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**Commuting patterns in one- and two-earner households in the
USA: An empirical investigation of common preference utility**

by

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Abstract

This paper examines the effect of various factors on the commuting behaviour of one- and two- worker households. The households' choices in the land- and labour markets are modeled in the context of Becker's common-preference framework. The empirical investigation using data from the 2007 American Community Survey also tests the Household Responsibility Hypothesis. I find that women have shorter work trips than men, but are willing to commute much longer if they earned more. There is no evidence that the presence of children decreases commuting for married women. Non-white workers commute considerably longer than white workers, with non-white women being the most disadvantaged.

Keywords: common-preference, family utility, commuting patterns, Household Responsibility Hypothesis, simultaneous equations

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Contents

1. Introduction.....	1
1.1 Background.....	1
1.2 Aim of the study.....	2
1.3 Limitations.....	2
1.4 Main findings.....	2
1.5 Outline.....	3
2.Theoretical framework.....	4
2.1 Modelling household behaviour.....	4
2.2 Commuting.....	5
2.3 The Household Responsibility Hypothesis.....	8
2.4 Literature review.....	9
3. Methodology.....	15
3.1 Method.....	15
3.2 Hypotheses.....	18
4. Data and descriptive statistics.....	19
4.1 Data source and limitations.....	19
4.2 Descriptive statistics.....	20
5. Empirical analysis.....	23
5.1 Instrumenting endogenous variables.....	23
5.2 Regression over the whole sample.....	24
5.3 Regressions over sub-samples for gender and working hours	26
5.4 Regressions over sub-samples for gender and marital status	28
6. Conclusion.....	30
Bibliography.....	32
Appendix A.....	34
Appendix B.....	35
Appendix C.....	36

1. Introduction

In this section I will present the background and purpose of the study. Then I will describe the limitations, the method and the main findings of my analysis. The section will end with an outline of the rest of the study.

1.1 Background

Over the past two decades the labour markets have changed dramatically. Women have caught up with men's labour force participation, and labour mobility has increased substantially. Workers move across countries and even continents to locate closer to job opportunities. Improved transportation infrastructure has enabled workers to take increasingly longer daily trips to work. Thanks to communication technologies like the Internet it is already possible to seek jobs outside the geographic region of residence.

The fact that women participate in the labour force equally with men raises the question how two-worker households make their work and residence decisions. How do working spouses decide on this, and how does this affect their commuting trips to the workplace?

I am particularly interested in the choice of residence and work locations for households. The main factors determining these choices is the availability of jobs in geographical space, the costs of living in a given area, and the additional costs imposed by the journey to work. Having in mind the spatial distribution of employment opportunities, and the mismatch due to imperfect information, spouses often have to take long trips to work. Under the assumption of a common preference utility function for the household, both spouses would like to minimise the joint dis-utility from commuting. However, the distribution of employment opportunities can be assumed exogenous to the household, since employers locate themselves independently from workers. Therefore the only choice for households is the place of residence. As known from the joint utility model, also called Becker's unitary model, the household maximises its joint utility by choosing residence and employment subject to both spouses' income and family unearned income. When analysing location decisions of the household, we need to step back and look at the more general models of economic behaviour within the household. The most prominent works in this area are the ones by (Becker, 1974) on household production and by (Samuelson, 1956) on social

indifference curves.

1.2 Aim of the study

The current study aims to analyse patterns within the commuting behaviour of one- and two- worker households. This includes a race and gender profile of commuters, as well as testing some hypotheses on how household responsibilities affect the choice of residence and job locations. I am going to test to what extent wage differences, gender differences and household responsibilities affect the commuting behaviour of married couples. I will also compare married and unmarried individuals in order to see how marriage affects work-and-residence decisions.

1.3 Limitations

This investigation is based on the common-preference household utility framework. Therefore the scope of the study is limited by the assumptions of the common-preference model. The limitations imposed on the dataset for this study are derived from the underlying theoretical framework. Only individuals living in metropolitan areas and earning non-zero income are included in the empirical investigation. Most factors in the theoretical model are represented by proxies in the empirical setup, which may give rise to measurement errors.

1.4 Main findings

Higher earnings are related to longer commuting times, but women's commuting exhibits larger marginal response to earnings than that of men. If women earned more, they would commute even longer than men. Self-employed workers have considerably shorter work trips than wage-earners. There is no significant evidence that the presence of children increases commuting for married women. However the analysis suggests that moving to a new residence increases the husbands' work-trips and decreases commuting for wives. There is also significant evidence that white workers have considerably shorter work trips than non-white workers with the same characteristics. Non-white women are most disadvantaged by having the lowest earnings and longest commuting times.

1.5 Outline

The next section presents the theoretical framework of this study. This includes the common-preference utility model, the Household Responsibility Hypothesis, and a review of previous research in this area. Section 3 develops the formal model specification based on the theories in section 2. Section 4 describes the dataset used for this empirical investigation. It also states the limitations of the data and presents summary statistics. Section 5 starts with an endogeneity test on the data and extends the model from section 3. Then it moves on to presenting and discussing the results from estimation. Section 6 summarises the empirical findings and makes some suggestions for future research.

2.Theoretical framework

2.1 Modelling household behaviour

In the past decades there has been a lively discussion about household behaviour within labour and land markets. How do spouses choose the number of labour hours to supply, how do they take decisions about residence location, and an even more recent question, how do they decide on the combination of job and residence with respect to the journey to work?

These choices can be viewed as a typical problem of distributing resources within a two-earner household. Under the Becker common-preference model, family decision-making is viewed as a black-box: the couple behaves like an individual, with one joint utility function.

This family of utility models was introduced more than five decades ago, with the first theoretical study on the topic by Samuelson (1956). Later on the concept was developed further by Becker (1974, 1981). Samuelson started off by addressing the problem of community indifference curves. He posed the question how a group of agents who have their own individual utility levels, can form a minimal-requirements contour for the whole group. This contour defined in n -space (n being the number of its group members), shows the combinations of individual well-being levels that satisfy the group as a whole. Samuelson's approach, however, leads to an infinite number of community indifference contours and therefore fails to construct an aggregated demand curve for society. The problem comes from the clash of interests within the group about what is the optimal allocation of utilities that maximises total utility. However, if the same group-utility approach is applied to a household, it becomes credible to assume that household members have common interests when maximising utility. The relations between family members are not based on individual maximisation, but on common goals. Samuelson argued further that the joint decision of the family is reached through a consensus between the parties. He constructed "social indifference curves" based on consensus to describe how family members maximise a single utility function, subject to total family income. As a result, the optimisation problem of the family depends only on prices and the family's total income. However, Samuelson did not specify how this consensus is achieved in practice, and what are the conditions to maintain it.

Gary Becker, who is well known for his common-preference model, took a different

approach to family utility. He addressed the intra-family decision problem. In his model the family consists of "selfish" children and an "altruist" parent. Becker proves that at least one altruist parent in the family, who acts with concern for the well-being of all family members is enough to achieve the desired outcome. The altruist parent can make positive transfers to the selfish kids in such a way, that they find it in their interest to choose actions that maximise family utility. Therefore, in the altruist model family demand is the same as the one for Samuelson's consensus model. One interesting point by Becker is the possibility that an individual acts as an altruist in an economic context. Even though this deviates from the traditional economic assumption that individuals are selfish, Becker's model is probably closer to how people act within a family.

Recently another theory of household behaviour has emerged. Since the early 1980's the common-preference model of household behaviour has received some critique from theoretical economists. Manser & Brown (1980) were the first to point out that the assumption of income pooling in common preference theory does not fair well in empirical testing. They suggest also that the restrictions imposed on individual demand functions are not realistic and put forward examples where family demand changes significantly when income is transferred between spouses. As an alternative, Manser & Brown (1980) introduce the Family Bargaining Model, which distinguishes the preferences of family members. The family demand outcome is determined by a cooperative bargaining game, where the family members reach a Nash bargaining solution(Lundberg & Pollak, 1996).

However, in my study I will implement the traditional common preference model, and will base my specifications on the theory of income pooling and joint utility function. This will allow me to use recent and accessible data for estimation. I will also compare my results with those of previous studies of common preference.

2.2 Commuting

Commuting is defined as travelling back and forth regularly. In the context of labour markets, commuting is the journey to and from the job every working day. The length and the direction of the trip are a direct result of the household's choice of residence and work location. The main factors determining these choices are the availability of jobs in geographical space, the cost of living in a given area, and the additional costs imposed by the

journey to work. Having in mind the spatial distribution of employment opportunities, and the mismatch due to imperfect information, spouses often have to take long trips to work. Under the assumption of a common-preference utility function for the household, both spouses would like to minimise the joint dis-utility from commuting. However, the distribution of employment opportunities can be assumed exogenous to the household, since employers locate themselves independently from workers. Therefore the only choice for households is to choose their place of residence as a function of the exogenously given locations of employment. According to the well-known joint utility models already introduced above, the household maximises its joint utility subject to both spouses' wages and the family's unearned income.

