest income trends, for workers the higher the income, the more time spent traveling. It should be noted that in the very lowest income category (less than $5000 household income) women show a surprisingly high average time in travel, which may be due to transit/carpool dependence in one or zero car households. Non-workers show a high variability in the time spent traveling, and no clear trend can be inferred from the data.

Table A6 compares the amount of explained variance due to income, gender, and work status. All three variables are significant in many cases, but their importance varies greatly. The amount of variance in time spent at home explained by work status is more than 20 times the amount explained by gender and income. We obviously get an even starker result for time at work, where income is not even a significant factor. However for time spent shopping, gender explains three times as much as work status and income. For time at other activities, both gender and income are not significant, and work status is the most important factor. Finally, for the amount of travel undertaken, it is income which explains the most variance, followed by gender and work status. In general, the interaction (multiple variable) effects are not particularly important compared with the variables alone.

Life-Cycle

Previous research has found relationships between demographic factors and the use of time. First, as noted above, because men are more likely to be in the workforce then women, there is an obvious disparity between men and women on the amount of time spent at home, work, shopping, and other activities. However, corroborating the above evidence, even after controlling the decision to work, it has been found that working women spend more time shopping and at home, and at less time at work than working men (Levinson and Kumar 1995a), indicating that traditional gender roles remain.

Figures 8-12 show how the use of time varies with age for male and female workers and non-workers. Time spent at home (figure 8) rises sharply with age for non-workers. For workers, it is saucer-shaped, declining from the teen years to the early twenties, flat through the middle years, but rising as men enter their fifties and women their late forties. The rise in time at home in the later years is statistically significant for all groups.

Time at work (figure 9) follows the opposite pattern, it is basically hump shaped, peaking in the middle years for men and women, lower in the early years due to school and in the later years due to semi-retirement, or women in the cohort which never joined the workforce full-time holding part time jobs. Women show a dip from the late twenties to their thirties, which can possibly be ascribed to leaving the full-time workforce for childcare (and more part-time work). This basically supports part of the "Mommy Track" argument, that women with children work less than those without, what effect that has on their careers is beyond the scope of this research. However as shown in figure 4, female workers at the highest household income levels (> $65,000) do work somewhat more than those with incomes between $30,000 and $65,000, all full-time income levels, perhaps because those at the highest incomes can afford more or better day care. The time spent at work in the early thirties for women is statistically different from the average for women at the 95% confidence level (2-tailed), suggesting that it is more than simply noise in the data.

Figure 10, showing time spent shopping, reflects high variability among non-working men and women. Among workers, time spent shopping rises with age, for women peaking in the middle years, when family size is the largest, for men increasing in the fifties and sixties, perhaps explainable by the same reasons that they spend less time at work. Generally non-workers spend more time shopping than workers at all age levels, though for men, their is a small sample size of non-workers so that the behavior of non-working males cannot be separated from randomness in the data.

Figure 11 illustrates time at other activities. This value drops almost monotonically with age. The first explanation is the transitions from school to work, shown in workers as they move from part-time to full-time work as they finish school in their twenties. The non-workers trend may also be explained by a shift from school to home activities.

Daily travel duration (Figure 12) is interesting. Teenage girls travel more than their male counterparts, but roles reverse by the late twenties. There is a slight peak in driving towards middle age for male workers and female non-workers between 46 and 50, though female workers peak in their twenties and female non-workers actually drive more in their teens. Again, male non-workers have the highest variability, associated with small sample size.

Age and life cycle stage are interrelated variables. The NPTS database characterized respondents by whether they were single or lived in a two+ adult household, whether they had children, and if so, whether the children were between 0 and 5 years, between 6 and 15 years, or between 16 and 21 years. It is expected that adults with young children will spend time at home to be with that child, but that as the child ages, that staying home will be less important. Singles and couples also have different life styles, it is posited that singles without children spend more time out of the home than individuals belonging to couples.

Table 3 charts time use by life cycle category and gender. Women without children spend less time at home and shopping, and more time at work and traveling than those with young children. Men in couples with children actually spend less time at home and more at work than those without children - suggesting that household roles are split, while women stay at home to rear children, men work outside the home more to compensate. However, the relatively few single men with children work less and are home more than single men without kids, suggesting that child care responsibilities eats into other options.

It might be thought that women with children shop more than those without, which is true for women in couples, but not single women. Uniformly, singles spend more time at other activities than couples. Except for childless households, singles also spend more time at home. Singles spend more time shopping in 4 of 5 child categories. Members of couples (2+ adult households) consistently spend more time at work and spend more time in travel for 4 of 5 child categories.

The age of the oldest child has a significant impact on time use. Members of households with young children (0-5) spend more time at home than those with children 6-15, and more still than those with children 16-21, and still more than childless households. The time at home comes principally from time at work (and travel to work), presumably as parents (usually women as noted in the age graphs) drop out of the workforce or spend less time at work to care for children. The variation in time use by age, number of children, and number of adults in the household is large than the differences over the range of both spatial variation and income.

The ANOVA of life-cycle and the five activities (Table A7) shows a significant relationship between the life-cycle stage and the duration of home, work, and other activities at the 10% level. For time at home and work, the life-cycle stage explains about 2% of the variation in duration at those activities.

CHOICE MODEL

To test in a multivariate context the hypotheses and observations outlined above, a logit model is formulated and estimated from the 1990 NPTS data. The logit functional form was chosen for its ease of estimation and clarity of results rather than because of theoretical precepts relating to the expectations of the distribution of error terms. The theory of logit analysis used below follows Train (1986). The use of logit, or any discrete choice structure, is perhaps unusual in activity duration analysis (as opposed to say activity pattern analysis where it is often used), other model forms: simultaneous equations, duration models, or micro-economic models (Becker 1965), have been used more often. The appropriate method depends on how the problem is defined, and here it is defined in somewhat more macroscopic terms (share of the day for each activity) than it would be in a more detailed scheduling or time-of-day model.

We may posit that individuals choose (or refine) an activity plan at the beginning of the day. This plan devotes a certain percentage of the day to specific activities: home, work, shop, travel, other. While other decisions (such as the sequence and location of activities) are also made, they are not treated here, as they can be thought to be second order decision. In the ideal model there is a feedback between decision: whether I actually undertake activity X may depend on its location relative to others, its time sensitivity, etc., but in this analysis that is not incorporated, it will await further research.

The share of the day spent at any activity depends on a number of factors, but in the use of time, only one activity can be undertaken at a time. In other words for each time slice, for instance each minute, a decision-maker chooses between one of the specified activities. But one minute is very much like the next, the choices are highly connected - switching between activities such as home, work, shop, etc. implies changing locations, which requires transportation, so a simple choice model is not appropriate at that scale. In the aggregate (for example one day), the individual decision-maker chooses the amount of time to spend at each activity. It is this aggregated quantity which is estimated here.

The objective is to explain the shares (minutes per day divided by total minutes in a day) associated with each activity. For this estimation, a weighted logit model is employed, where each individual chooses the proportion of the day spent at each activity. The utility of the activites are thus estimated as the dependent variables. The applied model gives the share of the day associated with each activity. The weights for the choices are the observed number of minutes per day spent at that activity, which sums 1440 minutes for all of the activities. This is mathematically analogous to estimation and application of a multinomial logit model with the decision unit being the choice of activity of each individual for each minute (thus there would be 1440 observations per individual). While as a realistic choice structure, each minute is not a useful partition of time -- it is far too disaggregated and interdependent, in aggregation it does provide meaningful results.

Four alternatives are defined: time spent at (and in travel to) home, work, shop, and other, which by definition add to 1440 minutes for all of the individuals in the sample. The independent explanatory variables are specific to the decision maker, and include: Activity Frequency, Day, Month, Gender, Age, Household Income, Life Cycle, Residential Density, Region, and Metropolitan Population.

The parameter vector (ß) is estimated for each choice and each variable, but is assumed to be constant over all individuals (n), and the mode specific alternative (a_i) is estimated for three of the choices. The variables are estimated for three of the four available choices, one choice (work) is considered the base to normalize the values. Furthermore, a number of variables are dummy variables describing a range of value, one class of the dummy for each variable (for instance one of the four seasons) is suppressed for a similar reason. The model is estimated using the Alogit package (Daly 1993)

Table 4 presents the results of this weighted logit analysis. The largest part of the explanatory value of the model falls on the activity specific constants. Because of the large sample, most of the variables introduced into the model were statistically significant, though their actual impact on time is in many cases small. Some of the insignificant variables for one choice were significant for others, and are left in for explanatory purposes. This model is for understanding rather than prediction, and findings of insignificance of hypothesized variables are as important as findings of significance.

The next most significant variable (for shop and other activities) was activity frequency. One naturally expects that the more times one pursues an out-of-home activity, the longer one will spend at that activity. Similarly, the more times one has to return home, the less time one is actually spending at home, since the trip to return home implies the trip to leave home. The research could be extended through estimation of a multi-stage model considering both activity frequency and duration.

The single variate analysis noted that even after controlling for work status and income, gender roles in activitiy patterns remain. The results for gender largely corroborate what was found earlier. Men spend less time at home and shop but spend more time at other activities than women. Age patterns are less sharp, while in the single variate analysis, there was no assumption of linearity in the effect of age on duration at various activities, this model is estimated with age as a linear variable. The results for age only indicate that time at other declines with age, the home and shop activities show no significant relationship, reflecting in part the non-linearity in the relationship between age and those activities.

Singles spend more time at work and less time at home, shop, and other activities than persons living in households with two or more adults. This is not obvious in Table 3, but it must be remembered that singles are much less likely to have children than two adult households, so while for each category, singles spend more time at home, they don’t overall. Dummy variables for children need to be compared to the suppressed classes (youngest child 16-21 and retired) who spend more time at home than do presumably younger households with younger children. The correlation between number of children, number of household adults, and age should be noted, making direct interpretation less immediately obvious than comparing what happens when these related variables change together.