Standard economic theory has been used in past years to model the determinants of commuting behaviour of both male and female workers. The cost of commuting can be decomposed in two components: the direct costs incurred for the trip (gasoline, vehicle depreciation, fare for public transportation), and the indirect opportunity cost equal to the value of time (White, 1977).

The value of time is usually based on the wage rate of the worker. It has been established empirically that women have lower wages than men on average. This suggests that *ceteris paribus* women value their time at a lower rate and incur lower opportunity costs than men for the same trip length. Therefore, women should be more willing to take longer trips to work than men.

On the other hand, the direct travel expenses have an opposite effect on commuting behaviour within the household. Given that men earn more than their spouses, the same trip will cost a larger share of total earnings for women than for men. This poses a direct monetary disincentive for women to accept longer commutes, since it costs them more than men on a relative base. However, the net effect from the direct and indirect costs is ambiguous and can not be predicted by standard economic theory. More sophisticated socio-economic and empirical analysis is required for that purpose.

Another way of looking at gender differences in commuting is to consider the spatial distribution of jobs in urban space. In traditional mono-centric city models all jobs are located in the central business district (CBD) and there is no ambiguity about the optimal residence location. In cities with a single employment centre (CBD) it is reasonable to expect that housing costs and commuting time are linear functions of distance to CBD.

However, modern cities do not concentrate all employment opportunities in the central district. Instead, there is a ring of suburban business districts, which offer employment. In the CBD there are mostly office jobs, which are typically female occupations. However, industry and production, which typically employs more men than women, is concentrated in the suburbs. If a two-earner household resides halfway between CBD and the suburbs, then both spouses will have equal commuting distances, and *ceteris paribus* they will earn equal shares of the household's income and have equal leisure times. However, this distribution within the household is hardly realistic, because of gender differences in wages, employment opportunities, and household responsibilities.

In the multi-centric case the spouses may work at different employment centres and therefore at different distances from home. This change from mono-centric to multi-centric spatial distribution caused a major shift in the analysis of work-trip behaviour. Earlier models and empirical works emphasised the close spatial relationship between the land- and labour- markets, which lead most economists to the conclusion that households face a simple trade-off problem by substituting work-trip costs for housing costs (Alonso, 1960; Herbert & Stevens, 1960; Kain, 1962).

However, in a multi-centric city the commuting patterns differ substantially from the mono-centric theory. In this new setting, working household members commute both to the central business district(CBD) and the suburban employment centres. Therefore the land- and labour-market argument put forward by Alonso (1960) and Kain (1962) is not as straightforward as it used to be. In a mono-centric city the housing price function peaks at the CBD, because workers are willing to pay more for residences closer to their jobs. In multi-centric cities workers have similar preferences, because they strive to minimise commuting costs. However, in this case the housing price function has several peaks, one at the CBD, and one at each suburban centre (O'Sullivan, 1995, p. 251). Therefore, households face very different options for the choice of residence.

Another major shift in the labour market in the early 1970s was women's increased labour-force participation rate. Until then, married women were occupied mainly in household production and part-time jobs, and were considered a secondary earner in the household. As Kain (1962, p. 146) points out "... [*women*] tend to seek nearby jobs ... with a more casual attitude in job seeking than that of the primary wage earner." The latter also concludes that the primary earner (the husband) chooses the residential location closer to his

job opportunities, while the wife as a secondary earner chooses her place of employment conditional on the residence. As a result, the household's residence-location choice is reduced to a minimisation of the husband's commuting costs. However, this reasoning soon proved unrealistic, and White (1977) took a different view on the household residential decision. His model builds on the hypothesis that the husband's and wife's leisure times are valued equally, but that their wage rates and therefore opportunity costs of commuting differ. Based on that, White derived conditions for housing market equilibrium for one- and two-worker households. Madden (1981) augments this model with the idea that women have more household responsibilities than men, and therefore are more likely to seek nearby jobs in order to minimise commuting time. In the same study Madden develops a model of partial equilibrium for individuals and households. In this model both individuals and households are fully compensated for their commuting by means of the land- and labour- markets. Namely, workers would accept a longer commute if this will reward them with a higher wage or a lower housing cost.

2.3 The Household Responsibility Hypothesis

A substantial body of economic research has suggested that the source of differences in commuting behaviour of men and women is not monetary related. The alternative explanation is based on the different roles of spouses in the family. Traditionally women have been taking the primary responsibility for household production and childcare. The first mentioning of this phenomenon in economic literature is by Pratt (1911, p. 126). In his investigation of the causes of congestion in New York City he states that “...*women, on the whole, live much closer to their places of employment than the men. . . . It appears that men are more mobile in respect to their residence than women.*” Several studies have concluded that married women and those with children have considerably shorter commuting times than both their spouses and single women with children (Madden, 1981; Turner & Niemeier, 1997). Therefore, it seems that married women tend to prioritize home responsibilities over work/career advancement and are not willing to undertake long journeys to work. However, not all empirical research in the field confirms the Household Responsibility Hypothesis. Studies by Madden (1981), Preston & McLafferty (1993) and Singell & Lillydahl (1986) found that the presence of children and their number reduces women's commuting time

significantly, and increases the gap between men's and women's commuting.

However, Gordon, Kumar, & Richardson (1989) found no significant difference in commuting time across all females, and therefore found no evidence in favour of the Household Responsibility Hypothesis. Another study by White (1986) concludes that the commuting time of women in single-earner households is not affected by the number of children, and in fact the presence of a young child is positively related to the length of trip to work. A later study on the topic by Johnston-Anumonwo (1992) finds evidence that the Household Responsibility Hypothesis holds, but the presence of children does not decrease the length of trips to work for women.

In this paper I will test the Household Responsibility Hypothesis using US data from 2007. The hypothesised outcome here is that married women have shorter commuting times than a married man in the same situation. An additional hypothesis is that the presence of children adds a burden on wives' household responsibilities, and therefore married women with children will have shorter commutes than women in the same situation without children.

2.4 Literature review

There are several studies investigating the commuting behaviour of one- and two-worker households. I will make a short review of the most relevant studies based on the common-preference model with joint family utility.

One of the earliest and most prominent common-preference model specifications that was successfully supported by empirical evidence was developed by White (1977). The author constructs probably the first model on work-trip behaviour which takes into account gender differences and their role in household time-allocation. White (1977) based his model on the concept of housing market equilibrium. He defines a relationship between wage rates and housing consumption in the two types of households. By using data from the *1970 Census Population* he infers two assumptions for his model:

- that married women are more likely to work in the suburbs than other individuals
- female workers have shorter commuting trips on average

The logic behind this model is that two-worker households are less likely to locate beyond a certain distance from CBD than one-worker households. For each mile further from

the centre, two-worker households incur twice as high marginal costs for commuting and this effect can be offset only by much higher total income of the two-worker household. Empirical data has shown that higher-income households prefer locating in the suburbs. Therefore two-worker households choose their location so that women workers have shorter commutes than men. The novelty feature of this model is that it does not assume women to be secondary earners and take a casual attitude towards job-seeking. The author uses descriptive statistics for groups from the *1970 Census of Population* to prove the validity of his hypotheses. He concludes that in the housing market two-worker households outbid other households in the vicinity of the suburban employment ring, while single-worker households outbid others in a region around the central business district (CBD).

The seminal study by Madden (1981) puts forward another model specification based on common preference. He specifies time constraints and utility functions for one- and two-worker households. Commuting is included as a function of distance to work, direction of travel from city centre, and the speed of travel. Then household utility is maximised with respect to income and time constraints. The dynamics of this specification allows for cases when residence location is predetermined, as well as for predetermined job location. In the first case, the optimal work trip length is such that the marginal change in work-trip cost equals the marginal change in earnings. However, when job location is predetermined, work trip length is such that the marginal change in trip cost equals the marginal change in housing cost. Therefore, Madden's model achieves commuting equilibrium in two markets simultaneously: the land and labour market. The author uses data from the *1976 Panel Survey of Income Dynamics* (PSID). It is worth mentioning that until 1975 this survey contained interviews only with the household head, but in 1976 wives were also interviewed for the first time. The survey contains detailed information on labour-force participation, household and housing characteristics, and work-trip variables. By using this unique for its time data source, Madden estimates the determinants of work-trip length. The results confirm that the women with the shortest work trips and the men with the longest trips belong to the same type of households: two-worker with children. The estimation method implemented by Madden is superior to previous studies on commuting behaviour. It consists of least-square regressions performed in 2 stages. First the author estimates the hourly wage as a function of demographic and human-capital characteristics, and housing costs are estimated as a function of city size and distance from city centre. Then commuting distance

is regressed on the predicted wage and housing value, as well as spouse earnings and presence of children. Estimation is run separately for 5 categories of households: two-worker with children, two-earner without children (called 'couple'), one-worker family with children, one-worker couple, and unmarried men. The findings confirm that married women with children have significantly shorter work trips than women without children. There is also a racial differential in work trips especially for two-worker households and couples. Madden concludes also that women choose jobs closer to their residence because their lower hourly wage and less working hours reduce the earnings return to commuting. After decomposing the work-trip differentials of males and females, the author finds that if women had the same weekly working hours and hourly wage as men, they would actually commute longer than men.

Just 5 years after the appearance of Madden's model specification, Singell & Lillydahl (1986) improve and test it empirically with a more comprehensive dataset. These authors use the same specification as Madden (1981), by estimating simultaneous equations for commuting time, hourly wage and housing cost. However, they introduce three new features in order to test the hypothesis that residence location decisions are taken with respect to the male's job location, which disadvantages women in the labour market. First, a variable for recent movers to residence is included in the estimation. In this way the researchers can distinguish whether the choice of new residence advantaged the male worker. Second, by including dummies for typically male- and female- dominated occupations, they test the hypothesis that local labour markets have distinct spatial patterns for each gender. Third, Singell & Lillydahl introduce a variable for the income ratio between spouses. In this way they can investigate how relative male/female earnings within the household affect commuting patterns. This study uses U.S. Census data from 1980 on 50,000 households in the USA. Unlike most other researchers, the hypotheses here are tested only on two-earner households. The results are quite conclusive: residential selection is based more on the male's than the female's job location. The estimates show that in households that moved recently, the husband's commuting time decreases, while the wife's commuting increased. However, when estimating on split samples for moved/not-moved households, they find that decisions about job and residence location were taken simultaneously for both workers, even though most males' earnings exceed women's earnings. The presence of children increases further the gender differences in commuting time. Therefore, this study finds persistent evidence of the

significant divide between men's and women's commuting patterns.

The next notable work on gender differentials in commuting is by Johnston-Anumonwo (1992). This paper was published in *The Professional Geographer* journal, and has therefore received less attention from economists. The purpose of the study is to test the Household Responsibility Hypothesis by focusing on household type. The paper includes a review of previous research on common preference, but does not state explicitly the model underlying the empirical investigation. The author points out that most of the factors and categories in the investigation are borrowed from a previous study by Hanson & Johnston (1985)¹. However, this paper is not available from any library in Sweden so I was not able to identify the exact theoretical model which specifies these factors. The dataset used is from the *1977 Travel Demand for Baltimore MSA*, and sex-differences in commuting distance were investigated through one-tailed student *t*-tests on pairs of sub-populations. This includes two categories each for income level, occupation type, child presence, marital status, travel mode and residential location. The investigation indicates that men in two-worker households travel longer than women, even when presence of children is controlled for. This implies that the commuting gender-differential is the same for parents and non-parents. The author also finds that the number of workers in the household has a much larger impact on commuting differentials than the presence of children. The final outcome of the analysis is that women in two-worker households have different sensitivity to commuting than men in two-worker households. However, in single-worker households men and women do not differ significantly in their commuting behaviour.

The last part of this review presents the most recent study based on common-preference utility and household responsibilities. Lee & McDonald (2003) performed an extensive analysis of various determinants of commuting time and distance. This study implements the theoretical framework developed by White (1986) and Madden (1981). The authors estimate multiple regressions for commuting time and distance dependent on variables for age, education, full/part time status, employment status (self-employed or working for wage), recent mover, home ownership status, marital status, number of children, number of rooms, and occupational characteristics. The estimation is controlled for possible endogeneity of the housing price, wage rate and choice of transportation mode. The dataset

1 Hanson, S. and Johnston, I. (1985) Gender differences in work-trip length: explanations and implications, *Urban Geography*, 6(3), pp. 193-219.

for this analysis is obtained from The Korean Population Census for 1995 and includes more than 73,000 observations. There are some interesting features of this study that distinguish it from previous research. The most significant is that the analysis is performed on non-US data. The specific urban-planning policies in the US pose the question whether urban commuters behave the same way in a different urban environment. The second new feature of this study is the hypothesis that the presence of parents or parents-in-law in the household has a significant effect on household responsibilities. A variable for the presence of elderly relatives above 60 years of age in the household is present in the model. The authors hypothesise that this variable has a significant positive impact on commuting time, since the presence of elderly relatives reduces the burden of childcare for married women. The estimation is performed first across a joint sample, and later across separate samples for men and women. The findings confirm that married women have shorter trips than other workers. Self employed and part-time workers have shorter trips, while full-timers and high-income earners have the longest commutes. The analysis sheds some light on issues not investigated before. For workers with less education, there is a wider disparity between men's and women's trips. Another finding is that women in Korea are still employed mainly in the service and sales sector, and have difficulties to access faraway jobs in production. Workers who move from one part of Seoul to another have increased their commuting time, implying that most workers are striving for better homes rather than proximity to work. However, workers who move in to Seoul for the first time have chosen residence with respect to their jobs. When it comes to testing the Household Responsibility Hypothesis for presence of children, the results are quite interesting. For married women commuting times do not depend significantly on the number of workers in the household. However, married women's commuting is strongly dependent on the number of children. This result is in strong contrast with the findings of Johnston-Anumonwo (1992), which claim that wives' commuting is more affected by 2 workers in the household than by the presence of children. Finally, the last inference from Lee & McDonald's analysis is that the presence of elderly relatives in the household increases wives' commuting significantly. This result means that children in the family are an obstacle to working women, and without the presence of elderly parents, married women would have shorter commutes.

The disparity between the two above-mentioned studies deepens even further the doubts that analysis on US data is not globally representative. The fact that Korean wives

react differently than American wives to a working husband and a child implies that cultural norms and social institutions differ across countries and this leads to different economic and commuting behaviour. However, there has been a limited number of analyses on non-US data, so we can not draw parallels between commuting behaviour in the USA and other countries.

3. Methodology

3.1 Method

In the case of one-worker households, the individual takes residential and employment decisions based on housing consumption, composite good consumption, and leisure. The quantities are chosen such that individual utility is maximised.

$$U = f(H, X, L) \quad (1)$$

Where H is housing consumption, X is composite-good consumption, and L is leisure. On the other hand the worker has his income constraint, based on his hourly wage W . However, the hourly wage depends on the distance to work and labour-market conditions. Therefore, W is endogenous in distance (u) and market factors (Z).

$$W = W(u, Z)$$

Similarly, the housing costs H are endogenous in distance (u) from employment centres (both CBD and suburban centres), and the amount of housing consumed (Q). Madden (1981) points out that housing costs are negatively related to the distance from employment, according to empirical evidence. The amount of housing Q can be measured with the number of bedrooms in the housing unit.

$$H = h(u, Q)$$

By expressing the individual time-constraint in terms of income and consumption, we can put a monetary value on commuting time (C). If the total time-endowment is T and leisure time is L , we have the following full-income constraint.

$$X + H(u, Q) + W(u, Z) \cdot (L + C) = W(u, Z) \cdot T \quad (2)$$

Madden (1981) shows that maximising (1) subject to (2) yields the equilibrium length of the trip-to-work for a one-worker household as a function of hourly wage (W), housing costs (H) and hours of work (M):

$$C^* = f_2[W(u, Z), H(u, Q), M] \quad (3)$$

For two-worker households Madden (1981) augments the utility function and income constraint with the spouse's leisure time and income. Therefore equation (1) is transformed into a joint utility function for the household:

$$U = f(H, X, L_i, L_j) \quad (4)$$

U is the joint utility of the household, where i stands for the own characteristics and j for the spouse's characteristics. The time constraint is individual for each spouse, where total time endowment (T) is allocated between work (M), commuting (C) and leisure (L). The full-income constraint, however, is determined by the joint consumption and income of the household.

$$T_i = M_i + C_i + L_i$$

$$T_j = M_j + C_j + L_j$$

$$X + H(u, Q) + W_i(u, Z) \cdot (L_i + C_i) + W_j(u, Z) \cdot (L_j + C_j) = W_i(u, Z) \cdot T_i + W_j(u, Z) \cdot T_j \quad (5)$$

After maximising (4) subject to (5) each worker's commuting time is found to be a function of the spouse's wage and hours at work.

$$C_{i,j}^* = f[w_i, w_j, rH, M_i, M_j, S] \quad (6)$$

Here rH is the rent times amount of housing consumed by the household. It is important to emphasise that the optimal commute time depends on both spouses wages and number of hours at work. S represents additional characteristics of the household, which may affect the choice of residence.

In order to test the model empirically I have to translate the arguments on the right-hand side of equation (6) to actual variables from my dataset. I need a model specification that determines commuting distance based on the wage and housing-costs variation. However, due to the structure of the statistical data provided by U.S. Census, it is not possible to map together both spouses information in the same equation. As a workaround I introduce a manually calculated variable *INCSHARE* equal to the ratio between own total income and total income of the family. According to the US Census definitions, the primary family includes only individuals directly related to the head of the household.