Spatial variables including density, metropolitan city size and region of the country were tested. High density urban living is positively associated with time at other activities, and negatively associated with time shopping. After controlling for other variables, density has a different effect than noted in the section above and on Figure 1, suggesting that self-selection biased that single variate analysis. City size, reflecting access to out-of-home activities, was positively associated with time at other and negatively associated with time spent shopping, while inspection of table 2 provides us with little to go on.

Region of the country suggest that those in the south central and western areas of the country spend less time at home, shopping, and other activities, and thus spend more time at work than those from other areas, while those in the north-east spend more time shopping than those from different regions.

The seasonal factors suggest time at home is higher in winter, spring, and summer, and time at shop lower in those seasons than the suppressed autumn season (defined to be coincident with the months of October, November, and December, and including the important Christmas holiday).

CONCLUSIONS

The consideration of activity duration in travel demand forecasting is essential to improve results. Travel duration depends on activity duration as well as the more traditional activity frequency. Activities are rarely complementary, rather, they are mostly strict substitutes, only time at home and time at shop were positively associated in a test of the correlations between activity durations for various activities. However, as expected travel and activity are mostly complements, the amount of time spent at an activity is positively associated with travel to that activity. Aside from the complementary return trip to home, in general, travel durations between other activities (neither home nor work) are uncorrelated.

The time at an activity is very constant, with only relatively small variations explainable by economic, demographic, locational, or temporal factors. Travel and work were positively associated with income, but most other activities were independent of income, suggesting that the primary trade-off between money and time is located in the decision to work, those with more money don't spend particularly more time out of the home purchasing services that with less money they would perform at home. Men and women, and workers and non-workers had markedly different behaviors, as has been found in earlier research.

An attempt was made to disentangle the longitudinal trend effects using the NPTS cross-sectional survey. The cause of the rise in travel over the past few decades can largely be lain on the discretionary time loss due to changes in labor force participation, particularly by women, rather than the concomitant rise in low density living, sunbelt migration, and per capita income.

Future research should be directed at developing better explanatory measures for the use of time. These may include additional variables, mathematical transformation of the data, different functional forms of the independent equations, or alternative model formulations. In addition, data need to be analyzed explaining the use of time by children and the elderly. Policy implications need to be considered after a thorough understanding of the mechanics of activity choice.

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AUTHOR'S NOTE

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Figure 1: Residential Density vs. Time Use

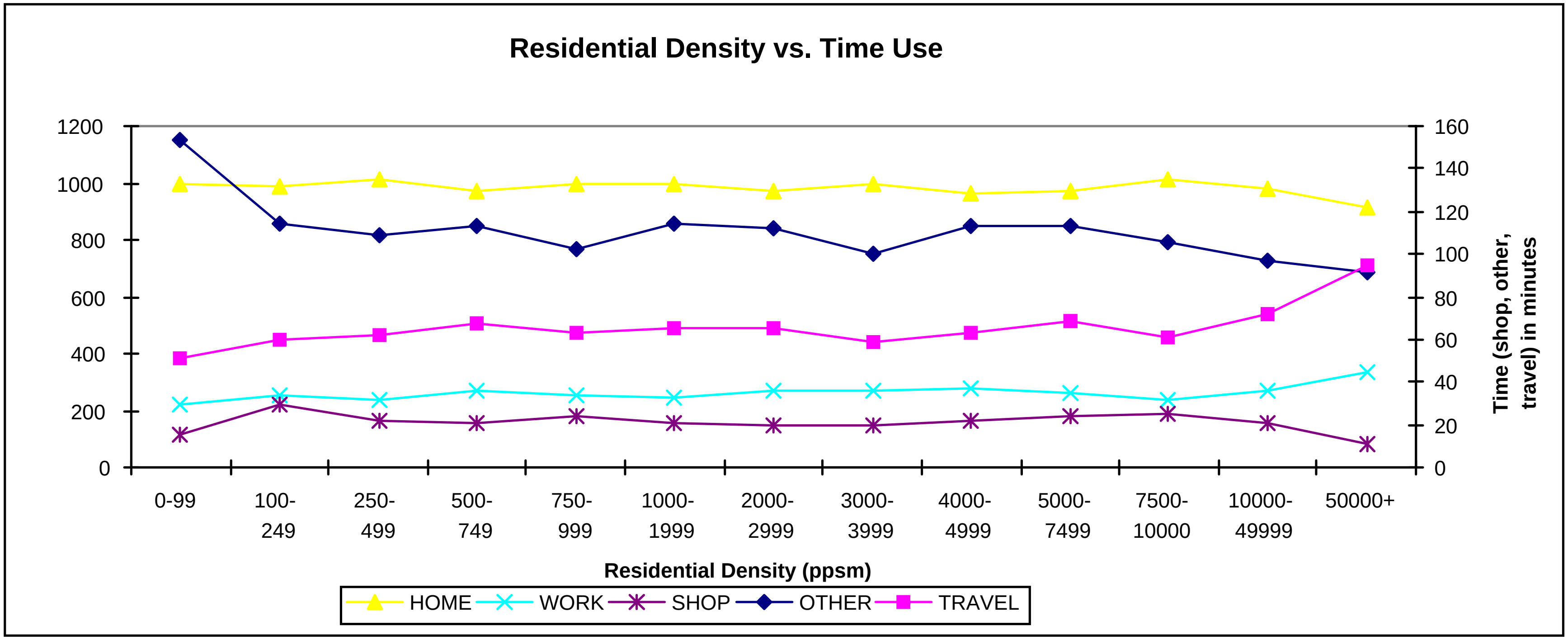

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Figure 2: Census Division vs. Activity Duration