I will use annual earned income as a proxy for w_i and the variable *INCSHARE* to capture the inverse effect of the spouse's earnings. Housing consumption is measured as the average housing costs per month (*RENT*) and the dummy variable *CITY* which indicates whether the residence is located within the city centre. The number of hours at work is represented by the dummy *FULL* which is equal to one if the person has worked full-time during the past 12 months (full-time equals at least 35 hours per week). The spouse's hours of work can not be observed due to limitations of the dataset, and I expect that the *INCSHARE* variable will also account for work-hours variation, since it is based on total annual income. Following the specification by Singell & Lillydahl (1986) I include some

additional demographic variables to represent the S factor from equation (6). The $RACE$ dummy will reveal possible racial differences in commuting behaviour. Similarly, the gender dummy $SEXD$ is to identify different intercept for men and women in the commuting equation. By including the dummy variable $MOVED$ I try to identify whether households that moved into their residence less than 2 years ago have a higher or lower commuting time on average. $WRKCC$ indicates whether the person works in the central city. The coefficient for this variable will give me a hint about the attractiveness of central city employment compared to suburban employment. $CAR2$ is a dummy for households which have two or more own cars in the household, and will tell me how access to own vehicles affects commuting time. Finally, the $KIDS1$ and $KIDS2$ variables are included to test the household responsibility hypothesis (HRH) on two levels. $KIDS1$ is for presence of children less than 7 years old, while $KIDS2$ is for children aged 7-18 years.

Thus my specification for empirical estimation is:

$$\ln(C) = f[\ln(EARN), \ln(RENT), CITY, MOVED, \ln(HOURS), SEXD, \ln(INCSHARE), RACE, KIDS1, KIDS2, CAR2, WRKCC] \quad (7)$$

This is the main equation which will identify how various factors affect commuting time. However, I suspect that some of the variables on the right-hand side are endogenous. For instance, commuting time and income might be mutually dependent, as well as commuting time and rent. In case of endogeneity the OLS estimates will be inconsistent. To avoid this, I need to instrument the suspected variables and estimate equation (7) simultaneously with the following two equations.

$$\ln(EARN) = g(AGE, EDUC00, RACE, HOURS, PROF) \quad (8)$$

$$\ln(RENT) = h(\ln(C), BEDRM, KIDS, RACE, REGION, AGEHOME2) \quad (9)$$

The choice of instruments is justified empirically in section 5.1. The three equations above will be estimated as a system of simultaneous equations using Two-Stage Least Squares (2SLS). In this way we can capture the feedback effect of commuting on earnings and rent, as well as we include additional explanatory variables in the analysis. Equation (7) estimates the log of commute time based on earnings, housing cost, dummies for residence in the city ($CITY$) and recent change of residence ($MOVED$), working hours ($HOURS$), share of own earnings in total family earnings ($INCSHARE$), dummies for race, gender, presence of children in pre-school and school age, ownership of more than 1 car in the household ($CAR2$) and dummy for central city jobs ($WRKCC$). Equation (8) models the log of

individual earnings as a function of age, education and experience as measures of human capital, as well as working hours and occupation categories. Equation (9) estimates the housing cost, based on distance to work (proxied by commuting time), and number of bedrooms, presence of children, regional dummies and age of the home.. The set of equations above will be estimated separately for males and females.

3.2 Hypotheses

By using both the theoretical framework and literature review from the previous sections, I will attempt to construct expectations about the outcomes of my analysis. According to the model specification by Madden (1981) commuting time is a function of wage, housing cost, working hours and a set of demographic characteristics of the household. I expect workers to accept longer trips to work if they are compensated with a higher wage or lower housing costs. Also, the presence of children will lead to shorter commuting times for married women. One-worker households that have changed residence are expected to decrease their commuting, while in two-worker households residential change is expected to increase work trips for females and decrease commuting for males.

4. Data and descriptive statistics

4.1 Data source and limitations

The data used in this study was obtained from the American Community Survey 2007. The ACS is conducted by the U.S. Census Bureau annually and provides social, demographic, economic and housing information on households and individuals. For the purpose of this study I have extracted selected variables over a representative nationwide sample. The data was obtained from the Minnesota Population Center at University of Minnesota in the USA. The data can be accessed upon registration on the IPUMS website.

The original 5-percent sample from ACS 2007 contains survey information on 72,092 individuals. I use data on the individuals' family situation, housing costs, presence of children, income, average hours of work per week, length of trip to work, means of transportation, etc. I exclude persons who live in non-metropolitan areas, since the proposed theoretical framework is valid only for multi-centric cities. That is because workers in rural areas are often forced to commute to metropolitan centres, where there are more job opportunities. As mentioned in the theory above, the geographical distribution of employers is exogenous to the household. After excluding non-metropolitan residents I have 31,228 individual observations left.

To narrow down the sample only to persons relevant for my analysis, I exclude individuals with zero earned income. I do that because people who are not engaged in any income-generating activity do not commute at all. Therefore they do not provide any information to the commuting equation in my model. After excluding these individuals, there are 16,928 individuals in my sample. However, most of the observations are lost when taking logarithm of commuting time, housing cost, and working hours variables, because the logarithm operator is defined only on positive numbers. One limitation of the data for this study is related to the presence of self-employed persons in the dataset. Most of them work at home or their work locations change every day. They report mostly zero commuting times. However, from a pragmatic point of view these workers face the same time and income constraints as wage-earners. In order to capture their reactions to commuting, I set commuting times from 0 to 1 for these workers. Finally the total number of observations valid for my specification is 3,468.

A full list and description of the extracted variables can be found in Appendix A. Using information from the survey I construct several additional variables necessary for estimating the specification from section 3. A full list of constructed variables follows in Appendix B.

4.2 *Descriptive statistics*

The purpose of this section is to give the reader a feeling about the dataset used for empirical estimation. I will present mean values and standard deviations of some relevant variables across different sections of the data. The reader should keep in mind that mean values do not control for other variables and therefore cannot be used for statistical inference. First I will summarise the data across 4 separate domains for single and married males and females. In this way we can compare the average values of some relevant variables between gender and marital-status groups.

From Table 1 I can draw some inference about households' behaviour. Married men have the longest work-trips, 5 minutes longer on average than the other 3 groups. Married women also commute slightly longer than their single counterparts. This difference may be due to the fact that two-worker households have to choose residence location with respect to both spouses' job locations. On the other hand, the shortest commutes belong to single men. I can hypothesise that single men are more mobile and can minimise their commuting to a larger degree. Married men also have the highest earnings amongst all groups. This can be related to their commuting times. Higher earnings probably motivate this group to undertake longer commutes. The data also shows that women work shorter hours than men on average. My hypothesis is that women's role in household production leads to a trade-off between working hours and household responsibilities. The *INCSHARE* variable speaks in favour of the same hypothesis. I notice that married women earn around one third of the family's total earnings on average, while married men stand for more than two thirds of family earnings. This kind of evidence seems to validate Kain's (1962) hypothesis that women are secondary earners in two-worker households. However, this assertion would be wrong under the common preference model, since it does not control for other explanatory variables. Educational attainment is higher for married person than for singles. The positive relationship between education and earnings in Table 1 seems to fit human-capital theory confirming the positive returns to education. When looking at the *CITY* and *WRKCC*

Table 1: Descriptive statistics on groups with different gender and marital status
**Standard deviation in parentheses*

	Single men	Married men	Single women	Married women
Commuting time (<i>TRANTIME</i>)	19.06 (18.14)	24.40 (19.48)	19.72 (18.41)	19.77 (17.93)
Earned income (<i>INCEARN</i>)	34651 (48767)	73052 (82486)	29984 (35523)	40250 (44781)
Hours of work (<i>UHRSWORK</i>)	38.34 (13.53)	44.03 (11.74)	35.68 (12.85)	36.52 (12.39)
Share of total family income (<i>INCSHARE</i>)	0.64 (0.42)	0.67 (0.25)	0.68 (0.40)	0.38 (0.23)
Educational attainment (<i>EDUC00</i>)	10.13 (2.66)	11.16 (2.81)	10.61 (2.51)	11.30 (2.53)
Central city resident (<i>CITY</i>)	0.35 (0.48)	0.23 (0.42)	0.37 (0.48)	0.22 (0.42)
Central city job (<i>WRKCC</i>)	0.23 (0.42)	0.23 (0.42)	0.26 (0.44)	0.22 (0.41)
Presence of children (<i>KIDS</i>)	0.06 (0.24)	0.52 (0.50)	0.20 (0.40)	0.49 (0.50)
Observations	3634	5103	4032	4159

variables I notice a similar pattern. Single men and women tend to live and work in the city centre, while married persons prefer residence and employment in the suburbs. Having in mind that more than 50% of married persons have children, the preference for suburban residence might be related to the higher value of suburban residences as well as the better access to amenities for child-rearing (like schools, kinder gardens, medical centres). I notice also that very few single men have a child in their household, while for single women this share is significantly high. There is probably a substantial number of women which are heads of households and have increased household responsibilities due to the burden of child-rearing.

In Table 2 I present mean values of some variables by controlling only for gender and race. The first obvious disparity is that non-white persons commute longer than white persons from the corresponding gender group. Work-trips are longest for non-white females. Some researchers have hypothesised that Black and Hispanic women are the most

Table 2: Descriptive statistics on groups with different gender and race
**Standard deviation in parentheses*

	White men	Non-white men	White women	Non-white women
Commuting time (TRANTIME)	22.07 (18.78)	22.50 (20.09)	18.75 (17.22)	22.45 (20.25)
Earned income (INCEARN)	62467 (78498)	40806 (49288)	36632 (43539)	31323 (32010)
Hours of work (UHRSWORK)	42.03 (13.05)	40.55 (12.06)	35.85 (12.83)	36.81 (12.01)
Share of total family income (INCSHARE)	0.67 (0.32)	0.61 (0.35)	0.52 (0.36)	0.56 (0.35)
Educational attainment (EDUC00)	10.98 (2.66)	9.98 (3.05)	11.16 (2.42)	10.41 (2.79)
Central city resident (CITY)	0.23 (0.42)	0.43 (0.49)	0.24 (0.42)	0.46 (0.50)
Central city job (WRKCC)	0.22 (0.41)	0.28 (0.45)	0.21 (0.41)	0.32 (0.47)
Presence of children (KIDS)	0.33 (0.47)	0.34 (0.47)	0.33 (0.47)	0.39 (0.49)
Observations	6564	2173	5976	2215

disadvantaged category in the labour market. This is due to the male-female wage differentials on one side, and to the generally lower earnings of blacks and hispanics compared to whites on the other side. This claim finds further support in the mean values for earnings. Non-white women earn less than white women, despite the larger number of hours at work. When it comes to the share in family earnings, I notice that the disparity between men's and women's share in earnings is more balanced for non-white individuals than for whites. Educational attainment of non-white persons is generally lower than that of white persons. This fact probably contributes to the lower earnings of the non-white group as a whole. The CITY and WRKCC variables exhibit a common pattern once again. Non-white persons prefer a central city residence almost two times more often than white persons. They also prefer employment in the city. I suspect non-white persons choose jobs in the city as a consequence of their residence and the strive towards minimising commuting.

5. Empirical analysis

5.1 Instrumenting endogenous variables

As mentioned above in section 3, earned income and housing cost are endogenous in the commuting equation (7). In order to avoid biased estimates, I choose to instrument those two variables using appropriate exogenous factors. I start by drawing on the specification from Singell & Lillydahl (1986). I instrument earned income through *AGE*, *EDUC00*, *RACE*, *HOURS* and *PROF*. Age and education are purely exogenous and provide a rough approximation of accumulated human capital and experience. The number of hours of work per week (*HOURS*) will capture the effect of longer working hours on earnings. The dummy variable for full-time will identify the earnings variation between part- and full-time workers. *PROF* consists of 3 dummies representing 4 occupation categories. *PROF1*, *PROF2*, *PROF3*, *PROF4* stand for occupation categories as defined above in section 4.2.

On the other hand, the choice of instruments for housing cost is not that obvious. Therefore I borrow heavily from the instrumenting equation (4) in Singell & Lillydahl (1986). The housing value depends on distance from employment centres. Since there is no measurement of distance in the dataset, I will use commuting time $\ln(C)$ as a proxy for distance. Other suitable instruments for housing value are number of bedrooms (*BEDRM*), presence of children, regional dummies (*REGION*) and a dummy for housing built more than 7 years ago (*AGEHOME2*).

To verify empirically whether earnings and housing value really are endogenous in commuting, I run a Durbin-Wu-Hausman test for endogeneity. First I estimate the commuting equation with instrumental variables as described above, and then I run OLS on the same equation without instruments. The null hypothesis is that the OLS estimates are consistent, not deteriorated by endogeneity. However, if the null is rejected, instruments should be used to correct the estimates. Detailed output from the Durbin-Wu-Hausman test in STATA follows below.

```
ivreg lntrantime city self moved lnhrswork lnincshare race kids1 kids2 car2 wrkcc (lnrentgrs
lnincearn = lntrantime educ00 uhrswork bedrm kids prof1 prof2 prof3 region2 region3 region4
region5 region6 region7 region8 region9 agehome2 )
```

```

Instrumented: lnrentgrs lninearn
Instruments:  city self moved lnuhrswork lnincshare race kids1 kids2 car2
              wrkcc lntrantime educ00 uhrswork bedrm kids prof1 prof2 prof3
              region2 region3 region4 region5 region6 region7 region8
              region9 agehome2

```

Tests of endogeneity of: lnrentgrs lninearn

H0: Regressors are exogenous

Wu-Hausman F test:	250.49904	F(2,3453)	P-value = 0.00000
Durbin-Wu-Hausman chi-sq test:	439.41886	Chi-sq(2)	P-value = 0.00000

The rejection of the Chi-squared test indicates that the instruments are necessary to account for endogeneity. Therefore there is evidence that earnings and housing cost are endogenous in the equation for commuting time. This confirms the specifications of equations (8) and (9) from section 3.1. Therefore we need to model the latter two variables as functions of exogenous variables.

$$\ln(EARN) = g[AGE, EDUC00, RACE, HOURS, PROF]$$

$$\ln(RENT) = h[\ln(C), BEDRM, KIDS, RACE, REGION, AGEHOME2]$$

5.2 Regression over the whole sample

As a starting point for my analysis I will test an extended version of equation (7) by including additional demographic variables. In this way I identify the sub-groups of individuals that react differently to factors in the commuting equation. For example, workers who have changed residence recently are likely to have moved closer to their job. Thus, I include dummy variables SELF and SEXD. The first dummy indicates that the person is self-employed, while SEXD is a gender dummy equal to 1 for males. If these two effects turn out significant in the estimation, I can expect that self-employed workers and wage-earners react differently to commuting factors. By the same reasoning, a significant gender dummy prompts that I need to estimate commuting separately for men and women. The variable *MOVED* indicates whether moving into the current residence happened less than 2 years ago. I include also dummies for gender, race, presence of children and self-employed individuals. Thus I estimate the following augmented specification of the commuting equation over the entire sample of men and women together:

$$\ln(C) = f[\ln(EARN), \ln(RENT), CITY, MOVED, \ln(HOURS), \ln(INCSHARE), RACE, SELF, SEXD, KIDS1, KIDS2, CAR2, WRKCC]$$

Where $\ln(EARN)$ and $\ln(RENT)$ are instrumented as described in the previous section.

Below I present the estimation results for the commuting equation.

Table 3: Regression results for all individuals * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

	Coef.	SE
lninearn	0.18 **	(0.06)
lnrentgrs	-0.02	(0.08)
city	0.04	(0.03)
self	-1.11 ***	(0.06)
moved	-0.04	(0.03)
lnuhrwork	-0.09	(0.07)
lnincshare	-0.02	(0.04)
race	-0.16 ***	(0.03)
sexd	-0.03	(0.03)
kids1	-0.03	(0.04)
kids2	0.03	(0.04)
car2	0.04	(0.03)
wrkcc	0.06	(0.03)
_cons	0.59	(0.45)
N	3468	
R2	0.16	

As seen from Table 3 there are significant effects for earnings, self-employed individuals and the dummy for race. This implies that these effects exhibit the same behaviour for all categories of workers. Both men and women commute longer if they have higher earnings. In terms of elasticities, the estimation shows that a 10% increase in earnings leads to 1.8% increase in commuting time. The estimated coefficient for *SELF* indicates that self a self-employed person has commuting times 1.11 times shorter than a wage-earning individual with the same characteristics. This may be due to the fact that self-employed persons often work from home or very close to their residence. The racial differential in commuting also turns out significant. The outcome is that a non-white worker commutes 18% longer than a white person in the same situation.

The remaining coefficients are not significant, but despite that I will include their size and magnitude in my discussion. Living in the central city has a slightly positive effect on commuting. City-dwellers commute 4% longer than suburban residents in the same situation. A similar result is observed for persons working in the city centre. They commute 6% longer than workers at suburban locations. The combination of these two results confirm the multi-

centric hypothesis and shows that employment is no longer concentrated in the Central Business District (CBD). Central city residents and workers commute most probably to suburban centres. Another interesting finding is that persons who have changed residence in the past 2 years have 4% shorter commutes than workers who have not changed residence in a similar situation. This implies that the residence location has been affected to some degree by the job location. The coefficient for gender shows that men have work-trips 3% shorter than women. This result contradicts the predictions of my model, but the coefficient is insignificant. The presence of children in pre-school age decreases the length of work trips, thus validating one aspect of the Household Responsibility Hypothesis. However, if the child is of school-age (older than 7 years), it has a positive effect on commuting compared to households without children. If the household owns two or more cars, the family members have 4% longer commutes than those in households with one or no own cars. This outcome is in line with expectations, because commuting by car allows for longer and more flexible trips.