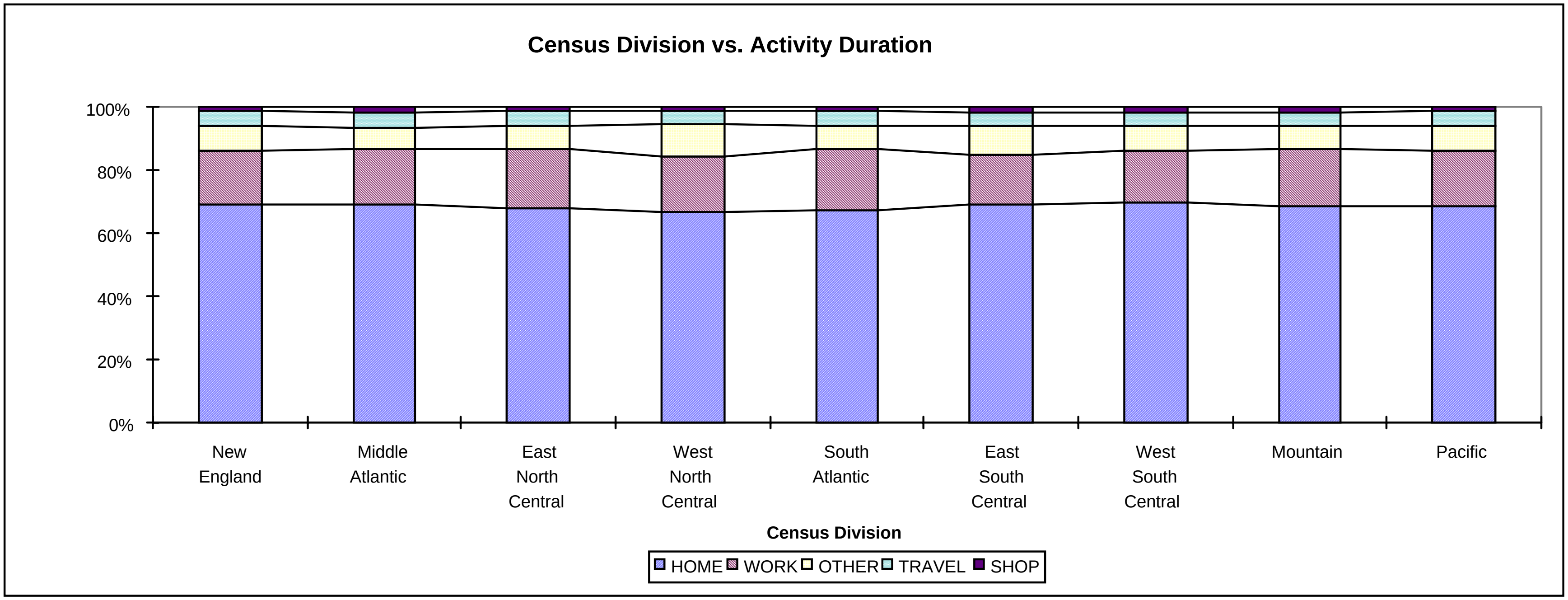

Figure 3: Time at Home by Income Level

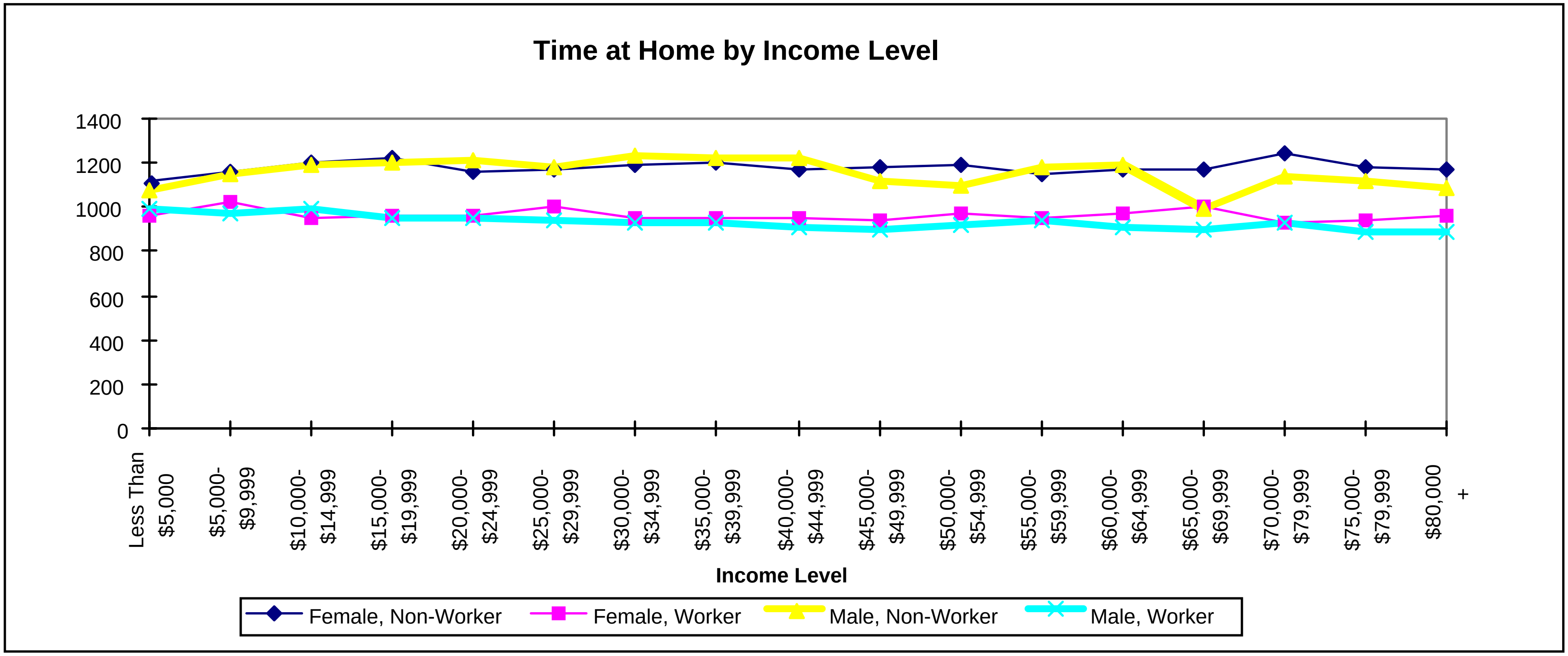

Figure 4: Time at Work by Income Level

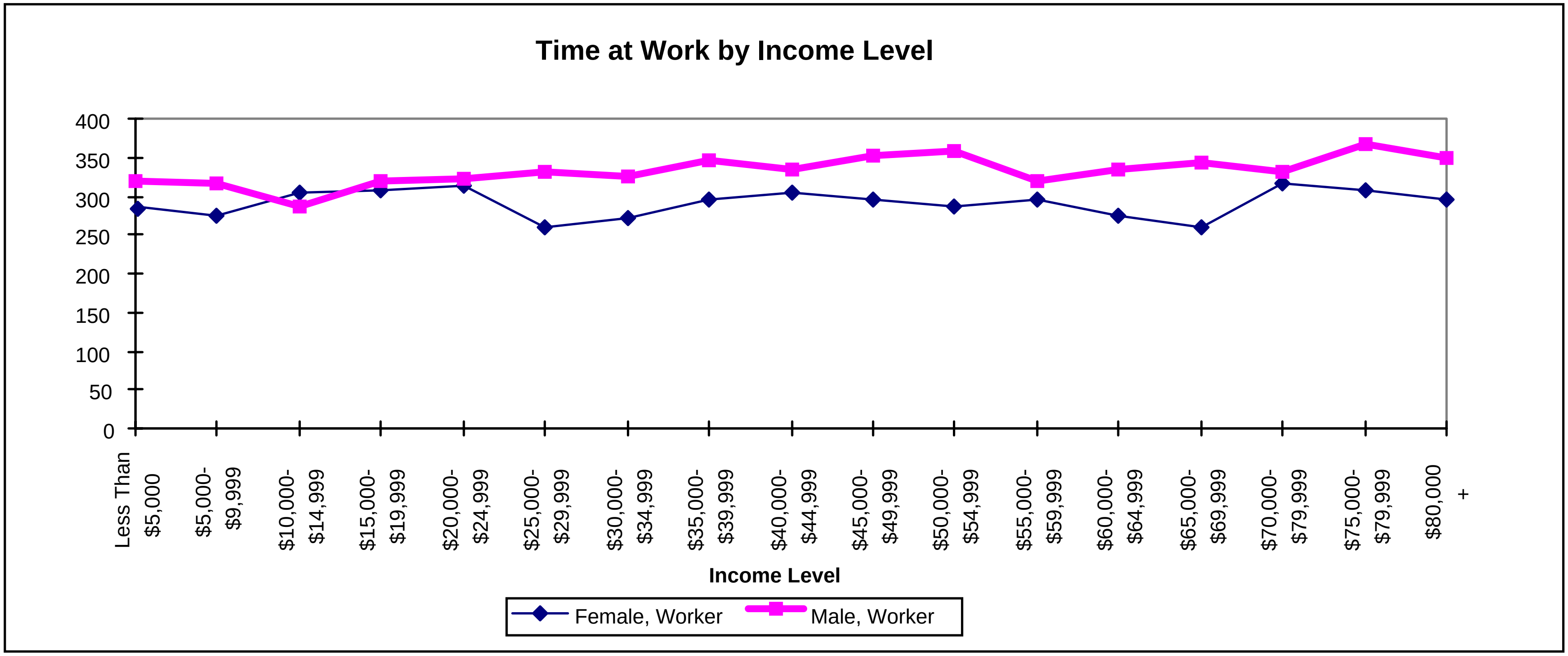

Figure 5: Time at Shop by Income Level

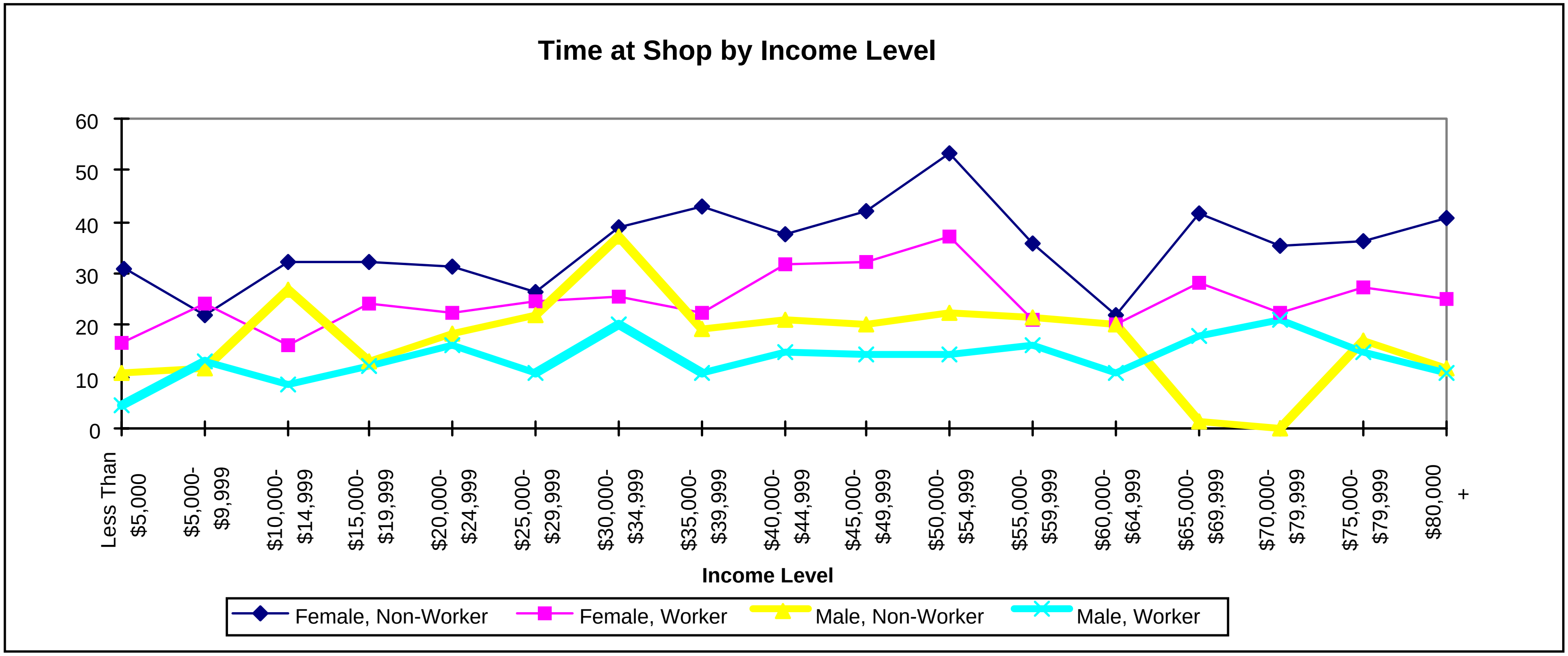

Figure 6: Time at Other by Income Level

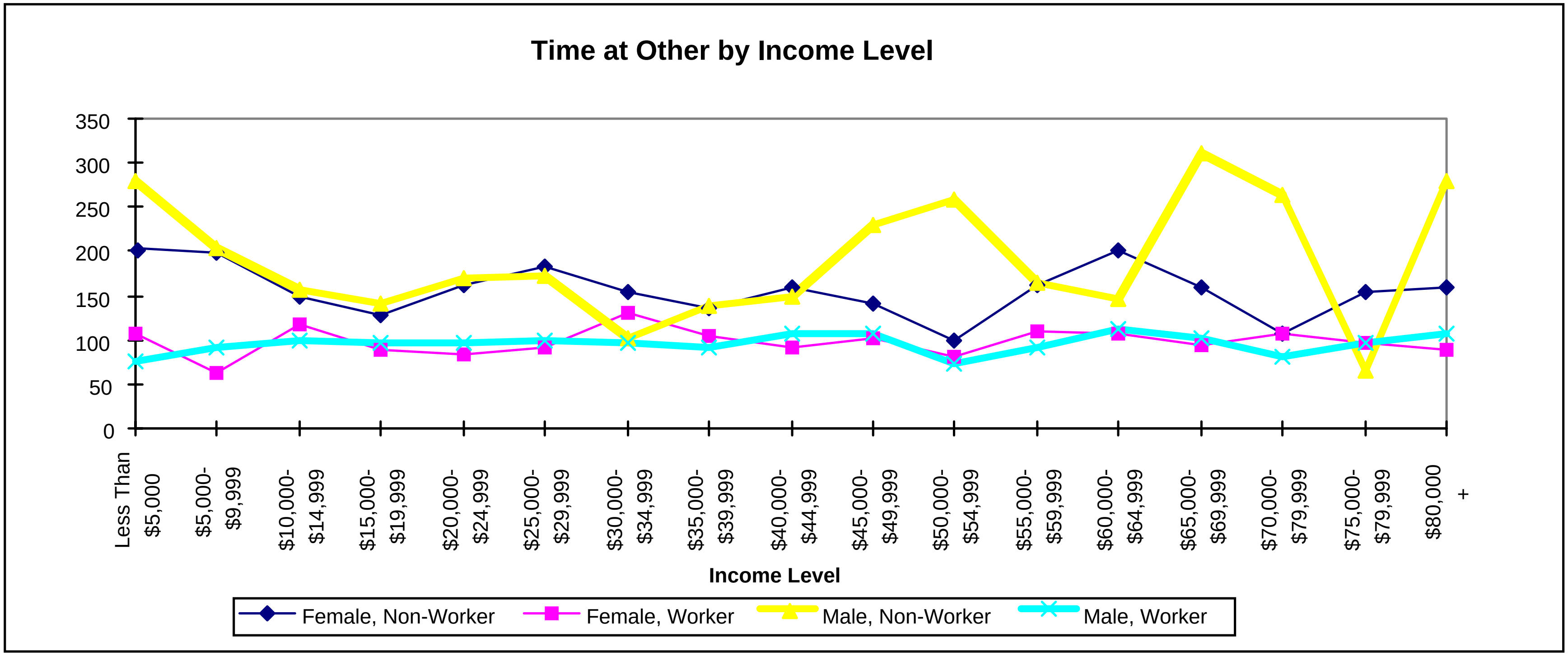

Figure 7: Time in Travel by Income Level

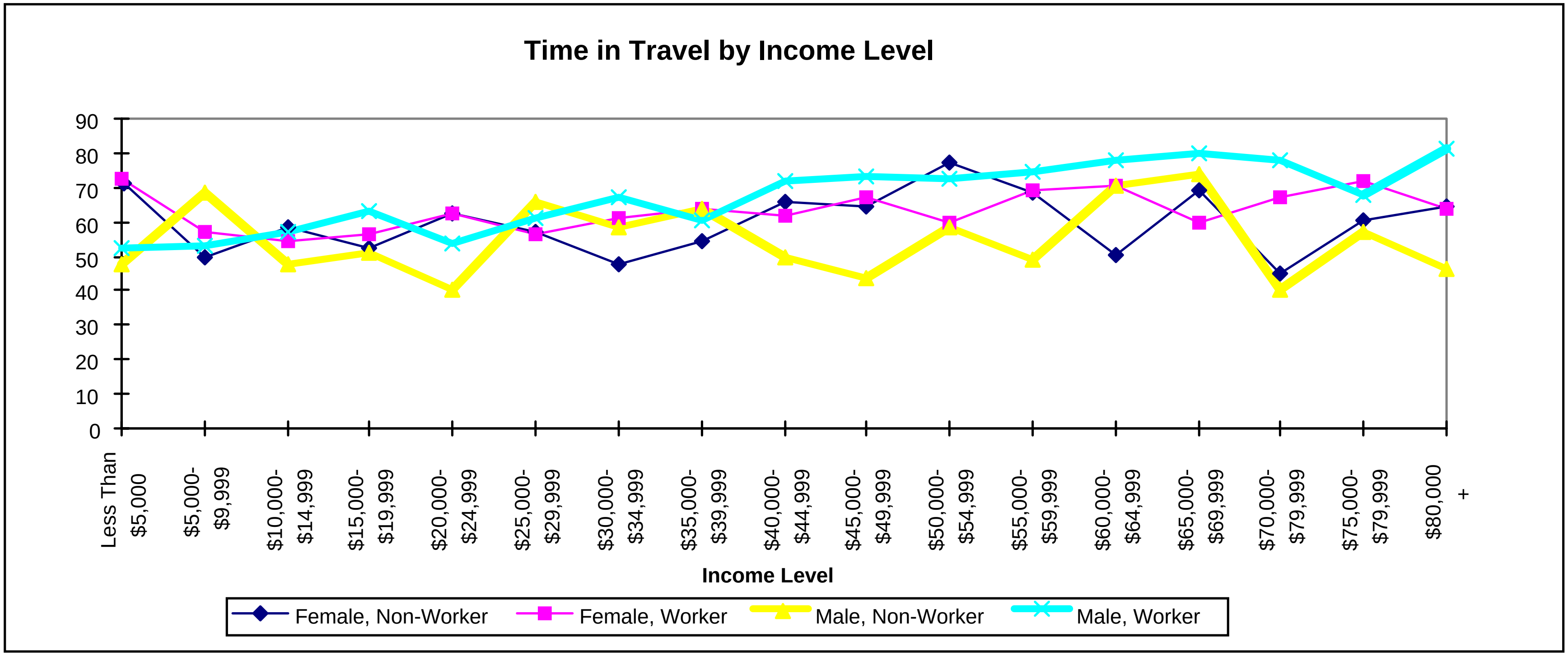

Figure 8: Time at Home by Age

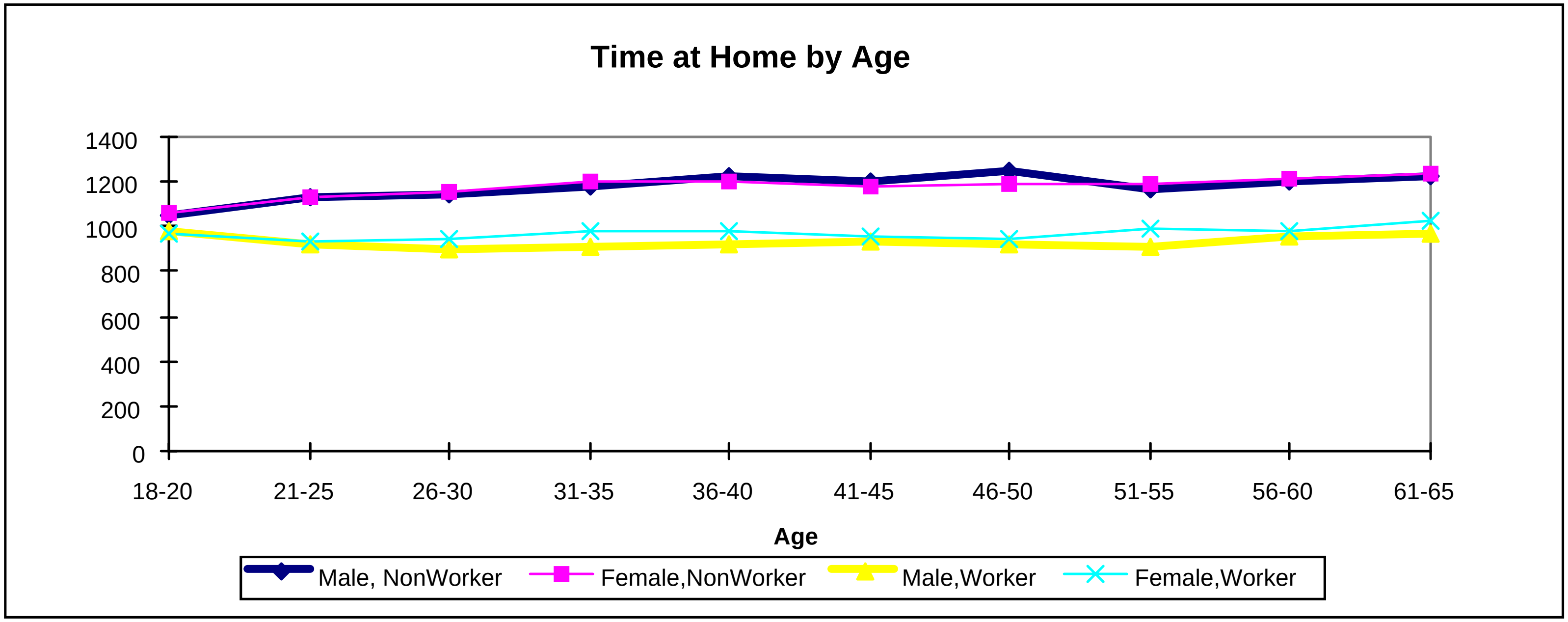

Figure 9: Time at Work by Age

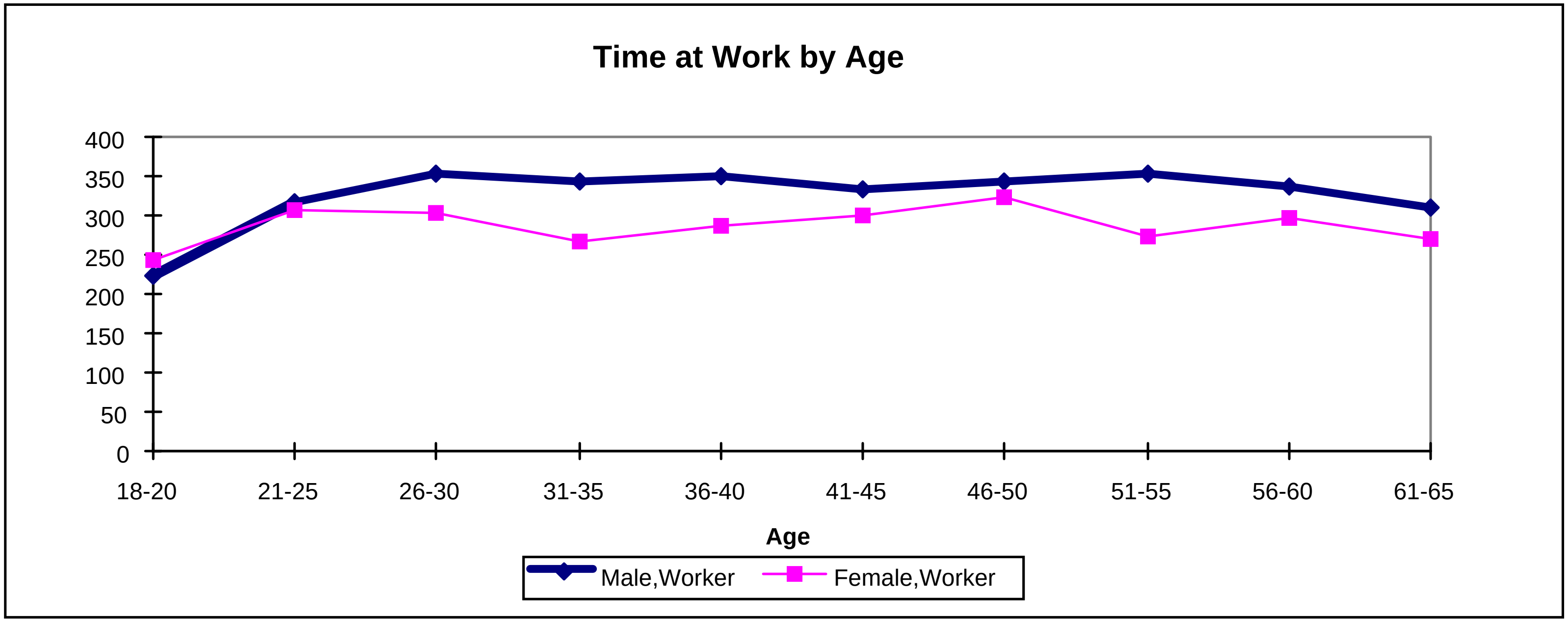

Figure 10: Time at Shop by Age