5.3 Regressions over sub-samples for gender and working hours

By testing the theoretical model above on different groups of individuals I can obtain a better understanding of these groups' commuting patterns. The next set of tests will distinguish groups by gender and full-time employment status. I want to investigate whether full-time and part-time workers react differently to factors of commuting. To achieve this I estimate equations (7)-(9) over 4 sub-samples: full-time males, full-time & part-time males, full-time females, and full-time & part-time females. In this way I can isolate the bias of part-time workers, who face a looser time constraint and are therefore likely to behave differently. People working at least 35 hours a week are classified as full-time employees, while workers with less than 35 hours a week are classified as part-time employees. These categories were defined according to the U.S. Census Bureau concepts for Current Population Survey (CPS) and American Community Survey (ACS) ("US Census: Concepts," n.d.).

The first interesting result reported in Table 4 is the different sign of the earnings coefficient for men and women. Higher earnings seem to decrease the commuting time of full-time men slightly, while women commute longer if they earn more. Central city residence also has opposite effects for men and women: men living in the city commute longer than

men in the suburbs, but women living in the city have shorter trips than females living in the suburbs. This phenomenon may be due to the different spatial distribution of typically male and female occupations, as pointed out by Singell & Lillydahl (1986) and Johnston-Anumonwo (1992).

Table 4: Regression results over gender and full-time status * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

	Males				Females			
	Full-time		Full&part-time		Full-time		Full&part-time	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
lninccarn	-0.13	(0.09)	0.02	(0.06)	0.27 **	(0.09)	0.19 ***	(0.05)
lnrentgrs	0	(0.14)	-0.08	(0.12)	0.04	(0.14)	0.07	(0.11)
city	0.04	(0.05)	0.02	(0.05)	-0.04	(0.05)	-0.02	(0.05)
moved	-0.03	(0.05)	0	(0.05)	-0.06	(0.05)	-0.04	(0.05)
lnincshare	0.05	(0.07)	0.03	(0.06)	-0.08	(0.07)	0.04	(0.05)
race	-0.03	(0.05)	-0.1 *	(0.05)	-0.21 ***	(0.05)	-0.23 ***	(0.05)
kids1	-0.07	(0.06)	-0.04	(0.06)	0.04	(0.07)	-0.01	(0.06)
kids2	0.1	(0.07)	0.09	(0.07)	-0.01	(0.06)	-0.03	(0.06)
car2	-0.01	(0.05)	0.01	(0.05)	0.08	(0.05)	0.06	(0.05)
wrkcc	0.1	(0.05)	0.12 *	(0.05)	0.06	(0.05)	0.08	(0.05)
_cons	4.27 ***	(0.81)	3.27 ***	(0.71)	0	(0.82)	0.64	(0.63)
	N 1558		N 1774		N 1294		N 1694	
	R2 .		R2 0.01		R2 0.01		R2 0.05	

Recent movers to a new residence exhibit shorter commuting times in all four categories. This reaffirms once again the hypothesis that residence is chosen as dependent on job location, aiming to minimise commuting. The coefficients for income share are not significant but they hint at a certain gender disparity. Among full-time workers, men who earn a larger share of family income tend to commute longer, while women who earn a larger share commute less. This outcome is quite interesting, because it relates to a different attitude towards commuting by the men and women. As earner of higher income (and often primary earner in the family) men measure the return to commuting mainly through earnings. However, the case is not the same for women. Even when they are the primary earner in the family, they measure the return to commuting as a combination of wage gains and trade-off with household responsibilities. Another striking result is the coefficient for race. While for men the variable race has a slight negative effect on commuting, the effect for women is quite negative. This implies that non-white women have about 20% longer work trips than white women in the same situation. I can hypothesise that this is due to a combination of factors. On one hand, the spatial distribution of typically non-white female

jobs is less uniform than other jobs, which puts this group at a disadvantage. On the other hand, in non-white families the residence location might be decided more in favour of the husband, than the same decision in white families. The effect of children on commuting is ambiguous in this estimation. However, ownership of two or more cars increases females' commuting time more than that of males. This implies that the first car in the household tends to increase the husband's commuting, while the second car(when there is one) is used by the wife as a secondary earner. The coefficient for central city job in this estimation shows significance and it is larger for men than for women. This says something about the spatial distribution of male and female jobs. While men are willing to undertake longer work-trips to the city, women seem to prefer shorter trips to jobs in the suburbs.

5.4 Regressions over sub-samples for gender and marital status

The next part of the analysis is crucial for testing the Household Responsibility Hypothesis. We divide the surveyed individuals into four groups: single men, single women, married men, and married women. The first two groups include males and females whose marital status is not “married, spouse presents”. Therefore, this sub-sample stands for one-worker households. The third and fourth sub-samples contain married men and women respectively. By estimating the commuting equation separately we can identify the gender differences between men and women in two-worker households.

Table 5: Regression results over gender and marital status * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

	Single men		Married men		Single women		Married women	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
lnincome	0.16	(0.11)	0.1	(0.21)	0.28 ***	(0.08)	0.33	(0.2)
lnrentgrs	-0.07	(0.13)	-0.21	(0.25)	-0.05	(0.12)	-0.07	(0.23)
city	0.12 *	(0.06)	-0.04	(0.08)	0.04	(0.05)	-0.09	(0.1)
self	-1.21 ***	(0.11)	-0.94 ***	(0.12)	-0.81 ***	(0.1)	-1.71 ***	(0.15)
moved	-0.06	(0.06)	0.06	(0.09)	-0.03	(0.05)	-0.06	(0.12)
lnhrswork	-0.04	(0.13)	-0.05	(0.19)	-0.2	(0.11)	-0.22	(0.15)
lnincshare	-0.09	(0.07)	0.1	(0.17)	-0.07	(0.06)	-0.14	(0.19)
race	-0.08	(0.06)	-0.09	(0.08)	-0.18 ***	(0.05)	-0.28 **	(0.09)
kids1	-0.17	(0.14)	-0.08	(0.09)	0.05	(0.08)	-0.01	(0.1)
kids2	0.25	(0.15)	0.03	(0.1)	0.02	(0.07)	0	(0.1)
car2	0.03	(0.06)	0.04	(0.08)	0.12 *	(0.05)	-0.09	(0.1)
wrkcc	0.03	(0.06)	0.17 *	(0.09)	0.05	(0.05)	-0.03	(0.11)
_cons	0.71	(0.93)	2.78 *	(1.18)	0.43	(0.67)	-0.58	(1.47)
	N	1108	N	666	N	1238	N	456
	R2	0.15	R2	0.11	R2	0.08	R2	0.29

The most significant coefficient in this estimation is the dummy for self-employed workers. They are negative and around -1 implying about 100% shorter commuting time for the self-employed in all four categories of workers. This confirms once again that self-employed persons optimise their location choices better than wage earners, and often they work from home. Interestingly, the income share estimates have different sign for married men and married women. This supports the Household Responsibility Hypothesis because it hints that husbands as primary earners tend to increase commuting when they have a higher earnings share. Wives, on the contrary, decrease their work trips as their earnings share increases. This effect can be attributed to the burden of household responsibilities on wives' time budgets. The racial dummy again shows very strong negative effects for white women's commuting. Married white women's commuting time is about 28% shorter than that of married non-white women. However, the effect of children on commuting is insignificant in all four categories. The dummy for recent movers shows that a new residence has a positive effect on married men's commuting, and a negative effect on married women's commuting. This implies that the choice of new residence has decreased the commuting time of wives and has increased the work-trip length for husbands. This finding is rather strange, and contradicts completely Singell & Lillydahl's (1986) conclusions. Further investigation of this result remains to be done in future research. This will require larger dataset, refined model specifications and more advanced econometric methods.

6. Conclusion

After performing a series of tests and estimations, I found significant differences in men's and women's commuting behaviour. The descriptive analysis showed that women have considerably shorter commuting times than men, and that they earn a considerably smaller share of family income than men. Even though these results do not control for other factors, they suggest that men are still primary earners in two-worker households, and that women still undertake shorter work trips than their spouses.

By controlling for all factors simultaneously, I disclose further aspects of households' commuting patterns. In general, higher earnings are related to longer work trips in a general analysis of all individuals. However, a differentiated estimation shows that the commuting gains from earnings are several times larger for women than for men. This implies that if women earned more, they would be willing to commute longer. This outcome confirms the conclusions by Madden (1981) that if women had the same wage and weekly hours as men, they would commute even longer than men.

Resent movers to a new residence exhibit shorter commuting times across all categories of workers. This implies that residential location choice often is based on job location and aims to minimise commuting. Workers who are self employed or do not work for wage tend to have shorter commuting trips than full time wage earners. This result is consistent with the findings of Lee & McDonald (2003).

Men who work full-time and earn a larger share of family income have longer work-trips, while full-time female workers who earn a larger share of family income commute less. This result suggests that women measure the return to commuting not only through earnings, but probably through household responsibilities too.

What is common for all estimations performed above is the fact that most factors turn out statistically insignificant. This may be due to the large number of requirements on the dataset, which leaves a very limited sample of observations. Another possible cause is that of using proxy-variables for some of the factors in the model. To remedy that, future research needs to control strictly for correlation and endogeneity in the specification.

Even though women's labour-force participation has increased dramatically in the past years and is catching up with male participation, there are still significant gender disparities in the labour market. The earnings of females are still lower than those of males, despite the

fact the women have higher educational attainment on average. The specific role of men and women in household production also causes different preferences for commuting, which constitutes a weak evidence for validity of the Household Responsibility Hypothesis.

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Appendix A

The variables extracted from ACS 2007 for the purpose of this study are listed below. Codes and descriptions are taken from the IPUMS website.

<i>age</i> -	respondent's age
<i>sex</i> -	gender (2 codes: male and female)
<i>race</i> -	respondent's race (9 codes: White, Black, Native Indian, Chinese, Japanese, Asian or Pacific, Other, 2 races, 3+ races)
<i>metro</i> -	metropolitan central city status. Indicates whether respondent lives in metropolitan area and whether in the central city(5 codes: outside metro, in metro, in central city, in metro but outside central city, metro N/A, central city N/A)
<i>educ00</i> -	Educational attainment (16 codes: from 'no school completed' to 'doctorate degree')
<i>marst</i> -	marital status (6 codes: married with spouse, married no spouse, separated, divorced, widowed, never married)
<i>ynrch</i> -	age of youngest own child
<i>occ</i> -	main occupation for persons that have been employed in the past 5 years (encoded by the ACS occupations table)
<i>inccarn</i> -	earned income, including wage, own business, farm and self-employed
<i>inctot</i> -	total personal income from all sources during the past 12 months
<i>ftotinc</i> -	total family income, all sources (family defined as persons related to head of household)
<i>uhrswork</i> -	average hours of work per week during the past 12 months
<i>region</i> -	census region of residence (9 codes: New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, Pacific)
<i>rentgrs</i> -	monthly cost of housing unit, including utilities
<i>bedrooms</i> -	number of bedrooms in housing unit
<i>builtyr2</i> -	decade when housing unit was built
<i>movedin</i> -	years since moved into current housing unit
<i>vehicles</i> -	number of own cars, vans and trucks available to the household
<i>trantime</i> -	travel time to work in minutes
<i>tranwork</i> -	primary means of transportation to work (13 codes)
<i>pwtype</i> -	metropolitan central city status of place of work (see <i>metro</i>)

Appendix B

List of constructed variables used in estimation.

city -	central city status of residence (when <i>metro</i> =2)
wrkcc -	central city status of place of work (when <i>pwtype</i> =1)
self -	dummy for self-employed person (when <i>classwkr</i> =1)
moved -	moved in current residence in the past 2 years (when <i>movedin</i> ≤2)
incshare -	ratio of own income to total family income (equals <i>inctot/ftotinc</i>)
race -	dummy for race, 1 for white, 0 for non-white (when <i>raced</i> =100)
kids -	presence of own children (when <i>ynpch</i> ≤18)
kids1 -	presence of own children in pre-school age, under 7 years (when <i>ynpch</i> ≤6)
kids2 -	presence of own children in school age, 7-18 years (when 7≤ <i>ynpch</i> ≤18)
car2 -	indicates whether the households own 2 or more cars (when <i>vehicle</i> >1)
prof1 -	Occupation within management, professional, sales & office (when <i>occ</i> in 1÷354 or 470÷613)
prof2 -	Occupation within service (when <i>occ</i> in 360÷465)
prof3 -	Occupation within construction & maintenance (when <i>occ</i> in 620÷762)
prof4 -	Occupation within production and transportation (when <i>occ</i> in 770÷992)
agehome1 -	Indicates whether the housing unit was built in the last 7 years (when <i>builtyr2</i> ≤2)
agehome2 -	Indicates whether the housing unit was built more than 7 years ago (when <i>builtyr2</i> >2)
region1 -	recoded from <i>region</i> : New England Division
region2 -	recoded from <i>region</i> : Middle Atlantic Division
region3 -	recoded from <i>region</i> : East North Central Division
region4 -	recoded from <i>region</i> : West North Central Division
region5 -	recoded from <i>region</i> : South Atlantic Division
region6 -	recoded from <i>region</i> : East South Central Division
region7 -	recoded from <i>region</i> : West South Central Division
region8 -	recoded from <i>region</i> : Mountain Division
region9 -	recoded from <i>region</i> : Pacific Division

Appendix C

	Coef.	Std. Err.
Rent	R2= 0.16	
lntrantime	-0.07 **	(0.02)
bedrm	0.13 ***	(0.01)
kids	-0.03 *	(0.02)
race	0.09 ***	(0.02)
region2	0	(0.04)
region3	-0.26 ***	(0.04)
region4	-0.23 ***	(0.05)
region5	-0.08	(0.04)
region6	-0.38 ***	(0.06)
region7	-0.33 ***	(0.04)
region8	-0.19 ***	(0.05)
region9	0.1 **	(0.04)
agehome2	-0.13 ***	(0.03)
_cons	6.96 ***	(0.08)
Earnings	R2= 0.35	
Age	0.01 ***	(0)
Educational	0.08 ***	(0.01)
race	0.06 *	(0.03)
Usual	0.04 ***	(0)
prof1	0.09 *	(0.04)
prof2	-0.2 ***	(0.05)
prof3	0.18 **	(0.06)
_cons	7.08 ***	(0.08)
Commuting	R2= 0.14	
lninccarn	0.18 **	(0.06)
lnrentgrs	-0.02	(0.08)
city	0.04	(0.03)
self	-1.11 ***	(0.06)
moved	-0.04	(0.03)
lnuhrswork	-0.09	(0.07)
lnincshare	-0.02	(0.04)
race	-0.16 ***	(0.03)
sexd	-0.03	(0.03)
kids1	-0.03	(0.04)
kids2	0.03	(0.04)
car2	0.04	(0.03)
wrkcc	0.06	(0.03)
_cons	0.59	(0.45)
N	3468	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Single men			Married men			Single women			Married women		
	Coef.	SE		Coef.	SE		Coef.	SE		Coef.	SE
Rent	R2= 0.1		Rent	R2=0.16		Rent	R2= 0.18		Rent	R2= 0.19	
Intrantime	-0.15 ***	(0.04)	Intrantime	-0.08	(0.05)	Intrantime	0.04	(0.05)	Intrantime	-0.03	(0.04)
bedrm	0.1 ***	(0.01)	bedrm	0.15 ***	(0.02)	bedrm	0.14 ***	(0.01)	bedrm	0.13 ***	(0.02)
kids	-0.03	(0.05)	kids	-0.08 *	(0.03)	kids	-0.11 ***	(0.03)	kids	-0.07	(0.04)
race	0.05	(0.03)	race	0.04	(0.03)	race	0.13 ***	(0.03)	race	0.07	(0.04)
region2	0.05	(0.07)	region2	-0.03	(0.1)	region2	-0.03	(0.06)	region2	0.01	(0.1)
region3	-0.25 ***	(0.07)	region3	-0.28 **	(0.1)	region3	-0.25 ***	(0.07)	region3	-0.22 *	(0.11)
region4	-0.2 *	(0.09)	region4	-0.29 *	(0.14)	region4	-0.22 **	(0.09)	region4	-0.15	(0.14)
region5	-0.08	(0.07)	region5	-0.12	(0.1)	region5	-0.08	(0.07)	region5	-0.02	(0.1)
region6	-0.53 ***	(0.1)	region6	-0.24	(0.14)	region6	-0.38 ***	(0.1)	region6	-0.19	(0.14)
region7	-0.3 ***	(0.07)	region7	-0.34 **	(0.11)	region7	-0.38 ***	(0.07)	region7	-0.24 *	(0.11)
region8	-0.18 *	(0.09)	region8	-0.27 *	(0.12)	region8	-0.14	(0.09)	region8	-0.24	(0.13)
region9	0.06	(0.07)	region9	0.07	(0.1)	region9	0.11	(0.06)	region9	0.2 *	(0.1)
agehome2	-0.05	(0.05)	agehome2	-0.09	(0.05)	agehome2	-0.21 ***	(0.05)	agehome2	-0.12	(0.07)
Earnings	R2= 0.36		Earnings	R2=0.23		Earnings	R2= 0.42		Earnings	R2= 0.33	
Age	0.02 ***	(0)	Age	0.01 *	(0)	Age	0.02 ***	(0)	Age	0.01	(0)
Education	0.08 ***	(0.01)	Education	0.05 ***	(0.01)	Education	0.12 ***	(0.01)	Education	0.05 ***	(0.01)
race	0.13 *	(0.05)	race	0.08	(0.06)	race	0.02	(0.05)	race	-0.07	(0.08)
Hours	0.04 ***	(0)	Hours	0.02 ***	(0)	Hours	0.04 ***	(0)	Hours	0.04 ***	(0)
prof1	0.1	(0.08)	prof1	0.25 ***	(0.08)	prof1	0.01	(0.1)	prof1	0.35 *	(0.15)
prof2	-0.06	(0.09)	prof2	-0.13	(0.09)	prof2	-0.28 **	(0.1)	prof2	-0.07	(0.15)
prof3	0.2 *	(0.09)	prof3	-0.02	(0.09)	prof3	-0.21	(0.37)	prof3	1.23	(0.83)
Commuting	R2= 0.15		Commuting	R2=0.11		Commuting	R2= 0.08		Commuting	R2= 0.29	
lninccarn	0.16	(0.11)	lninccarn	0.1	(0.21)	lninccarn	0.28 ***	(0.08)	lninccarn	0.33	(0.2)
lnrentgrs	-0.07	(0.13)	lnrentgrs	-0.21	(0.25)	lnrentgrs	-0.05	(0.12)	lnrentgrs	-0.07	(0.23)
city	0.12 *	(0.06)	city	-0.04	(0.08)	city	0.04	(0.05)	city	-0.09	(0.1)
self	-1.21 ***	(0.11)	self	-0.94 ***	(0.12)	self	-0.81 ***	(0.1)	self	-1.71 ***	(0.15)
moved	-0.06	(0.06)	moved	0.06	(0.09)	moved	-0.03	(0.05)	moved	-0.06	(0.12)
lnuhrswork	-0.04	(0.13)	lnuhrswork	-0.05	(0.19)	lnuhrswork	-0.2	(0.11)	lnuhrswork	-0.22	(0.15)
lnincshare	-0.09	(0.07)	lnincshare	0.1	(0.17)	lnincshare	-0.07	(0.06)	lnincshare	-0.14	(0.19)
race	-0.08	(0.06)	race	-0.09	(0.08)	race	-0.18 ***	(0.05)	race	-0.28 **	(0.09)
kids1	-0.17	(0.14)	kids1	-0.08	(0.09)	kids1	0.05	(0.08)	kids1	-0.01	(0.1)
kids2	0.25	(0.15)	kids2	0.03	(0.1)	kids2	0.02	(0.07)	kids2	0	(0.1)
car2	0.03	(0.06)	car2	0.04	(0.08)	car2	0.12 *	(0.05)	car2	-0.09	(0.1)
wrkcc	0.03	(0.06)	wrkcc	0.17 *	(0.09)	wrkcc	0.05	(0.05)	wrkcc	-0.03	(0.11)
N	1108		N	666		N	1238		N	456	