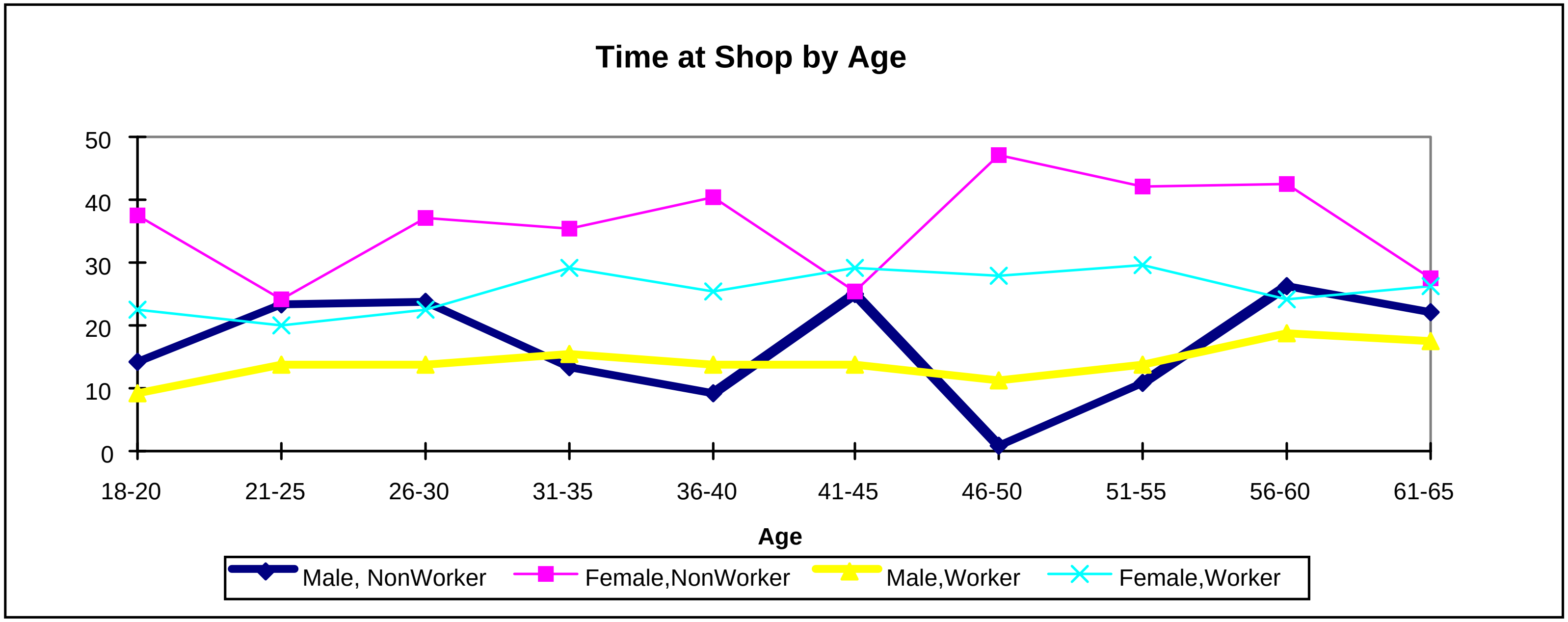

Figure 11: Time at Other by Age

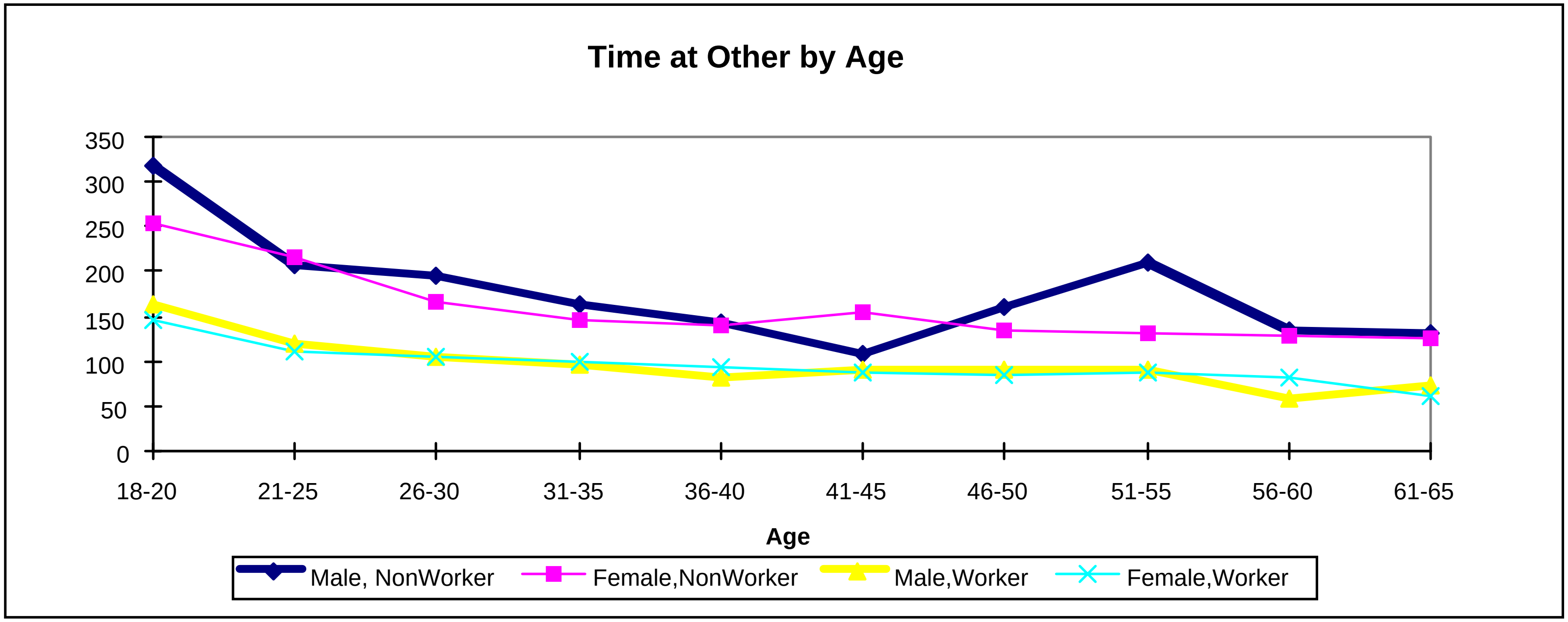

Figure 12: Time at Travel by Age

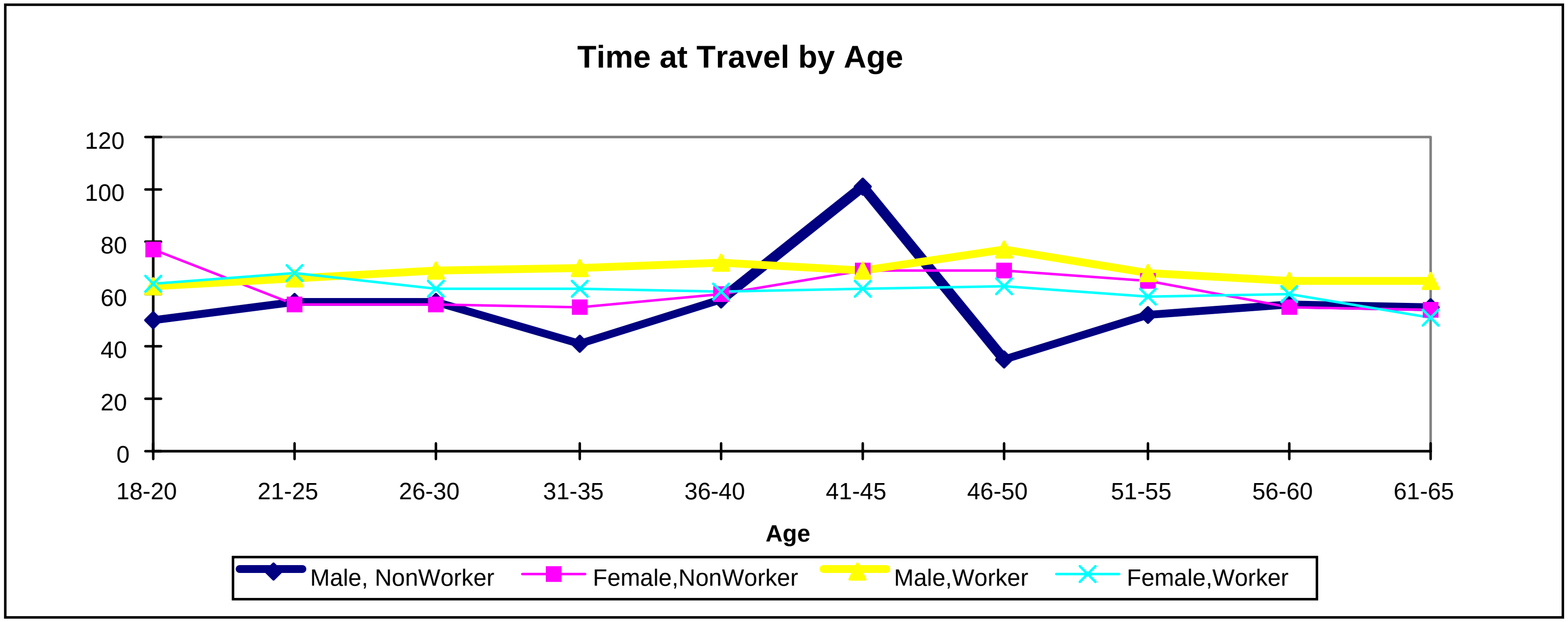

TABLE 1: Descriptive Statistics and Models to Predict Travel Duration by Activity Duration and Number