Full-time males			Full & part-time males			Full-time females			Full & part-time females		
	Coef.	SE		Coef.	SE		Coef.	SE		Coef.	SE
Rent	R2=.		Rent	R2=.		Rent	R2=.		Rent	R2=0.1	
Intrantime	-0.43 ***	(0.12)	Intrantime	-0.26 **	(0.1)	Intrantime	0.58 ***	(0.14)	Intrantime	0.18 **	(0.07)
bedrm	0.12 ***	(0.01)	bedrm	0.12 ***	(0.01)	bedrm	0.14 ***	(0.02)	bedrm	0.15 ***	(0.01)
kids	0	(0.03)	kids	0.02	(0.03)	kids	-0.07	(0.04)	kids	-0.07 **	(0.03)
race	0.03	(0.03)	race	0.04	(0.03)	race	0.2 ***	(0.04)	race	0.16 ***	(0.03)
region2	0.02	(0.08)	region2	0.03	(0.06)	region2	-0.14	(0.09)	region2	-0.04	(0.06)
region3	-0.31 ***	(0.08)	region3	-0.27 ***	(0.07)	region3	-0.2 *	(0.09)	region3	-0.22 ***	(0.06)
region4	-0.26 *	(0.11)	region4	-0.23 **	(0.08)	region4	-0.08	(0.13)	region4	-0.2 **	(0.08)
region5	-0.15	(0.08)	region5	-0.11	(0.06)	region5	-0.2 *	(0.09)	region5	-0.08	(0.06)
region6	-0.45 ***	(0.11)	region6	-0.46 ***	(0.09)	region6	-0.24	(0.13)	region6	-0.28 **	(0.09)
region7	-0.33 ***	(0.08)	region7	-0.33 ***	(0.07)	region7	-0.26 **	(0.1)	region7	-0.32 ***	(0.07)
region8	-0.22 *	(0.1)	region8	-0.2 *	(0.08)	region8	-0.2	(0.12)	region8	-0.19 *	(0.08)
region9	0.02	(0.07)	region9	0.06	(0.06)	region9	0.09	(0.08)	region9	0.14 *	(0.06)
agehome2	-0.04	(0.05)	agehome2	-0.06	(0.04)	agehome2	-0.2 ***	(0.06)	agehome2	-0.16 ***	(0.04)
_cons	8.04 ***	(0.35)	_cons	7.53 ***	(0.31)	_cons	5.07 ***	(0.43)	_cons	6.18 ***	(0.23)
Earnings	R2=0.32		Earnings	R2=0.32		Earnings	R2=0.26		Earnings	R2=0.38	
Age	0.01 ***	(0)	Age	0.02 ***	(0)	Age	0.01 ***	(0)	Age	0.01 ***	(0)
Education	0.07 ***	(0.01)	Education	0.07 ***	(0.01)	Education	0.11 ***	(0.01)	Education	0.1 ***	(0.01)
race	0.15 ***	(0.04)	race	0.11 **	(0.04)	race	0.08 *	(0.04)	race	0	(0.04)
Hours	0.01 ***	(0)	Hours	0.03 ***	(0)	Hours	0.01 *	(0)	Hours	0.04 ***	(0)
prof1	0.19 ***	(0.05)	prof1	0.15 **	(0.06)	prof1	0.14	(0.08)	prof1	0.11	(0.08)
prof2	-0.08	(0.06)	prof2	-0.09	(0.06)	prof2	-0.24 **	(0.08)	prof2	-0.22 **	(0.08)
prof3	0.08	(0.06)	prof3	0.13 *	(0.06)	prof3	0.29	(0.32)	prof3	0.05	(0.34)
_cons	8.28 ***	(0.13)	_cons	7.39 ***	(0.11)	_cons	8.11 ***	(0.16)	_cons	6.75 ***	(0.13)
Commuting	R2=.		Commuting	R2=0.01		Commuting	R2=0.01		Commuting	R2=0.05	
lninccarn	-0.13	(0.09)	lninccarn	0.02	(0.06)	lninccarn	0.27 **	(0.09)	lninccarn	0.19 ***	(0.05)
lnrentgrs	0	(0.14)	lnrentgrs	-0.08	(0.12)	lnrentgrs	0.04	(0.14)	lnrentgrs	0.07	(0.11)
city	0.04	(0.05)	city	0.02	(0.05)	city	-0.04	(0.05)	city	-0.02	(0.05)
moved	-0.03	(0.05)	moved	0	(0.05)	moved	-0.06	(0.05)	moved	-0.04	(0.05)
lnincshare	0.05	(0.07)	lnincshare	0.03	(0.06)	lnincshare	-0.08	(0.07)	lnincshare	0.04	(0.05)
race	-0.03	(0.05)	race	-0.1 *	(0.05)	race	-0.21 ***	(0.05)	race	-0.23 ***	(0.05)
kids1	-0.07	(0.06)	kids1	-0.04	(0.06)	kids1	0.04	(0.07)	kids1	-0.01	(0.06)
kids2	0.1	(0.07)	kids2	0.09	(0.07)	kids2	-0.01	(0.06)	kids2	-0.03	(0.06)
car2	-0.01	(0.05)	car2	0.01	(0.05)	car2	0.08	(0.05)	car2	0.06	(0.05)
wrkcc	0.1	(0.05)	wrkcc	0.12 *	(0.05)	wrkcc	0.06	(0.05)	wrkcc	0.08	(0.05)
_cons	4.27 ***	(0.81)	_cons	3.27 ***	(0.71)	_cons	0	(0.82)	_cons	0.64	(0.63)
N	1558		N	1774		N	1294		N	1694	