	Home	Work & Related	Shopping	Personal Business	School Church	Doctor Dentist	Friends Relatives	Social Recreation	TOTAL OTHER
Descriptive Statistics									
Activity Duration									
Mean	984	492	65.6	89.5	204	85.1	178	150	193
Std. Dev.	257	158	82.7	118.1	161	75.3	147.9	137	168
Travel Duration									
Mean	28.8	24.1	14.7	24.1	17.8	19.1	23.2	23.6	30.2
Std. Dev.	40.1	24.5	17	30.1	14.3	11.9	24.5	28.3	32.7
Number of Stops									
Mean	1.41	1.13	1.27	1.65	1.16	1.07	1.25	1.29	1.84
Std. Dev.	0.69	0.47	0.64	1.08	0.46	0.26	0.6	0.63	1.29
MODEL (Dep = Travel Duration)									
Coefficients									
Number of Stops	7.89	16.90	10.82	11.24	8.63	20.77	14.46	16.40	12.23
(t - stat)	12.40	22.93	22.91	20.61	8.57	6.23	13.41	16.36	32.41
Activity Duration	-0.024	0.000	0.031	0.028	0.020	0.005	0.027	0.043	0.028
(t - stat)	-13.623	-0.098	8.334	5.660	7.057	0.415	6.095	9.172	9.668
Constant	41.22	5.18	-0.84	3.22	3.72	-3.51	0.52	-3.78	3.65
(t - stat)	20.36	3.61	-1.28	3.07	2.83	-1.00	0.33	-2.76	4.18
N	8038	4287	2589	2260	850	165	1201	1750	4768
Adj. R-Square	0.04	0.11	0.22	0.20	0.14	0.20	0.17	0.23	0.24
Std. Error	39.42	23.17	15.05	26.89	13.25	10.62	22.41	24.91	31.87
F-Stat	181.20	262.91	376.70	291.09	72.56	22.24	123.41	262.42	740.80
Sig. F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

note: Mean daily activity duration, daily travel duration, and number of stops are only for those making trips (number of stops • 1), as are associated regressions. Durations are daily totals in minutes. Number of Stops represents activity frequency.

Table 2: Activity Durations (daily total, in minutes) by CMSA

		Home			Work			Shop			Other			Travel			
CMSA Name	1990 Pop.	Mean	Std Dev	Diff. Mean	Mean	Std Dev	Diff. Mean	Mean	Std Dev	Diff. Mean	Mean	Std Dev	Diff. Mean	Mean	Std Dev	Diff. Mean	Cases
Hartford, CT	1.1	998	249	0.90	243	266	-1.06	23	60	0.37	108	151	0.41	67	66	-0.44	301
Providence, RI	1.1	1055	238	1.62	181	256	-1.68	20	38	-0.37	134	142	1.13	50	35	-2.90	30
Buffalo, NY	1.2	1045	323	0.92	241	297	-0.30	20	31	-0.41	62	118	-1.77	72	114	0.13	24
Portland, OR	1.5	1012	261	0.72	242	287	-0.44	17	50	-0.67	102	146	-0.12	67	54	-0.20	49
Milwaukee, WI	1.6	975	253	-0.25	334	265	1.84	21	40	-0.15	56	107	-2.93	53	34	-2.99	43
Cincinnati, OH	1.7	974	261	-0.31	265	297	0.14	34	80	1.24	99	131	-0.32	67	56	-0.30	67
Denver, CO	1.8	973	266	-0.47	287	290	0.97	24	51	0.42	94	146	-0.76	63	43	-1.47	112
Pittsburgh,PA	2.2	1054	239	2.67	203	257	-2.02	28	59	0.99	94	129	-0.74	60	44	-1.83	86
Seattle, WA	2.6	965	261	-0.73	258	256	-0.07	18	56	-0.75	118	190	0.67	82	88	1.40	98
Cleveland, OH	2.8	953	257	-1.16	254	271	-0.21	20	51	-0.39	120	156	0.93	93	141	1.64	91
Miami, FL	3.2	1009	251	0.90	204	258	-2.03	33	72	1.48	131	146	1.72	63	49	-1.18	90
Houston, TX	3.7	981	252	-0.16	243	265	-0.71	20	48	-0.52	132	169	1.87	64	47	-1.28	134
Dallas, TX	3.9	1001	263	0.71	264	276	0.19	20	41	-0.63	91	123	-1.24	64	63	-0.88	130
Boston, MA	4.2	966	255	-0.78	271	276	0.41	11	23	-4.74	115	154	0.70	78	67	1.37	113
Detroit, MI	4.7	960	254	-1.18	281	271	0.96	21	59	-0.16	112	150	0.57	66	49	-0.73	156
Philadelphia, PA	5.9	988	260	0.16	260	264	0.02	25	59	0.60	98	142	-0.69	70	63	0.24	198
San Francisco, CA	6.3	1026	271	2.17	214	257	-2.49	19	41	-0.92	112	165	0.61	68	69	-0.11	210
Chicago, IL	8.1	993	269	0.52	263	271	0.18	25	67	0.71	96	155	-0.95	64	58	-1.49	299
Los Angeles, CA	14.5	962	255	-1.84	279	276	1.47	22	58	0.09	110	156	0.75	66	57	-1.01	501
New York, NY	18.1	979	256	-0.61	267	273	0.80	21	53	-0.43	100	157	-0.92	72	67	1.55	1237
Average		985	258		260	272		22	55		105	154		69	66		3969

Note: Difference of Means column represents difference of means (t-test) of city's average duration for a given activity from the average of all cities. An absolute value greater than 1.96 indicates the values are significantly different at 95% confidence level.

Table 3: Life Cycle Stage,Gender, and Activity Duration (in minutes)

			HOME				WORK			
Number of Adults	Youngest Child	Gender	Mean	Std Dev	Difference of Means Total	Difference of Means M-F	Mean	Std Dev	Difference of Means Total	Difference of Means M-F
1	None	Male	933	270	-3.40	-1.88	292	270	2.12	1.88
1	None	Female	971	250	-0.93		253	263	-0.47	
2+	None	Male	943	261	-5.64	-4.09	305	283	5.73	4.97
2+	None	Female	982	249	-0.33		255	261	-0.68	
1	0-5	Male	1154	305	1.36	0.89	133	217	-1.43	-0.51
1	0-5	Female	1040	247	1.98		180	249	-2.81	
2+	0-5	Male	932	249	-5.97	-12.88	341	280	8.28	14.81
2+	0-5	Female	1084	242	11.24		158	234	-11.78	
1	6-15	Male	1045	298	1.07	1.25	193	247	-1.41	-1.39
1	6-15	Female	968	248	-0.69		267	261	0.28	
2+	6-15	Male	937	260	-4.71	-6.76	315	280	5.16	7.34
2+	6-15	Female	1026	240	4.43		213	250	-4.77	
1	16-21	Male	910	282	-1.05	-1.11	256	268	-0.06	0.64
1	16-21	Female	997	225	0.38		207	243	-1.42	
2+	16-21	Male	956	258	-2.11	-1.99	289	276	2.00	2.34
2+	16-21	Female	993	248	0.65		243	256	-1.22	
1	retired	Male	1196	214	3.55	0.36	0	0	-86.53	NA
1	retired	Female	1162	241	2.45		0	0	-86.53	
2+	retired	Male	1105	246	6.81	-0.43	135	230	-7.47	-0.16
2+	retired	Female	1115	232	8.40		139	229	-7.85	
		TOTAL	984	257			260	271		

note: Difference of Means "Total" is difference of means t-test between the cell and overall average for that activity. Difference of Means "M-F" is difference of means between male and females in the same life-cycle stage (number of children, number of adults per household). An absolute value of greater than 1.96 indicates the two values are statistically different at the 95% confidence level.

Table 3 Continued

			SHOP				OTHER				TRAVEL				
Number of Adults	Youngest Child	Gender	Mean	Std Dev	Difference of Means Total	Difference of Means M-F	Mean	Std Dev	Difference of Means Total	Difference of Means M-F	Mean	Std Dev	Difference of Means Total	Difference of Means M-F	Cases
1	None	Male	16	46	-2.02	-2.95	128	178	1.79	0.52	72	74	1.65	1.11	333
1	None	Female	30	69	2.13		121	156	1.23		66	56	0.33		324
2+	None	Male	16	49	-3.95	-4.52	109	164	-0.09	-0.70	67	61	1.15	0.82	1489
2+	None	Female	25	59	2.12		114	161	0.82		65	60	0.07		1371
1	0-5	Male	16	20	-0.70	-1.03	111	172	0.01	-0.32	27	31	-2.92	-2.34	6
1	0-5	Female	26	47	0.81		134	159	1.33		60	52	-0.75		78
2+	0-5	Male	13	44	-5.09	-6.33	86	139	-4.78	-3.52	68	63	1.39	3.97	899
2+	0-5	Female	31	70	3.93		110	145	0.08		57	52	-4.10		827
1	6-15	Male	5	12	-6.56	-3.91	131	168	0.66	0.35	65	62	0.03	0.18	27
1	6-15	Female	23	43	0.45		119	152	0.66		63	56	-0.38		119
2+	6-15	Male	12	37	-5.87	-6.39	106	166	-0.58	-0.36	69	65	1.69	1.83	731
2+	6-15	Female	29	59	3.38		109	161	-0.09		63	68	-0.83		718
1	16-21	Male	6	11	-5.08	-2.96	189	168	1.88	1.00	79	99	0.56	0.83	16
1	16-21	Female	40	73	1.71		138	185	1.00		57	44	-1.09		43
2+	16-21	Male	15	56	-2.08	-2.58	110	159	0.02	-0.39	70	74	1.46	1.98	378
2+	16-21	Female	29	86	1.69		115	162	0.55		60	62	-1.28		348
1	retired	Male	31	38	0.93	0.39	146	168	0.77	-0.43	67	78	0.12	-0.25	13
1	retired	Female	25	40	0.31		179	199	1.15		74	60	0.53		11
2+	retired	Male	16	33	-2.01	-3.26	122	157	1.04	1.28	61	70	-0.67	1.45	196
2+	retired	Female	31	57	2.50		102	153	-0.74		53	48	-3.68		229
		TOTAL	21	56			110	158			65	62			8159

Table 4: Weekday Duration Choice, Adults 18-65 pursuing all four primary activities (home, work, shop, other)

	HOME			SHOP			OTHER		
Variable	Estimate	Std. Error	"T" Ratio	Estimate	Std. Error	"T" Ratio	Estimate	Std. Error	"T" Ratio
const [1]	0.8508	3.00E-02	28.4	-2.258	7.71E-02	-29.3	-1.488	5.34E-02	-27.9
male [1,0]	-0.2735	8.98E-03	-30.5	-0.2578	2.25E-02	-11.5	6.83E-02	1.56E-02	4.4
age [N]	3.74E-04	4.38E-04	0.9	-1.48E-03	1.03E-03	-1.4	-2.28E-03	7.41E-04	-3.1
Res. Density class [1-13]				-1.43E-02	4.40E-03	-3.3	1.96E-02	3.05E-03	6.4
Northeast [1,0]	-1.22E-02	1.39E-02	-0.9	0.2035	3.30E-02	6.2	-0.5096	2.30E-02	-22.1
Southcent [1,0]	-0.2066	1.68E-02	-12.3	-0.4371	4.54E-02	-9.6	-0.3103	2.71E-02	-11.4
West [1,0]	-0.1556	1.44E-02	-10.8	-0.2397	3.59E-02	-6.7	-0.2654	2.32E-02	-11.5
1990 Metro Pop [N]	7.00E-10	7.64E-10	0.9	-5.46E-09	1.84E-09	-3	1.55E-08	1.39E-09	11.1
Household Income [N]	2.80E-04	1.17E-03	0.2	-1.08E-02	2.82E-03	-3.8	-3.12E-03	2.01E-03	-1.6
Winter [1,0]	2.76E-02	1.37E-02	2	-3.19E-03	3.27E-02	-0.1	-0.184	2.26E-02	-8.1
Spring [1,0]	2.71E-02	1.31E-02	2.1	-7.27E-02	3.09E-02	-2.4	-0.2194	2.15E-02	-10.2
Summer [1,0]	4.18E-02	1.35E-02	3.1	-5.61E-02	3.20E-02	-1.7	-0.1006	2.25E-02	-4.5
Single [1,0]	-9.05E-02	6.15E-03	-14.7	-2.03E-02	1.47E-02	-1.4	-8.51E-02	1.11E-02	-7.7
Childless [1,0]	-0.1074	1.51E-02	-7.1	-5.73E-02	3.50E-02	-1.6	-0.1464	2.51E-02	-5.8
Young. Child 0-5 [1,0]	-4.64E-02	1.72E-02	-2.7	-0.2239	4.03E-02	-5.6	-0.2994	2.90E-02	-10.3
Young. Child 6-15 [1,0]	-9.18E-02	1.65E-02	-5.5	-0.3084	3.95E-02	-7.8	-0.2801	2.80E-02	-10
Activity Frequency [1-N]	-7.35E-03	4.39E-03	-1.7	0.6695	2.20E-02	30.5	0.3626	4.76E-03	76.2

Note: Work utility forced = 0

Table 4: Continued (Summary Statistics)

Summary Statistics	Value
N	752
Likelihood with zero coefficients	-375297
Likelihood with constants only	-281194
Final value of likelihood	-276186
Rho-Squared w.r.t. Zero	0.2641
Rho-Squared w.r.t. Constants	0.0178

Appendices

Table A1: Correlations of Activity Duration vs. Activity Duration

ACTIVITY DURATION	Home	Work	Work Related	Shop	Personal Business	School/ Church	Medical	Vacation	Visiting	Pleasure Driving	Other Social/ Rec	Other
Home	1.00											
Work	-0.74 **	1.00										
Work-Related	-0.10 **	-0.07 **	1.00									
Shop	0.07 **	-0.22 **	-0.03 *	1.00								
Personal Business	-0.12 **	-0.14 **	-0.01	-0.03 *	1.00							
School/Church	-0.08 **	-0.18 **	-0.03 *	-0.06 **	-0.04 **	1.00						
Medical	0.01	-0.06 **	-0.01	0.00	-0.01	-0.02	1.00					
Vacation	-0.03 *	-0.03 **	0.00	-0.01	-0.01	-0.01	0.00	1.00				
Visit Friends	-0.09 **	-0.20 **	-0.03 **	-0.02	-0.05 **	-0.02	-0.02	-0.01	1.00			
Pleasure Driving	0.00	-0.03 *	-0.01	-0.01	-0.01	-0.01	0.00	0.00	-0.01	1.00		
Other Social Rec.	-0.15 **	-0.18 **	0.00	-0.04 **	-0.03 *	-0.03 *	0.00	0.00	-0.05 **	0.01	1.00	
Other	-0.03 *	-0.05 **	-0.01	-0.01	0.01	-0.01	-0.01	0.00	-0.02	0.00	0.00	1.00

ACTIVITY DURATION

Table A2: Correlations of Activity Duration vs. Duration of Travel to an Activity

TRAVEL DURATION \ ACTIVITY DURATION	Home	Work	Work Related	Shop	Personal Business	School/ Church	Medical	Vacation	Visiting	Pleasure Driving	Other Social/ Rec	Other
Home	-0.17 **	-0.06 **	0.01	-0.04 **	0.03 *	-0.01	-0.01	0.03 *	0.02	0.02	0.07 **	0.01
Work	-0.51 **	0.60 **	0.00	-0.15 **	-0.06 **	-0.12 **	-0.03 *	-0.02	-0.14 **	-0.03 *	-0.11 **	-0.03 *
Work-Related	-0.07 **	-0.04 **	0.40 **	-0.02	-0.01	-0.02	-0.01	0.00	-0.02	0.00	0.00	-0.01
Shop	0.07 **	-0.17 **	-0.02	0.50 **	-0.01	-0.05 **	-0.01	-0.01	-0.01	-0.01	-0.03	-0.01
Personal Business	-0.05 **	-0.14 **	0.00	-0.03	0.47 **	-0.04 **	-0.01	0.00	-0.03 *	-0.01	0.00	-0.01
School/ Church	-0.04 **	-0.15 **	-0.03 *	-0.05 **	-0.03 *	0.70 **	-0.01	-0.01	0.00	-0.01	-0.03 *	0.00
Medical	0.02	-0.05 **	-0.01	0.00	0.00	-0.01	0.70 **	0.00	-0.02	-0.01	-0.01	-0.01
Vacation	-0.03 *	-0.04 **	0.00	-0.01	-0.01	-0.01	0.00	0.42 **	-0.01	0.00	0.00	0.00
Visit Friends	-0.06 **	-0.17 **	-0.03 *	0.01	-0.02	-0.02	-0.02	0.00	0.61 **	0.00	-0.02	-0.01
Pleasure Driving	0.00	-0.04 **	-0.01	-0.01	-0.01	0.02	-0.01	0.00	-0.01	0.44 **	0.00	0.00
Other Social Rec.	-0.10 **	-0.15 **	-0.01	-0.01	-0.03 *	-0.03 *	0.00	0.00	-0.04 **	0.00	0.61 **	-0.01
Other	-0.02	-0.05 **	-0.01	-0.01	0.01	0.00	-0.01	0.00	-0.02	0.00	0.01	0.66 **

ACTIVITY DURATION

Table A3: Correlations of Travel Duration vs. Travel Duration

TRAVEL DURATION	Home		Work		Work Related	Shop		Personal Business		School/ Church		Medical	Vacation	Visiting	Pleasure Driving	Other Social/ Rec	Other
Home	1.00																
Work	0.13	**	1.00														
Work-Related	0.04	**	0.02		1.00												
Shop	0.01		-0.09	**	-0.02	1.00											
Personal Business	0.12	**	-0.07	**	0.00	0.03	*	1.00									
School/ Church	0.04	**	-0.10	**	-0.02	-0.03	*	-0.03	*	1.00							
Medical	0.00		-0.02		0.00	0.01		0.01		-0.01		1.00					
Vacation	0.09	**	-0.03		0.00	-0.02		0.05	**	-0.01		0.00	1.00				
Visit Friends	0.12	**	-0.11	**	-0.01	0.02		0.00		-0.01		-0.02	0.03	1.00			
Pleasure Driving	0.07	**	-0.03	*	0.00	-0.01		-0.01		0.00		-0.01	0.00	-0.01	1.00		
Other Social Recreational	0.14	**	-0.09	**	0.01	0.02		0.02		-0.03	*	-0.01	0.00	0.00	0.02	1.00	
Other	0.04	**	-0.03	*	-0.01	-0.01		0.00		0.00		-0.01	0.00	0.00	0.02	0.00	1.00

TRAVEL DURATION

APPENDIX 2: Analyses of Variance

TABLE A4:ANOVA of Population Density

TIMEHOME BY DENSX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	1989448.534	12	165787.378	2.507	.003
DENSX	1989448.534	12	165787.378	2.507	.003
Explained	1989448.534	12	165787.378	2.507	.003
Residual	538647965.638	8146	66124.229		
Total	540637414.172	8158	66270.828		

TIMEWORK BY DENSX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	1820752.284	12	151729.357	2.066	.016
DENSX	1820752.284	12	151729.357	2.066	.016
Explained	1820752.284	12	151729.357	2.066	.016
Residual	598210171.470	8146	73436.063		
Total	600030923.754	8158	73551.229		

TIMESHOP BY DENSX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	44719.333	12	3726.611	1.177	.293
DENSX	44719.333	12	3726.611	1.177	.293
Explained	44719.333	12	3726.611	1.177	.293
Residual	25794993.911	8146	3166.584		
Total	25839713.244	8158	3167.408		

TIMEOTHE BY DENSX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	425344.951	12	35445.413	1.412	.152
DENSX	425344.951	12	35445.413	1.412	.152
Explained	425344.951	12	35445.413	1.412	.152
Residual	204442596.434	8146	25097.299		
Total	204867941.385	8158	25112.520		

TIMETRAV BY DENSX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	156049.832	12	13004.153	3.368	.000
DENSX	156049.832	12	13004.153	3.368	.000
Explained	156049.832	12	13004.153	3.368	.000
Residual	31452940.421	8146	3861.152		
Total	31608990.252	8158	3874.600		

Table A5: ANOVA of Census Region and Metropolitan Population

TIMEHOME BY CENSDX, POP90Y

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	1951983.461	16	121998.966	1.833	.022
CENSDX	1179442.404	8	147430.300	2.215	.024
POP90Y	1190190.791	8	148773.849	2.235	.022
2-way Interactions	971841.637	9	107982.404	1.622	.103
CENSDX POP90Y	971841.637	9	107982.404	1.622	.103
Explained	2923825.098	25	116953.004	1.757	.011
Residual	385644936.817	5794	66559.361		
Total	388568761.915	5819	66775.866		

TIMEWORK BY CENSDX, POP90Y

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	1885836.305	16	117864.769	1.595	.062
CENSDX	1129467.056	8	141183.382	1.910	.054
POP90Y	1206085.081	8	150760.635	2.040	.038
2-way Interactions	807059.636	9	89673.293	1.213	.281
CENSDX POP90Y	807059.636	9	89673.293	1.213	.281
Explained	2692895.941	25	107715.838	1.458	.066
Residual	428177369.320	5794	73900.133		
Total	430870265.261	5819	74045.414		

TIMESHOP BY CENSDX, POP90Y

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	41869.116	16	2616.820	.907	.560
CENSDX	29468.755	8	3683.594	1.277	.250
POP90Y	15363.267	8	1920.408	.666	.722
2-way Interactions	39506.853	9	4389.650	1.522	.134
CENSDX POP90Y	39506.853	9	4389.650	1.522	.134
Explained	81375.969	25	3255.039	1.129	.299
Residual	16711431.150	5794	2884.265		
Total	16792807.119	5819	2885.858		

TIMEOTHE BY CENSDX, POP90Y

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	576156.166	16	36009.760	1.505	.088
CENSDX	353825.887	8	44228.236	1.849	.063
POP90Y	277917.150	8	34739.644	1.452	.169
2-way Interactions	172173.702	9	19130.411	.800	.616
CENSDX POP90Y	172173.702	9	19130.411	.800	.616
Explained	748329.869	25	29933.195	1.251	.180
Residual	138587319.963	5794	23919.109		
Total	139335649.831	5819	23944.948		

TIMETRAV BY CENSDX, POP90Y

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	145697.837	16	9106.115	2.323	.002
CENSDX	36884.892	8	4610.611	1.176	.309
POP90Y	72156.290	8	9019.536	2.301	.018
2-way Interactions	79305.170	9	8811.686	2.248	.017
CENSDX POP90Y	79305.170	9	8811.686	2.248	.017
Explained	225003.007	25	9000.120	2.296	.000
Residual	22711899.662	5794	3919.900		
Total	22936902.669	5819	3941.726		

Table A6: ANOVA by Gender, Work Status, and Household Income.

TIMEHOME BY SEXX, WORKX, HHINCX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	71228593.709	18	3957144.095	68.765	.000
SEXX	2385624.662	1	2385624.662	41.456	.000
WORKX	55356276.489	1	55356276.489	961.948	.000
HHINCX	2029758.807	16	126859.925	2.204	.004
2-way Interactions	3192303.705	33	96736.476	1.681	.009
SEXX WORKX	108460.125	1	108460.125	1.885	.170
SEXX HHINCX	1730307.173	16	108144.198	1.879	.018
WORKX HHINCX	1483754.937	16	92734.684	1.611	.057
3-way Interactions	611555.231	16	38222.202	.664	.832
SEXX WORKX HHINCX	611555.231	16	38222.202	.664	.832
Explained	75032452.644	67	1119887.353	19.461	.000
Residual	465604961.528	8091	57546.034		
Total	540637414.172	8158	66270.828		

TIMEWORK BY SEXX, WORKX, HHINCX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	117467621.790	18	6525978.988	109.790	.000
SEXX	3021117.976	1	3021117.976	50.826	.000
WORKX	96538834.291	1	96538834.291	1624.128	.000
HHINCX	860639.517	16	53789.970	.905	.563
2-way Interactions	1331364.065	33	40344.366	.679	.918
SEXX WORKX	289035.959	1	289035.959	4.863	.027
SEXX HHINCX	786719.536	16	49169.971	.827	.655
WORKX HHINCX	174046.221	16	10877.889	.183	1.000
3-way Interactions	299656.985	16	18728.562	.315	.996
SEXX WORKX HHINCX	299656.985	16	18728.562	.315	.996
Explained	119098642.840	67	1777591.684	29.905	.000
Residual	480932280.913	8091	59440.401		
Total	600030923.754	8158	73551.229		

TIMESHOP BY SEXX, WORKX, HHINCX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	555816.784	18	30878.710	9.923	.000
SEXX	305994.072	1	305994.072	98.337	.000
WORKX	98745.278	1	98745.278	31.734	.000
HHINCX	94050.636	16	5878.165	1.889	.017
2-way Interactions	86601.931	33	2624.301	.843	.722
SEXX WORKX	4407.322	1	4407.322	1.416	.234
SEXX HHINCX	53460.523	16	3341.283	1.074	.374
WORKX HHINCX	27409.625	16	1713.102	.551	.921
3-way Interactions	20619.845	16	1288.740	.414	.980
SEXX WORKX HHINCX	20619.845	16	1288.740	.414	.980
Explained	663038.560	67	9896.098	3.180	.000
Residual	25176674.684	8091	3111.689		
Total	25839713.244	8158	3167.408		

TIMEOTHE BY SEXX, WORKX, HHINCX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	6093225.937	18	338512.552	13.960	.000
SEXX	20167.943	1	20167.943	.832	.362
WORKX	4980778.361	1	4980778.361	205.409	.000
HHINCX	557623.922	16	34851.495	1.437	.114
2-way Interactions	1614217.912	33	48915.694	2.017	.000
SEXX WORKX	166969.491	1	166969.491	6.886	.009
SEXX HHINCX	621067.974	16	38816.748	1.601	.060
WORKX HHINCX	986763.814	16	61672.738	2.543	.001
3-way Interactions	969287.380	16	60580.461	2.498	.001
SEXX WORKX HHINCX	969287.380	16	60580.461	2.498	.001
Explained	8676731.230	67	129503.451	5.341	.000
Residual	196191210.155	8091	24248.079		
Total	204867941.385	8158	25112.520		

TIMETRAV BY SEXX, WORKX, HHINCX

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	355552.414	18	19752.912	5.153	.000
SEXX	47334.018	1	47334.018	12.349	.000
WORKX	25845.535	1	25845.535	6.743	.009
HHINCX	234230.975	16	14639.436	3.819	.000
2-way Interactions	168564.633	33	5108.019	1.333	.097
SEXX WORKX	17940.873	1	17940.873	4.681	.031
SEXX HHINCX	95547.949	16	5971.747	1.558	.071
WORKX HHINCX	43754.737	16	2734.671	.713	.783
3-way Interactions	72353.306	16	4522.082	1.180	.275
SEXX WORKX HHINCX	72353.306	16	4522.082	1.180	.275
Explained	596470.352	67	8902.543	2.323	.000
Residual	31012519.900	8091	3832.965		
Total	31608990.252	8158	3874.600		

Table A7: ANOVA of Life-Cycle Stage

TIMEHOME BY RELATE

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	11069804.903	9	1229978.323	18.921	.000
RELATE	11069804.903	9	1229978.323	18.921	.000
Explained	11069804.903	9	1229978.323	18.921	.000
Residual	529546716.972	8146	65006.963		
Total	540616521.876	8155	66292.645		

TIMEWORK BY RELATE

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	10240830.603	9	1137870.067	15.721	.000
RELATE	10240830.603	9	1137870.067	15.721	.000
Explained	10240830.603	9	1137870.067	15.721	.000
Residual	589587531.926	8146	72377.551		
Total	599828362.529	8155	73553.447		

TIMESHOP BY RELATE

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	18333.561	9	2037.062	.643	.761
RELATE	18333.561	9	2037.062	.643	.761
Explained	18333.561	9	2037.062	.643	.761
Residual	25809298.184	8146	3168.340		
Total	25827631.745	8155	3167.092		

TIMEOTHE BY RELATE

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	636459.245	9	70717.694	2.823	.003
RELATE	636459.245	9	70717.694	2.823	.003
Explained	636459.245	9	70717.694	2.823	.003
Residual	204082405.872	8146	25053.082		
Total	204718865.117	8155	25103.478		

TIMETRAV BY RELATE

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Main Effects	56571.233	9	6285.693	1.624	.102
RELATE	56571.233	9	6285.693	1.624	.102
Explained	56571.233	9	6285.693	1.624	.102
Residual	31536671.579	8146	3871.430		
Total	31593242.812	8155	3874.095		